HEAT TRANSFER AND PRESSURE DROP MEASUREMENTS IN LOW ASPECT RATIO CHANNELS WITH CIRCULAR PINS AND STRIP FINS

A Thesis

by

METAPUN NUNTAKULAMARAT

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Je-Chin Han
Committee Members,	Meinhard Taher Schobeiri
	Kuang-An Chang
Head of Department,	Andreas A. Polycarpou

August 2018

Major Subject: Mechanical Engineering

ABSTRACT

The heat transfer study of a rectangular duct has become important as it can replicate the channel geometry of the turbine blade or vane in a real engine. The low aspect ratio channel represents trailing edge channel of the vane where the internal features inside it are installed to not only strengthen the blade structure, but also promote higher turbulence in order to enhance heat transfer. With its ease of manufacturing, the circular pin is one of the most popular features introduced in this field of study. In addition, the strip fins are brought to compare with the circular pin. The strip fins provide relatively high area ratio with less area reduction on the end wall.

The tests were conducted at Turbomachinery Laboratory, Texas A&M University. The laboratory was capable of generating the range of Reynolds number from 20,000 to 80,000. The experiment was conducted to study heat transfer and pressure loss of seven different designs, including smooth channel (area ratio of unity), three area ratios from a circular pin shape, and the other three area ratios from a strip fin shape. The aspect ratio and spanwise space setups were varying from test by test. All the design configurations in this experiment were in staggered arrays as they gave us higher heat transfer than the in-line design.

DEDICATION

This thesis work is dedicated to my family.

ACKNOWLEDGEMENTS

I would like to express a sincere gratitude to Dr. Je-Chin Han, for the time and all the supports given to me as an advisee. I could not have completed this research without his advice and dedication. I would also extend my thanks to other committee members, Dr. Meinhard Taher Schobeiri, and Dr. Kuang-An Chang for their guidance and support throughout the course of this research.

Thanks would be extended to my friends, colleagues, the department faculty and other staff for making my time at Texas A&M University a great experience, especially Dr. Chao-Cheng Shiau and Dr. Andrew Chen who have assisted me in the research.

Finally, thank you my family for the encouragement and other supports throughout 2 years at Texas A&M University.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supervised by a thesis committee consisting of Professor Je-Chin Han and Professor Meinhard Taher Schobeiri of the Department of Mechanical Engineering and Professor Kuang-An Chang of the Department of Civil Engineering

All work for the thesis was completed independently by the student.

Funding Sources

This work was made possible in part by Thai Oil Public Company limited scholarship. The experimental test section is partially supported by the Marcus Easterling Endowment Fund, Texas A&M University.

Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Thai Oil Public Company limited.

NOMENCLATURE

A_c	Cross-sectional area of the test channel [m^2]
P	Peripheral length of the test channel [m]
D_h	Hydraulic diameter [m]
ρ	Fluid density [$\frac{kg}{m^3}$]
k	Thermal conductivity [$\frac{W}{mK}$]
μ	Dynamic viscosity [$\frac{kg}{ms}$]
Pr	Prandtl number
Re	Reynolds number
$\dot{m}$	Mass flow rate [$\frac{kg}{s}$]
Q_{net}	Heat supplied to fluid [W]
Q_{loss}	Heat loss to environment [W]
Q_{input}	Power supplied to heater [W]
$Q_{i/r}$	Heat supplied to copper plate per region [W]
Q_L	Heat loss at low temperature target [W]
Q_L	Heat supplied to heater at low temperature target [W]
$Q_{L,n}$	Local heat supplied to heater at low temperature target [W]
Q_H	Heat supplied to heater at high temperature target [W]
$Q_{H,n}$	Local heat supplied to heater at high temperature target [W]

P Static pressure [Pa]

ΔP Differential pressure [Pa]

T_w Wall temperature $[K]$

$T_{w,n}$ Local wall temperature $[K]$

$T_{L,room}$ Room temperature at low temperature target $[K]$

$T_{H,room}$ Room temperature at high temperature target $[K]$

T_b Fluid bulk temperature $[K]$

A Copper plate area $[m^2]$

h Heat transfer coefficient $[\frac{W}{m^2K}]$

h_n Local heat transfer coefficient $[\frac{W}{m^2K}]$

Nu Nusselt number

Nu_n Local Nusselt number

Nu_0 Nusselt number from smooth channel correlation

f Friction factor

f_0 Friction factor from smooth channel correlation

H Pin or fin height $[in]$

S Pin or fin spanwise space $[in]$

X Pin or fin streamwise pitch $[in]$

D Pin diameters $[in]$

W Fin width $[in]$

L Fin Length $[in]$

TABLE OF CONTENTS

Page

Page

LIST OF FIGURES

Page

Page

LIST OF TABLES

Page

1. INTRODUCTION

1.1 Overview

The huge demand of thermal efficiency improvement has turned the gas turbine cooling technology to becoming one of critical areas to study. The fact that the inlet temperature at rotor passage can rise to over 2,000 ℃, the melting point of metal[1], has posed threats to gas turbine daily operations in terms of service life. This has driven researchers to seek out novel technology to improve the heat transfer capability of a gas turbine. Multiple technologies have been used to extend the gas turbine life, one of which is to trap side stream from the compressor to cool turbine blades. Although, this cooler air buffer can protect the turbine blades from directly hitting the high-temperature gas, it leads to lower thermal efficiency. Moreover, the use of the compressed air increases the possibility of having higher concentration of NOx in exhaust gas. The turbine designers have put tremendous effort in maximizing the turbine thermal efficiency and minimizing the concentration of NOx in exhaust gas, while high reliability and integrity of the turbine parts remain unchanged.

It is due to the constraint of turbine blade geometry, airfoil shape, which causes the low aspect ratio on the trailing edge side, leading to conducting this experiment. The low aspect ratio has generated a special characteristic that pin-fins used in trailing edge portion of the turbine blades has certain height to diameter ratios, H/D, ranging from ½ to four. Unlike shell and tube heat exchanger, the end wall area dominates the heat transfer in short pin-fins.

1.2 Thermal and flow condition effect

Ligrani and Mahmood [2] observed the effect of temperature ratio of air inlet to local surface temperature. He found that when the temperature ratio decreased, average Nusselt number increased while the friction factor declined. Ames et al. [3] applied effective approach velocity by using the surface pressure distribution. He showed that the higher heat transfer rate in latter rows was caused by the significant level of turbulence generated by the wake from former rows at high Reynolds number. The conclusions from prior experimenting results were found to be conflicting among one another, observed by Chyu et al. [4], as a result of the unrealistic thermal boundary conditions. Most of the previous studies did not heat pin-fins and endwall together. However, by applying the idea of Naphthalene sublimation technique to both pin-fin and endwall, their heat-mass transfer was able to be separately quantified. He also found that the nature of thermal boundary condition did not dominate heat transfer coefficient. The experimenting result showed that the heat transfer coefficient on pin-fins was greater than that of endwall. However, the overall array average did not follow the pin-fin heat transfer coefficient as the wetted area of uncovered endwall occupied more area than that of the pin-fin. Khan et al. [5] applied Von Karman –Pohlhausen method to predict the fluid and heat transfer characteristic from a circular cylinder. It showed that thermal boundary condition either Isoflux or Isothermal insignificantly affected the local Nusselt number. Lau et al. [6] studied the effect of lateral flow to the turbulent heat transfer and friction in pin-fin channel. The results showed that the Nusselt number was an inversely linear relationship with an ejection ratio. The friction factor was independent of multiple Reynolds number

ranges but greatly relied on the ejection ratio. With an advance of computational fluid dynamics, CFD, a software suite, there is an increase in using computational prediction on heat transfer and corresponding pressure loss. Ames and Dvorak [7] compared his experimental data to that from the CFD prediction. The comparison indicated that CFD predicted lower heat transfer coefficients and pressure loss than his experiments since the turbulence model was unable to account for vortex shredding effect at backside of the pin.

1.3 Pin arrangement effect

Sparrow et al. [8] conducted an experiment to compare both the heat transfer coefficient and pressure drop between in-line and stagger designs. The result suggested that the staggered pin-fins gave higher heat transfer coefficient with higher pressure drop, leading designers to critical justification for the benefit from the effective heat transfer against high operating costs. VanFossen [9] compared heat transfer coefficients between inclined pins and normal pins. The results showed that the inclined pins gave the same average heat transfer coefficients as the perpendicular pins. Brigham and VanFossen. [10] found that the H/D ratio was contributing to distinctive heat transfer coefficients in the short pin design. If H/D ratio was greater than two, the Nusselt number is a function of H/D and Reynolds number. However, with the H/D ratio lower than two, the Nusselt number relied solely on varying Reynolds numbers. The naphthalene sublimation technique with heat-mass transfer analogy was applied to perform a heat transfer experiment with various height of pin-fin, H/D = 2, 3, and 4 by Park et al. [11]. It was concluded that the higher the H/D, the higher the heat transfer coefficient. Chyu et al. [12] confirmed the result of the previous study with regards to the transient liquid crystal

imaging technique that the higher H/D contributed to higher heat transfer coefficients and so did the thermal performance. Lau et al. [13] found that the reduction of streamwise-pin spacing resulted in an increase in endwall heat transfer. Lyall et al. [14] presented the heat transfer result of single row circular pins with varying spanwise. The experimental outcomes indicated that at S/D=2, the location of the highest heat transfer varied according to Reynolds numbers; however, if S/D = 4 or 8, the peak heat transfer was located at immediate downstream of the pin. The heat transfer augmentation of pins combined with that of endwall was reduced by increased spanwise space. The experiments conducted by Ostanek and Thole [15] generated the flow measurement by using TRDPIV and IR camera. The outcomes suggested that by reducing streamwise and spanwise space in pin-fin arrays, an increase in the heat transfer resulted from pin-fins in subsequent rows located in the wake region of the upstream portion. The results from multiple research appear to be in line with one another. This observation well agreed from the third row onwards. The wake regions downstream of the pins were observed to be asymmetry. Fluctuations in velocity are then calculated and indicated that an increase in S/D caused increasing unsteadiness to the flow. Following that, a rise in S/D contributed to an increase in the heat transfer on pin surface. Tarchi et al. [16] compared circular pins in the conventional staggered configuration to the pentagonal scheme. The experimenting result showed that the pentagonal arrangement produced more non-uniform of a heat transfer coefficient than the conventional design, while the former averaged heat transfer coefficient was similar to the latter one.

1.4 Pin shape effect

How the pin shape affect the heat transfer coefficients draws researchers' attention to dig deeper. Metzger et al. [17] compared the heat transfer coefficient and pressure drop of the circular pin array with those of the oblong pin array. The result suggested that the oblong pin provided higher heat transfer, but the pressure drop was rising. Uzol and Camci [18] presented the experimental results from the comparison of the heat transfer performance among circular pin, standard elliptical fin(SEF), and fin based on NACA four-digit symmetrical airfoil shapes(N fin). The circular pin generated 27% higher Nusselt number than SEF and N fin, causing relatively high-pressure loss. Moreover, regarding the circular pin feature, its Nusselt number had more reliance on Reynolds numbers than other shapes, while its pressure loss is less dependent on Reynolds numbers than others. Chyu et al. [19] studied heat and mass transfer of three different shapes, i.e. cubic, diamond, and circular shape by using heat and mass transfer analogy. The results showed that the cubic shape provided highest heat transfer followed by the diamond and circular pins, whereas the diamond pins gave the highest penalty in the pressure loss. Kirsch et al. [20] compared heat transfer on the pin surface of oblong with that of the cylindrical shape. The results indicated that the cylindrical pins generated higher channel turbulence, thereby resulting in higher overall heat transfer coefficients. The oblong pins created cyclical pattern at the peak locations of heat transfer: one at stagnation point and the other at boundary layer separation across the surface. Thus, the lower the pin Reynolds number and spanwise spacing, the worse heat transfer coefficient would be. The result of the experiments conducted by Xu et al. [21] regarding the six different shapes of pin-fins

in a wide channel, such as circular, elliptic, oblong, dropform, naca, and lancet, indicated that the circular pin produced the largest overall heat transfer as the Reynolds numbers went up. However, the reduction of thermal performance resulted from an increase of Reynolds numbers. Chyu [22] observed the effect of endwall on the heat transfer and the thermal performance. He found that the endwall fillet did not improve the heat transfer rate and the thermal performance since this application caused high-pressure drop

Despite the literature reviews mentioned previously, an area ratio does not draw much attention from researchers to be part of experiments. Considering that, including the area ratio in the current experiments would become a good step forward to figure out how to improve the heat transfer rate with increasing the area ratio.

2. OBJECTIVE

Even though the interest in improving the performance of gas turbines has generated a considerable number of research on thermal effectiveness particularly on the trailing edge cooling technology, one of the vulnerable area that has been treated to control temperatures at turbine blades, there still have opportunities for improvement, such as alternative designs of internal features. This research purposely concentrates on the heat transfer and provides comprehensive results of the comparisons of the overall heat transfer enhancement across multiple features and with a penalty pressure loss in term of friction factors and eventually thermal performance for being a guideline for turbine designers.

3. EXPERIMENTAL APPARATUS

In order to achieve the required Reynolds numbers, the experiment set up at Turbomachinery Laboratory, Texas A&M University. The fabricated test section made to fit the existing piping facility. Figure 1 represents the entire loop of the test. Compressors supply air through the 4-inch pipe. The pressure regulator is responsible for regulating the flow rate of inlet air. In some cases, the isolation valve can act as a flow control valve if the required pressure is too low or out of the control range of the pressure regulator. A restriction orifice with 3-inch hole size is located downstream of the pressure regulator in purpose of measuring mass flow rate. To avoid complexity of data processing while adjusting flow rate to a desired value, an inclined manometer is needed to measure pressure drop across the orifice instead of a pressure transducer as it can provide real-time pressure drop.

Figure 2 shows the fabricated test section starting with the reducer connected to the transition piece followed by the copper plate channel and the exit duct. The wire mesh size 16 is located upstream of the transition piece in order to kill vorticity of the mainstream flow. The transition piece provides the suitable entrance length for fully developed flow at the copper plate channel. There are two thermocouples installed at the transition piece to measure bulk temperature of inlet air and three thermocouples at exit duct for elevated temperature air. Figure 3 and Figure 4 show the copper plate channel assembly. The channel consists of fifteen copper plates while having insulating rubbers in between each copper plates to avoid heat conduction between the copper plates.

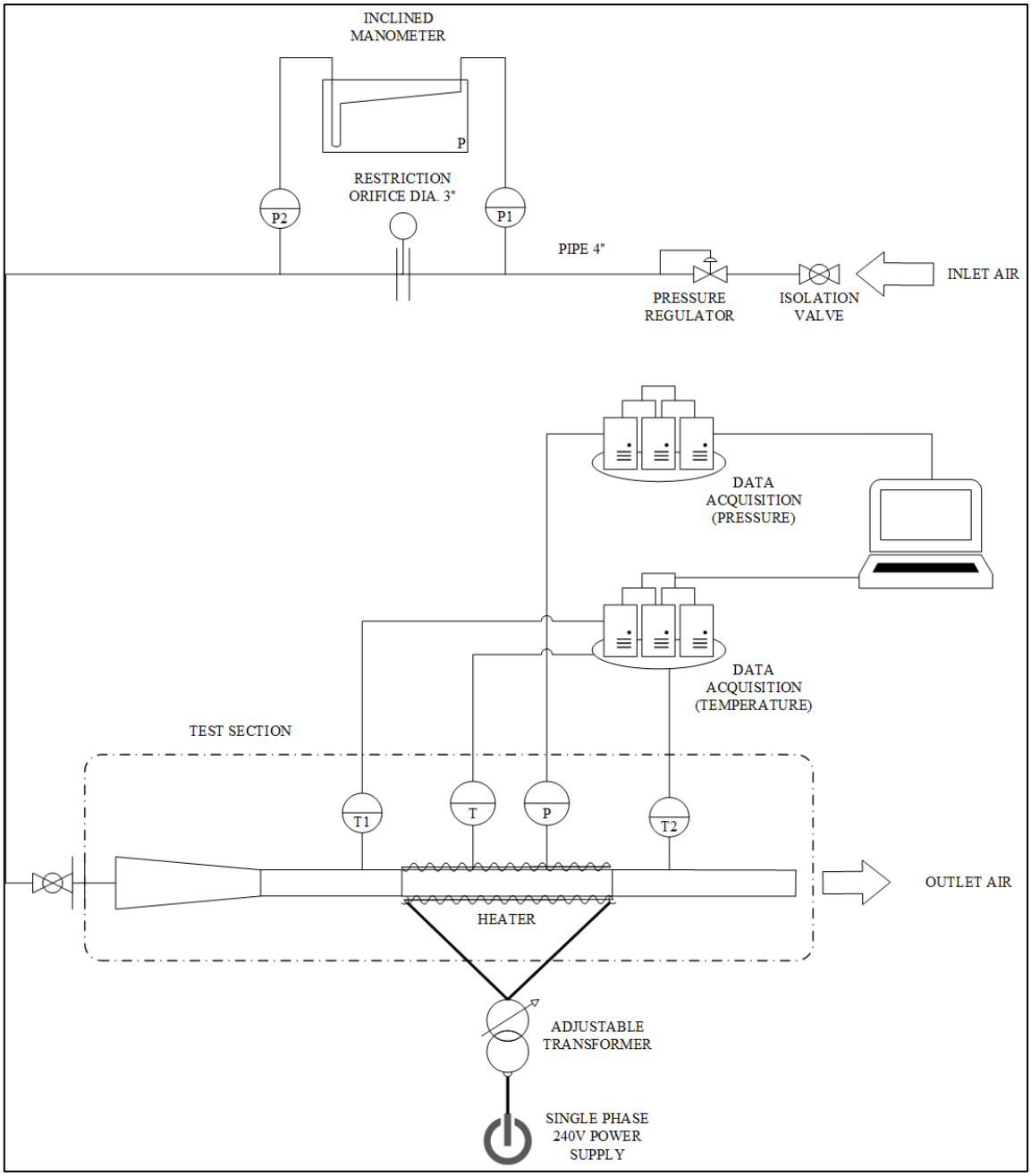

Figure 1 Piping and Instrument Diagram

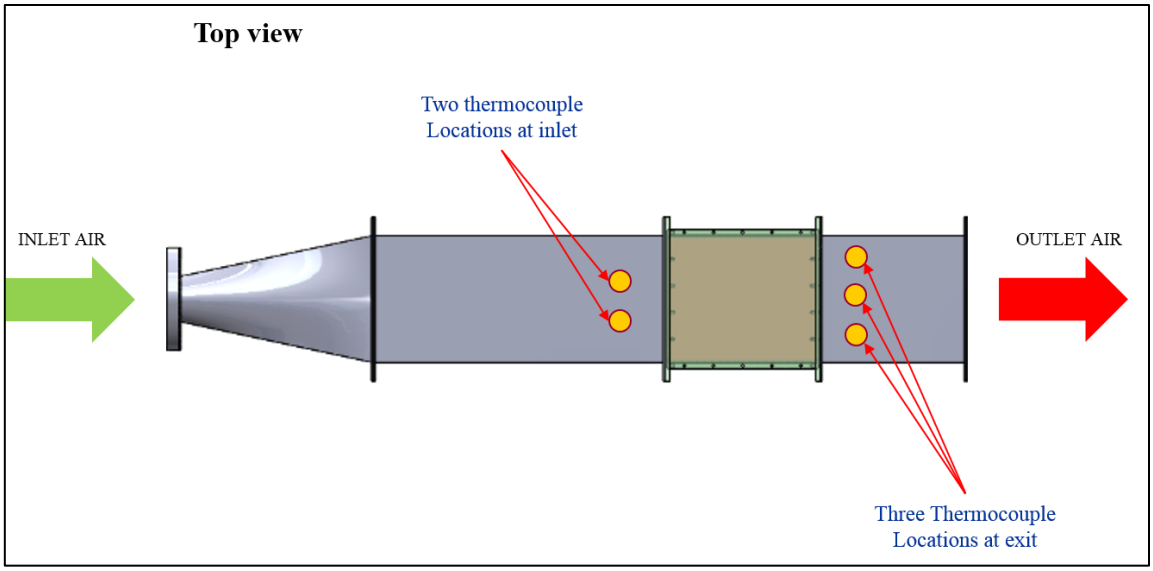

Figure 2 Fabricated test section assembly

The Garolite-G10, high-pressure fiberglass laminated, is the insulated material used as outer casing of the channel. There are also the insulation rubber pads between the Garolite and the copper plate. In addition, the outer most of the channel is atop by Styrofoam. All these layers added to minimize heat loss escaping the test section.

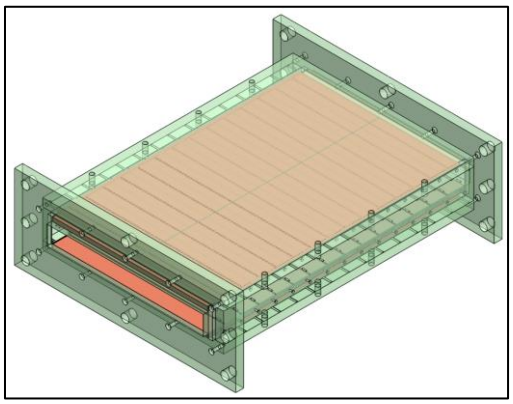

Figure 3 Copper plate channel assembly

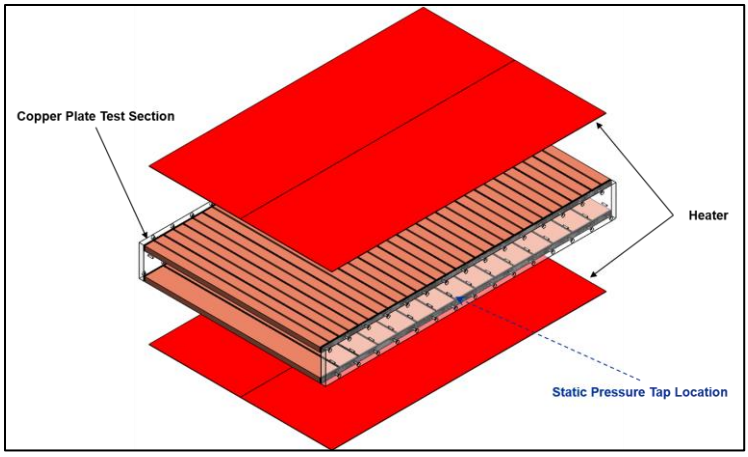

Figure 4 Rubber heater assembly

Fifteen static pressure traps are installed along the stremwise direction. This is to provide pressure drop data across the test section. Figure 5 shows all thermocouple locations. Each copper plate have either four or five T-type thermocouple installed at back side of the plate cosidering front side exposing the air flow.

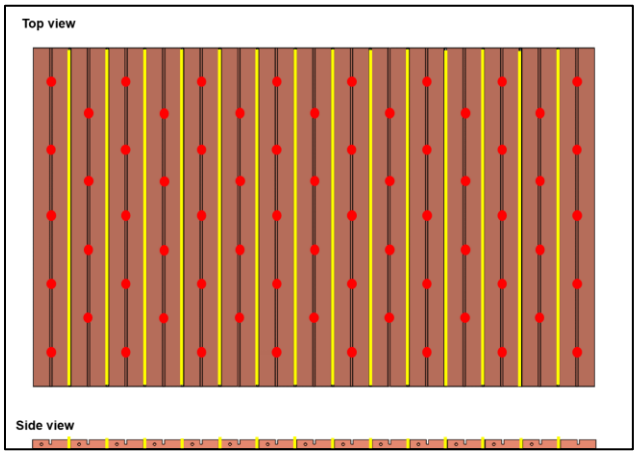

Figure 5 Thermocouple location

Four rubber heaters, Watlow F050150C8, are installed both top and bottom sides of the copper channel. Each side have two heaters. These heaters are connected to the adjustable transformer to control the supplied electrical voltage from 0 to 240 V. The temperature data is acquired through NI cDAQ-9178 and its corresponding modules, NI USB-9213. This data acquisition setup can be utilized up to 128 temperature points. The static pressure measurement is set through either pressure transcuder or micromanometer. This is to have low uncertainty throughout the range of required Reynolds numbers.

The pin-fin material inserted in the channel is copper. By using high thermal conductivity material, the temperatures become uniform on the surface for a given heat load. This can be further proved by the following methods which incorporate the measured information in this study.

1. The Biot number is calculated to see if the entire test surface will provide the same temperature. Biot number can be obtained from the following formula:

$$Bi = \frac{h}{k}\left(\frac{V}{A_s}\right) \tag{1}$$

With a typical heat transfer coefficient taken from the experiment ($90\,\frac{\mathrm{W}}{\mathrm{m}^2K}$) , the thermal conductivity of the copper ($401\,\frac{\mathrm{W}}{\mathrm{m}K}$), the volume of the copper plate and pin, and the surface area for convection heat transfer, the Biot number is 0.008 which is far less than the criteria of uniform temperature assumption (0.008<<0.1) This is often referred to as lumped system.

2. The fin equation taken from Bergman et al. [23] is applied to ensure that the temperature difference between pin base and center of the pin is zero. With the constant heat flux condition, an adiabatic boundary condition at tip of the pin as shown in Figure 6 , and the heat transfer coefficient taken from the experiment ($90\,\frac{\mathrm{W}}{\mathrm{m}^2K}$), the temperature distribution can be derived from the follwing formula:

$$\frac{\theta}{\theta_b} = \frac{cosh\, m(L-x)}{cosh\, mL} \tag{2}$$

The fin heat transfer can also be obtained from:

$$q_f = \sqrt{hPkA_c}\theta_b \tanh mL \tag{3}$$

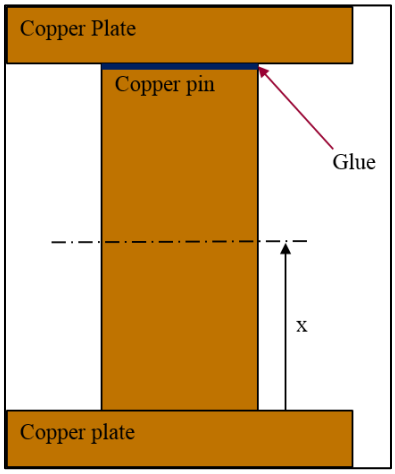

Figure 6 Single pin-fin assembly model

Where the location of x is the center of the pin, the corresponding θ represents the temperature difference between center of the pin and the cooling air. The result shows that the temperature difference between wall or pin base and center of pin is less than 0.71% (<0.33 °C).

3. The effect of the glue used to mount pins on the wall is investigated. By a known thermal conductivity of glue ($0.4\frac{\mathrm{W}}{\mathrm{m}K}$), measuring of heat flux and glue thickness (2.54e-05 m), the temperature drop across the thin glue is calculated from the formula below:

$$\Delta T = \frac{q''\Delta t}{k} \tag{4}$$

The temperature difference between pin and wall is estimated to be less than 0.11°C

4. EXPERIMENTAL PROCEDURE

4.1 Test matrix

This experimental study is focusing on different shapes and sizes of pin-fin as listed in Table 1 and Table 2. All scenarios are tested at Reynolds number ranging from 20,000 to 80,000.

Case	Nomenclature	Pin Geometry	Pin Dia.(D)	Spanwise Space(S)	Pin height(H)	Aspect ratio(H/D)	Streamwise Pitch(X)	S/D	X/D	Chanel width	Number of pins	Area ratio
1	Smooth	Smooth									0	1
2	Pin0.5_2S	Circular	0.5	2	1.2	2.4	1	4	2	9.57	68	1.35
3	Pin0.5_1S	Circular	0.5	1	1.2	2.4	1	2	2	9.57	128	1.67
4	Pin1_2S	Circular	1	2	1.2	1.2	1	2	1	9.57	68	1.52

Table 1 Circular pin test matrix

Case	Nomenclature	Fin Geometry	Fin Width(w)	Spanwise Space(S)	Fin height(H)	Aspect ratio(H/W)	Streamwise Pitch(X)	S/w	X/L	Chanel width	Number of fins	Area ratio
5	Fin0.125_2S	Strip	0.125	2	1.2	9.6	1	16	1	9.57	68	1.58
6	Fin0.125_1S	Strip	0.125	1	1.2	9.6	1	8	1	9.57	128	2.09
7	Fin0.25_2S	Strip	0.25	2	1.2	4.8	1	8	1	9.57	68	1.59

Table 2 Strip fin test matrix

4.2 Channel assembly and leak test

The copper channel is designed to be practically assemble and disassemble. Internal features, such as pins and fins, need to be installed by opening the top side of the channel. To ensure the legitimacy of the experiment, a leak test at the highest Reynolds

number, 80,000, and a soap test are required to be performed prior to conducting each experiment.

The features are attached on the copper plate by using Loctite® 401 at the bottom side and compensating the gap on the top side with thermally conductive compound, Dow Corning® 340 heat sink compound. Figure 7 to Figure 12 show the features assembly of all tests according to the test matrix.

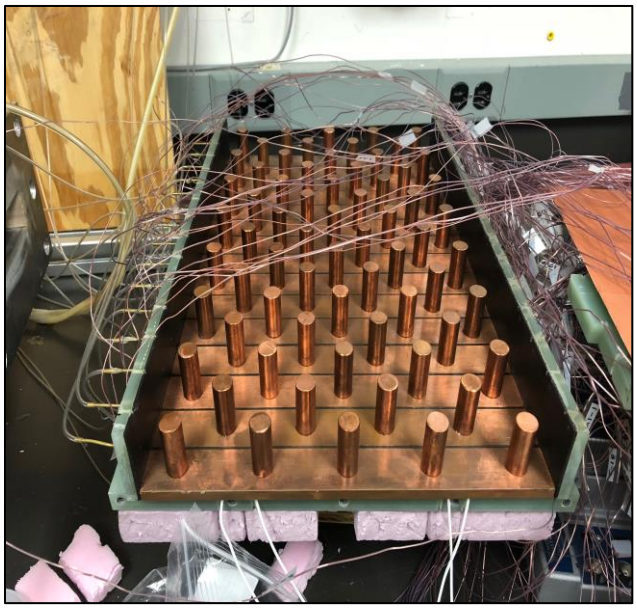

Figure 7 Pin0.5_2S assembly

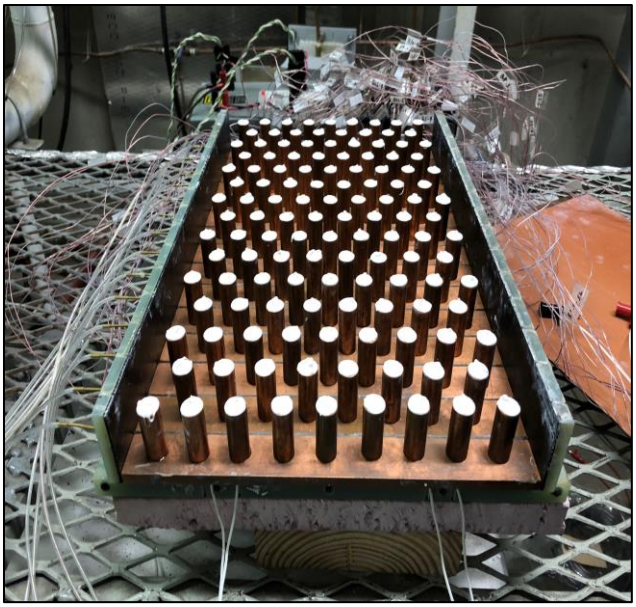

Figure 8 Pin0.5_1S assembly

Figure 9 Pin1_2S assembly

Figure 10 Fin0.125_2S assembly

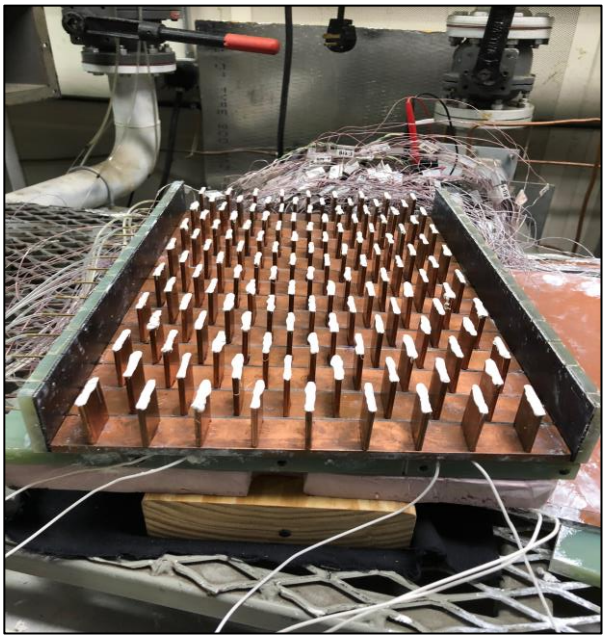

Figure 11 Fin0.125_1S assembly

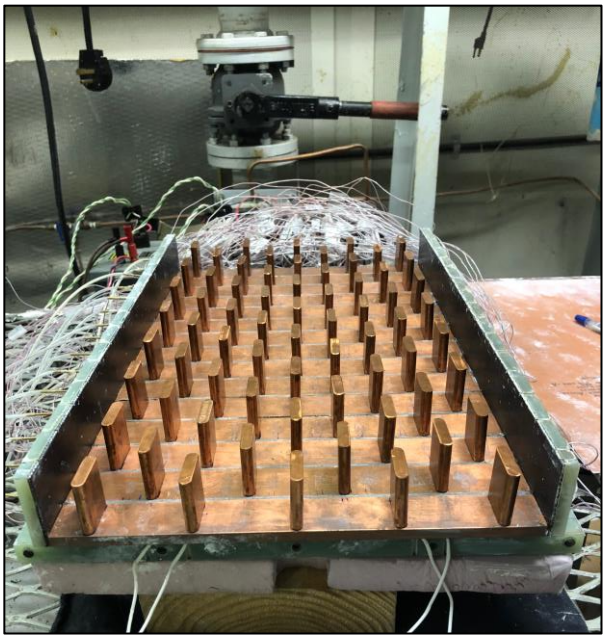

Figure 12 Fin0.25_2S assembly

4.3 Heat loss calibration

The heat loss can be estimated through the steady state heat loss with no-flow condition. The average wall temperature of is recorded at low and high power input around 35 deg C and 60 deg C respectively. The heat flux from the rubber heaters are then recorded by measuring electrical voltage and heater resistance. The heat loss for each region can be estimated by linear interpolation using the wall temperature at test condition according to Chen et al. [24].

4.4 Heat transfer test and pressure measurement

The heat transfer coefficient is determined by measuring wall temperatures, fluid bulk temperatures, and heat flux. The Dittus-Boelter correlation for fully developed turbulent flow in a smooth channel is used to find Nu_0. The result will be come out in a

normalized form of the Nusselt number. The static pressure is measured along the streamwise direction to calculate pressure drop across the test section and used to calculate friction factors of each design. Lastly, thermal performance is evaluated across the Reynolds number range.

5. DATA REDUCTION

The goal of this experiment is to find the regionally averaged heat transfer coefficient and pressure drop across the set of pin-fin configurations. The net heat transfer through the heated copper plate with regard to predetermined heat loss. The heat transfer coefficient is then determined by the calculated local surface area, the local bulk mean temperature, the regionally averaged wall temperature. Thus, the heat transfer coefficient is given as:

$$h_n = \frac{Q_{net,n}}{A_n(T_{w,n} - T_{b,n})} \tag{5}$$

Where the local net heat transfer can be obtained by measuring voltage and resistance supplied to the heaters. The predetermined heat loss and the area ratio are applied in order to define local net heat transfer.

$$Q_{net,n} = \frac{V^2}{R}\left(\frac{A_n}{\Sigma A_n}\right) - Q_{loss,n} \tag{6}$$

The steady state heat loss are then calculated from a heat loss calibration as:

$$Q_{loss,n} = \left(\frac{Q_{H,n} - Q_{L,n}}{\left(T_{H,w,n} - T_{H,room}\right) - \left(T_{L,w,n} - T_{L,room}\right)}\right)\Big(\left(T_{w,n} - T_{room}\right) - \left(T_{L,w,n} - T_{L,room}\right)\Big) + Q_{L,n} \tag{7}$$

The local exit bulk temperature are calculated from interpolation method with counterchecking of energy conservation method.

$$T_{b,n} = (T_{outlet} - T_{inlet})\left(\frac{x_n}{L}\right) + T_{inlet} \tag{8}$$

The local exit fluid bulk temperature at each copper plate can be found as:

$$T_{b,n,exit} = T_{b,n,inlet} + \frac{Q_{i/r}}{\dot{m}C_p} \tag{9}$$

Then the Average bulk temperature from energy conservation method can be defined as:

$$T_{b,n} = \frac{T_{b,n,inlet} + T_{b,n,exit}}{2} \tag{10}$$

As a result, the local normalized Nusselt number can be determined as:

$$\left(\frac{Nu}{Nu_0}\right)_n = \frac{\left(\frac{h_n D_h}{k}\right)}{0.023Re^{0.8}Pr^{0.4}} \tag{11}$$

The pressure drop across the test section are measured at the same period of the heat transfer measurements for all configurations. With the use of correlation between Reynolds number and friction factor for fully developed turbulent flow proposed by Blasius, the friction factor ratio are then obtained as:

$$\frac{f}{f_0} = \frac{\Delta P}{2\left(\frac{L}{D_h}\right)\rho v^2}\left(\frac{\mathrm{Re}_{\mathrm{D_h}}^{0.25}}{0.079}\right) \tag{12}$$

The thermal performance is then introduced as a good indicator for each pin-fin shape and arrangement. The thermal performance is the parameter related between heat transfer coefficient and its corresponding pressure loss or in this case friction factor, the thermal performance can be obtained from;

$$Thermal\ performance = \frac{\frac{Nu}{Nu_0}}{\left(\frac{f}{f_0}\right)^{\frac{1}{3}}} \tag{13}$$

6. UNCERTAINTY ANALYSIS

The uncertainty for the experiment was derived from Kline and McClintock [25]'s approach. At 20k Re, the uncertainty was ± 1.4%, while at 80k Re, it was ± 1.1%. It appears that the uncertainty of both Reynolds number ranges were not much different because those Reynolds number ranges did not apply the same instrument methods: digital manometer used at 20K Re to 30K Re and inclined manometer used at 40K Re to 80K Re. The uncertainty was expected to be as low as ± 0.2°C and ± 3% for temperature and power measurement, respectively. By excluding heat loss and flow fluctuation, the calculated of uncertainty of heat transfer coefficient was less than 4%. Considering all experimental scenarios, the smooth channel feature generated the highest heat loss, which accounted for 8% of the total input power at Reynolds 20k (the lowest Reynolds number) and 4% at 80k Re (the highest Reynolds number). By taking the uncertainty of flow and pressure measurement into account, the uncertainty of friction factors varied based on Reynolds number. At lower Reynolds numbers, the uncertainty was about 7.2%. When increasing Reynolds numbers to 40,000, the uncertainty reduced sharply to 2.5% and to the lowest value, 2.2%, when Reynolds number was 80,000.

7. RESULT AND DISCUSSION

The following heat transfer results showing in section 7.3 to 7.5 did not include the results from the last copper plate. This is because heat conduction through the exit flange can mislead the results. The first copper plate also faces the same effect, leading heat transfer enhancement to rising more than what it was supposed to be. Considering that consequence, the results of the first copper plate need to be cut down to certain levels, but still show the entrance effect, causing higher heat transfer coefficients. As a result, Array averaged normalized Nu in section 7.9 to 7.10 and Thermal performance in section 7.11 to 7.12 are then calculated based on thirteen rows basis. While the friction factors in section, 7.7 to 7.8 include all the fifteen rows

7.1 Heat loss summary

Heat loss is an important parameter in the copper plate test as it can affect bulk temperature calculation. Thus, the heat loss calibration is conducted for every pin-fin configuration. Figure 13 shows the example of the heat loss calibration plot from Pin1_2S case. This plot covers a range of actual heat test condition meaning that the actual temperature difference, Tw-Troom, is within the calibration. Then, the heat loss during heat transfer test can be obtained from an interpolation method.

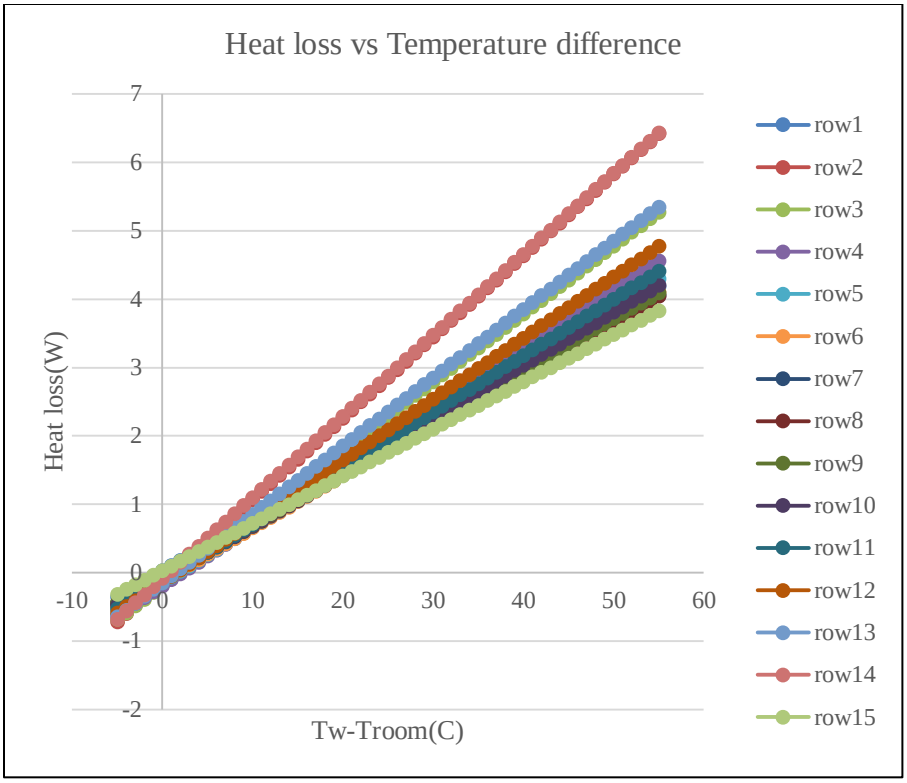

Figure 13 Heat loss calibration

Percent heat losses during the heat transfer test are then interested. Figure 14 shows dependency between heat loss and Reynolds number. All pin-fin configurations and a smooth channel show that the heat loss drops with an increase in Reynolds number. The smooth channel produces highest heat loss compared to pin-fin configurations. While the circular pin design gives the lowest heat loss. Configurations of the circular pins do not affect the different amount in heat loss particularly at high Reynolds number. The strip fins design produces relatively high heat loss and it shows a wider gap among the strip fin design unlike the circular pin

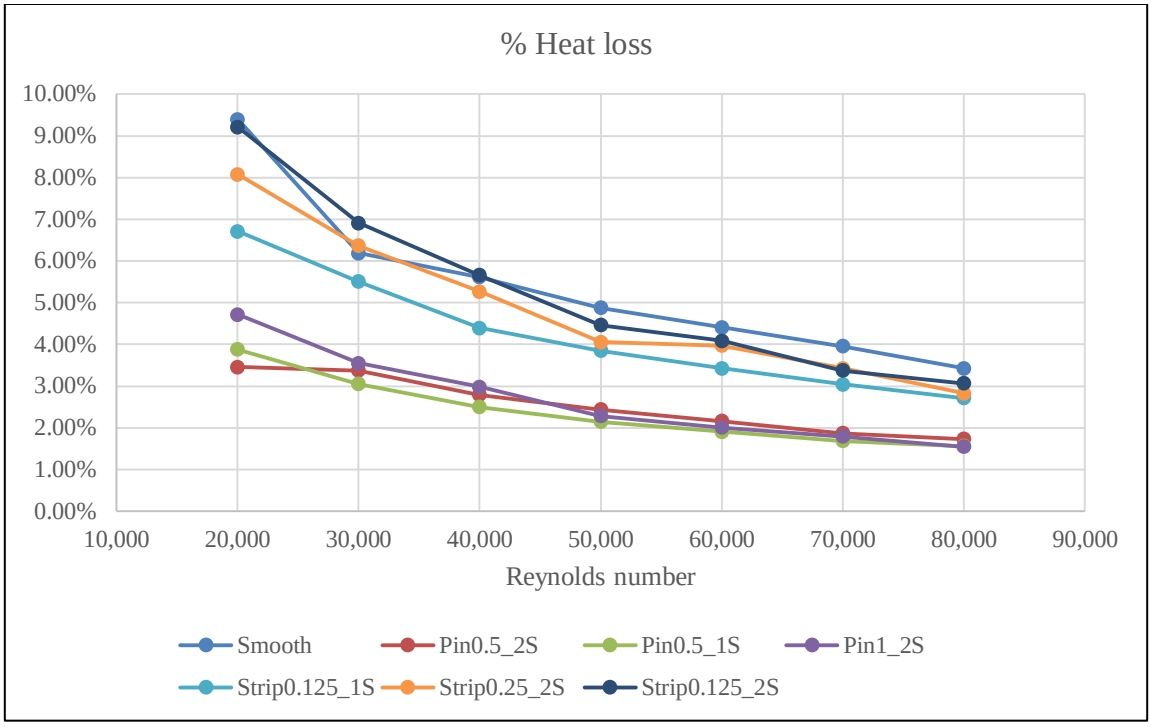

Figure 14 Heat loss vs Reynolds number

7.2 Temperature measurement consistency

Temperatures are recorded through T-type thermocouples. Though, it is believed that using high thermal conductive material such copper will provide a uniform temperature distribution, the previous study show that endwall heat transfer coefficient depends on the flow Reynolds number. Thus, it is interested to check the consistency of the temperature reading on a couple plate. Figure 15 and Figure 16 represent wall temperature reading of a circular pin case. The plot represent spanwise thermocouple location of all 15 rows. The results indicate that the higher the Reynolds number, the more the temperature difference on a copper plate.

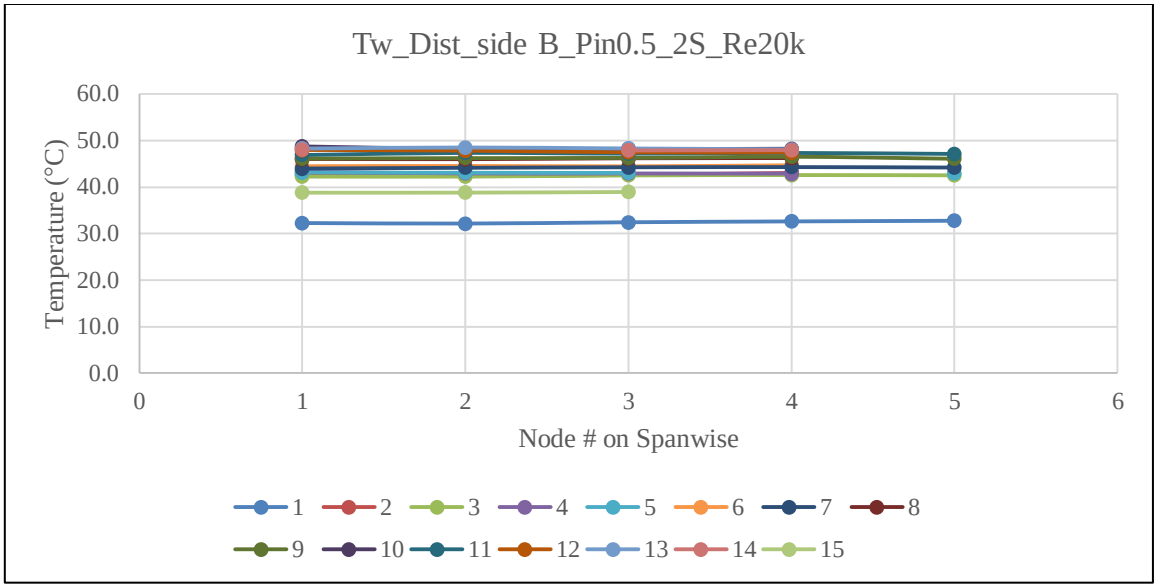

Figure 15 Temperature measurement at Reynolds number 20,000

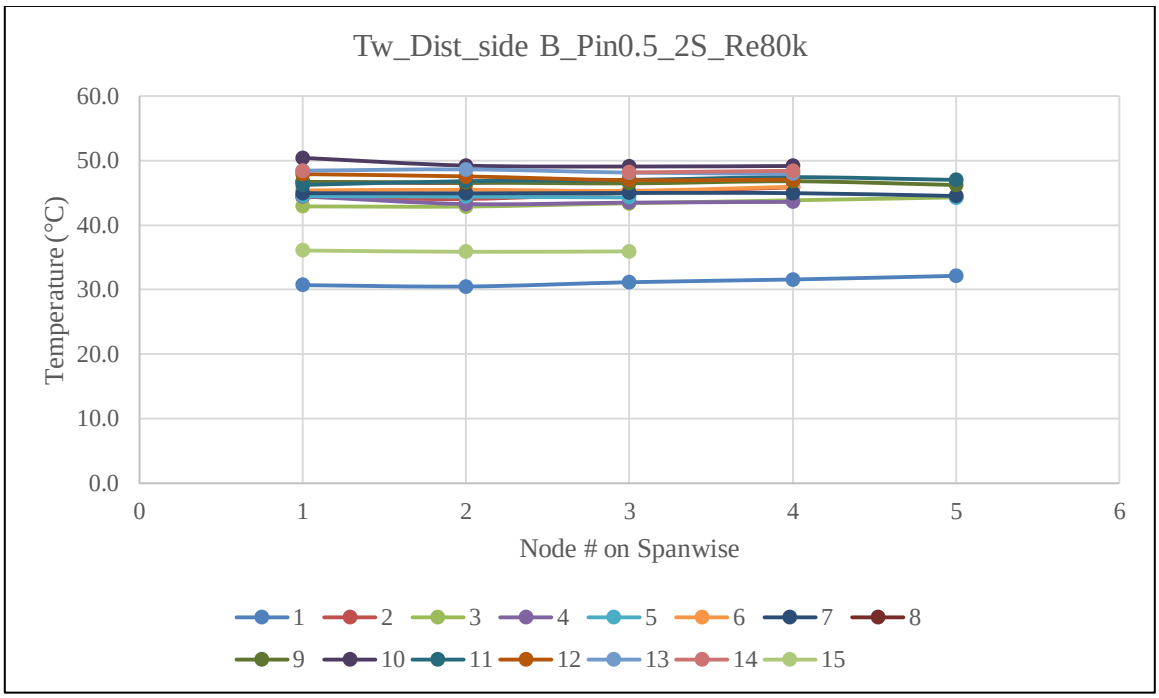

Figure 16 Temperature measurement at Reynolds number 80,000

Figure 17 shows the wall temperature reading of a Pin1_2S case at Reynolds number 80,000. This case generates the highest variation in wall temperature. The wall temperature readings are positively correlated with the turbulent intensity in the channel. From the highest deviation in wall temperature case, Pin1_2S_Re80k, the percent different of heated top and bottom wall average temperature is 7%, while the Pin0.5_1S_Re80k, Pin0.5_2S_Re80k, and Smooth_Re80k are 4.9%, 1.89% and 0.67% respectively. The maximum temperature between taken from represent copper plate at the middle of the test section is about 1.7 °C.

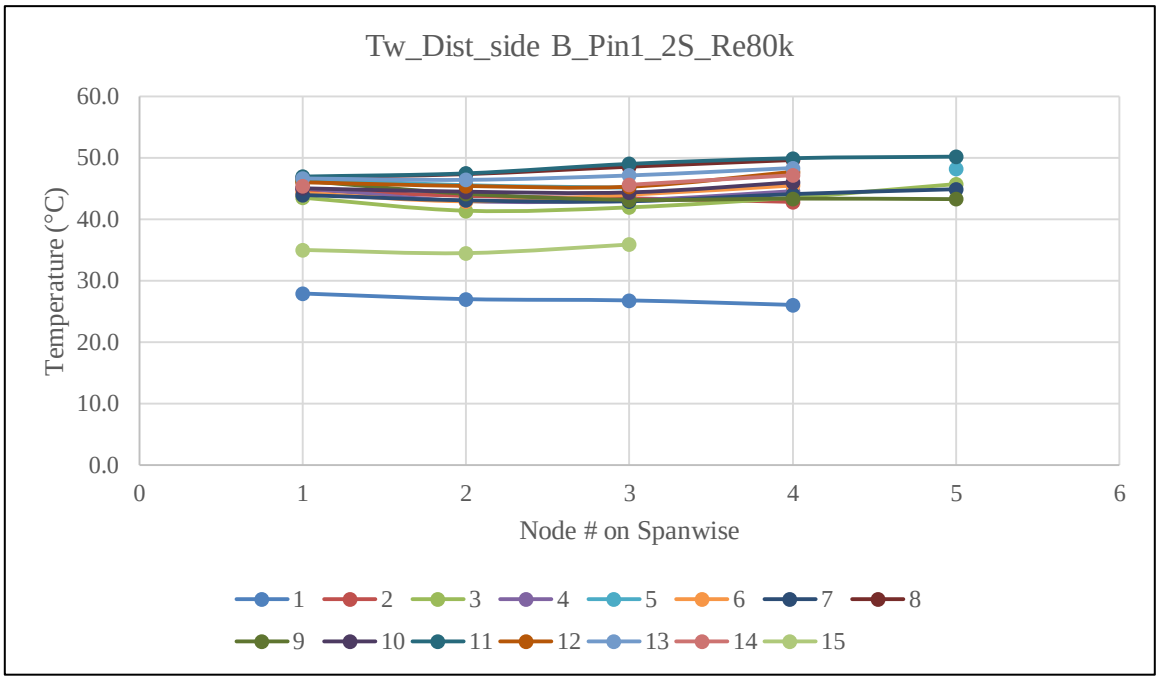

Figure 17 Temperature measurement of Pin1_2S at Reynolds number 80,000

The summation of power input of the four heaters, two heaters on top and the other two on bottom, are then provides for each case as shown in Table 3 with percent different between top side heaters and bottom side heaters.

	Smooth_Re80k	Pin0.5_2S_Re80k	Pin0.5_1S_Re80k	Pin1_2S_Re80k
Top(W)	229.09	602.91	803.34	903.38
Bottom(W)	231.89	608.98	822.55	908.12
%Different	1.22%	1.01%	2.39%	0.52%

Table 3 Heater power consumption

Figure 18 and Figure 19 showed the plot between the wall temperature and the fluid bulk temperature in different cases. The former plot illustrates the smooth channel test at lowest Reynolds number 20,000, which was the highest heat loss case. It was observed that the heat loss did not affect the fluid bulk temperature calculation, resulting in almost no difference at exit temperature from either interpolation or conservation of energy method. The same behavior also appeared in the latter plot. Moreover, it was observed that, in the circular pin case, the exit air temperature is of greater value due to the higher heat transfer enhancement. The fluid and wall temperature difference was maintained between 20°C to 30°C.

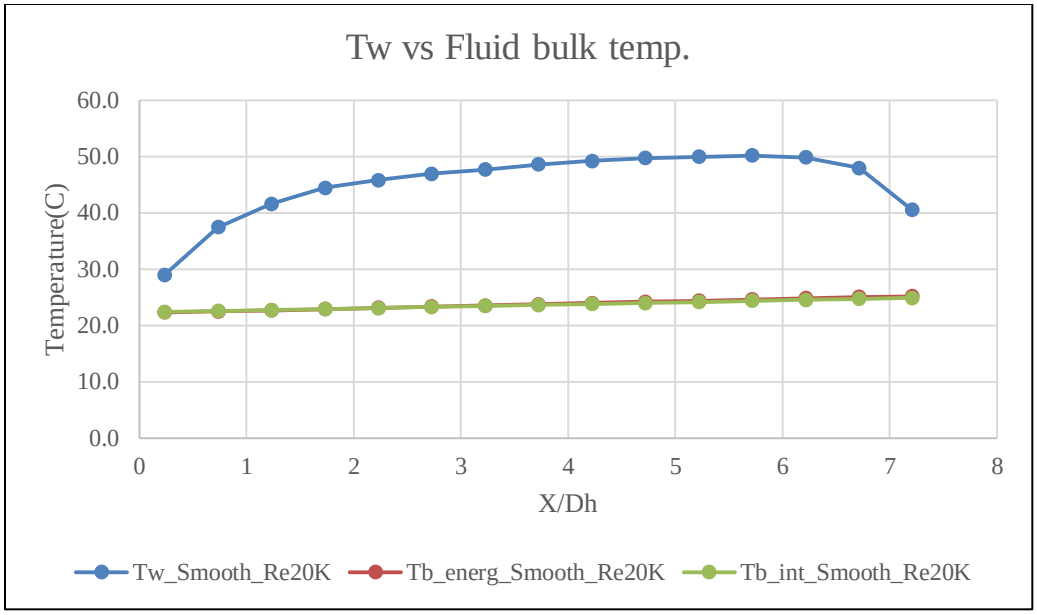

Figure 18 Wall temperature vs Fluid bulk temperature (Smooth_Re20k)

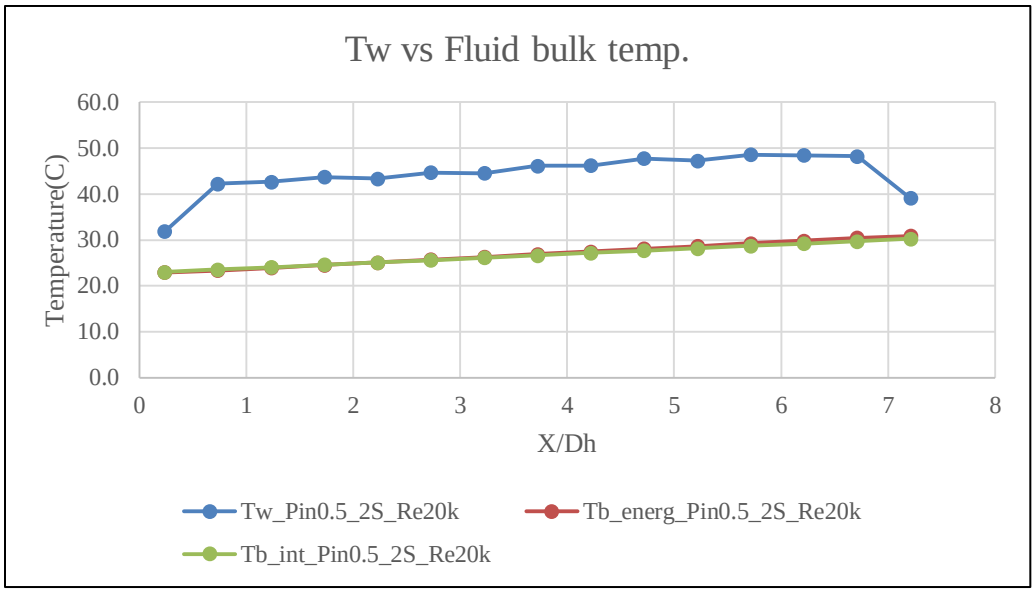

Figure 19 Wall temperature vs Fluid bulk temperature (Pin_2S_Re20k)

7.3 Heat transfer comparison: Smooth Channel vs Circular Pins (Total area)

The heat transfer test is conducted to compare heat transfer improvement of smooth channel to that of pin-fin channel. The normalized Nusselt number with total area basis was then introduced for benchmarking. Figure 20 shows the normalized Nusselt number of smooth channel and Pin0.5_2S channel. The Heat transfer enhancement resulted from smooth channel has weak correlation with Reynolds number. The trend of normalized Heat transfer enhancement at each Reynold number from Pin0.5_2S appears to be in line with one another. The normalized Nusselt number looks correlated with a Reynolds number: the higher the Reynolds numbers, the higher the coefficients. The maximum normalized Nusselts number, approximately 3.5, took place at 20,000 Re. The normalized Nusselt numbers range from 2.8 to 3.5.

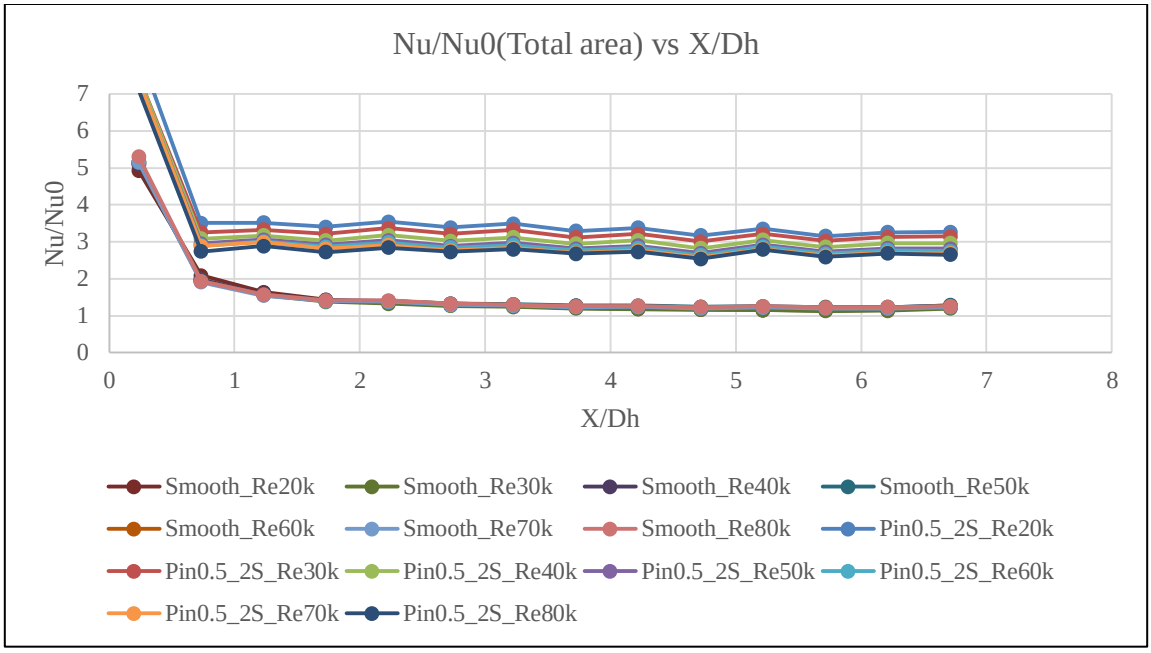

Figure 20 Normalized Nu(Total area) vs X/Dh of Pin0.5_2S

Figure 21 shows the normalized Nusselt number of Pin0.5_1S. The normalized Nusselt numbers range from approximately 2.7 to 4.3. There are wider gaps between low Reynolds numbers ranging from 20,000 to 50,000. After Re 50,000, the normalized Nusselt number change insignificantly until Re 70,000. At Re 80,000, the heat transfer characteristic changed significantly, not following other Reynolds number trends and show steep drop at fourth and eighth row. Figure 22 shows the heat transfer characteristic of Pin1_2S. This design gives the highest friction factor, which will be discussed later in this report. The normalized Nusselt number ranges from 3.5 to 4.3. The heat transfer characteristic of this design is different from the other pin designs. The fluctuation in heat transfer does not exactly follow the number of pins in each row and there is an abrupt drop in heat transfer at eighth row.

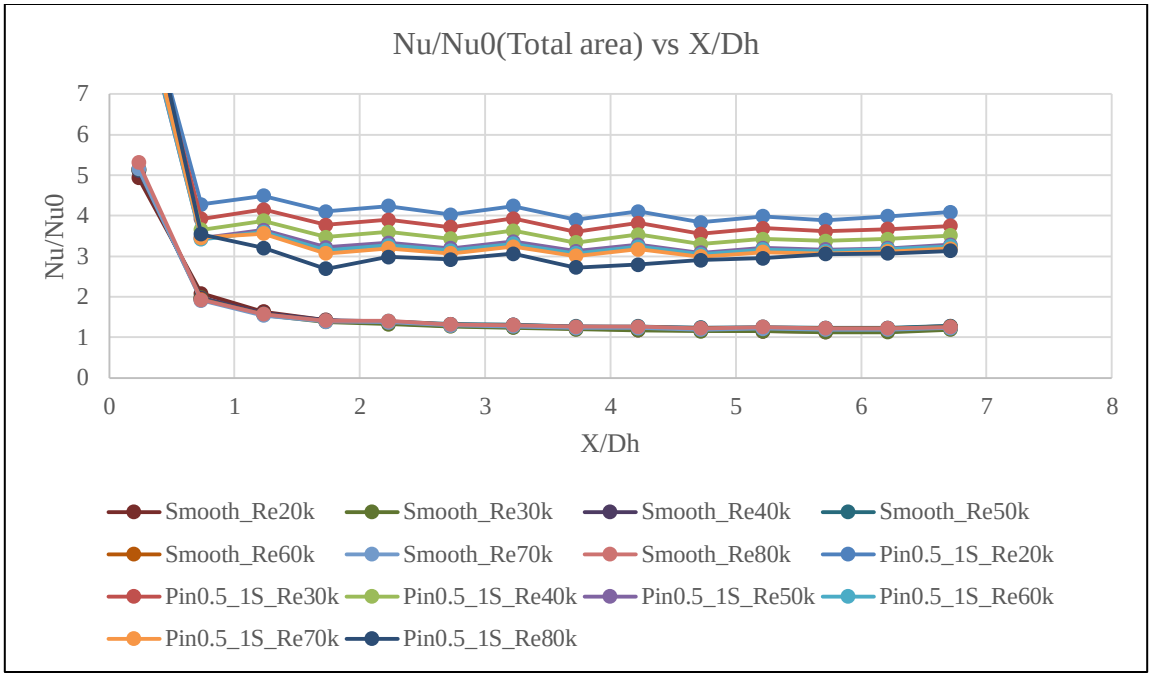

Figure 21 Normalized Nu(Total area) vs X/Dh of Pin0.5_1S

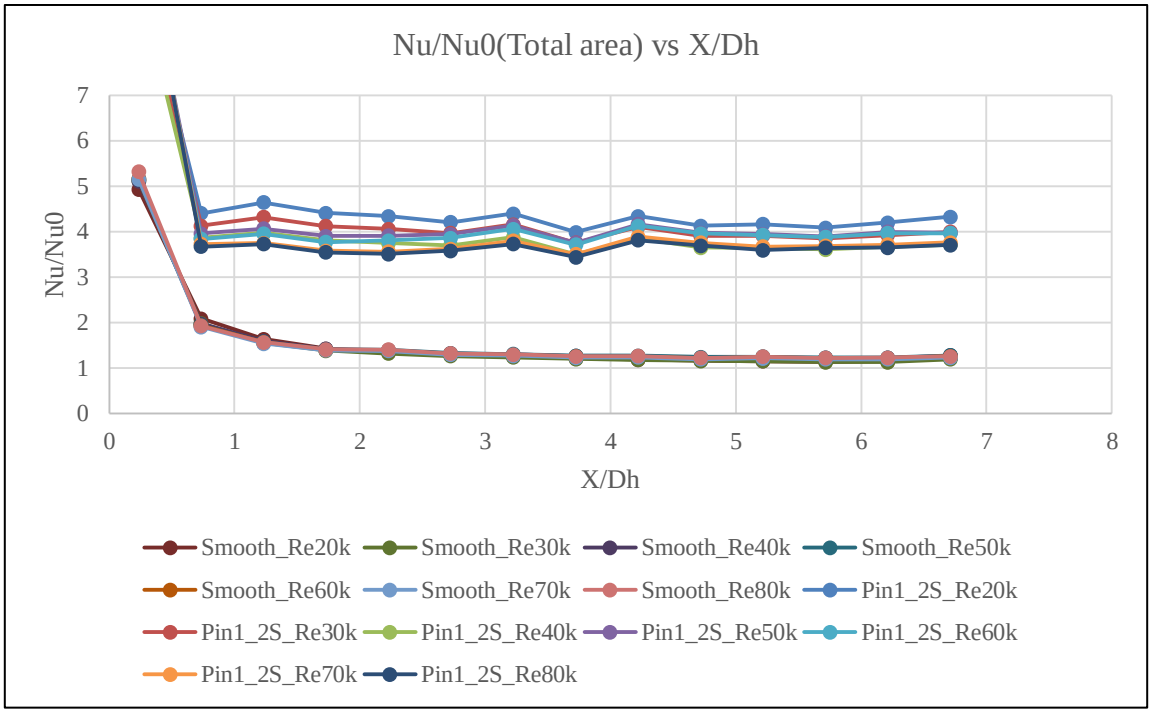

Figure 22 Normalized Nu(Total area) vs X/Dh of Pin1_2S

7.4 Heat transfer comparison: Smooth Channel vs Strip Fins (Total area)

Figure 23 shows the comparison of Heat transfer enhancement between smooth channel and strip fin channel for total area basis, Fin0.125_2S. It appears that both smooth channel and fin channel heat transfer characteristic had weak Reynolds number dependency. The fin channel gave little different in heat transfer at entrance section. As flow pass by copper plate 4th row, the normalized Nu became independent of Reynolds number. The normalized Nusselt numbers of the fin channel range from 1.5 to 1.75.

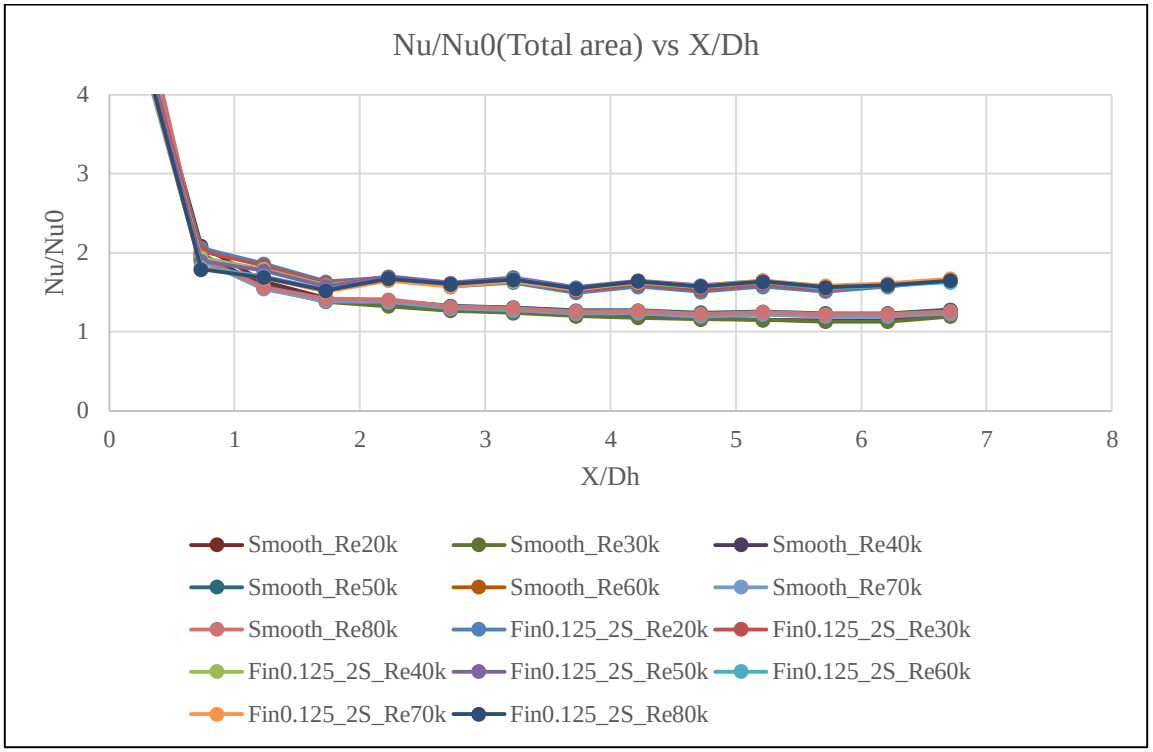

Figure 23 Normalized Nu(Total area) vs X/Dh of Fin0.125_2S

Figure 24 illustrates the normalized Nu of Fin0.125_1S. With its double amount of pin comparing to Fin0.125_2S case, the normalized Nu was shifted to a new range, 1.7 to 2.3. This configuration generate a wider range of normalized Nu and greater Reynolds number dependency. The normalized Nu at Re 20,000 has a wider gap than the rest. Figure 25 indicates the heat transfer characteristic of the thickest pin in this present. Though the Fin0.25_2S had the same spanwise and steamwise space as that of Fin0.125_2S, Fin0.25_2S provided higher Heat transfer enhancement ranging from 1.8 to 2.2.

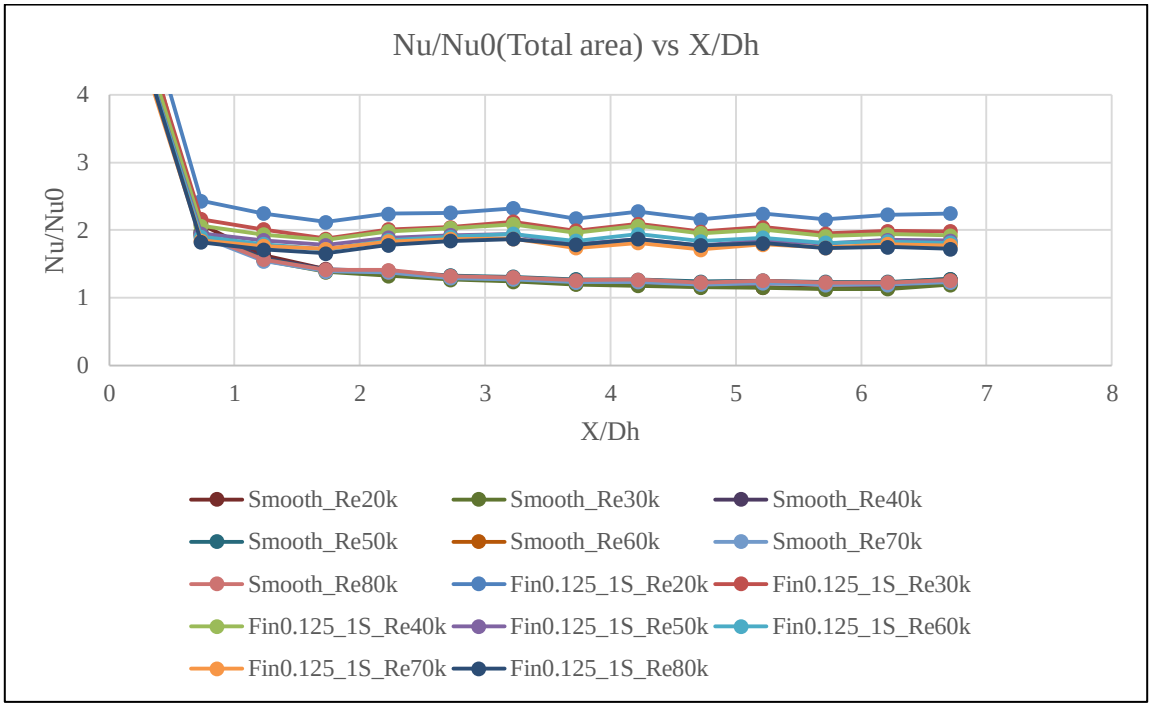

Figure 24 Normalized Nu(Total area) vs X/Dh of Fin0.125_1S

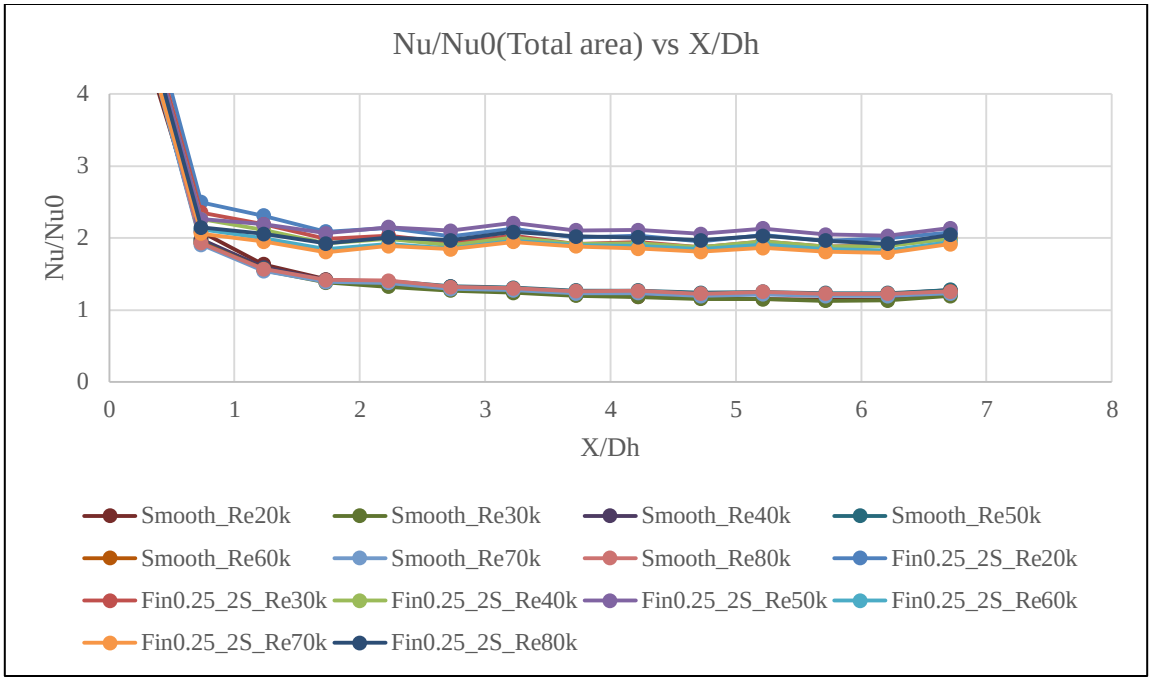

Figure 25 Normalized Nu(Total area) vs X/Dh of Fin0.25_2S

7.5 Heat transfer comparison: Smooth Channel vs Circular Pins (Smooth area)

According to the experimenting results showing in Figure 26, the smooth channel generated predictable outcomes: Reynolds numbers have nearly no correlation with Heat transfer enhancement, while the circular pins affected the Nusselts numbers when Reynolds numbers were changed. the pin feature appears to behave in line with one another even though Reynolds numbers were varied. The smooth area basis gave almost the same results as total area basis. The magnitude of Nu was in a range between 3.5 and 5.

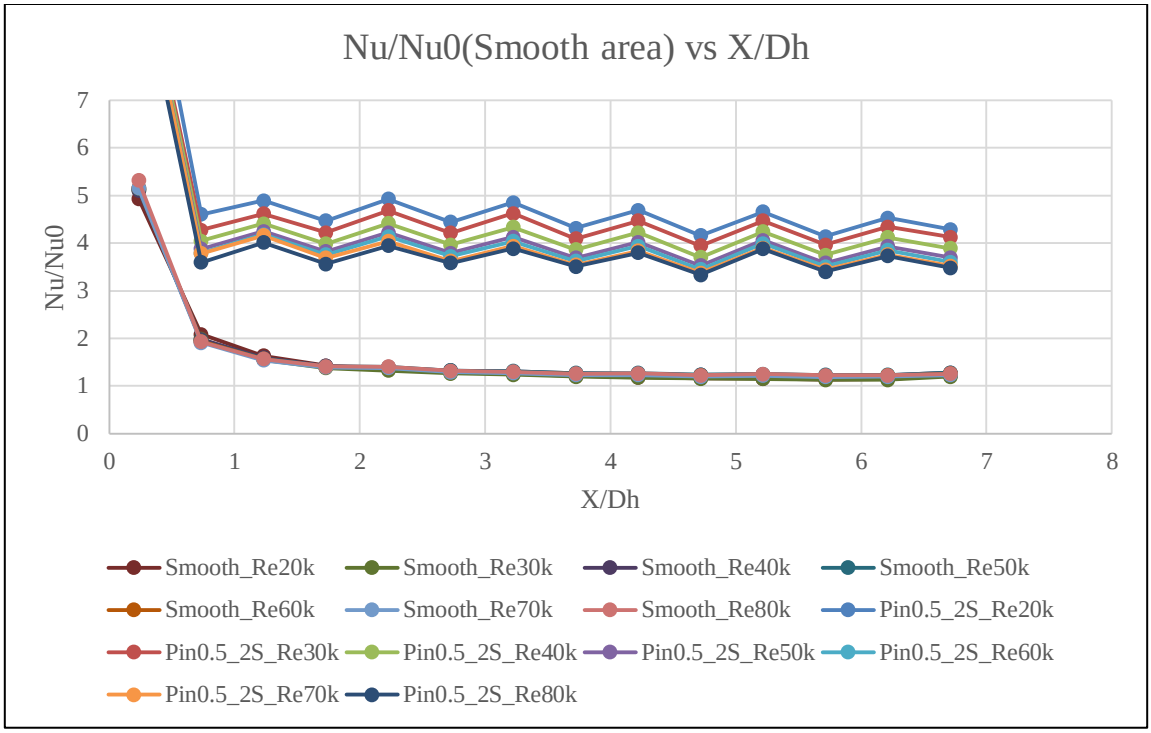

Figure 26 Normalized Nu(Smooth area) vs X/Dh of Pin0.5_2S

According to the trends in Figure 27, it is obvious that trends of pins from 20k to 70k shared some characteristics, making them move in the same direction, but testing pins at 80k Re were showing little off from others. The magnitude of Heat transfer enhancement with the smooth area basis was in between 4.2 and 7.8.

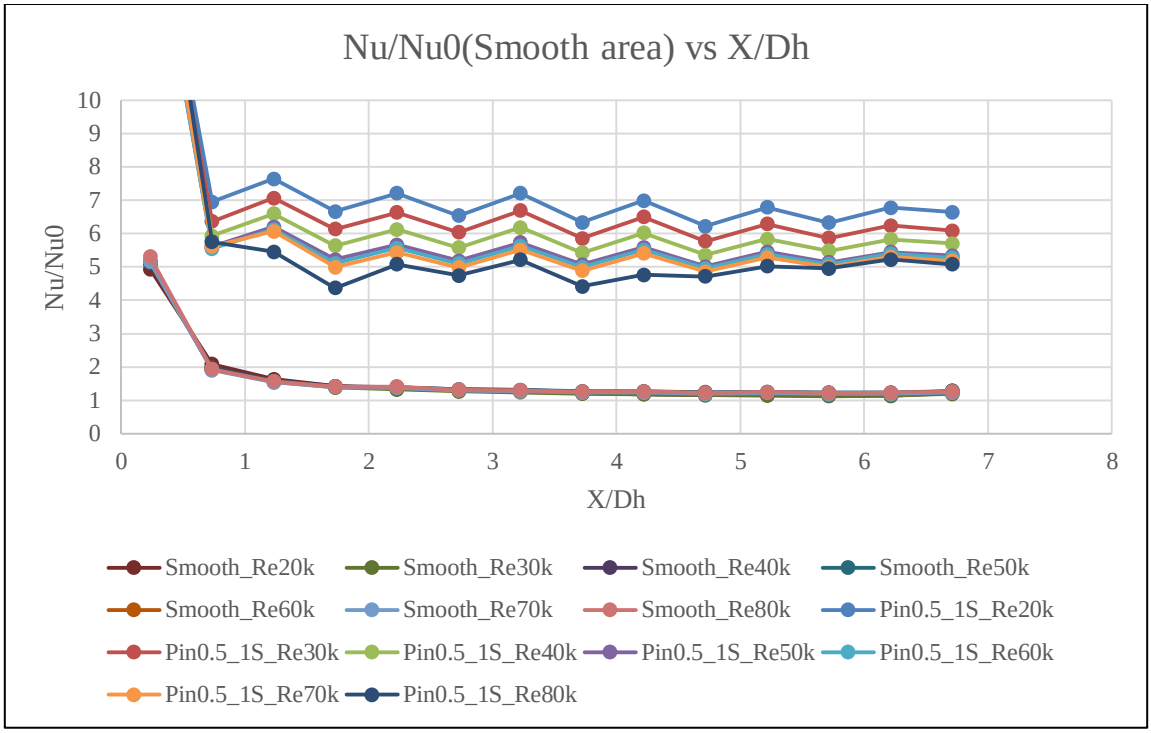

Figure 27 Normalized Nu(Smooth area) vs X/Dh of Pin0.5_1S

Figure 28 shows that when pins were involved, trends moved differently and varied from Reynolds number to Reynolds number. Those trends associated with pin1_2S indicates moderate fluctuation across Reynolds number range. The trends of Heat transfer enhancement from smooth area basis were in a range between 5 and 7.4.

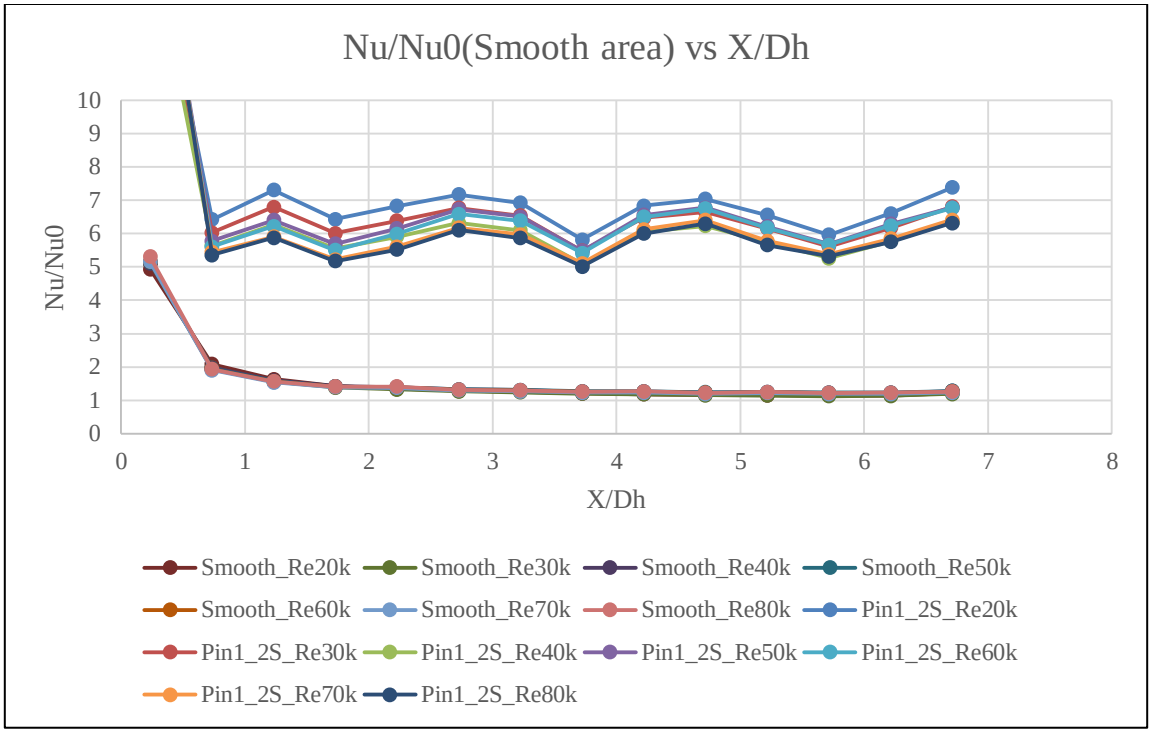

Figure 28 Normalized Nu(Smooth area) vs X/Dh of Pin1_2S

7.6 Heat Transfer Comparison: Smooth Channel vs Strip Fins (Smooth area)

Figure 29 shows striking findings from experiments. The heat transfer enhancement obtained by using strip fins appeared to be overlapped among one another, generating a stronger fluctuating line. The magnitude of the normalized Nu was in a range from 2.2 to 3.1. The trend of the normalized Nu did not have a strong correlation with Reynolds number.

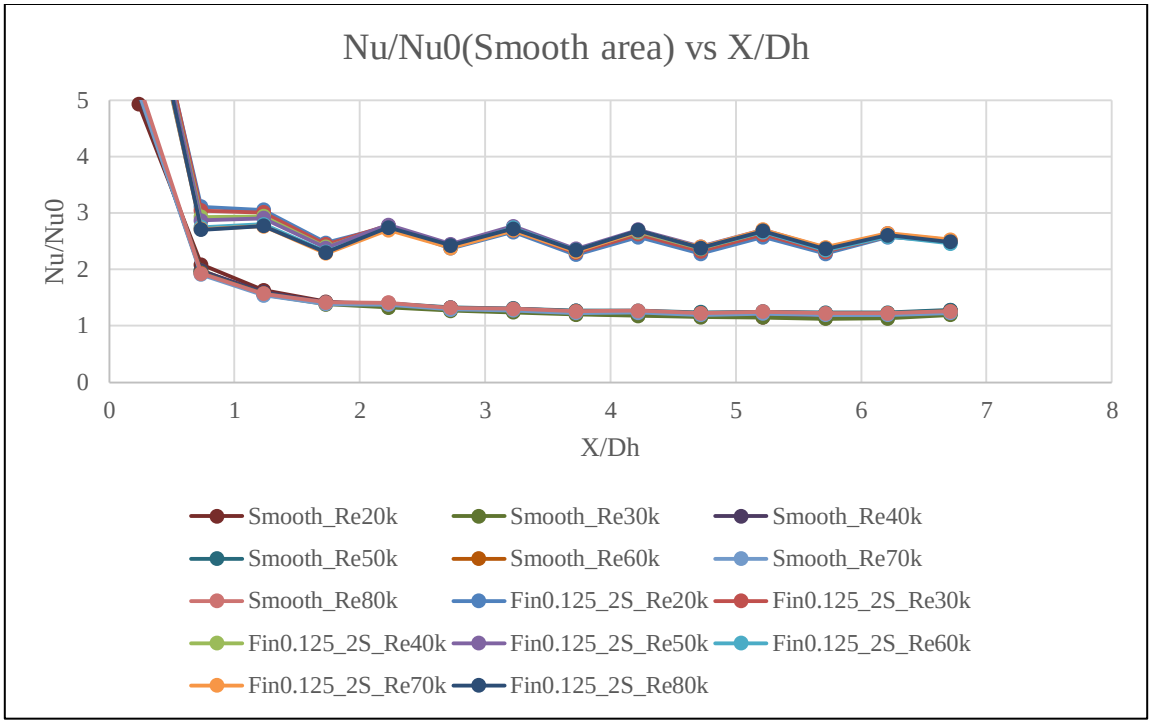

Figure 29 Normalized Nu(Smooth area) vs X/Dh of Fin0.125_2S

In Figure 30, the results from strip fins indicated a correlation between Heat transfer enhancement and Reynolds number: the higher Reynolds number, the lower Heat transfer enhancement. This is not true across all points of streamwise direction as Fin0.125_1S provided higher heat transfer at X/Dh between 3.5 and 5.5. The range of heat transfer was shifted to between 3.2 to 5.

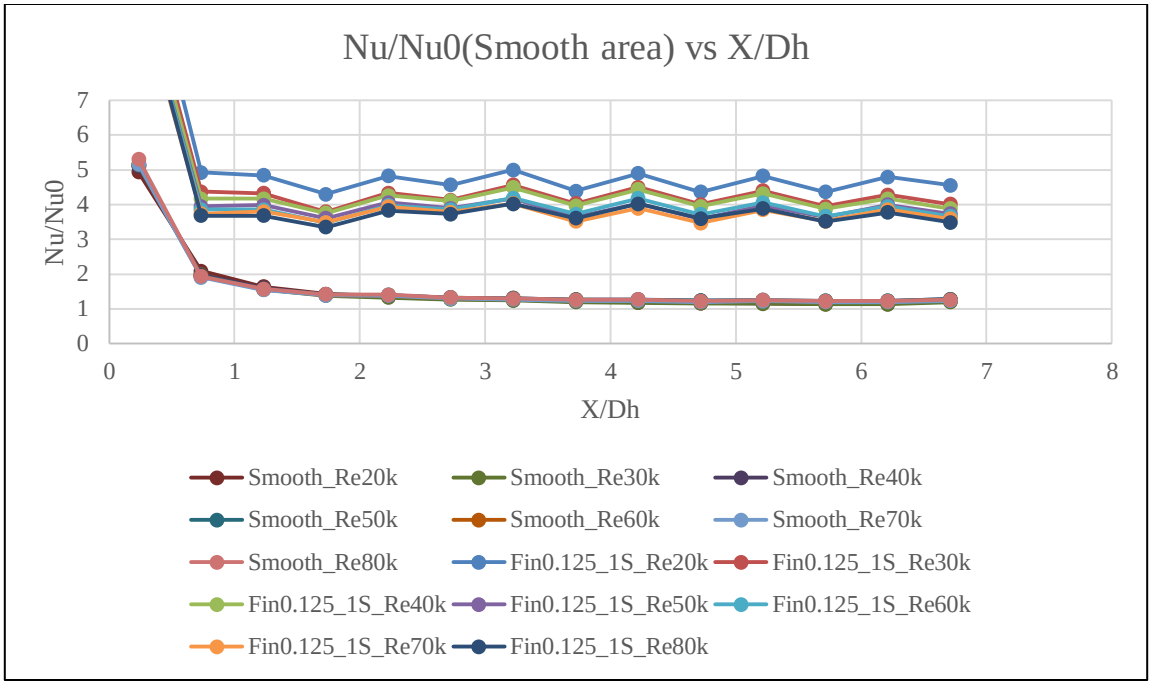

Figure 30 Normalized Nu(Smooth area) vs X/Dh of Fin0.125_1S

According to Figure 31, inserting thickest pins generated distinct variations of Heat transfer enhancements when altering Reynolds numbers. The range of normalized Nu was between 2.7 to 3.8. The trend did not follow Reynolds number. The lower Reynolds number gave higher normalized Nu only at entrance section up to the second copper plate, X/Dh = 0.73. After that point, the normalized Nu of Reynolds number 50,000 provided the highest heat transfer. Also, heat transfer enhancement at Re=80,000 provided higher normalized Nu than those of Re=60,000 and 70,000.

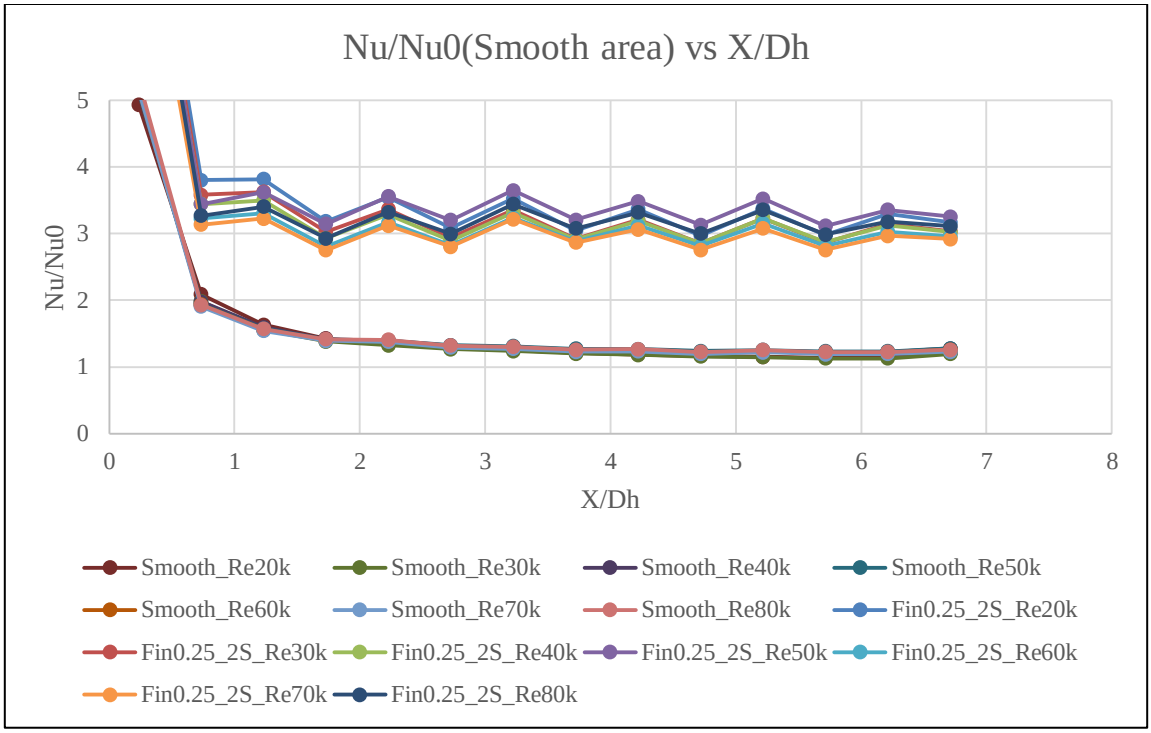

Figure 31 Normalized Nu(Smooth area) vs X/Dh of Fin0.25_2S

7.7 Friction Factor Comparison: Smooth Channel vs Circular Pins

Figure 32 and Figure 33 show the raw data measurement of pressure drop in a channel with pin shape features. The lower the streamwise pitch, the higher the pressure drop. Also higher pressure drop will reduce fluctuation of the data taken from pressure transducer.

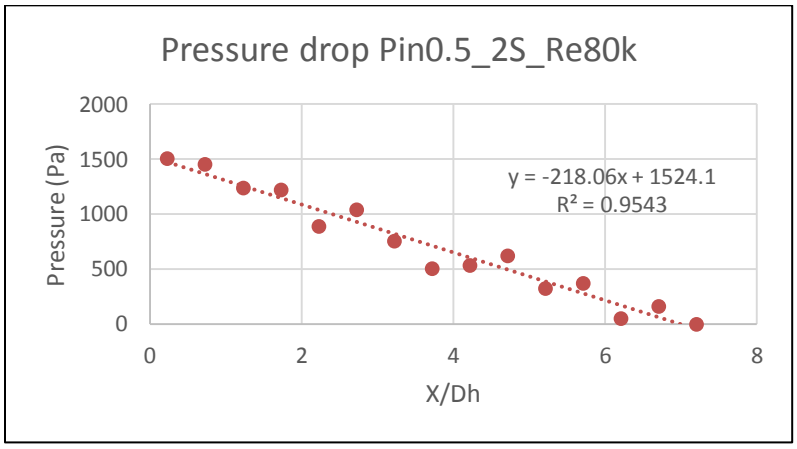

Figure 32 Pressure drop Pin0.5_2S_Re80k

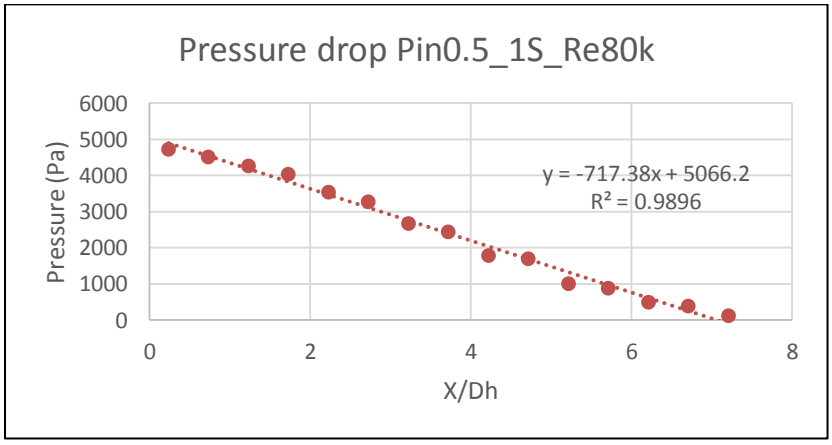

Figure 33 Pressure drop Pin0.5_1S_Re80k

From the Figure 34 below, it is observed that a friction factor varies, depending on techniques and Reynolds numbers. By applying the smooth channel feature, a friction factors are moving between one and two. Looking at a green line, circular pins with a diameter of 0.5 inches can provide a constant friction factor. However, high Reynolds numbers, such as 80k, can cause the friction factor to significantly increase when the circular pin feature with 1-inch spanwise space was tested. Increasing the diameter of circular pins made the purple line act totally different from the rest. In the middle of Reynolds number range, the friction factors strikingly increased, but at the beginning and the tail of the Reynold number range, the line appears to be flat

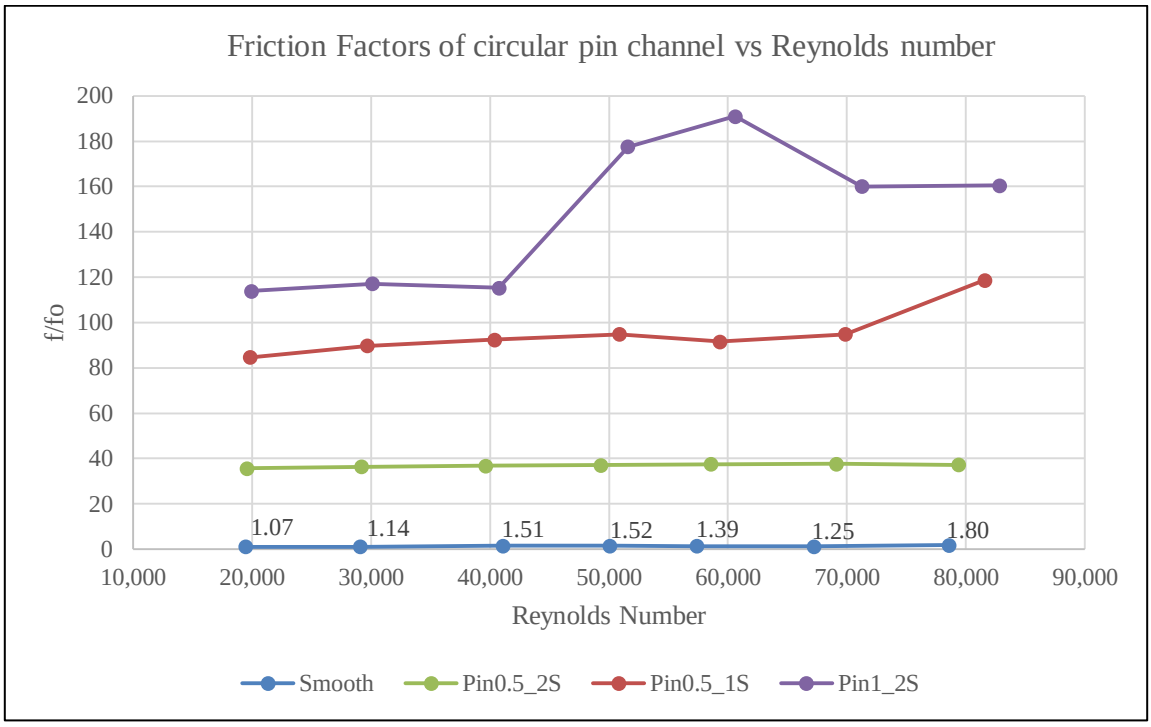

Figure 34 Friction Factors of circular pin channel vs Reynolds number

7.8 Friction Factor Comparison: Smooth Channel vs Strip Fins

Figure 35 and Figure 36 show the raw data measurement of pressure drop in a channel with fin shape features. The lower the streamwise pitch, the higher the pressure drop.

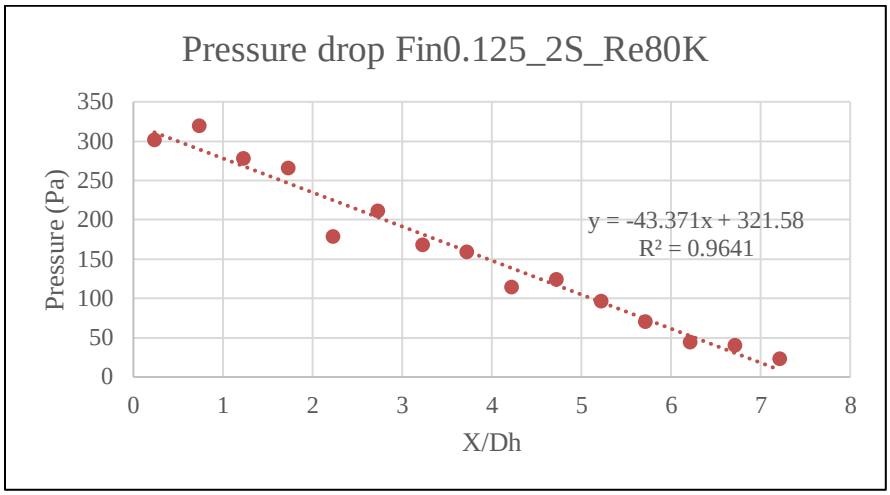

Figure 35 Pressure drop Fin0.125_2S_Re80k

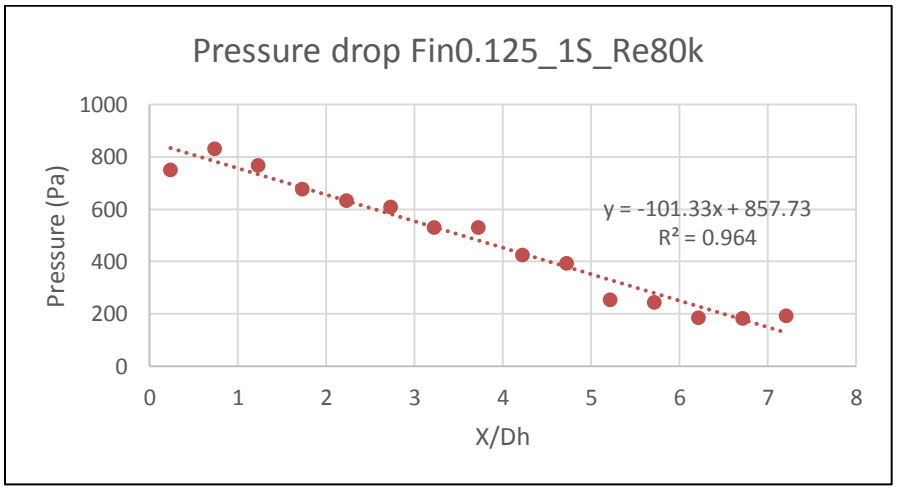

Figure 36 Pressure drop Fin0.125_1S_Re80k

When comparing the results from different strip fin cases showing in Figure 37, it is found that the friction factors from smooth channel are moving between one and two. The friction factors resulted from Fin0.125_1S are more than those from smooth channel and appear to be a linear line with little steepness across the Reynolds number range. When looking at the rest of the trends, it is obvious that trends of Fin0.125_2S and Fin0.25_2S are fluctuating when varying Reynolds numbers.

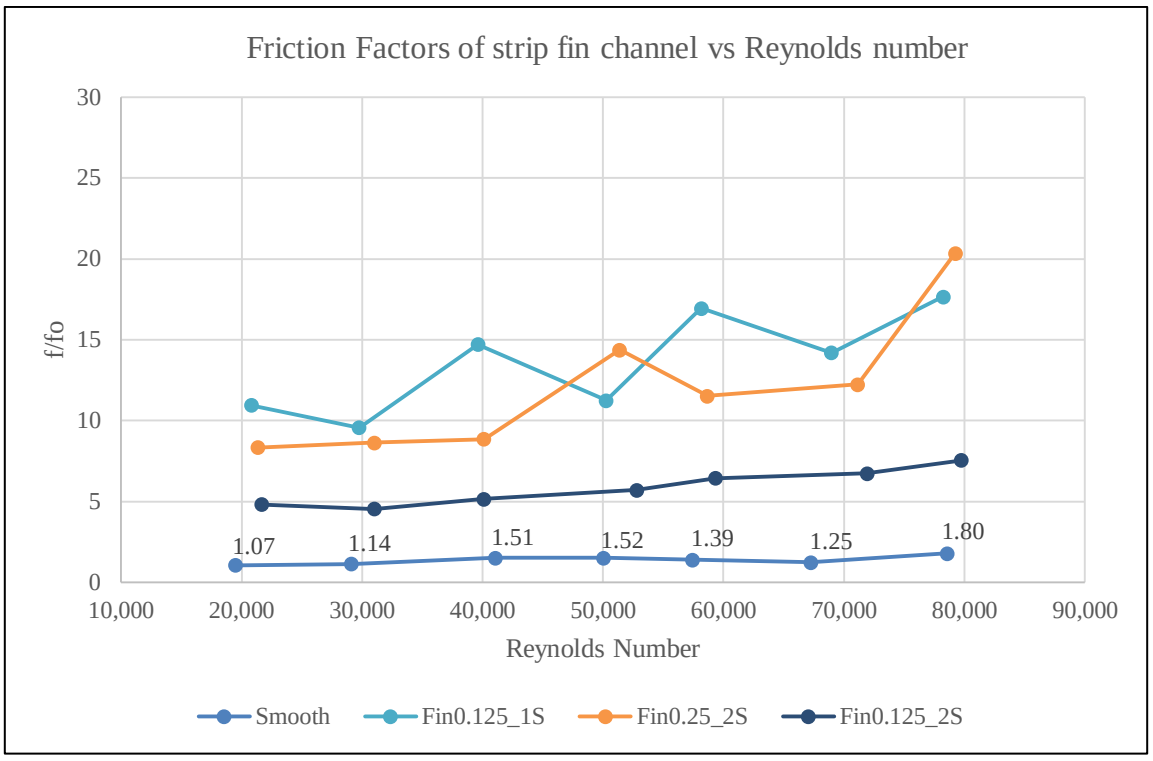

Figure 37 Friction Factors of strip fin channel vs Reynolds number

7.9 Array average normalized Nusselt number(Total area)

According to Figure 38, Fin0.125_2S shows similar characteristics to the smooth feature, which generated a flat line across determined Reynold numbers. Additionally, Pin0.5_2S and Fin0.125_1S produce Heat transfer enhancements very close to each other. Pin0.5_2S and Pin0.5_1S lines are approximately parallel, which Pin0.5_1S can obviously generate higher heat transfer rate than Pin0.5_2S. The last dark blue line, Pin1_2S, shows that at low Reynolds numbers, it could yield similar heat transfer results to Pin0.5_1S, but when Reynolds numbers were getting bigger, this feature made heat transfer values hugely off from Pin0.5_1S.

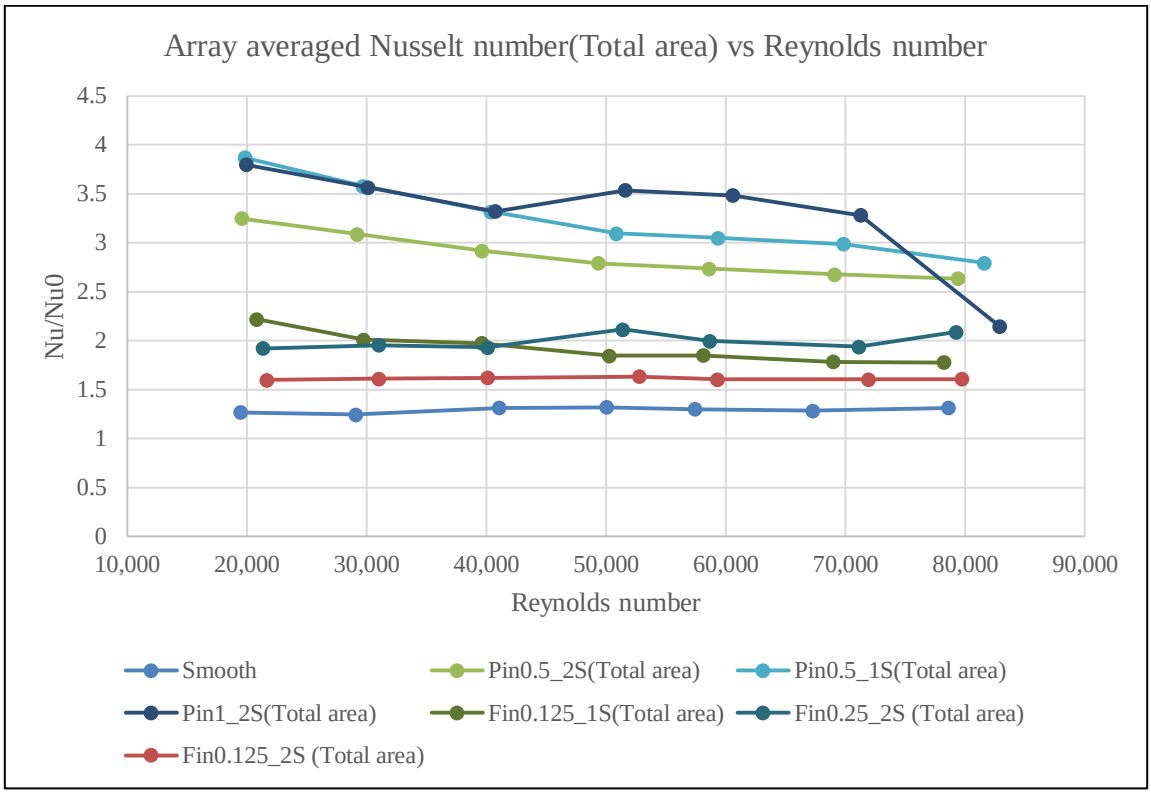

Figure 38 Array averaged Nu(Total area) vs Reynolds number

7.10 Array averaged normalized Nusselt number(Smooth area)

Figure 39 shows that the average Nusselt numbers of Smooth, Pin1_2S, and Fin0.125_2S, became constant over the range of Reynolds numbers. Pin1_2S generated the highest values among the three. Pin0.5_2S and Fin0.125_1S converged into a single line after 30k Re. Looking at Pin0.5_1S and Fin0.25_2S, both trends are correlated between spanwise space and average Nusselt number, but for Fin0.25_2S, Reynolds numbers appear to have stronger effect on average Nusselt numbers than those of Fin0.5_1S.

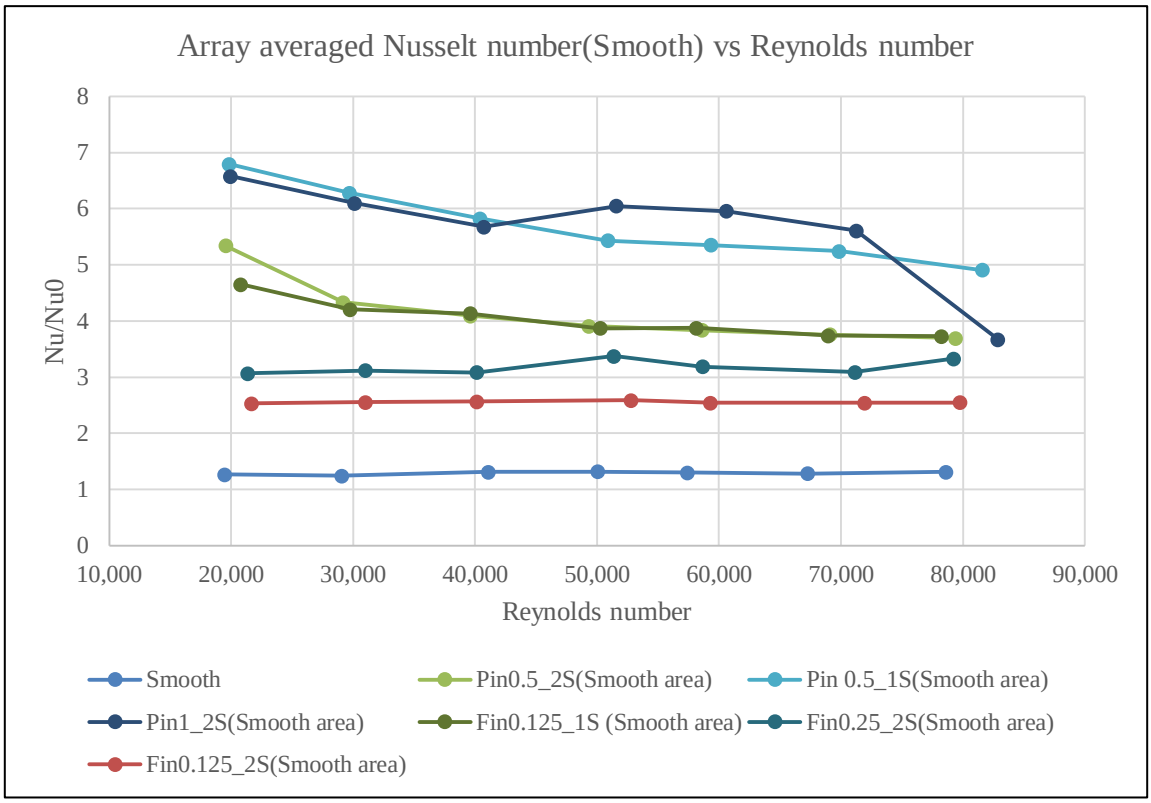

Figure 39 Array averaged Nu (Smooth area) vs Reynolds number

7.11 Thermal performance comparison(Total area)

In this section, the thermal performance is calculated based on the total area basis as shown in Figure 40. Thermal performance appears to decrease as Reynolds number increase. The Smooth case generated the best thermal performance, while the Pin1_2S gave the poorest performance. Fin0.25_2S and Fin0.125_2S give comparable performance level. Though the area ratio of Fin0.25_2S and Fin0.125_2S were less than that of Fin0.125_1S, those two prior features gave better results than the Fin0.125_1S. The only circular pin case that performed as good as the strip fin design is Pin0.5_2S.

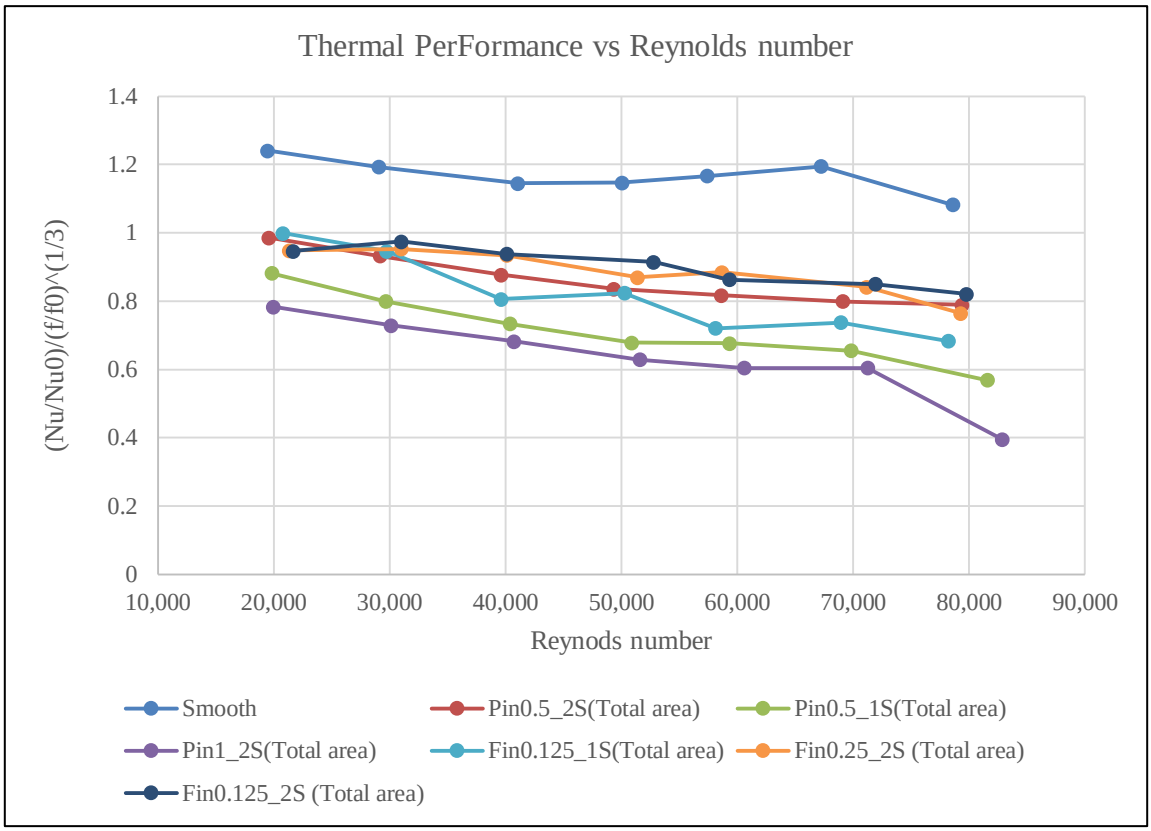

Figure 40 Thermal performance (Total area) vs Reynolds number

7.12 Thermal performance comparison(Smooth area)

Figure 41 provides thermal performance data based on a smooth area basis. All the-inserted-pin cases yielded better thermal performance than the regular smooth one at low Reynolds numbers. Smooth channel performance have the weakest Reynolds dependency. Circular pin cases tend to have worse thermal performance than the smooth channel when the Reynold number is increased. Pin1_2S appears to have poorer thermal performance than the smooth channel at Re 50,000. Pin0.5_2S and Pin0.5_1S show similar characteristics when Pin0.5_2S was at Re 60,000 and Pin0.5_1S was at Re 70,000. All strip fin cases also gave better thermal performance than that of the smooth channel over the range of tested Reynolds number. Fin0.125_1S yielded the best thermal performance. The Strip0.25_2S created almost the same thermal performance as Strip0.125_2S as the area ratio was about the same level.

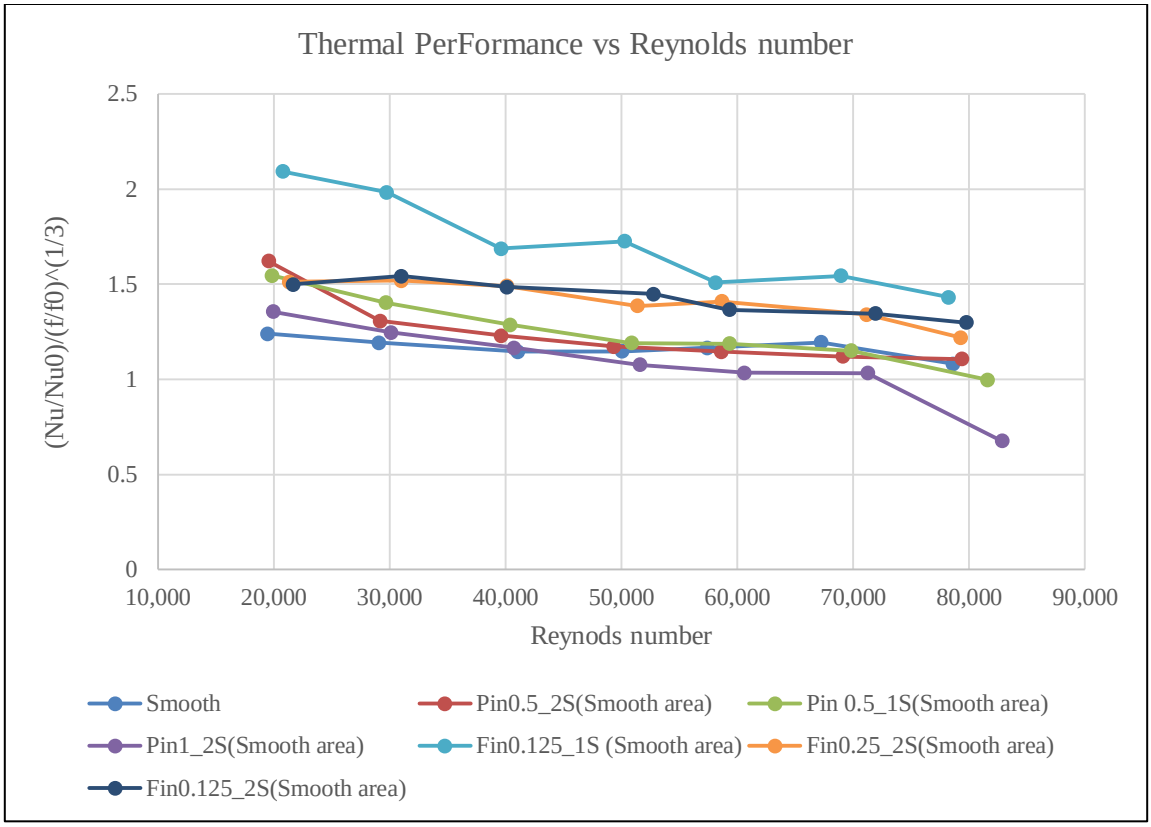

Figure 41 Thermal performance(Smooth area) vs Reynolds number

8. CONCLUSION

The pin arrangement and pin shape effects on heat transfer and pressure drop have been investigated in low aspect ratio channel (AR=9.57:1.2). The experiments of circular pins have four key parameters, including pin aspect ratio H/D (1.2 and 2.4), spanwise pitch S/D (2 and 4), streamwise pitch X/D (1 and 2), and area ratio (1.35, 1.67, and 1.52). The strip fin features also have those parameters, which are H/W (4.8 and 9.6), S/W (8 and 16), X/L (1), and area ratio (1.58, 1.59, and 2.09). A wide range of Reynolds numbers (20,000 to 80,000) was involved to observe the behaviors of heat transfer and pressure loss. The smooth channel heat transfer and pressure loss was investigated and used as a reference case. Regionally averaged heat transfer test method was applied: the copper plates and copper features were introduced in this experiment. According to the results, the conclusions are as follows:

1. The pressure loss is presented as the normalized friction factor. In circular pin cases, the pressure loss is primarily determined by S/D. Reducing S/D can increase the friction factor when H/D is fixed, and the friction factor became highest in the condition of lowest H/D and S/D.
2. In circular pin cases, the pressure loss tend to increase with an increase of Reynolds number in the higher blockage flow channel.
3. For strip fin cases, decreasing S/W by two times can increase friction factor by three times. However, when H/W was reduced, the pressure loss turns out to be decreasing.

4. Though the area ratios of circular pin and strip fin cases are at the same level, the circular pins generate much higher pressure loss in the channel, almost ten times in the highest case. It is observable that shape of the feature does affect the flow interaction between pin-fin and endwall, which will determine secondary flow behavior and its corresponding pressure loss.
5. Pin1_2S shows a sharp increase in friction factor at Reynolds numbers between 50,000 and 60,000. As a result, the heat transfer enhancement also increase at these Re range. The high noise from higher turbulent flow is observed during the test. More research in flow visualization is needed to describe the phenomenon.
6. The heat transfer enhancement from circular pins have a strong dependency on Reynolds numbers: the lower the Reynolds number, the higher heat transfer enhancement. On the contrary, the strip fins have a random impact from Reynolds number. Moreover, Circular pins provide higher heat transfer improvement
7. In circular pin cases, decreasing S/D, H/D, and X/D can drive up the heat transfer enhancement.
8. For strip fins, the increase in the heat transfer results from the decrease in S/W and the rise in H/W. Additionally, it must be noted that doubling the number of pins can affect the heat transfer more than varying the fin shapes.
9. The area ratios of Fin0.125_2S and Fin0.25_2S appears to be equivalent. However, the heat transfer of the latter is 20% higher than the former.
10. Different calculation bases, smooth area and total area, are presented in this research. The smooth area calculation base will dramatically increase heat transfer

enhancement more than the total area base. Thus, for the copper plate test method, it is critical to be aware of which calculation basis is considered.

11. Thermal performance has correlations with Reynolds numbers: the higher the Reynolds number, the lesser the thermal performance. The strip fin designs generate better performance than the circular pin design regardless of the calculation bases and Reynolds numbers.
12. All strip fin designs provide better thermal performance than the smooth channel over the tested Reynolds number ranges when considering smooth area basis. While, Pin1_2S gives poorer performance than that of smooth channel onset at Re=50,000, followed by Pin0.5_2S and Pin0.5_1S at Re=60,000 and 70,000 respectively.
13. Based on smooth area basis, the thermal performance comparison can be order from low to high performance: Pin1_2S, Pin0.5_2S, Pin0.5_1S, Fin0.25_2S, Fin0.125_2S, and Fin0.125_1S.

REFERENCES

[1] Han, J. C., 2013, "Fundamental Gas Turbine Heat Transfer," ASME Journal of Thermal Science and Engineering Applications, 5(2), p. 021007.

[2] Ligrani, P. M., and Mahmood, G. I., 2003, "Variable property Nusselt numbers in a channel with pin fins," AIAA Journal of thermophysics and heat transfer, 17(1), pp. 103-111.

[3] Ames, F. E., Dvorak, L. A., and Morrow, M. J., 2005, "Turbulent Augmentation of Internal Convection Over Pins in Staggered-Pin Fin Arrays," ASME Journal of Turbomachinery, 127(1), pp. 183-190.

[4] Chyu, M. K., Hsing, Y. C., Shih, T. P., and Natarajan, V., 1999, "Heat transfer contributions of pins and endwall in pin-fin arrays: effects of thermal boundary condition modeling," ASME Journal of Turbomachinery, 121(2), pp. 257-263.

[5] Khan, W., Culham, R., and Yovanovich, M., 2003, "Fluid Flow and Heat Transfer From a Pin Fin: Analytical Approach," Proc. 41st Aerospace Sciences Meeting and Exhibit, p. 163.

[6] Lau, S., Han, J. C., and Kim, Y., 1989, "Turbulent heat transfer and friction in pin fin channels with lateral flow ejection," ASME Journal of Heat Transfer, 111(1), pp. 51-58.

[7] Ames, F., and Dvorak, L., 2006, "Turbulent transport in pin fin arrays: experimental data and predictions," ASME Journal of Turbomachinery, 128(1), pp. 71-81.

[8] Sparrow, E., Ramsey, J., and Altemani, C., 1980, "Experiments on in-line pin fin arrays and performance comparisons with staggered arrays," ASME Journal of Heat Transfer, 102(1), pp. 44-50.

[9] VanFossen, G. J., 1981, "Heat Transfer Coefficients for Staggered Arrays of Short Pin Fins," ASME Paper No. 81-GT-75.

[10] Brigham, B. A., and VanFossen, G. J., 1984, "Length to Diameter Ratio and Row Number Effects in Short Pin Fin Heat Transfer," ASME Journal of Engineering for Gas Turbines and Power, 106(1), pp. 241-244.

[11] Park, J. S., Kim, K. M., Lee, D. H., Cho, H. H., and Chyu, M. K., 2008, "Heat Transfer on Rotating Channel With Various Heights of Pin-Fin," ASME paper No. GT2008-50783.

[12] Chyu, M. K., Siw, S. C., and Moon, H. K., 2009, "Effects of Height-to-Diameter Ratio of Pin Element on Heat Transfer from Staggered Pin-Fin Arrays," ASME Paper No. GT2009-59814.

[13] Lau, S. C., Kim, Y. S., and Han, J. C., 1985, "Effects of fin configuration and entrance length on Local endwall heat/mass transfer in a pin fin channel," ASME paper(85-WA).

[14] Lyall, M. E., Thrift, A. A., Thole, K. A., and Kohli, A., 2011, "Heat Transfer From Low Aspect Ratio Pin Fins," ASME Journal of Turbomachinery, 133(1), p. 011001.

[15] Ostanek, J. K., and Thole, K. A., 2012, "Effects of varying streamwise and spanwise spacing in pin-fin arrays," ASME Paper No. GT2012-68127.

[16] Tarchi, L., Facchini, B., and Zecchi, S., 2008, "Experimental Investigation of Innovative Internal Trailing Edge Cooling Configurations With Pentagonal Arrangement and Elliptic Pin Fin," International Journal of Rotating Machinery.

[17] Metzger, D., Fan, C., and Haley, S., 1984, "Effects of Pin Shape and Array Orientation on Heat Transfer and Pressure Loss in Pin Fin Arrays," ASME Journal of Engineering for Gas Turbines and Power, 106(1), pp. 252-257.

[18] Uzol, O., and Camci, C., 2005, "Heat Transfer, Pressure Loss and Flow Field Measurements Downstream of Staggered Two-Row Circular and Elliptical Pin Fin Arrays," ASME Journal of heat transfer, 127(5), pp. 458-471.

[19] Chyu, M. K., Hsing, Y. C., and Natarajan, V., 1998, "Convective Heat Transfer of Cubic Fin Arrays in a Narrow Channel," ASME Journal of Turbomachinery, 120(2), pp. 362-367.

[20] Kirsch, K. L., Ostanek, J. K., and Thole, K. A., 2014, "Comparison of Pin Surface Heat Transfer in Arrays of Oblong and Cylindrical Pin Fins," ASME Journal of Turbomachinery, 136(4), p. 041015.

[21] Xu, J., Yao, J., Su, P., Lei, J., Wu, J., and Gao, T., 2017, "Heat Transfer and Pressure Loss Characteristics of Pin-Fins With Different Shapes in a Wide Channel," ASME Paper No. GT2017-63761.

[22] Chyu, M. K., 1990, "Heat Transfer and Pressure Drop for Short Pin-Fin Arrays With Pin-Endwall Fillet," ASME Journal of Heat Transfer, 112(4), pp. 926-932.

[23] Bergman, T. L., Incropera, F. P., DeWitt, D. P., and Lavine, A. S., 2011, Fundamentals of heat and mass transfer, John Wiley & Sons.

[24] Chen, A. F., Shiau, C. C., Han, J. C., and and Krewinkel, R., 2018, "Heat transfer in a rotating two-pass rectangular channel featuring reduced cross-sectional area after tip turn (AR=4:1 to 2:1) with profiled 60 deg angled ribs," ASME Paper No. GT2018-76999.

[25] Kline, S. J., and McClintock, F. A., 1953, "Describing uncertainty in single-sample experiments," Mechanical engineering, 75, pp. 3-8.

APPENDIX A

REGIONAL HEAT LOSS CORRELATIONS

Heat loss_Smooth Channel										
X-Distance(inch)	Copper area(m^2)	Area ratio	T_high	T-Troom_High	T_low	T-Troom_Low	Power_High (W)	Power_Low (W)	m	c
0.5000	0.0054	0.0292	48.2203	23.7203	32.7216	8.5216	0.9156	0.2147	0.0461	-0.1783
1.5625	0.0123	0.0667	60.3087	35.8087	35.8492	11.6492	2.0927	0.4907	0.0663	-0.2817
2.6250	0.0123	0.0667	67.9037	43.4037	38.1111	13.9111	2.0927	0.4907	0.0543	-0.2649
3.6875	0.0123	0.0667	73.2976	48.7976	40.0280	15.8280	2.0927	0.4907	0.0486	-0.2784
4.7500	0.0123	0.0667	75.1044	50.6044	40.9537	16.7537	2.0927	0.4907	0.0473	-0.3022
5.8125	0.0123	0.0667	76.0603	51.5603	41.5509	17.3509	2.0927	0.4907	0.0468	-0.3218
6.8750	0.0123	0.0667	75.8674	51.3674	41.6335	17.4335	2.0927	0.4907	0.0472	-0.3323
7.9375	0.0123	0.0667	75.6641	51.1641	41.7393	17.5393	2.0927	0.4907	0.0476	-0.3449
9.0000	0.0123	0.0667	75.0057	50.5057	41.4538	17.2538	2.0927	0.4907	0.0482	-0.3405
10.0625	0.0123	0.0667	74.3813	49.8813	41.1598	16.9598	2.0927	0.4907	0.0487	-0.3346
11.1250	0.0123	0.0667	72.7945	48.2945	40.3968	16.1968	2.0927	0.4907	0.0499	-0.3177
12.1875	0.0123	0.0667	70.2647	45.7647	39.2686	15.0686	2.0927	0.4907	0.0522	-0.2957
13.2500	0.0123	0.0667	65.5607	41.0607	37.6883	13.4883	2.0927	0.4907	0.0581	-0.2930
14.3125	0.0123	0.0667	58.1440	33.6440	35.4110	11.2110	2.0927	0.4907	0.0714	-0.3099
15.3750	0.0054	0.0292	46.8055	22.3055	32.2690	8.0690	0.9156	0.2147	0.0492	-0.1826

Table A1 Heat loss correlations Smooth channel

Heat loss Pin0.5_2S										
X-Distance(inch)	Copper area(m^2)	Area ratio	T_high	T-Troom_High	T_low	T-Troom_Low	Power_High (W)	Power_Low(W)	m	c
0.5000	0.0054	0.0292	40.1239	20.5239	27.2015	6.8015	0.9436	0.2777	0.0485	-0.0523
1.5625	0.0123	0.0667	48.9547	29.3547	29.9884	9.5884	2.1567	0.6348	0.0770	-0.1035
2.6250	0.0123	0.0667	54.6811	35.0811	31.8143	11.4143	2.1567	0.6348	0.0643	-0.0992
3.6875	0.0123	0.0667	58.9241	39.3241	33.1631	12.7631	2.1567	0.6348	0.0573	-0.0966
4.7500	0.0123	0.0667	60.7791	41.1791	33.5869	13.1869	2.1567	0.6348	0.0544	-0.0822
5.8125	0.0123	0.0667	61.7104	42.1104	33.8032	13.4032	2.1567	0.6348	0.0530	-0.0758
6.8750	0.0123	0.0667	61.9196	42.3196	33.7178	13.3178	2.1567	0.6348	0.0525	-0.0641
7.9375	0.0123	0.0667	61.8029	42.2029	33.6875	13.2875	2.1567	0.6348	0.0526	-0.0646
9.0000	0.0123	0.0667	61.3662	41.7662	33.5443	13.1443	2.1567	0.6348	0.0532	-0.0642
10.0625	0.0123	0.0667	60.9132	41.3132	33.5508	13.1508	2.1567	0.6348	0.0540	-0.0759
11.1250	0.0123	0.0667	59.4929	39.8929	33.2022	12.8022	2.1567	0.6348	0.0562	-0.0844
12.1875	0.0123	0.0667	57.1416	37.5416	32.4708	12.0708	2.1567	0.6348	0.0598	-0.0865
13.2500	0.0123	0.0667	53.6281	34.0281	31.3899	10.9899	2.1567	0.6348	0.0661	-0.0912
14.3125	0.0123	0.0667	47.8210	28.2210	29.3599	8.9599	2.1567	0.6348	0.0790	-0.0732
15.3750	0.0054	0.0292	39.0346	19.4346	26.3421	5.9421	0.9436	0.2777	0.0494	-0.0155

Table A2 Heat loss correlations Pin0.5_2S

Heat loss Pin0.5_1S										
X-Distance(inch)	Copper area(m^2)	Area ratio	T_high	T-Troom_High	T_low	T-Troom_Low	Power_High (W)	Power_Low(W)	m	c
0.5000	0.0054	0.0292	34.8272	13.6272	26.8858	5.3858	0.8123	0.4565	0.0432	0.2240
1.5625	0.0123	0.0667	41.9698	20.7698	30.2757	8.7757	1.8567	1.0434	0.0678	0.4484
2.6250	0.0123	0.0667	46.7511	25.5511	32.4132	10.9132	1.8567	1.0434	0.0556	0.4371
3.6875	0.0123	0.0667	50.3943	29.1943	33.7633	12.2633	1.8567	1.0434	0.0480	0.4544
4.7500	0.0123	0.0667	51.6157	30.4157	33.7742	12.2742	1.8567	1.0434	0.0448	0.4932
5.8125	0.0123	0.0667	52.3785	31.1785	33.8496	12.3496	1.8567	1.0434	0.0432	0.5100
6.8750	0.0123	0.0667	52.1765	30.9765	33.5080	12.0080	1.8567	1.0434	0.0429	0.5286
7.9375	0.0123	0.0667	52.1421	30.9421	33.4870	11.9870	1.8567	1.0434	0.0429	0.5291
9.0000	0.0123	0.0667	51.6734	30.4734	33.2522	11.7522	1.8567	1.0434	0.0434	0.5329
10.0625	0.0123	0.0667	51.2854	30.0854	33.2658	11.7658	1.8567	1.0434	0.0444	0.5211
11.1250	0.0123	0.0667	50.1203	28.9203	32.9728	11.4728	1.8567	1.0434	0.0466	0.5087
12.1875	0.0123	0.0667	48.3673	27.1673	32.5302	11.0302	1.8567	1.0434	0.0504	0.4876
13.2500	0.0123	0.0667	45.6766	24.4766	31.7152	10.2152	1.8567	1.0434	0.0570	0.4609
14.3125	0.0123	0.0667	41.4545	20.2545	29.9626	8.4626	1.8567	1.0434	0.0690	0.4598
15.3750	0.0054	0.0292	35.1840	13.9840	26.9513	5.4513	0.8123	0.4565	0.0417	0.2292

Table A3 Heat loss correlations Pin0.5_1S

Heat loss Pin1_2S										
X-Distance(inch)	Copper area(m^2)	Area ratio	T_high	T-Troom_High	T_low	T-Troom_Low	Power_High (W)	Power_Low(W)	m	c
0.5000	0.0054	0.0292	38.3948	17.9948	26.5819	5.8819	1.3468	0.4431	0.0746	0.0043
1.5625	0.0123	0.0667	48.6267	28.2267	30.0211	9.3211	3.0783	1.0129	0.1093	-0.0055
2.6250	0.0123	0.0667	55.2915	34.8915	32.1986	11.4986	3.0783	1.0129	0.0883	-0.0024
3.6875	0.0123	0.0667	59.3624	38.9624	33.3670	12.6670	3.0783	1.0129	0.0785	0.0179
4.7500	0.0123	0.0667	60.3374	39.9374	33.4134	12.7134	3.0783	1.0129	0.0759	0.0483
5.8125	0.0123	0.0667	60.6290	40.2290	33.3981	12.6981	3.0783	1.0129	0.0750	0.0602
6.8750	0.0123	0.0667	60.3788	39.9788	33.1757	12.4757	3.0783	1.0129	0.0751	0.0760
7.9375	0.0123	0.0667	60.0802	39.6802	33.0681	12.3681	3.0783	1.0129	0.0756	0.0775
9.0000	0.0123	0.0667	59.5995	39.1995	32.8687	12.1687	3.0783	1.0129	0.0764	0.0830
10.0625	0.0123	0.0667	59.4269	39.0269	32.9444	12.2444	3.0783	1.0129	0.0771	0.0686
11.1250	0.0123	0.0667	58.3448	37.9448	32.6861	11.9861	3.0783	1.0129	0.0796	0.0592
12.1875	0.0123	0.0667	56.6892	36.2892	32.2920	11.5920	3.0783	1.0129	0.0836	0.0434
13.2500	0.0123	0.0667	53.6996	33.2996	31.5396	10.8396	3.0783	1.0129	0.0920	0.0160
14.3125	0.0123	0.0667	48.1931	27.7931	29.7636	9.0636	3.0783	1.0129	0.1103	0.0134
15.3750	0.0054	0.0292	39.6876	19.2876	26.8482	6.1482	1.3468	0.4431	0.0688	0.0203

Table A4 Heat loss correlations Pin1_2S

Heat loss Fin0.125_2S										
X-Distance(inch)	Copper area(m^2)	Area ratio	T_high	T-Troom_High	T_low	T-Troom_Low	Power_High (W)	Power_Low(W)	m	c
0.5000	0.0054	0.0292	39.4031	18.5031	27.5610	5.5610	1.4232	0.4440	0.0757	0.0233
1.5625	0.0123	0.0667	49.2665	28.3665	31.5690	9.5690	3.2530	1.0149	0.1191	-0.1245
2.6250	0.0123	0.0667	55.5556	34.6556	34.1361	12.1361	3.2530	1.0149	0.0994	-0.1913
3.6875	0.0123	0.0667	60.7851	39.8851	35.9796	13.9796	3.2530	1.0149	0.0864	-0.1929
4.7500	0.0123	0.0667	63.0167	42.1167	36.3814	14.3814	3.2530	1.0149	0.0807	-0.1456
5.8125	0.0123	0.0667	64.8082	43.9082	36.7328	14.7328	3.2530	1.0149	0.0767	-0.1153
6.8750	0.0123	0.0667	65.2193	44.3193	36.5186	14.5186	3.2530	1.0149	0.0751	-0.0755
7.9375	0.0123	0.0667	65.3377	44.4377	36.4665	14.4665	3.2530	1.0149	0.0747	-0.0654
9.0000	0.0123	0.0667	64.7584	43.8584	36.2312	14.2312	3.2530	1.0149	0.0755	-0.0602
10.0625	0.0123	0.0667	63.7344	42.8344	36.1339	14.1339	3.2530	1.0149	0.0780	-0.0873
11.1250	0.0123	0.0667	61.8516	40.9516	35.7506	13.7506	3.2530	1.0149	0.0823	-0.1165
12.1875	0.0123	0.0667	58.9115	38.0115	34.9555	12.9555	3.2530	1.0149	0.0893	-0.1424
13.2500	0.0123	0.0667	54.9298	34.0298	33.6383	11.6383	3.2530	1.0149	0.1000	-0.1484
14.3125	0.0123	0.0667	49.0744	28.1744	31.2959	9.2959	3.2530	1.0149	0.1186	-0.0872
15.3750	0.0054	0.0292	41.0897	20.1897	28.0167	6.0167	1.4232	0.4440	0.0691	0.0283

Table A5 Heat loss correlations Fin0.125_2S

Heat loss Fin0.125_1S										
X-Distance(inch)	Copper area(m^2)	Area ratio	T_high	T-Troom_High	T_low	T-Troom_Low	Power_High (W)	Power_Low(W)	m	c
0.5000	0.0054	0.0292	37.7432	17.0432	26.9162	5.7162	1.4237	0.4322	0.0875	-0.0681
1.5625	0.0123	0.0667	47.4301	26.7301	30.2461	9.0461	3.2541	0.9879	0.1282	-0.1714
2.6250	0.0123	0.0667	53.8057	33.1057	32.4812	11.2812	3.2541	0.9879	0.1038	-0.1835
3.6875	0.0123	0.0667	57.8817	37.1817	33.7820	12.5820	3.2541	0.9879	0.0921	-0.1712
4.7500	0.0123	0.0667	59.1224	38.4224	34.0470	12.8470	3.2541	0.9879	0.0886	-0.1505
5.8125	0.0123	0.0667	59.4040	38.7040	34.0582	12.8582	3.2541	0.9879	0.0877	-0.1396
6.8750	0.0123	0.0667	59.2112	38.5112	33.8507	12.6507	3.2541	0.9879	0.0876	-0.1207
7.9375	0.0123	0.0667	58.8417	38.1417	33.7663	12.5663	3.2541	0.9879	0.0886	-0.1256
9.0000	0.0123	0.0667	58.3812	37.6812	33.5499	12.3499	3.2541	0.9879	0.0895	-0.1170
10.0625	0.0123	0.0667	58.0245	37.3245	33.5763	12.3763	3.2541	0.9879	0.0908	-0.1363
11.1250	0.0123	0.0667	56.8915	36.1915	33.2464	12.0464	3.2541	0.9879	0.0939	-0.1428
12.1875	0.0123	0.0667	55.0686	34.3686	32.7160	11.5160	3.2541	0.9879	0.0992	-0.1541
13.2500	0.0123	0.0667	52.1026	31.4026	31.8116	10.6116	3.2541	0.9879	0.1090	-0.1688
14.3125	0.0123	0.0667	46.8609	26.1609	29.9772	8.7772	3.2541	0.9879	0.1304	-0.1564
15.3750	0.0054	0.0292	38.8540	18.1540	27.1870	5.9870	1.4237	0.4322	0.0815	-0.0557

Table A6 Heat loss correlations Fin0.125_1S

Heat loss Fin0.25_2S										
X-Distance(inch)	Copper area(m^2)	Area ratio	T_high	T-Troom_High	T_low	T-Troom_Low	Power_High (W)	Power_Low(W)	m	c
0.5000	0.0054	0.0292	38.3763	18.3763	26.7349	6.3349	1.4690	0.4419	0.0853	-0.0985
1.5625	0.0123	0.0667	48.5908	28.5908	30.3762	9.9762	3.3577	1.0100	0.1261	-0.2482
2.6250	0.0123	0.0667	55.4171	35.4171	32.7922	12.3922	3.3577	1.0100	0.1020	-0.2536
3.6875	0.0123	0.0667	59.6364	39.6364	34.2707	13.8707	3.3577	1.0100	0.0911	-0.2539
4.7500	0.0123	0.0667	61.1261	41.1261	34.5627	14.1627	3.3577	1.0100	0.0871	-0.2232
5.8125	0.0123	0.0667	61.5160	41.5160	34.6257	14.2257	3.3577	1.0100	0.0860	-0.2138
6.8750	0.0123	0.0667	61.5484	41.5484	34.4622	14.0622	3.3577	1.0100	0.0854	-0.1911
7.9375	0.0123	0.0667	61.3174	41.3174	34.4300	14.0300	3.3577	1.0100	0.0860	-0.1971
9.0000	0.0123	0.0667	60.6611	40.6611	34.1528	13.7528	3.3577	1.0100	0.0872	-0.1899
10.0625	0.0123	0.0667	60.2580	40.2580	34.1855	13.7855	3.3577	1.0100	0.0887	-0.2126
11.1250	0.0123	0.0667	58.8907	38.8907	33.7857	13.3857	3.3577	1.0100	0.0921	-0.2222
12.1875	0.0123	0.0667	56.7882	36.7882	33.1452	12.7452	3.3577	1.0100	0.0976	-0.2345
13.2500	0.0123	0.0667	53.4606	33.4606	32.0824	11.6824	3.3577	1.0100	0.1078	-0.2494
14.3125	0.0123	0.0667	47.8824	27.8824	30.0754	9.6754	3.3577	1.0100	0.1289	-0.2376
15.3750	0.0054	0.0292	39.2652	19.2652	27.0158	6.6158	1.4690	0.4419	0.0812	-0.0953

Table A7 Heat loss correlations Fin0.25_2S

APPENDIX B

PRESSURE DROP ACROSS EXPERIMENT TEST SECTION

Pressure drop_Smooth Channel							
Streamwise Distance(m)	Pressure(Pa) at Re=20,000	Pressure(Pa) at Re=30,000	Pressure(Pa) at Re=40,000	Pressure(Pa) at Re=50,000	Pressure(Pa) at Re=60,000	Pressure(Pa) at Re=70,000	Pressure(Pa) at Re=80,000
0.0127	7.9629	17.4188	35.3353	48.2750	64.6984	69.6752	114.4664
0.0397	6.9675	15.4281	31.8515	41.8051	54.7448	62.7077	94.5592
0.0667	6.4698	14.4327	29.8608	40.3121	51.7587	63.2054	94.5592
0.0937	5.9722	13.4374	28.8654	38.3214	48.7726	60.7170	90.5778
0.1207	5.4745	12.4420	24.8840	32.8469	40.8098	53.7494	66.1914
0.1476	5.4745	11.9443	24.8840	35.8330	46.7819	57.2332	82.6149
0.1746	4.9768	11.4466	23.8886	33.3446	43.7958	54.2471	77.1404
0.2016	4.9768	11.4466	22.3956	32.3492	43.2982	53.2518	74.6520
0.2286	4.9768	11.4466	21.4002	30.8562	39.8144	51.2610	65.6938
0.2556	4.9768	10.9490	21.4002	29.3631	38.3214	48.7726	61.2146
0.2826	4.4791	10.9490	19.9072	26.8747	36.8283	45.2889	56.2378
0.3096	4.4791	9.4559	18.4142	22.8933	34.3399	39.8144	45.7866
0.3366	3.9814	8.9582	16.4234	19.9072	31.3538	32.3492	37.8237
0.3635	3.4838	7.9629	14.4327	17.4188	24.8840	28.8654	34.3399
0.3905	3.4838	7.9629	12.4420	16.4234	23.8886	27.8701	33.8422

Table B1 Pressure drop Smooth channel

Pressure drop Pin0.5_2S							
Streamwise Distance(m)	Pressure(Pa) at Re=20,000	Pressure(Pa) at Re=30,000	Pressure(Pa) at Re=40,000	Pressure(Pa) at Re=50,000	Pressure(Pa) at Re=60,000	Pressure(Pa) at Re=70,000	Pressure(Pa) at Re=80,000
0.0127	161.2752	307.1566	503.8244	691.0063	926.1392	1222.8908	1508.9451
0.0397	159.7107	343.0643	541.4868	722.4923	943.1566	1233.9525	1456.7193
0.0667	112.0290	289.5893	457.5712	610.8758	809.4066	1038.9294	1237.2750
0.0937	120.2624	157.5690	320.8493	472.2145	658.3891	888.4511	1223.0414
0.1207	98.3371	207.4417	329.1705	433.0306	567.7038	721.3317	891.1739
0.1476	113.3563	114.5381	251.6397	371.9927	546.8448	718.4618	1041.8187
0.1746	90.0612	163.2119	271.9540	356.4817	473.1782	605.0161	756.5562
0.2016	110.7447	197.7133	461.7821	400.0912	625.9115	654.6600	503.3993
0.2286	94.9673	84.9667	176.9335	240.6141	298.6242	412.6576	535.5375
0.2556	76.2981	181.6460	264.3937	346.3447	427.6211	528.6021	622.9976
0.2826	57.2683	69.7984	117.6941	148.1773	197.9074	246.4325	324.0238
0.3096	37.9762	143.6006	191.2982	222.8352	269.6482	338.8116	369.0723
0.3366	4.2586	31.8804	35.6351	23.6644	24.7312	26.1705	51.7132
0.3635	22.0106	93.9354	118.1589	124.0629	141.1037	163.8838	164.4282
0.3905	42.6609	12.1362	15.4761	0.0000	6.8904	0.0000	0.0000

Table B2 Pressure drop Pin0.5_2S

Pressure drop Pin0.5_1S							
Streamwise Distance(m)	Pressure(Pa) at Re=20,000	Pressure(Pa) at Re=30,000	Pressure(Pa) at Re=40,000	Pressure(Pa) at Re=50,000	Pressure(Pa) at Re=60,000	Pressure(Pa) at Re=70,000	Pressure(Pa) at Re=80,000
0.0127	369.1084	695.4127	1156.3672	1750.8900	2215.7112	2994.2191	4733.6358
0.0397	323.0232	688.7570	1118.6854	1727.7476	2163.5356	2902.6066	4518.0926
0.0667	346.1317	677.7730	1084.4124	1635.0547	1988.7975	2660.4823	4268.2520
0.0937	258.1787	621.5573	1006.2346	1534.9773	1916.9327	2556.4694	4040.4275
0.1207	254.5474	547.2084	864.5314	1327.4497	1654.4906	2192.4665	3546.2942
0.1476	246.6437	494.6412	790.1984	1197.6644	1509.1049	2002.5650	3283.0066
0.1746	248.0883	440.7016	679.0503	1024.6584	1279.7052	1671.2888	2681.0427
0.2016	200.4421	392.6140	612.8698	931.6599	1170.3906	1540.5712	2452.1333
0.2286	189.7972	291.4807	426.8761	717.0768	886.7110	1148.9732	1789.2676
0.2556	158.1015	319.7962	457.1686	734.3779	908.6758	1168.1747	1703.5527
0.2826	88.8707	227.7717	293.6884	471.0372	573.1661	721.1221	1019.8041
0.3096	118.3486	237.2356	296.6481	444.9966	539.9241	669.9151	880.8202
0.3366	95.1875	119.1954	146.4212	231.5070	273.7887	328.4357	501.7729
0.3635	75.8248	139.7826	156.7326	235.3165	273.5234	315.3398	394.2599
0.3905	40.3987	71.0714	63.1601	68.3322	76.6470	77.2544	129.1047

Table B3 Pressure drop Pin0.5_1S

Pressure drop Pin1_2S							
Streamwise Distance(m)	Pressure(Pa) at Re=20,000	Pressure(Pa) at Re=30,000	Pressure(Pa) at Re=40,000	Pressure(Pa) at Re=50,000	Pressure(Pa) at Re=60,000	Pressure(Pa) at Re=70,000	Pressure(Pa) at Re=80,000
0.0127	515.8650	920.0595	1444.1638	3096.4288	4517.7833	4756.1551	6355.3997
0.0397	430.8704	794.5481	1253.0500	3118.3385	4465.6513	4676.3926	5837.3962
0.0667	398.6083	766.6641	1181.7409	2770.3920	4081.1382	4108.8578	5299.5962
0.0937	399.6181	724.0010	1155.2347	2863.1724	4174.3525	4260.3670	5510.9296
0.1207	317.4464	537.6243	824.8145	2232.1458	3217.0839	3162.2343	3863.0698
0.1476	344.6628	614.7149	961.5805	2486.5170	3699.7885	3596.9551	4647.9838
0.1746	276.2791	435.3667	639.6014	1741.8267	2474.7939	2380.5480	3067.0938
0.2016	308.6529	509.0035	757.9268	1883.0758	2879.1047	2759.4273	3675.4733
0.2286	219.0762	277.4096	380.7536	1135.6000	1709.5059	1740.7774	2371.2760
0.2556	206.1483	355.2942	532.7132	1377.9259	2054.4293	1974.5748	2629.5000
0.2826	138.4772	161.1655	193.6864	618.9283	903.2959	667.1363	988.6301
0.3096	209.2443	281.3295	369.3231	858.5378	1353.5236	1305.5132	1634.0509
0.3366	85.7562	68.3526	39.6969	354.9693	578.7227	58.6145	60.2788
0.3635	89.9967	96.6139	110.7577	312.8145	540.9518	432.9734	578.5694
0.3905	23.6886	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table B4 Pressure drop Pin1_2S

Pressure drop Fin0.125_2S							
Streamwise Distance(m)	Pressure(Pa) at Re=20,000	Pressure(Pa) at Re=30,000	Pressure(Pa) at Re=40,000	Pressure(Pa) at Re=50,000	Pressure(Pa) at Re=60,000	Pressure(Pa) at Re=70,000	Pressure(Pa) at Re=80,000
0.0127	23.8886	42.8005	68.1822	116.4571	160.2530	233.9096	302.5894
0.0397	22.3956	39.8144	67.1868	119.4432	169.2112	243.8632	320.0082
0.0667	18.9118	34.8376	59.7216	107.0012	144.3272	214.0024	278.7008
0.0937	17.4188	33.3446	57.7309	111.9780	143.3318	209.0256	266.2588
0.1207	13.9350	19.9072	49.7680	79.6288	99.5360	129.3968	179.1648
0.1476	11.9443	24.3863	44.7912	78.1358	108.4942	164.2344	211.5140
0.1746	10.9490	17.9165	34.8376	52.2564	83.6102	104.5128	168.2158
0.2016	10.4513	19.4095	32.3492	57.7309	85.6010	106.0058	159.2576
0.2286	8.9582	14.4327	27.3724	39.8144	59.7216	79.6288	114.4664
0.2556	9.4559	13.4374	24.8840	49.2703	63.7030	92.0708	124.4200
0.2826	7.4652	11.9443	21.4002	36.3306	49.2703	72.1636	97.0476
0.3096	6.4698	11.4466	18.9118	32.3492	41.8051	59.7216	71.1682
0.3366	4.9768	9.4559	13.4374	19.9072	24.3863	34.8376	44.7912
0.3635	3.9814	8.4606	10.9490	22.3956	28.3678	42.3028	40.8098
0.3905	2.9861	4.9768	8.4606	12.4420	15.9258	21.4002	23.8886

Table B5 Pressure drop Fin0.125_2S

Pressure drop Fin0.125_1S							
Streamwise Distance(m)	Pressure(Pa) at Re=20,000	Pressure(Pa) at Re=30,000	Pressure(Pa) at Re=40,000	Pressure(Pa) at Re=50,000	Pressure(Pa) at Re=60,000	Pressure(Pa) at Re=70,000	Pressure(Pa) at Re=80,000
0.0127	42.8005	75.1497	182.6486	224.4537	399.6370	459.3586	751.7334
0.0397	42.3028	74.1543	180.6578	223.9560	401.6278	492.7032	831.5690
0.0667	40.8098	73.1590	174.1880	207.5326	374.7530	447.9120	768.5956
0.0937	40.3121	72.6613	171.2019	204.0488	373.2600	423.0280	677.4268
0.1207	34.8376	59.2239	149.3040	169.2112	318.5152	348.3760	634.1339
0.1476	34.3399	57.7309	139.3504	163.2390	313.5384	343.3992	608.1090
0.1746	28.3678	47.2796	111.9780	131.8852	258.7936	278.7008	529.4740
0.2016	28.8654	48.2750	109.4896	126.9084	248.8400	266.2588	530.3965
0.2286	19.9072	32.3492	69.6752	89.5824	176.6764	186.6300	425.5594
0.2556	18.9118	33.8422	71.1682	97.0476	163.2390	194.0952	393.8309
0.2826	12.4420	20.9026	56.2378	67.1868	102.0244	130.3922	254.0714
0.3096	9.9536	19.9072	48.7726	57.2332	77.1404	113.4710	244.8110
0.3366	6.4698	14.9304	24.8840	37.3260	54.7448	79.6288	185.0516
0.3635	8.4606	16.4234	31.3538	47.2796	64.6984	84.6056	182.2900
0.3905	7.4652	15.9258	32.3492	48.2750	65.6938	85.6010	191.9447

Table B6 Pressure drop Fin0.125_1S

Pressure drop Fin0.25_2S							
Streamwise Distance(m)	Pressure(Pa) at Re=20,000	Pressure(Pa) at Re=30,000	Pressure(Pa) at Re=40,000	Pressure(Pa) at Re=50,000	Pressure(Pa) at Re=60,000	Pressure(Pa) at Re=70,000	Pressure(Pa) at Re=80,000
0.0127	34.3399	67.1868	107.9966	296.2366	286.0749	412.4035	804.8006
0.0397	35.3353	69.6752	111.9780	271.9898	271.2590	404.1075	840.6290
0.0667	31.3538	59.7216	104.5128	286.2802	274.1401	389.0551	747.4571
0.0937	29.8608	63.7030	102.0244	270.0984	269.8712	399.9033	742.4022
0.1207	27.3724	49.7680	79.6288	200.1184	178.4048	256.9987	555.4173
0.1476	23.8886	47.7773	84.6056	201.2471	185.4483	293.4602	588.0881
0.1746	18.9118	37.3260	64.6984	199.6538	172.3369	249.1336	512.8931
0.2016	18.4142	39.8144	57.2332	184.6251	174.6287	256.3328	475.4038
0.2286	16.9211	32.3492	47.2796	132.3483	112.8977	170.5960	354.4539
0.2556	16.4234	25.8794	44.7912	121.4464	116.1854	180.7462	330.8656
0.2826	10.4513	17.4188	32.3492	129.2261	108.1541	130.9165	239.3072
0.3096	8.4606	14.9304	27.3724	55.7658	46.3134	74.6455	157.8387
0.3366	5.4745	8.9582	19.9072	44.9592	30.3789	37.4285	104.8443
0.3635	4.9768	9.9536	14.9304	56.9187	56.9545	76.1694	129.4028
0.3905	3.9814	5.9722	10.9490	45.0196	32.2275	45.3222	75.3114

Table B7 Pressure drop Fin0.25_2S

APPENDIX C

TABULATED HEAT TRANSFER TEST DATA

Section	X_center (inch)	X/L	X/D_h	Cu Area (m^2, heater)	Area ratio (section/whole)	T (^oC)	ΔT (^oC)	q (W)	T_bulk_int (^oC)	T_bulk_exit_eng (^oC)	T_bulk_eng (^oC)
Inlet						22.3054	-1.4946				
1	0.5000	0.0315	0.2345	0.0054	0.0292	28.9942	5.1942	4.6087	22.3901	22.3982	22.3518
2	1.5625	0.0984	0.7327	0.0123	0.0667	37.4449	13.6449	10.5341	22.5701	22.6105	22.5043
3	2.6250	0.1654	1.2309	0.0123	0.0667	41.5881	17.7881	10.5341	22.7501	22.8227	22.7166
4	3.6875	0.2323	1.7291	0.0123	0.0667	44.4572	20.6572	10.5341	22.9302	23.0349	22.9288
5	4.7500	0.2992	2.2273	0.0123	0.0667	45.8028	22.0028	10.5341	23.1102	23.2471	23.1410
6	5.8125	0.3661	2.7256	0.0123	0.0667	46.9685	23.1685	10.5341	23.2902	23.4593	23.3532
7	6.8750	0.4331	3.2238	0.0123	0.0667	47.7094	23.9094	10.5341	23.4702	23.6716	23.5655
8	7.9375	0.5000	3.7220	0.0123	0.0667	48.6218	24.8218	10.5341	23.6502	23.8838	23.7777
9	9.0000	0.5669	4.2202	0.0123	0.0667	49.2062	25.4062	10.5341	23.8303	24.0960	23.9899
10	10.0625	0.6339	4.7184	0.0123	0.0667	49.7275	25.9275	10.5341	24.0103	24.3082	24.2021
11	11.1250	0.7008	5.2167	0.0123	0.0667	49.9797	26.1797	10.5341	24.1903	24.5205	24.4143
12	12.1875	0.7677	5.7149	0.0123	0.0667	50.2090	26.4090	10.5341	24.3703	24.7327	24.6266
13	13.2500	0.8346	6.2131	0.0123	0.0667	49.8313	26.0313	10.5341	24.5503	24.9449	24.8388
14	14.3125	0.9016	6.7113	0.0123	0.0667	47.9686	24.1686	10.5341	24.7304	25.1571	25.0510
15	15.3750	0.9685	7.2095	0.0054	0.0292	40.5067	16.7067	4.6087	24.9104	25.2500	25.2036
Exit						24.9951	1.1951				

Table C1a Smooth channel Re20k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m^2)	K_f (W/m/K)	HTC ($W/m^2/K$)	Nu	Nu/Nu0
Inlet										
1	0.0612	0.0461	-0.1783	4.5474	0.0133	841.7418	0.0258	127.4571	267.1565	4.9329
2	0.6230	0.0663	-0.2817	9.9111	0.0591	802.6229	0.0259	53.9587	113.0394	2.0872
3	0.7013	0.0543	-0.2649	9.8328	0.0666	796.2853	0.0259	42.2703	88.5056	1.6342
4	0.7254	0.0486	-0.2784	9.8088	0.0689	794.3370	0.0259	36.8995	77.2187	1.4258
5	0.7391	0.0473	-0.3022	9.7950	0.0702	793.2221	0.0259	34.9550	73.1104	1.3500
6	0.7631	0.0468	-0.3218	9.7710	0.0724	791.2774	0.0259	33.4178	69.8578	1.2899
7	0.7964	0.0472	-0.3323	9.7377	0.0756	788.5815	0.0259	32.5333	67.9724	1.2551
8	0.8377	0.0476	-0.3449	9.6965	0.0795	785.2418	0.0259	31.4454	65.6644	1.2125
9	0.8835	0.0482	-0.3405	9.6506	0.0839	781.5325	0.0260	30.7981	64.2783	1.1869
10	0.9271	0.0487	-0.3346	9.6070	0.0880	778.0008	0.0260	30.2522	63.1051	1.1652
11	0.9889	0.0499	-0.3177	9.5452	0.0939	772.9903	0.0260	29.9731	62.4897	1.1538
12	1.0825	0.0522	-0.2957	9.4516	0.1028	765.4106	0.0260	29.6226	61.7260	1.1397
13	1.2195	0.0581	-0.2930	9.3146	0.1158	754.3223	0.0260	29.8376	62.1408	1.1474
14	1.4160	0.0714	-0.3099	9.1181	0.1344	738.4036	0.0260	31.7753	66.1412	1.2213
15	0.6399	0.0492	-0.1826	3.9688	0.1389	734.6261	0.0260	47.1025	97.9929	1.8094
Exit								0.0000		0.0000

Table C1b Smooth channel Re20k part2

Section	X_center (inch)	X/L	X/D_h	Cu Area (m^2, heater)	Area ratio (section/whole)	T (^oC)	ΔT (^oC)	q (W)	T_bulk_int (^oC)	T_bulk_exit_eng (^oC)	T_bulk_eng (^oC)
Inlet						22.4671	-1.5329				
1	0.5000	0.0315	0.2345	0.0054	0.0292	28.6460	4.6460	6.0562	22.5394	22.5488	22.5079
2	1.5625	0.0984	0.7327	0.0123	0.0667	37.8195	13.8195	13.8428	22.6932	22.7354	22.6421
3	2.6250	0.1654	1.2309	0.0123	0.0667	41.9961	17.9961	13.8428	22.8469	22.9221	22.8288
4	3.6875	0.2323	1.7291	0.0123	0.0667	44.5558	20.5558	13.8428	23.0006	23.1088	23.0154
5	4.7500	0.2992	2.2273	0.0123	0.0667	45.6374	21.6374	13.8428	23.1544	23.2954	23.2021
6	5.8125	0.3661	2.7256	0.0123	0.0667	46.7303	22.7303	13.8428	23.3081	23.4821	23.3888
7	6.8750	0.4331	3.2238	0.0123	0.0667	47.3723	23.3723	13.8428	23.4618	23.6687	23.5754
8	7.9375	0.5000	3.7220	0.0123	0.0667	48.2303	24.2303	13.8428	23.6156	23.8554	23.7621
9	9.0000	0.5669	4.2202	0.0123	0.0667	48.6926	24.6926	13.8428	23.7693	24.0421	23.9487
10	10.0625	0.6339	4.7184	0.0123	0.0667	49.2600	25.2600	13.8428	23.9230	24.2287	24.1354
11	11.1250	0.7008	5.2167	0.0123	0.0667	49.4485	25.4485	13.8428	24.0767	24.4154	24.3221
12	12.1875	0.7677	5.7149	0.0123	0.0667	49.8468	25.8468	13.8428	24.2305	24.6021	24.5087
13	13.2500	0.8346	6.2131	0.0123	0.0667	49.6487	25.6487	13.8428	24.3842	24.7887	24.6954
14	14.3125	0.9016	6.7113	0.0123	0.0667	48.0571	24.0571	13.8428	24.5379	24.9754	24.8821
15	15.3750	0.9685	7.2095	0.0054	0.0292	40.1844	16.1844	6.0562	24.6917	25.0571	25.0162
Exit						24.7640	0.7640				

Table C2a Smooth Re30k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m^2)	K_f (W/m/K)	HTC ($W/m^2/K$)	Nu	Nu/Nu0
Inlet										
1	0.0360	0.0461	-0.1783	6.0202	0.0059	1114.3636	0.0259	182.4867	382.3308	5.1199
2	0.6346	0.0663	-0.2817	13.2081	0.0458	1069.6273	0.0259	70.7128	148.0836	1.9830
3	0.7126	0.0543	-0.2649	13.1302	0.0515	1063.3127	0.0259	55.5279	116.2309	1.5565
4	0.7204	0.0486	-0.2784	13.1223	0.0520	1062.6783	0.0259	49.3004	103.1481	1.3813
5	0.7218	0.0473	-0.3022	13.1209	0.0521	1062.5648	0.0259	47.2607	98.8354	1.3235
6	0.7426	0.0468	-0.3218	13.1001	0.0536	1060.8814	0.0259	45.2938	94.6787	1.2679
7	0.7711	0.0472	-0.3323	13.0717	0.0557	1058.5774	0.0259	44.2726	92.5018	1.2387
8	0.8095	0.0476	-0.3449	13.0333	0.0585	1055.4662	0.0259	42.8794	89.5500	1.1992
9	0.8491	0.0482	-0.3405	12.9937	0.0613	1052.2589	0.0259	42.2198	88.1322	1.1802
10	0.8946	0.0487	-0.3346	12.9482	0.0646	1048.5736	0.0260	41.3852	86.3506	1.1563
11	0.9525	0.0499	-0.3177	12.8903	0.0688	1043.8879	0.0260	41.1437	85.8075	1.1491
12	1.0532	0.0522	-0.2957	12.7896	0.0761	1035.7291	0.0260	40.4324	84.2857	1.1287
13	1.1972	0.0581	-0.2930	12.6455	0.0865	1024.0647	0.0260	40.5338	84.4586	1.1310
14	1.4081	0.0714	-0.3099	12.4347	0.1017	1006.9906	0.0260	42.8157	89.1727	1.1941
15	0.6142	0.0492	-0.1826	5.4420	0.1014	1007.3282	0.0260	65.0194	135.3551	1.8126
Exit								0.0000		0.0000

Table C2b Smooth Re30k part2

Section	X_center (inch)	X/L	X/D_h	Cu Area (m^2, heater)	Area ratio (section/whole)	T (^oC)	ΔT (^oC)	q (W)	T_bulk_int (^oC)	T_bulk_exit_eng (^oC)	T_bulk_eng (^oC)
Inlet						24.9943	3.1943				
1	0.5000	0.0315	0.2345	0.0054	0.0292	31.1361	9.3361	8.1871	25.0608	25.0720	25.0331
2	1.5625	0.0984	0.7327	0.0123	0.0667	40.5521	18.7521	18.7133	25.2020	25.2495	25.1607
3	2.6250	0.1654	1.2309	0.0123	0.0667	44.3582	22.5582	18.7133	25.3433	25.4270	25.3382
4	3.6875	0.2323	1.7291	0.0123	0.0667	46.8848	25.0848	18.7133	25.4845	25.6045	25.5157
5	4.7500	0.2992	2.2273	0.0123	0.0667	47.4674	25.6674	18.7133	25.6258	25.7820	25.6932
6	5.8125	0.3661	2.7256	0.0123	0.0667	48.7193	26.9193	18.7133	25.7671	25.9595	25.8707
7	6.8750	0.4331	3.2238	0.0123	0.0667	49.1634	27.3634	18.7133	25.9083	26.1370	26.0482
8	7.9375	0.5000	3.7220	0.0123	0.0667	49.9796	28.1796	18.7133	26.0496	26.3145	26.2257
9	9.0000	0.5669	4.2202	0.0123	0.0667	50.1883	28.3883	18.7133	26.1908	26.4920	26.4032
10	10.0625	0.6339	4.7184	0.0123	0.0667	50.7636	28.9636	18.7133	26.3321	26.6695	26.5807
11	11.1250	0.7008	5.2167	0.0123	0.0667	50.6870	28.8870	18.7133	26.4734	26.8470	26.7582
12	12.1875	0.7677	5.7149	0.0123	0.0667	50.9626	29.1626	18.7133	26.6146	27.0245	26.9358
13	13.2500	0.8346	6.2131	0.0123	0.0667	50.8399	29.0399	18.7133	26.7559	27.2020	27.1133
14	14.3125	0.9016	6.7113	0.0123	0.0667	49.6120	27.8120	18.7133	26.8971	27.3795	27.2908
15	15.3750	0.9685	7.2095	0.0054	0.0292	41.2477	19.4477	8.1871	27.0384	27.4572	27.4183
Exit						27.1049	5.3049				

Table C3a Smooth Re40k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m^2)	K_f (W/m/K)	HTC ($W/m^2/K$)	Nu	Nu/Nu0
Inlet										
1	0.2522	0.0461	-0.1783	7.9348	0.0308	1468.7612	0.0260	241.7588	502.7364	5.1071
2	0.9617	0.0663	-0.2817	17.7517	0.0514	1437.5717	0.0261	93.6526	194.6690	1.9776
3	0.9604	0.0543	-0.2649	17.7529	0.0513	1437.6758	0.0261	75.6077	157.0947	1.5959
4	0.9405	0.0486	-0.2784	17.7729	0.0503	1439.2885	0.0261	67.2557	139.6831	1.4190
5	0.9125	0.0473	-0.3022	17.8008	0.0488	1441.5512	0.0261	66.0002	137.0185	1.3919
6	0.9388	0.0468	-0.3218	17.7746	0.0502	1439.4269	0.0261	62.7141	130.1423	1.3221
7	0.9595	0.0472	-0.3323	17.7539	0.0513	1437.7504	0.0261	61.8253	128.2446	1.3028
8	0.9976	0.0476	-0.3449	17.7157	0.0533	1434.6601	0.0261	59.9522	124.3075	1.2628
9	1.0271	0.0482	-0.3405	17.6862	0.0549	1432.2718	0.0261	59.6844	123.7007	1.2566
10	1.0748	0.0487	-0.3346	17.6385	0.0574	1428.4101	0.0261	58.4659	121.1250	1.2305
11	1.1241	0.0499	-0.3177	17.5893	0.0601	1424.4217	0.0262	58.8273	121.8231	1.2375
12	1.2263	0.0522	-0.2957	17.4871	0.0655	1416.1466	0.0262	58.1628	120.3970	1.2231
13	1.3943	0.0581	-0.2930	17.3191	0.0745	1402.5397	0.0262	58.2352	120.4970	1.2241
14	1.6762	0.0714	-0.3099	17.0371	0.0896	1379.7068	0.0262	60.7402	125.6280	1.2762
15	0.7749	0.0492	-0.1826	7.4122	0.0946	1372.0220	0.0262	96.5580	199.6269	2.0279
Exit								0.0000		0.0000

Table C3b Smooth Re40k part2

Section	X_center (inch)	X/L	X/D_h	Cu Area (m^2, heater)	Area ratio (section/whole)	T (^oC)	ΔT (^oC)	q (W)	T_bulk_int (^oC)	T_bulk_exit_eng (^oC)	T_bulk_eng (^oC)
Inlet						25.0233	3.4233				
1	0.5000	0.0315	0.2345	0.0054	0.0292	31.4067	9.8067	10.0153	25.0891	25.1013	25.0623
2	1.5625	0.0984	0.7327	0.0123	0.0667	41.6542	20.0542	22.8922	25.2288	25.2795	25.1904
3	2.6250	0.1654	1.2309	0.0123	0.0667	45.6319	24.0319	22.8922	25.3686	25.4578	25.3686
4	3.6875	0.2323	1.7291	0.0123	0.0667	48.1333	26.5333	22.8922	25.5083	25.6360	25.5469
5	4.7500	0.2992	2.2273	0.0123	0.0667	48.5271	26.9271	22.8922	25.6481	25.8142	25.7251
6	5.8125	0.3661	2.7256	0.0123	0.0667	49.8204	28.2204	22.8922	25.7878	25.9925	25.9033
7	6.8750	0.4331	3.2238	0.0123	0.0667	50.2655	28.6655	22.8922	25.9275	26.1707	26.0816
8	7.9375	0.5000	3.7220	0.0123	0.0667	51.0797	29.4797	22.8922	26.0673	26.3489	26.2598
9	9.0000	0.5669	4.2202	0.0123	0.0667	51.2157	29.6157	22.8922	26.2070	26.5272	26.4380
10	10.0625	0.6339	4.7184	0.0123	0.0667	51.8563	30.2563	22.8922	26.3468	26.7054	26.6163
11	11.1250	0.7008	5.2167	0.0123	0.0667	51.6716	30.0716	22.8922	26.4865	26.8836	26.7945
12	12.1875	0.7677	5.7149	0.0123	0.0667	52.0946	30.4946	22.8922	26.6263	27.0619	26.9727
13	13.2500	0.8346	6.2131	0.0123	0.0667	52.0110	30.4110	22.8922	26.7660	27.2401	27.1510
14	14.3125	0.9016	6.7113	0.0123	0.0667	50.9090	29.3090	22.8922	26.9058	27.4183	27.3292
15	15.3750	0.9685	7.2095	0.0054	0.0292	41.8065	20.2065	10.0153	27.0455	27.4963	27.4573
Exit						27.1113	5.5113				

Table C4a Smooth Re50k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m^2)	K_f (W/m/K)	HTC ($W/m^2/K$)	Nu	Nu/Nu0
Inlet										
1	0.2739	0.0461	-0.1783	9.7414	0.0274	1803.1573	0.0261	285.4146	593.4686	5.1480
2	1.0480	0.0663	-0.2817	21.8442	0.0458	1768.9933	0.0261	107.6990	223.8486	1.9418
3	1.0405	0.0543	-0.2649	21.8517	0.0455	1769.6068	0.0261	87.3303	181.4380	1.5739
4	1.0109	0.0486	-0.2784	21.8813	0.0442	1772.0022	0.0261	78.3205	162.6522	1.4109
5	0.9722	0.0473	-0.3022	21.9200	0.0425	1775.1370	0.0261	77.5878	161.0642	1.3971
6	0.9997	0.0468	-0.3218	21.8925	0.0437	1772.9062	0.0261	73.7709	153.0775	1.3279
7	1.0210	0.0472	-0.3323	21.8712	0.0446	1771.1856	0.0261	72.7745	150.9479	1.3094
8	1.0596	0.0476	-0.3449	21.8326	0.0463	1768.0576	0.0261	70.6871	146.5580	1.2713
9	1.0863	0.0482	-0.3405	21.8059	0.0475	1765.8966	0.0261	70.6115	146.3411	1.2694
10	1.1377	0.0487	-0.3346	21.7545	0.0497	1761.7296	0.0261	69.0617	143.0704	1.2411
11	1.1832	0.0499	-0.3177	21.7090	0.0517	1758.0475	0.0262	69.8053	144.5514	1.2539
12	1.2958	0.0522	-0.2957	21.5964	0.0566	1748.9308	0.0262	68.6709	142.1440	1.2330
13	1.4739	0.0581	-0.2930	21.4183	0.0644	1734.5023	0.0262	68.7069	142.1603	1.2332
14	1.7831	0.0714	-0.3099	21.1091	0.0779	1709.4631	0.0262	71.2179	147.2954	1.2777
15	0.8122	0.0492	-0.1826	9.2031	0.0811	1703.5204	0.0262	115.4066	238.5901	2.0696
Exit								0.0000		0.0000

Table C4b Smooth Re50k part2

Section	X_center (inch)	X/L	X/D_h	Cu Area (m^2, heater)	Area ratio (section/whole)	T (^oC)	ΔT (^oC)	q (W)	T_bulk_int (^oC)	T_bulk_exit_eng (^oC)	T_bulk_eng (^oC)
Inlet						25.0976	3.2976				
1	0.5000	0.0315	0.2345	0.0054	0.0292	31.2308	9.4308	10.7360	25.1590	25.1705	25.1341
2	1.5625	0.0984	0.7327	0.0123	0.0667	41.2119	19.4119	24.5394	25.2893	25.3371	25.2538
3	2.6250	0.1654	1.2309	0.0123	0.0667	45.0526	23.2526	24.5394	25.4197	25.5036	25.4203
4	3.6875	0.2323	1.7291	0.0123	0.0667	47.5633	25.7633	24.5394	25.5500	25.6702	25.5869
5	4.7500	0.2992	2.2273	0.0123	0.0667	47.9715	26.1715	24.5394	25.6804	25.8367	25.7535
6	5.8125	0.3661	2.7256	0.0123	0.0667	49.3444	27.5444	24.5394	25.8107	26.0033	25.9200
7	6.8750	0.4331	3.2238	0.0123	0.0667	49.8161	28.0161	24.5394	25.9411	26.1699	26.0866
8	7.9375	0.5000	3.7220	0.0123	0.0667	50.6224	28.8224	24.5394	26.0714	26.3364	26.2531
9	9.0000	0.5669	4.2202	0.0123	0.0667	50.7380	28.9380	24.5394	26.2018	26.5030	26.4197
10	10.0625	0.6339	4.7184	0.0123	0.0667	51.4288	29.6288	24.5394	26.3321	26.6695	26.5863
11	11.1250	0.7008	5.2167	0.0123	0.0667	51.1695	29.3695	24.5394	26.4624	26.8361	26.7528
12	12.1875	0.7677	5.7149	0.0123	0.0667	51.6040	29.8040	24.5394	26.5928	27.0026	26.9194
13	13.2500	0.8346	6.2131	0.0123	0.0667	51.4935	29.6935	24.5394	26.7231	27.1692	27.0859
14	14.3125	0.9016	6.7113	0.0123	0.0667	50.4450	28.6450	24.5394	26.8535	27.3358	27.2525
15	15.3750	0.9685	7.2095	0.0054	0.0292	41.4728	19.6728	10.7360	26.9838	27.4086	27.3722
Exit						27.0452	5.2452				

Table C5a Smooth Re60k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m^2)	K_f (W/m/K)	HTC ($W/m^2/K$)	Nu	Nu/Nu0
Inlet										
1	0.2566	0.0461	-0.1783	10.4794	0.0239	1939.7627	0.0261	319.4680	664.1395	5.1621
2	1.0054	0.0663	-0.2817	23.5340	0.0410	1905.8389	0.0261	119.6943	248.7358	1.9333
3	0.9981	0.0543	-0.2649	23.5413	0.0407	1906.4317	0.0261	97.1038	201.7132	1.5678
4	0.9735	0.0486	-0.2784	23.5660	0.0397	1908.4288	0.0261	86.6944	180.0206	1.3992
5	0.9364	0.0473	-0.3022	23.6030	0.0382	1911.4297	0.0261	85.7485	177.9880	1.3834
6	0.9681	0.0468	-0.3218	23.5714	0.0394	1908.8664	0.0261	81.1120	168.2993	1.3081
7	0.9903	0.0472	-0.3323	23.5491	0.0404	1907.0653	0.0261	79.8770	165.6734	1.2877
8	1.0283	0.0476	-0.3449	23.5112	0.0419	1903.9905	0.0261	77.5526	160.7904	1.2498
9	1.0536	0.0482	-0.3405	23.4858	0.0429	1901.9374	0.0261	77.5156	160.6521	1.2487
10	1.1072	0.0487	-0.3346	23.4322	0.0451	1897.5990	0.0261	75.6115	156.6459	1.2175
11	1.1482	0.0499	-0.3177	23.3913	0.0468	1894.2816	0.0262	76.6695	158.7770	1.2341
12	1.2597	0.0522	-0.2957	23.2797	0.0513	1885.2463	0.0262	75.3762	156.0388	1.2128
13	1.4322	0.0581	-0.2930	23.1072	0.0584	1871.2750	0.0262	75.5451	156.3286	1.2151
14	1.7357	0.0714	-0.3099	22.8037	0.0707	1846.6999	0.0262	78.2781	161.9224	1.2586
15	0.7859	0.0492	-0.1826	9.9501	0.0732	1841.7811	0.0262	127.1162	262.8459	2.0430
Exit								0.0000		0.0000

Table C5b Smooth Re60k part2

Section	X_center (inch)	X/L	X/D_h	Cu Area (m^2, heater)	Area ratio (section/whole)	T (^oC)	ΔT (^oC)	q (W)	T_bulk_int (^oC)	T_bulk_exit_eng(^oC)	T_bulk_eng(^oC)
Inlet						25.5308	3.5308				
1	0.5000	0.0315	0.2345	0.0054	0.0292	31.3135	9.3135	11.4756	25.5858	25.5972	25.5640
2	1.5625	0.0984	0.7327	0.0123	0.0667	40.9437	18.9437	26.2299	25.7025	25.7491	25.6732
3	2.6250	0.1654	1.2309	0.0123	0.0667	44.6852	22.6852	26.2299	25.8193	25.9009	25.8250
4	3.6875	0.2323	1.7291	0.0123	0.0667	46.8636	24.8636	26.2299	25.9360	26.0527	25.9768
5	4.7500	0.2992	2.2273	0.0123	0.0667	47.2136	25.2136	26.2299	26.0528	26.2046	26.1286
6	5.8125	0.3661	2.7256	0.0123	0.0667	48.6463	26.6463	26.2299	26.1696	26.3564	26.2805
7	6.8750	0.4331	3.2238	0.0123	0.0667	49.1080	27.1080	26.2299	26.2863	26.5082	26.4323
8	7.9375	0.5000	3.7220	0.0123	0.0667	49.9538	27.9538	26.2299	26.4031	26.6600	26.5841
9	9.0000	0.5669	4.2202	0.0123	0.0667	49.9850	27.9850	26.2299	26.5198	26.8119	26.7360
10	10.0625	0.6339	4.7184	0.0123	0.0667	50.7896	28.7896	26.2299	26.6366	26.9637	26.8878
11	11.1250	0.7008	5.2167	0.0123	0.0667	50.4164	28.4164	26.2299	26.7534	27.1155	27.0396
12	12.1875	0.7677	5.7149	0.0123	0.0667	50.9156	28.9156	26.2299	26.8701	27.2674	27.1914
13	13.2500	0.8346	6.2131	0.0123	0.0667	50.8412	28.8412	26.2299	26.9869	27.4192	27.3433
14	14.3125	0.9016	6.7113	0.0123	0.0667	49.9670	27.9670	26.2299	27.1036	27.5710	27.4951
15	15.3750	0.9685	7.2095	0.0054	0.0292	41.0874	19.0874	11.4756	27.2204	27.6374	27.6042
Exit						27.2753	5.2753				

Table C6a Smooth Re70k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m^2)	K_f (W/m/K)	HTC ($W/m^2/K$)	Nu	Nu/Nu0
Inlet										
1	0.2512	0.0461	-0.1783	11.2244	0.0219	2077.6593	0.0261	362.7334	753.1349	5.1573
2	0.9744	0.0663	-0.2817	25.2555	0.0371	2045.2482	0.0261	134.1919	278.5236	1.9073
3	0.9673	0.0543	-0.2649	25.2626	0.0369	2045.8230	0.0261	108.4401	224.9967	1.5407
4	0.9297	0.0486	-0.2784	25.3001	0.0354	2048.8645	0.0261	97.9025	203.0631	1.3905
5	0.8911	0.0473	-0.3022	25.3388	0.0340	2051.9961	0.0261	96.9714	201.0628	1.3768
6	0.9260	0.0468	-0.3218	25.3039	0.0353	2049.1681	0.0261	91.1686	188.9661	1.2940
7	0.9474	0.0472	-0.3323	25.2824	0.0361	2047.4326	0.0261	89.7145	185.8884	1.2729
8	0.9869	0.0476	-0.3449	25.2430	0.0376	2044.2370	0.0262	86.8013	179.7905	1.2312
9	1.0077	0.0482	-0.3405	25.2222	0.0384	2042.5510	0.0262	87.0462	180.2360	1.2342
10	1.0664	0.0487	-0.3346	25.1635	0.0407	2037.8014	0.0262	84.3704	174.6356	1.1959
11	1.1006	0.0499	-0.3177	25.1293	0.0420	2035.0296	0.0262	86.0004	177.9485	1.2186
12	1.2134	0.0522	-0.2957	25.0165	0.0463	2025.8962	0.0262	84.2526	174.2722	1.1934
13	1.3827	0.0581	-0.2930	24.8471	0.0527	2012.1803	0.0262	84.3527	174.4196	1.1944
14	1.6873	0.0714	-0.3099	24.5426	0.0643	1987.5164	0.0262	86.9302	179.6877	1.2305
15	0.7571	0.0492	-0.1826	10.7184	0.0660	1984.0109	0.0262	143.0741	295.6380	2.0245
Exit								0.0000		0.0000

Table C6b Smooth Re70k part2

Section	X_center (inch)	X/L	X/D_h	Cu Area (m^2, heater)	Area ratio (section/whole)	T (^oC)	ΔT (^oC)	q (W)	T_bulk_int (^oC)	T_bulk_exit_eng (^oC)	T_bulk_eng (^oC)
Inlet						25.4809	3.4809				
1	0.5000	0.0315	0.2345	0.0054	0.0292	31.3044	9.3044	13.4453	25.5327	25.5475	25.5142
2	1.5625	0.0984	0.7327	0.0123	0.0667	41.3111	19.3111	30.7322	25.6429	25.6998	25.6237
3	2.6250	0.1654	1.2309	0.0123	0.0667	45.0293	23.0293	30.7322	25.7530	25.8521	25.7760
4	3.6875	0.2323	1.7291	0.0123	0.0667	47.2362	25.2362	30.7322	25.8632	26.0044	25.9282
5	4.7500	0.2992	2.2273	0.0123	0.0667	47.4772	25.4772	30.7322	25.9733	26.1567	26.0805
6	5.8125	0.3661	2.7256	0.0123	0.0667	48.9749	26.9749	30.7322	26.0835	26.3090	26.2328
7	6.8750	0.4331	3.2238	0.0123	0.0667	49.4239	27.4239	30.7322	26.1936	26.4612	26.3851
8	7.9375	0.5000	3.7220	0.0123	0.0667	50.2455	28.2455	30.7322	26.3038	26.6135	26.5374
9	9.0000	0.5669	4.2202	0.0123	0.0667	50.1994	28.1994	30.7322	26.4139	26.7658	26.6897
10	10.0625	0.6339	4.7184	0.0123	0.0667	51.0503	29.0503	30.7322	26.5241	26.9181	26.8420
11	11.1250	0.7008	5.2167	0.0123	0.0667	50.5930	28.5930	30.7322	26.6342	27.0704	26.9943
12	12.1875	0.7677	5.7149	0.0123	0.0667	51.1757	29.1757	30.7322	26.7443	27.2227	27.1465
13	13.2500	0.8346	6.2131	0.0123	0.0667	51.0812	29.0812	30.7322	26.8545	27.3750	27.2988
14	14.3125	0.9016	6.7113	0.0123	0.0667	50.3096	28.3096	30.7322	26.9646	27.5273	27.4511
15	15.3750	0.9685	7.2095	0.0054	0.0292	41.0137	19.0137	13.4453	27.0748	27.5939	27.5606
Exit						27.1266	5.1266				

Table C7a Smooth Re80k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m^2)	K_f (W/m/K)	HTC ($W/m^2/K$)	Nu	Nu/Nu0
Inlet										
1	0.2508	0.0461	-0.1783	13.1945	0.0187	2442.3441	0.0261	423.1635	878.7418	5.3129
2	0.9988	0.0663	-0.2817	29.7334	0.0325	2407.8818	0.0261	153.6790	319.0265	1.9289
3	0.9860	0.0543	-0.2649	29.7462	0.0321	2408.9157	0.0261	124.9677	259.3396	1.5680
4	0.9478	0.0486	-0.2784	29.7843	0.0308	2412.0050	0.0261	112.8529	234.1225	1.4155
5	0.9035	0.0473	-0.3022	29.8286	0.0294	2415.5924	0.0261	112.3329	232.9681	1.4085
6	0.9414	0.0468	-0.3218	29.7908	0.0306	2412.5282	0.0261	105.3900	218.4983	1.3211
7	0.9623	0.0472	-0.3323	29.7698	0.0313	2410.8311	0.0261	103.7797	215.0900	1.3004
8	1.0008	0.0476	-0.3449	29.7314	0.0326	2407.7183	0.0261	100.5659	208.3617	1.2598
9	1.0180	0.0482	-0.3405	29.7141	0.0331	2406.3209	0.0262	101.1677	209.5408	1.2669
10	1.0790	0.0487	-0.3346	29.6531	0.0351	2401.3808	0.0262	97.9109	202.7296	1.2257
11	1.1094	0.0499	-0.3177	29.6228	0.0361	2398.9219	0.0262	100.1268	207.2507	1.2531
12	1.2269	0.0522	-0.2957	29.5052	0.0399	2389.4033	0.0262	97.8005	202.3702	1.2235
13	1.3967	0.0581	-0.2930	29.3355	0.0454	2375.6575	0.0262	98.0593	202.8401	1.2264
14	1.7118	0.0714	-0.3099	29.0204	0.0557	2350.1414	0.0262	100.6701	208.1734	1.2586
15	0.7535	0.0492	-0.1826	12.6918	0.0560	2349.2889	0.0262	168.5415	348.4107	2.1065
Exit								0.0000		0.0000

Table C7b Smooth Re80k part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.7847	0.7847				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0027	0.0075	0.0300	31.8613	9.8613	13.3174	23.0269	23.0508	22.9177
2	1.5625	0.0984	0.7327	0.0123	0.0010	0.0049	0.0162	0.0646	42.2561	20.2561	28.7321	23.5415	23.6250	23.3379
3	2.6250	0.1654	1.2309	0.0123	0.0013	0.0061	0.0172	0.0685	42.6262	20.6262	30.4397	24.0562	24.2333	23.9292
4	3.6875	0.2323	1.7291	0.0123	0.0010	0.0049	0.0162	0.0646	43.6931	21.6931	28.7321	24.5708	24.8075	24.5204
5	4.7500	0.2992	2.2273	0.0123	0.0013	0.0061	0.0172	0.0685	43.3497	21.3497	30.4397	25.0855	25.4158	25.1117
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0049	0.0162	0.0646	44.6773	22.6773	28.7321	25.6001	25.9900	25.7029
7	6.8750	0.4331	3.2238	0.0123	0.0013	0.0061	0.0172	0.0685	44.5566	22.5566	30.4397	26.1148	26.5984	26.2942
8	7.9375	0.5000	3.7220	0.0123	0.0010	0.0049	0.0162	0.0646	46.1699	24.1699	28.7321	26.6294	27.1726	26.8855
9	9.0000	0.5669	4.2202	0.0123	0.0013	0.0061	0.0172	0.0685	46.2234	24.2234	30.4397	27.1441	27.7809	27.4767
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0049	0.0162	0.0646	47.7819	25.7819	28.7321	27.6587	28.3551	28.0680
11	11.1250	0.7008	5.2167	0.0123	0.0013	0.0061	0.0172	0.0685	47.2320	25.2320	30.4397	28.1734	28.9634	28.6592
12	12.1875	0.7677	5.7149	0.0123	0.0010	0.0049	0.0162	0.0646	48.5710	26.5710	28.7321	28.6880	29.5376	29.2505
13	13.2500	0.8346	6.2131	0.0123	0.0013	0.0061	0.0172	0.0685	48.4438	26.4438	30.4397	29.2027	30.1459	29.8417
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0049	0.0162	0.0646	48.2320	26.2320	28.7321	29.7173	30.7201	30.4330
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0027	0.0075	0.0300	39.0751	17.0751	13.3174	30.2320	30.9862	30.8532
Exit									30.4742	8.4742				

Table C8a Pin0.5_2S Re20k part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channe)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.4112	0.0497	-0.0792	12.9062	0.0309	1718.8930	2388.9634	0.0259	194.5664	270.4136	407.0475	565.7255	7.5147	10.4441
2	1.3144	0.0747	-0.1995	27.4177	0.0457	1692.5178	2220.3487	0.0259	90.4383	118.6425	188.9143	247.8294	3.4876	4.5753
3	1.0467	0.0610	-0.2114	29.3930	0.0344	1712.6727	2380.3182	0.0260	92.2278	128.1807	192.3583	267.3447	3.5512	4.9356
4	0.9402	0.0537	-0.2246	27.7919	0.0327	1715.6183	2250.6533	0.0260	89.7183	117.6980	186.8392	245.1071	3.4493	4.5250
5	0.8540	0.0504	-0.2225	29.5857	0.0281	1723.9009	2395.9234	0.0261	94.3865	131.1809	196.2620	272.7702	3.6233	5.0357
6	0.8798	0.0486	-0.2218	27.8524	0.0306	1719.3514	2255.5506	0.0261	90.1263	118.2332	187.1191	245.4744	3.4545	4.5318
7	0.8678	0.0478	-0.2099	29.5719	0.0285	1723.0947	2394.8029	0.0261	93.4338	129.8568	193.6925	269.1990	3.5759	4.9698
8	0.9413	0.0477	-0.2121	27.7908	0.0328	1715.5495	2250.5631	0.0262	87.7947	115.1745	181.7274	238.4011	3.3550	4.4012
9	0.9590	0.0482	-0.2084	29.4807	0.0315	1717.7813	2387.4182	0.0262	90.0338	125.1314	186.0809	258.6203	3.4353	4.7745
10	1.0509	0.0493	-0.2192	27.6812	0.0366	1708.7848	2241.6887	0.0262	84.9163	111.3984	175.2399	229.8905	3.2352	4.2441
11	1.0777	0.0514	-0.2203	29.3620	0.0354	1710.8634	2377.8036	0.0263	89.7686	124.7628	184.9752	257.0835	3.4149	4.7461
12	1.2430	0.0549	-0.2164	27.4891	0.0433	1696.9288	2226.1353	0.0263	85.3460	111.9621	175.5984	230.3607	3.2418	4.2528
13	1.4112	0.0615	-0.2139	29.0285	0.0464	1691.4347	2350.8010	0.0264	87.9073	122.1759	180.5976	250.9994	3.3341	4.6338
14	1.7571	0.0744	-0.1955	26.9751	0.0612	1665.1952	2184.5052	0.0264	89.9391	117.9876	184.4957	242.0328	3.4061	4.4683
15	0.8583	0.0598	-0.1636	12.4591	0.0644	1659.3511	2306.2104	0.0264	187.6438	260.7924	384.3478	534.1768	7.0956	9.8617
Exit														

Table C8b Pin0.5_2S Re20k part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.8570	1.6570				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0027	0.0075	0.0300	31.7545	10.5545	17.9071	23.0783	23.0959	22.9764
2	1.5625	0.0984	0.7327	0.0123	0.0010	0.0049	0.0162	0.0646	43.1251	21.9251	38.6344	23.5488	23.6114	23.3537
3	2.6250	0.1654	1.2309	0.0123	0.0013	0.0061	0.0172	0.0685	43.3641	22.1641	40.9305	24.0192	24.1576	23.8845
4	3.6875	0.2323	1.7291	0.0123	0.0010	0.0049	0.0162	0.0646	44.4678	23.2678	38.6344	24.4896	24.6731	24.4153
5	4.7500	0.2992	2.2273	0.0123	0.0013	0.0061	0.0172	0.0685	44.0508	22.8508	40.9305	24.9601	25.2193	24.9462
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0049	0.0162	0.0646	45.3871	24.1871	38.6344	25.4305	25.7348	25.4770
7	6.8750	0.4331	3.2238	0.0123	0.0013	0.0061	0.0172	0.0685	45.1851	23.9851	40.9305	25.9009	26.2809	26.0079
8	7.9375	0.5000	3.7220	0.0123	0.0010	0.0049	0.0162	0.0646	46.8123	25.6123	38.6344	26.3714	26.7964	26.5387
9	9.0000	0.5669	4.2202	0.0123	0.0013	0.0061	0.0172	0.0685	46.6747	25.4747	40.9305	26.8418	27.3426	27.0695
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0049	0.0162	0.0646	48.4089	27.2089	38.6344	27.3122	27.8581	27.6004
11	11.1250	0.7008	5.2167	0.0123	0.0013	0.0061	0.0172	0.0685	47.5206	26.3206	40.9305	27.7826	28.4043	28.1312
12	12.1875	0.7677	5.7149	0.0123	0.0010	0.0049	0.0162	0.0646	49.0879	27.8879	38.6344	28.2531	28.9198	28.6620
13	13.2500	0.8346	6.2131	0.0123	0.0013	0.0061	0.0172	0.0685	48.8144	27.6144	40.9305	28.7235	29.4660	29.1929
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0049	0.0162	0.0646	48.8572	27.6572	38.6344	29.1939	29.9815	29.7237
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0027	0.0075	0.0300	38.6615	17.4615	17.9071	29.6644	30.2204	30.1009
Exit									29.8858	8.6858				

Table C9a Pin0.5_2S Re30k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.4598	0.0485	-0.0523	17.4473	0.0257	2323.6981	3229.5376	0.0259	267.8262	372.2320	560.2266	778.6179	7.4827	10.3996
2	1.5847	0.0770	-0.1035	37.0498	0.0410	2287.1156	3000.3785	0.0259	116.8308	153.2659	244.0398	320.1463	3.2595	4.2760
3	1.3261	0.0643	-0.0992	39.6044	0.0324	2307.6712	3207.2629	0.0260	119.2908	165.7936	248.8306	345.8313	3.3235	4.6191
4	1.2367	0.0573	-0.0966	37.3977	0.0320	2308.5961	3028.5579	0.0260	115.5560	151.5935	240.7043	315.7707	3.2150	4.2176
5	1.1602	0.0544	-0.0822	39.7703	0.0283	2317.3359	3220.6953	0.0260	121.3855	168.7048	252.4957	350.9253	3.3725	4.6871
6	1.2065	0.0530	-0.0758	37.4279	0.0312	2310.4602	3031.0034	0.0261	115.7743	151.8798	240.4895	315.4888	3.2121	4.2138
7	1.1946	0.0525	-0.0641	39.7359	0.0292	2315.3331	3217.9117	0.0261	120.0636	166.8677	249.0540	346.1419	3.3265	4.6233
8	1.2835	0.0526	-0.0646	37.3509	0.0332	2305.7076	3024.7686	0.0261	112.7983	147.9757	233.6595	306.5289	3.1209	4.0942
9	1.2905	0.0532	-0.0642	39.6401	0.0315	2309.7472	3210.1482	0.0262	116.4600	161.8593	240.9118	334.8257	3.2177	4.4721
10	1.3945	0.0540	-0.0759	37.2399	0.0361	2298.8544	3015.7782	0.0262	108.9675	142.9503	225.1020	295.3027	3.0066	3.9442
11	1.3943	0.0562	-0.0844	39.5363	0.0341	2303.6990	3201.7423	0.0263	116.7139	162.2121	240.7728	334.6324	3.2159	4.4695
12	1.5799	0.0598	-0.0865	37.0545	0.0409	2287.4103	3000.7651	0.0263	109.7878	144.0264	226.1738	296.7087	3.0209	3.9630
13	1.7330	0.0661	-0.0912	39.1975	0.0423	2283.9587	3174.3067	0.0263	113.6815	157.9976	233.8743	325.0447	3.1238	4.3415
14	2.1122	0.0790	-0.0732	36.5222	0.0547	2254.5513	2957.6587	0.0264	114.6578	150.4152	235.5602	309.0223	3.1463	4.1275
15	0.8462	0.0494	-0.0155	17.0609	0.0473	2272.2385	3158.0177	0.0264	252.5524	351.0041	518.1509	720.1400	6.9207	9.6186
Exit									0				0	

Table C9b Pin0.5_2S Re30k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.8836	1.7836				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0027	0.0075	0.0300	31.4484	10.3484	21.9064	23.0889	23.0990	22.9913
2	1.5625	0.0984	0.7327	0.0123	0.0010	0.0049	0.0162	0.0646	43.4946	22.3946	47.2628	23.5251	23.5637	23.3313
3	2.6250	0.1654	1.2309	0.0123	0.0013	0.0061	0.0172	0.0685	43.4967	22.3967	50.0717	23.9613	24.0560	23.8099
4	3.6875	0.2323	1.7291	0.0123	0.0010	0.0049	0.0162	0.0646	44.7763	23.6763	47.2628	24.3975	24.5207	24.2884
5	4.7500	0.2992	2.2273	0.0123	0.0013	0.0061	0.0172	0.0685	44.3538	23.2538	50.0717	24.8337	25.0130	24.7669
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0049	0.0162	0.0646	45.6900	24.5900	47.2628	25.2699	25.4777	25.2454
7	6.8750	0.4331	3.2238	0.0123	0.0013	0.0061	0.0172	0.0685	45.5152	24.4152	50.0717	25.7061	25.9701	25.7239
8	7.9375	0.5000	3.7220	0.0123	0.0010	0.0049	0.0162	0.0646	47.0310	25.9310	47.2628	26.1423	26.4348	26.2024
9	9.0000	0.5669	4.2202	0.0123	0.0013	0.0061	0.0172	0.0685	46.8306	25.7306	50.0717	26.5785	26.9271	26.6809
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0049	0.0162	0.0646	48.6931	27.5931	47.2628	27.0147	27.3918	27.1594
11	11.1250	0.7008	5.2167	0.0123	0.0013	0.0061	0.0172	0.0685	47.5118	26.4118	50.0717	27.4509	27.8841	27.6379
12	12.1875	0.7677	5.7149	0.0123	0.0010	0.0049	0.0162	0.0646	49.1462	28.0462	47.2628	27.8871	28.3488	28.1164
13	13.2500	0.8346	6.2131	0.0123	0.0013	0.0061	0.0172	0.0685	48.7966	27.6966	50.0717	28.3233	28.8411	28.5950
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0049	0.0162	0.0646	48.9614	27.8614	47.2628	28.7595	29.3058	29.0735
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0027	0.0075	0.0300	38.1898	17.0898	21.9064	29.1957	29.5212	29.4135
Exit									29.4010	8.3010				

Table 10a Pin0.5_2S Re40k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.4498	0.0485	-0.0523	21.4566	0.0205	2857.6691	3971.6647	0.0259	341.8445	475.1046	715.0323	993.7709	7.4768	10.3915
2	1.6208	0.0770	-0.1035	45.6420	0.0343	2817.5233	3696.1998	0.0259	141.0913	185.0922	294.7365	386.6534	3.0820	4.0431
3	1.3410	0.0643	-0.0992	48.7307	0.0268	2839.4392	3946.3283	0.0260	145.3485	202.0092	303.2367	421.4465	3.1708	4.4069
4	1.2601	0.0573	-0.0966	46.0027	0.0267	2839.7904	3725.4113	0.0260	139.3500	182.8079	290.3467	380.8946	3.0360	3.9829
5	1.1821	0.0544	-0.0822	48.8896	0.0236	2848.6986	3959.1974	0.0260	145.9370	202.8271	303.6790	422.0612	3.1755	4.4133
6	1.2279	0.0530	-0.0758	46.0350	0.0260	2841.7810	3728.0226	0.0261	139.1658	182.5663	289.2161	379.4114	3.0242	3.9674
7	1.2172	0.0525	-0.0641	48.8546	0.0243	2846.6576	3956.3607	0.0261	143.7049	199.7250	298.2654	414.5372	3.1189	4.3347
8	1.3003	0.0526	-0.0646	45.9626	0.0275	2837.3115	3722.1593	0.0261	135.8298	178.1899	281.5585	369.3657	2.9442	3.8623
9	1.3041	0.0532	-0.0642	48.7677	0.0260	2841.5939	3949.3230	0.0262	140.3113	195.0084	290.4755	403.7105	3.0374	4.2215
10	1.4153	0.0540	-0.0759	45.8476	0.0299	2830.2121	3712.8458	0.0262	130.5544	171.2693	269.9309	354.1119	2.8226	3.7028
11	1.3994	0.0562	-0.0844	48.6724	0.0279	2836.0401	3941.6041	0.0262	141.3718	196.4823	291.9233	405.7228	3.0525	4.2425
12	1.5894	0.0598	-0.0865	45.6735	0.0336	2819.4657	3698.7480	0.0263	132.6239	173.9842	273.5105	358.8079	2.8600	3.7519
13	1.7385	0.0661	-0.0912	48.3333	0.0347	2816.2817	3914.1434	0.0263	137.5593	191.1836	283.3278	393.7765	2.9627	4.1176
14	2.1283	0.0790	-0.0732	45.1345	0.0450	2786.1946	3655.1010	0.0263	137.9174	180.9286	283.7045	372.1809	2.9666	3.8918
15	0.8279	0.0494	-0.0155	21.0785	0.0378	2807.3208	3901.6894	0.0264	312.1311	433.8082	641.2581	891.2377	6.7054	9.3193
Exit									0				0	0

Table 10b Pin0.5_2S Re40k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/ whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_ eng (C)	T_bulk_eng (C)
Inlet									22.8890	1.7890				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0027	0.0075	0.0300	30.8394	9.7394	23.8750	23.0719	23.0776	22.9833
2	1.5625	0.0984	0.7327	0.0123	0.0010	0.0049	0.0162	0.0646	42.5857	21.4857	51.5102	23.4606	23.4847	23.2812
3	2.6250	0.1654	1.2309	0.0123	0.0013	0.0061	0.0172	0.0685	42.4524	21.3524	54.5715	23.8494	23.9160	23.7004
4	3.6875	0.2323	1.7291	0.0123	0.0010	0.0049	0.0162	0.0646	43.7094	22.6094	51.5102	24.2381	24.3231	24.1196
5	4.7500	0.2992	2.2273	0.0123	0.0013	0.0061	0.0172	0.0685	43.3607	22.2607	54.5715	24.6269	24.7544	24.5388
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0049	0.0162	0.0646	44.6431	23.5431	51.5102	25.0156	25.1615	24.9580
7	6.8750	0.4331	3.2238	0.0123	0.0013	0.0061	0.0172	0.0685	44.4966	23.3966	54.5715	25.4043	25.5928	25.3772
8	7.9375	0.5000	3.7220	0.0123	0.0010	0.0049	0.0162	0.0646	45.8664	24.7664	51.5102	25.7931	25.9999	25.7964
9	9.0000	0.5669	4.2202	0.0123	0.0013	0.0061	0.0172	0.0685	45.7206	24.6206	54.5715	26.1818	26.4312	26.2156
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0049	0.0162	0.0646	47.4698	26.3698	51.5102	26.5706	26.8383	26.6348
11	11.1250	0.7008	5.2167	0.0123	0.0013	0.0061	0.0172	0.0685	46.2227	25.1227	54.5715	26.9593	27.2696	27.0540
12	12.1875	0.7677	5.7149	0.0123	0.0010	0.0049	0.0162	0.0646	47.8143	26.7143	51.5102	27.3481	27.6767	27.4732
13	13.2500	0.8346	6.2131	0.0123	0.0013	0.0061	0.0172	0.0685	47.4788	26.3788	54.5715	27.7368	28.1080	27.8924
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0049	0.0162	0.0646	47.7173	26.6173	51.5102	28.1255	28.5151	28.3116
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0027	0.0075	0.0300	37.0960	15.9960	23.8750	28.5143	28.7038	28.6095
Exit									28.6972	7.5972				

Table 11a Pin0.5_2S Re50k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.4203	0.0485	-0.0523	23.4548	0.0176	3123.7988	4341.5389	0.0259	402.1601	558.9329	841.2363	1169.1726	7.3810	10.2583
2	1.5509	0.0770	-0.1035	49.9594	0.0301	3084.0372	4045.8292	0.0259	161.2560	211.5455	336.9246	441.9984	2.9562	3.8781
3	1.2739	0.0643	-0.0992	53.2976	0.0233	3105.5461	4316.1708	0.0260	166.9374	232.0141	348.3928	484.2056	3.0568	4.2484
4	1.1990	0.0573	-0.0966	50.3112	0.0233	3105.7585	4074.3245	0.0260	159.5049	209.2482	332.4978	436.1910	2.9173	3.8271
5	1.1281	0.0544	-0.0822	53.4434	0.0207	3114.0387	4327.9741	0.0260	166.2252	231.0243	346.1082	481.0305	3.0367	4.2206
6	1.1724	0.0530	-0.0758	50.3378	0.0228	3107.4014	4076.4798	0.0260	158.3191	207.6927	329.2678	431.9537	2.8890	3.7900
7	1.1637	0.0525	-0.0641	53.4078	0.0213	3111.9661	4325.0935	0.0261	162.9959	226.5360	338.6056	470.6031	2.9709	4.1291
8	1.2390	0.0526	-0.0646	50.2712	0.0241	3103.2897	4071.0858	0.0261	154.5980	202.8112	320.7922	420.8349	2.8146	3.6924
9	1.2450	0.0532	-0.0642	53.3265	0.0228	3107.2270	4318.5069	0.0261	159.0285	221.0221	329.6082	458.0983	2.8920	4.0193
10	1.3492	0.0540	-0.0759	50.1610	0.0262	3096.4873	4062.1620	0.0262	148.1629	194.3692	306.7372	402.3967	2.6913	3.5306
11	1.3270	0.0562	-0.0844	53.2446	0.0243	3102.4541	4311.8735	0.0262	161.0549	223.8384	333.0469	462.8775	2.9221	4.0613
12	1.5098	0.0598	-0.0865	50.0004	0.0293	3086.5727	4049.1553	0.0262	150.8128	197.8455	311.5122	408.6607	2.7332	3.5856
13	1.6514	0.0661	-0.0912	52.9201	0.0303	3083.5482	4285.5975	0.0263	156.1922	217.0801	322.2570	447.8814	2.8275	3.9297
14	2.0300	0.0790	-0.0732	49.4802	0.0394	3054.4576	4007.0248	0.0263	155.9056	204.5265	321.3005	421.5017	2.8191	3.6982
15	0.7739	0.0494	-0.0155	23.1012	0.0324	3076.7043	4276.0858	0.0263	358.5208	498.2818	738.0260	1025.7282	6.4754	8.9997
Exit									0				0	

Table 11b Pin0.5_2S Re50k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.8274	1.8274				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0027	0.0075	0.0300	31.0785	10.0785	28.4338	23.0101	23.0166	22.9220
2	1.5625	0.0984	0.7327	0.0123	0.0010	0.0049	0.0162	0.0646	43.7674	22.7674	61.3458	23.3985	23.4249	23.2207
3	2.6250	0.1654	1.2309	0.0123	0.0013	0.0061	0.0172	0.0685	43.4792	22.4792	64.9916	23.7869	23.8575	23.6412
4	3.6875	0.2323	1.7291	0.0123	0.0010	0.0049	0.0162	0.0646	44.8081	23.8081	61.3458	24.1753	24.2658	24.0616
5	4.7500	0.2992	2.2273	0.0123	0.0013	0.0061	0.0172	0.0685	44.4462	23.4462	64.9916	24.5636	24.6983	24.4820
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0049	0.0162	0.0646	45.7333	24.7333	61.3458	24.9520	25.1066	24.9025
7	6.8750	0.4331	3.2238	0.0123	0.0013	0.0061	0.0172	0.0685	45.6376	24.6376	64.9916	25.3404	25.5392	25.3229
8	7.9375	0.5000	3.7220	0.0123	0.0010	0.0049	0.0162	0.0646	47.0110	26.0110	61.3458	25.7288	25.9475	25.7433
9	9.0000	0.5669	4.2202	0.0123	0.0013	0.0061	0.0172	0.0685	46.8577	25.8577	64.9916	26.1172	26.3800	26.1638
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0049	0.0162	0.0646	48.7672	27.7672	61.3458	26.5055	26.7883	26.5842
11	11.1250	0.7008	5.2167	0.0123	0.0013	0.0061	0.0172	0.0685	47.3094	26.3094	64.9916	26.8939	27.2209	27.0046
12	12.1875	0.7677	5.7149	0.0123	0.0010	0.0049	0.0162	0.0646	49.0727	28.0727	61.3458	27.2823	27.6292	27.4251
13	13.2500	0.8346	6.2131	0.0123	0.0013	0.0061	0.0172	0.0685	48.6586	27.6586	64.9916	27.6707	28.0618	27.8455
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0049	0.0162	0.0646	49.0161	28.0161	61.3458	28.0591	28.4701	28.2659
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0027	0.0075	0.0300	37.4009	16.4009	28.4338	28.4474	28.6593	28.5647
Exit									28.6302	7.6302				

Table 12a Pin0.5_2S Re60k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.4367	0.0485	-0.0523	27.9971	0.0154	3728.7658	5182.3382	0.0259	462.1462	642.3031	966.8925	1343.8130	7.3931	10.2751
2	1.6495	0.0770	-0.1035	59.6962	0.0269	3685.1032	4834.3444	0.0259	180.9179	237.3391	378.0755	495.9826	2.8908	3.7924
3	1.3463	0.0643	-0.0992	63.6453	0.0207	3708.4820	5154.1473	0.0260	188.3211	261.7338	393.0928	546.3309	3.0057	4.1774
4	1.2677	0.0573	-0.0966	60.0781	0.0207	3708.6765	4865.2694	0.0260	179.7466	235.8026	374.7627	491.6367	2.8655	3.7592
5	1.1926	0.0544	-0.0822	63.7990	0.0183	3717.4410	5166.5986	0.0260	186.9696	259.8554	389.3743	541.1628	2.9772	4.1378
6	1.2355	0.0530	-0.0758	60.1103	0.0201	3710.6642	4867.8769	0.0260	178.5582	234.2436	371.4302	487.2650	2.8400	3.7257
7	1.2288	0.0525	-0.0641	63.7628	0.0189	3715.3295	5163.6640	0.0261	183.0462	254.4024	380.3296	528.5922	2.9081	4.0417
8	1.3045	0.0526	-0.0646	60.0413	0.0213	3706.4037	4862.2877	0.0261	174.1546	228.4667	361.4408	474.1602	2.7636	3.6255
9	1.3108	0.0532	-0.0642	63.6808	0.0202	3710.5523	5157.0246	0.0261	178.9038	248.6452	370.8729	515.4490	2.8358	3.9412
10	1.4247	0.0540	-0.0759	59.9211	0.0232	3698.9835	4852.5534	0.0262	166.1594	217.9781	344.0604	451.3596	2.6308	3.4512
11	1.3936	0.0562	-0.0844	63.5980	0.0214	3705.7275	5150.3189	0.0262	181.5158	252.2755	375.4303	521.7830	2.8706	3.9897
12	1.5910	0.0598	-0.0865	59.7548	0.0259	3688.7201	4839.0893	0.0262	169.2817	222.0741	349.7281	458.7948	2.6741	3.5080
13	1.7360	0.0661	-0.0912	63.2557	0.0267	3685.7798	5122.5951	0.0262	175.6141	244.0732	362.3985	503.6711	2.7710	3.8512
14	2.1406	0.0790	-0.0732	59.2052	0.0349	3654.7925	4794.5810	0.0263	174.3948	228.7817	359.4740	471.5800	2.7486	3.6058
15	0.7939	0.0494	-0.0155	27.6400	0.0279	3681.2005	5116.2307	0.0263	411.1462	571.4219	846.5219	1176.5187	6.4727	8.9959
Exit									0				0	

Table 12a Pin0.5_2S Re60k Part1

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.6054	1.1053				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0027	0.0075	0.0300	30.4756	8.9756	30.8743	22.7721	22.7798	22.6926
2	1.5625	0.0984	0.7327	0.0123	0.0010	0.0049	0.0162	0.0646	42.6614	21.1614	66.6111	23.1264	23.1562	22.9680
3	2.6250	0.1654	1.2309	0.0123	0.0013	0.0061	0.0172	0.0685	42.3859	20.8859	70.5699	23.4808	23.5549	23.3555
4	3.6875	0.2323	1.7291	0.0123	0.0010	0.0049	0.0162	0.0646	43.9005	22.4005	66.6111	23.8351	23.9313	23.7431
5	4.7500	0.2992	2.2273	0.0123	0.0013	0.0061	0.0172	0.0685	43.6375	22.1375	70.5699	24.1895	24.3300	24.1307
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0049	0.0162	0.0646	44.9478	23.4478	66.6111	24.5438	24.7064	24.5182
7	6.8750	0.4331	3.2238	0.0123	0.0013	0.0061	0.0172	0.0685	44.7864	23.2864	70.5699	24.8982	25.1052	24.9058
8	7.9375	0.5000	3.7220	0.0123	0.0010	0.0049	0.0162	0.0646	46.0864	24.5864	66.6111	25.2525	25.4815	25.2933
9	9.0000	0.5669	4.2202	0.0123	0.0013	0.0061	0.0172	0.0685	45.9685	24.4685	70.5699	25.6068	25.8803	25.6809
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0049	0.0162	0.0646	47.7213	26.2213	66.6111	25.9612	26.2567	26.0685
11	11.1250	0.7008	5.2167	0.0123	0.0013	0.0061	0.0172	0.0685	46.2849	24.7849	70.5699	26.3155	26.6554	26.4560
12	12.1875	0.7677	5.7149	0.0123	0.0010	0.0049	0.0162	0.0646	47.9074	26.4074	66.6111	26.6699	27.0318	26.8436
13	13.2500	0.8346	6.2131	0.0123	0.0013	0.0061	0.0172	0.0685	47.6051	26.1051	70.5699	27.0242	27.4305	27.2311
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0049	0.0162	0.0646	47.9408	26.4408	66.6111	27.3786	27.8069	27.6187
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0027	0.0075	0.0300	36.5575	15.0575	30.8743	27.7329	27.9813	27.8941
Exit									27.8997	6.3997				

Table 13a Pin0.5_2S Re70k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.3832	0.0485	-0.0523	30.4911	0.0124	4060.9281	5643.9862	0.0259	527.1566	732.6563	1103.6882	1533.9353	7.3954	10.2783
2	1.5259	0.0770	-0.1035	65.0852	0.0229	4017.7716	5270.7592	0.0259	205.6710	269.8119	430.1517	564.2993	2.8823	3.7812
3	1.2439	0.0643	-0.0992	69.3260	0.0176	4039.4870	5614.1868	0.0259	213.6721	296.9672	446.4150	620.4394	2.9913	4.1573
4	1.1870	0.0573	-0.0966	65.4241	0.0178	4038.6899	5298.2011	0.0260	201.2763	264.0467	420.0748	551.0798	2.8148	3.6926
5	1.1214	0.0544	-0.0822	69.4485	0.0159	4046.6218	5624.1030	0.0260	208.0741	289.1869	433.8059	602.9150	2.9068	4.0399
6	1.1673	0.0530	-0.0758	65.4438	0.0175	4039.9060	5299.7965	0.0260	197.9964	259.7438	412.3623	540.9622	2.7631	3.6248
7	1.1579	0.0525	-0.0641	69.4120	0.0164	4044.4960	5621.1484	0.0260	203.3615	282.6373	423.0926	588.0254	2.8350	3.9401
8	1.2295	0.0526	-0.0646	65.3816	0.0185	4036.0671	5294.7604	0.0261	193.7257	254.1412	402.6236	528.1864	2.6978	3.5392
9	1.2369	0.0532	-0.0642	69.3329	0.0175	4039.8910	5614.7483	0.0261	198.4068	275.7511	411.9218	572.4999	2.7601	3.8361
10	1.3411	0.0540	-0.0759	65.2700	0.0201	4029.1752	5285.7192	0.0261	185.1631	242.9083	384.0250	503.7875	2.5732	3.3757
11	1.3080	0.0562	-0.0844	69.2619	0.0185	4035.7525	5608.9964	0.0261	202.0973	280.8803	418.7096	581.9337	2.8056	3.8993
12	1.4914	0.0598	-0.0865	65.1197	0.0224	4019.8973	5273.5479	0.0262	189.2825	248.3124	391.7516	513.9238	2.6250	3.4436
13	1.6333	0.0661	-0.0912	68.9366	0.0231	4016.7945	5582.6481	0.0262	195.1712	271.2542	403.5197	560.8224	2.7038	3.7579
14	2.0161	0.0790	-0.0732	64.5950	0.0303	3987.5108	5231.0612	0.0262	193.9236	254.4008	400.5241	525.4321	2.6838	3.5207
15	0.7276	0.0494	-0.0155	30.1468	0.0236	4015.0654	5580.2449	0.0263	454.9875	632.3538	938.7444	1304.6921	6.2902	8.7423
Exit									0				0	

Table 13a Pin0.5_2S Re70k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.1892	1.5892				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0027	0.0075	0.0300	30.7865	10.1865	36.2972	22.3575	22.3679	22.2786
2	1.5625	0.0984	0.7327	0.0123	0.0010	0.0049	0.0162	0.0646	44.3701	23.7701	78.3109	22.7150	22.7535	22.5607
3	2.6250	0.1654	1.2309	0.0123	0.0013	0.0061	0.0172	0.0685	43.7126	23.1126	82.9650	23.0726	23.1620	22.9577
4	3.6875	0.2323	1.7291	0.0123	0.0010	0.0049	0.0162	0.0646	45.3489	24.7489	78.3109	23.4301	23.5475	23.3547
5	4.7500	0.2992	2.2273	0.0123	0.0013	0.0061	0.0172	0.0685	44.7962	24.1962	82.9650	23.7877	23.9560	23.7517
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0049	0.0162	0.0646	45.9229	25.3229	78.3109	24.1452	24.3415	24.1488
7	6.8750	0.4331	3.2238	0.0123	0.0013	0.0061	0.0172	0.0685	45.7743	25.1743	82.9650	24.5028	24.7500	24.5458
8	7.9375	0.5000	3.7220	0.0123	0.0010	0.0049	0.0162	0.0646	47.0158	26.4158	78.3109	24.8603	25.1356	24.9428
9	9.0000	0.5669	4.2202	0.0123	0.0013	0.0061	0.0172	0.0685	46.9114	26.3114	82.9650	25.2179	25.5440	25.3398
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0049	0.0162	0.0646	48.8411	28.2411	78.3109	25.5754	25.9296	25.7368
11	11.1250	0.7008	5.2167	0.0123	0.0013	0.0061	0.0172	0.0685	47.1214	26.5214	82.9650	25.9330	26.3381	26.1338
12	12.1875	0.7677	5.7149	0.0123	0.0010	0.0049	0.0162	0.0646	48.9846	28.3846	78.3109	26.2905	26.7236	26.5309
13	13.2500	0.8346	6.2131	0.0123	0.0013	0.0061	0.0172	0.0685	48.5440	27.9440	82.9650	26.6481	27.1321	26.9279
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0049	0.0162	0.0646	48.9602	28.3602	78.3109	27.0057	27.5177	27.3249
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0027	0.0075	0.0300	36.4393	15.8393	36.2972	27.3632	27.6964	27.6070
Exit									27.5315	6.9315				

Table 14a Pin0.5_2S Re80k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.4420	0.0485	-0.0523	35.8552	0.0122	4775.3379	6636.8921	0.0258	566.5325	787.3819	1187.5955	1650.5520	7.1216	9.8978
2	1.7267	0.0770	-0.1035	76.5841	0.0220	4727.6077	6201.9658	0.0259	218.3139	286.3975	457.1534	599.7219	2.7414	3.5963
3	1.3871	0.0643	-0.0992	81.5779	0.0167	4753.3791	6606.3731	0.0259	230.2992	320.0760	481.7376	669.5318	2.8888	4.0150
4	1.3216	0.0573	-0.0966	76.9893	0.0169	4752.6191	6234.7772	0.0259	216.8288	284.4493	453.0783	594.3759	2.7170	3.5643
5	1.2334	0.0544	-0.0822	81.7316	0.0149	4762.3355	6618.8209	0.0260	226.6861	315.0544	473.1729	657.6284	2.8375	3.9436
6	1.2667	0.0530	-0.0758	77.0441	0.0162	4756.0051	6239.2192	0.0260	218.3895	286.4967	455.3718	597.3847	2.7307	3.5823
7	1.2570	0.0525	-0.0641	81.7080	0.0152	4760.9590	6616.9078	0.0260	223.8189	311.0695	466.1989	647.9357	2.7956	3.8855
8	1.3258	0.0526	-0.0646	76.9851	0.0169	4752.3591	6234.4362	0.0260	214.5011	281.3956	446.3182	585.5076	2.6764	3.5111
9	1.3349	0.0532	-0.0642	81.6300	0.0161	4756.4170	6610.5952	0.0261	219.2556	304.7273	455.7295	633.3850	2.7329	3.7982
10	1.4503	0.0540	-0.0759	76.8606	0.0185	4744.6729	6224.3529	0.0261	203.9345	267.5338	423.4373	555.4910	2.5392	3.3311
11	1.4055	0.0562	-0.0844	81.5594	0.0169	4752.3038	6604.8785	0.0261	224.2877	311.7210	465.2072	646.5574	2.7897	3.8772
12	1.6096	0.0598	-0.0865	76.7013	0.0206	4734.8403	6211.4539	0.0261	208.6382	273.7044	432.2929	567.1084	2.5923	3.4008
13	1.7548	0.0661	-0.0912	81.2102	0.0212	4731.9518	6576.5929	0.0262	216.1114	300.3574	447.3071	621.6794	2.6824	3.7280
14	2.1677	0.0790	-0.0732	76.1431	0.0277	4700.3844	6166.2526	0.0262	214.0963	280.8646	442.6716	580.7238	2.6546	3.4824
15	0.7662	0.0494	-0.0155	35.5310	0.0211	4732.1624	6576.8855	0.0262	521.3866	724.6370	1076.9051	1496.7115	6.4578	8.9753
Exit									0				0	

Table 14b Pin0.5_2S Re80k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.9945	-0.0055				
1	0.5000	0.0315	0.2345	0.0054	0.0010	0.0048	0.0092	0.0298	29.9583	7.9583	18.8343	22.3659	22.3628	22.1786
2	1.5625	0.0984	0.7327	0.0123	0.0020	0.0097	0.0201	0.0650	40.6043	18.6043	41.0774	23.1551	23.1661	22.7645
3	2.6250	0.1654	1.2309	0.0123	0.0023	0.0109	0.0210	0.0681	40.6591	18.6591	43.0498	23.9443	24.0080	23.5871
4	3.6875	0.2323	1.7291	0.0123	0.0020	0.0097	0.0201	0.0650	42.9593	20.9593	41.0774	24.7336	24.8113	24.4097
5	4.7500	0.2992	2.2273	0.0123	0.0023	0.0109	0.0210	0.0681	43.1829	21.1829	43.0498	25.5228	25.6532	25.2323
6	5.8125	0.3661	2.7256	0.0123	0.0020	0.0097	0.0201	0.0650	44.7846	22.7846	41.0774	26.3120	26.4566	26.0549
7	6.8750	0.4331	3.2238	0.0123	0.0023	0.0109	0.0210	0.0681	44.6417	22.6417	43.0498	27.1013	27.2984	26.8775
8	7.9375	0.5000	3.7220	0.0123	0.0020	0.0097	0.0201	0.0650	46.8271	24.8271	41.0774	27.8905	28.1018	27.7001
9	9.0000	0.5669	4.2202	0.0123	0.0023	0.0109	0.0210	0.0681	46.6505	24.6505	43.0498	28.6797	28.9437	28.5227
10	10.0625	0.6339	4.7184	0.0123	0.0020	0.0097	0.0201	0.0650	48.6055	26.6055	41.0774	29.4690	29.7470	29.3453
11	11.1250	0.7008	5.2167	0.0123	0.0023	0.0109	0.0210	0.0681	48.6165	26.6165	43.0498	30.2582	30.5889	30.1679
12	12.1875	0.7677	5.7149	0.0123	0.0020	0.0097	0.0201	0.0650	49.7052	27.7052	41.0774	31.0474	31.3922	30.9905
13	13.2500	0.8346	6.2131	0.0123	0.0023	0.0109	0.0210	0.0681	50.0047	28.0047	43.0498	31.8367	32.2341	31.8132
14	14.3125	0.9016	6.7113	0.0123	0.0020	0.0097	0.0201	0.0650	50.0726	28.0726	41.0774	32.6259	33.0374	32.6358
15	15.3750	0.9685	7.2095	0.0054	0.0010	0.0048	0.0092	0.0298	40.7530	18.7530	18.8343	33.4151	33.4058	33.2216
Exit									33.7865	11.7865				

Table 15a Pin0.5_1S Re20k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5676	0.0432	0.2240	18.2667	0.0301	1986.9793	3381.2189	0.0258	261.7036	445.3379	548.5833	933.5176	9.9800	16.9829
2	1.7098	0.0678	0.4484	39.3676	0.0416	1963.4387	3188.0799	0.0259	112.5228	182.7059	235.3164	382.0885	4.2810	6.9511
3	1.4738	0.0556	0.4371	41.5760	0.0342	1978.5804	3366.9265	0.0260	118.3730	201.4339	246.9709	420.2674	4.4930	7.6456
4	1.4611	0.0480	0.4544	39.6163	0.0356	1975.8436	3208.2220	0.0260	108.4095	176.0270	225.6552	366.4015	4.1052	6.6657
5	1.4428	0.0448	0.4932	41.6070	0.0335	1980.0551	3369.4360	0.0261	112.1203	190.7938	232.8360	396.2142	4.2358	7.2081
6	1.4941	0.0432	0.5100	39.5833	0.0364	1974.1973	3205.5490	0.0261	106.8715	173.5298	221.4210	359.5264	4.0282	6.5406
7	1.4993	0.0429	0.5286	41.5505	0.0348	1977.3641	3364.8568	0.0262	112.7320	191.8347	233.0226	396.5318	4.2392	7.2138
8	1.5943	0.0429	0.5291	39.4831	0.0388	1969.2009	3197.4361	0.0263	103.9894	168.8499	214.4553	348.2160	3.9014	6.3349
9	1.6037	0.0434	0.5329	41.4461	0.0373	1972.3960	3356.4026	0.0263	109.7556	186.7698	225.8264	384.2860	4.1083	6.9911
10	1.7022	0.0444	0.5211	39.3752	0.0414	1963.8206	3188.7001	0.0264	102.6218	166.6293	210.6641	342.0601	3.8325	6.2229
11	1.7493	0.0466	0.5087	41.3005	0.0406	1965.4689	3344.6148	0.0264	107.0613	182.1849	219.2753	373.1381	3.9891	6.7883
12	1.8838	0.0504	0.4876	39.1936	0.0459	1954.7640	3173.9946	0.0265	104.7694	170.1164	214.0921	347.6262	3.8948	6.3241
13	2.0578	0.0570	0.4609	40.9920	0.0478	1950.7845	3319.6266	0.0266	107.3745	182.7180	218.9170	372.5285	3.9826	6.7772
14	2.3958	0.0690	0.4598	38.6816	0.0583	1929.2250	3132.5264	0.0266	110.5784	179.5486	224.9383	365.2374	4.0922	6.6445
15	1.0111	0.0417	0.2292	17.8231	0.0537	1938.7281	3299.1104	0.0267	264.2090	449.6013	536.2396	912.5125	9.7554	16.6007
Exit									0				0	

Table 15b Pin0.5_1S Re20k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.0200	0.5200				
1	0.5000	0.0315	0.2345	0.0054	0.0010	0.0048	0.0092	0.0298	29.5022	8.0022	23.8514	22.3485	22.3320	22.1760
2	1.5625	0.0984	0.7327	0.0123	0.0020	0.0097	0.0201	0.0650	40.6596	19.1596	52.0197	23.0466	23.0125	22.6723
3	2.6250	0.1654	1.2309	0.0123	0.0023	0.0109	0.0210	0.0681	40.4526	18.9526	54.5175	23.7448	23.7257	23.3691
4	3.6875	0.2323	1.7291	0.0123	0.0020	0.0097	0.0201	0.0650	42.7554	21.2554	52.0197	24.4429	24.4063	24.0660
5	4.7500	0.2992	2.2273	0.0123	0.0023	0.0109	0.0210	0.0681	42.8711	21.3711	54.5175	25.1410	25.1195	24.7629
6	5.8125	0.3661	2.7256	0.0123	0.0020	0.0097	0.0201	0.0650	44.3431	22.8431	52.0197	25.8391	25.8000	25.4597
7	6.8750	0.4331	3.2238	0.0123	0.0023	0.0109	0.0210	0.0681	44.0343	22.5343	54.5175	26.5373	26.5132	26.1566
8	7.9375	0.5000	3.7220	0.0123	0.0020	0.0097	0.0201	0.0650	46.1973	24.6973	52.0197	27.2354	27.1937	26.8535
9	9.0000	0.5669	4.2202	0.0123	0.0023	0.0109	0.0210	0.0681	45.8421	24.3421	54.5175	27.9335	27.9069	27.5503
10	10.0625	0.6339	4.7184	0.0123	0.0020	0.0097	0.0201	0.0650	47.7740	26.2740	52.0197	28.6316	28.5874	28.2472
11	11.1250	0.7008	5.2167	0.0123	0.0023	0.0109	0.0210	0.0681	47.7260	26.2260	54.5175	29.3298	29.3006	28.9440
12	12.1875	0.7677	5.7149	0.0123	0.0020	0.0097	0.0201	0.0650	48.7071	27.2071	52.0197	30.0279	29.9812	29.6409
13	13.2500	0.8346	6.2131	0.0123	0.0023	0.0109	0.0210	0.0681	49.0745	27.5745	54.5175	30.7260	30.6944	30.3378
14	14.3125	0.9016	6.7113	0.0123	0.0020	0.0097	0.0201	0.0650	49.1720	27.6720	52.0197	31.4242	31.3749	31.0346
15	15.3750	0.9685	7.2095	0.0054	0.0010	0.0048	0.0092	0.0298	39.4095	17.9095	23.8514	32.1223	31.6869	31.5309
Exit									32.4508	10.9508				

Table 16a Pin0.5_1S Re30k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5695	0.0432	0.2240	23.2819	0.0239	2532.5139	4309.5485	0.0258	354.0164	602.4255	742.1280	1262.8703	9.7743	16.6328
2	1.7475	0.0678	0.4484	50.2722	0.0336	2507.3014	4071.1622	0.0259	142.3556	231.1461	297.8011	483.5464	3.9222	6.3686
3	1.4901	0.0556	0.4371	53.0274	0.0273	2523.5447	4294.2858	0.0259	151.0395	257.0220	315.3122	536.5630	4.1529	7.0669
4	1.4753	0.0480	0.4544	50.5443	0.0284	2520.8746	4093.2012	0.0260	137.6587	223.5195	286.7841	465.6578	3.7771	6.1330
5	1.4512	0.0448	0.4932	53.0663	0.0266	2525.3939	4297.4325	0.0261	142.4353	242.3805	296.1234	503.9096	3.9001	6.6368
6	1.4967	0.0432	0.5100	50.5230	0.0288	2519.8117	4091.4755	0.0261	136.1769	221.1135	282.5299	458.7502	3.7211	6.0420
7	1.4947	0.0429	0.5286	53.0227	0.0274	2523.3234	4293.9091	0.0262	144.2140	245.4072	298.5910	508.1087	3.9326	6.6921
8	1.5887	0.0429	0.5291	50.4309	0.0305	2515.2189	4084.0179	0.0262	132.6462	215.3806	274.0784	445.0273	3.6098	5.8613
9	1.5903	0.0434	0.5329	52.9271	0.0292	2518.7738	4286.1671	0.0263	140.6458	239.3353	290.0148	493.5147	3.8197	6.4999
10	1.6875	0.0444	0.5211	50.3322	0.0324	2510.2948	4076.0225	0.0263	131.1382	212.9321	269.8598	438.1774	3.5542	5.7711
11	1.7311	0.0466	0.5087	52.7864	0.0318	2512.0754	4274.7685	0.0264	136.5536	232.3717	280.4335	477.2103	3.6935	6.2852
12	1.8587	0.0504	0.4876	50.1610	0.0357	2501.7562	4062.1583	0.0264	133.9326	217.4694	274.4941	445.7024	3.6153	5.8702
13	2.0333	0.0570	0.4609	52.4842	0.0373	2497.6923	4250.2930	0.0265	136.1255	231.6431	278.4254	473.7932	3.6670	6.2402
14	2.3682	0.0690	0.4598	49.6515	0.0455	2476.3431	4020.8944	0.0265	139.5292	226.5567	284.8127	462.4569	3.7512	6.0909
15	0.9760	0.0417	0.2292	22.8754	0.0409	2488.2943	4234.3007	0.0266	341.4626	581.0628	695.6081	1183.7079	9.1616	15.5902
Exit									0				0	

Table 16b Pin0.5_1S Re30k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.9616	0.1616				
1	0.5000	0.0315	0.2345	0.0054	0.0010	0.0048	0.0092	0.0298	29.2379	7.4379	28.8061	22.2623	22.2391	22.1004
2	1.5625	0.0984	0.7327	0.0123	0.0020	0.0097	0.0201	0.0650	40.8800	19.0800	62.8259	22.9013	22.8443	22.5417
3	2.6250	0.1654	1.2309	0.0123	0.0023	0.0109	0.0210	0.0681	40.5459	18.7459	65.8426	23.5402	23.4785	23.1614
4	3.6875	0.2323	1.7291	0.0123	0.0020	0.0097	0.0201	0.0650	43.1146	21.3146	62.8259	24.1791	24.0837	23.7811
5	4.7500	0.2992	2.2273	0.0123	0.0023	0.0109	0.0210	0.0681	43.0756	21.2756	65.8426	24.8181	24.7179	24.4008
6	5.8125	0.3661	2.7256	0.0123	0.0020	0.0097	0.0201	0.0650	44.4975	22.6975	62.8259	25.4570	25.3230	25.0205
7	6.8750	0.4331	3.2238	0.0123	0.0023	0.0109	0.0210	0.0681	44.1035	22.3035	65.8426	26.0960	25.9573	25.6401
8	7.9375	0.5000	3.7220	0.0123	0.0020	0.0097	0.0201	0.0650	46.2274	24.4274	62.8259	26.7349	26.5624	26.2598
9	9.0000	0.5669	4.2202	0.0123	0.0023	0.0109	0.0210	0.0681	45.7670	23.9670	65.8426	27.3738	27.1966	26.8795
10	10.0625	0.6339	4.7184	0.0123	0.0020	0.0097	0.0201	0.0650	47.6558	25.8558	62.8259	28.0128	27.8018	27.4992
11	11.1250	0.7008	5.2167	0.0123	0.0023	0.0109	0.0210	0.0681	47.5145	25.7145	65.8426	28.6517	28.4360	28.1189
12	12.1875	0.7677	5.7149	0.0123	0.0020	0.0097	0.0201	0.0650	48.3459	26.5459	62.8259	29.2907	29.0412	28.7386
13	13.2500	0.8346	6.2131	0.0123	0.0023	0.0109	0.0210	0.0681	48.6703	26.8703	65.8426	29.9296	29.6754	29.3583
14	14.3125	0.9016	6.7113	0.0123	0.0020	0.0097	0.0201	0.0650	48.6909	26.8909	62.8259	30.5685	30.2806	29.9780
15	15.3750	0.9685	7.2095	0.0054	0.0010	0.0048	0.0092	0.0298	38.4620	16.6620	28.8061	31.2075	30.5580	30.4193
Exit									31.5081	9.7081				

Table 17a Pin0.5_1S Re40k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5451	0.0432	0.2240	28.2610	0.0189	3074.1201	5231.1934	0.0258	440.6986	749.9315	924.0783	1572.4930	9.5171	16.1952
2	1.7421	0.0678	0.4484	61.0838	0.0277	3046.5270	4946.7150	0.0259	169.4518	275.1427	354.6385	575.8345	3.6524	5.9305
3	1.4786	0.0556	0.4371	64.3640	0.0225	3063.0477	5212.3516	0.0259	180.1189	306.5062	376.2475	640.2558	3.8750	6.5940
4	1.4782	0.0480	0.4544	61.3477	0.0235	3059.6891	4968.0865	0.0260	161.5849	262.3690	336.8926	547.0201	3.4697	5.6338
5	1.4469	0.0448	0.4932	64.3957	0.0220	3064.5541	5214.9150	0.0260	167.8519	285.6315	349.2976	594.3956	3.5974	6.1217
6	1.4904	0.0432	0.5100	61.3356	0.0237	3059.0818	4967.1005	0.0261	160.6619	260.8704	333.7052	541.8448	3.4368	5.5805
7	1.4848	0.0429	0.5286	64.3578	0.0226	3062.7507	5211.8461	0.0261	170.0811	289.4249	352.6052	600.0240	3.6315	6.1797
8	1.5772	0.0429	0.5291	61.2488	0.0251	3054.7528	4960.0714	0.0262	156.7143	254.4606	324.2845	526.5481	3.3398	5.4229
9	1.5740	0.0434	0.5329	64.2686	0.0239	3058.5056	5204.6223	0.0262	166.2845	282.9643	343.4439	584.4343	3.5371	6.0191
10	1.6689	0.0444	0.5211	61.1570	0.0266	3050.1771	4952.6417	0.0263	155.2805	252.1325	320.1177	519.7824	3.2969	5.3533
11	1.7072	0.0466	0.5087	64.1354	0.0259	3052.1664	5193.8350	0.0263	161.8088	275.3480	332.9549	566.5854	3.4291	5.8353
12	1.8253	0.0504	0.4876	61.0006	0.0291	3042.3746	4939.9726	0.0264	159.6608	259.2449	327.9249	532.4592	3.3773	5.4838
13	1.9932	0.0570	0.4609	63.8494	0.0303	3038.5595	5170.6803	0.0264	162.1366	275.9059	332.3928	565.6289	3.4233	5.8254
14	2.3143	0.0690	0.4598	60.5116	0.0368	3017.9860	4900.3724	0.0265	166.5333	270.4039	340.7754	553.3248	3.5097	5.6987
15	0.9240	0.0417	0.2292	27.8822	0.0321	3032.9086	5161.0642	0.0265	418.0687	711.4225	853.9124	1453.0925	8.7945	14.9654
Exit									0				0	0

Table 17a Pin0.5_1S Re40k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.3810	-0.3190				
1	0.5000	0.0315	0.2345	0.0054	0.0010	0.0048	0.0092	0.0298	28.5718	6.8718	34.0163	21.6714	21.6415	21.5112
2	1.5625	0.0984	0.7327	0.0123	0.0020	0.0097	0.0201	0.0650	41.0724	19.3724	74.1893	22.2886	22.2098	21.9257
3	2.6250	0.1654	1.2309	0.0123	0.0023	0.0109	0.0210	0.0681	40.7453	19.0453	77.7516	22.9058	22.8054	22.5076
4	3.6875	0.2323	1.7291	0.0123	0.0020	0.0097	0.0201	0.0650	43.6581	21.9581	74.1893	23.5229	23.3737	23.0895
5	4.7500	0.2992	2.2273	0.0123	0.0023	0.0109	0.0210	0.0681	43.6066	21.9066	77.7516	24.1401	23.9692	23.6714
6	5.8125	0.3661	2.7256	0.0123	0.0020	0.0097	0.0201	0.0650	44.9777	23.2777	74.1893	24.7573	24.5375	24.2534
7	6.8750	0.4331	3.2238	0.0123	0.0023	0.0109	0.0210	0.0681	44.5441	22.8441	77.7516	25.3745	25.1331	24.8353
8	7.9375	0.5000	3.7220	0.0123	0.0020	0.0097	0.0201	0.0650	46.5784	24.8784	74.1893	25.9917	25.7014	25.4172
9	9.0000	0.5669	4.2202	0.0123	0.0023	0.0109	0.0210	0.0681	46.1531	24.4531	77.7516	26.6088	26.2969	25.9992
10	10.0625	0.6339	4.7184	0.0123	0.0020	0.0097	0.0201	0.0650	47.9360	26.2360	74.1893	27.2260	26.8652	26.5811
11	11.1250	0.7008	5.2167	0.0123	0.0023	0.0109	0.0210	0.0681	47.7842	26.0842	77.7516	27.8432	27.4608	27.1630
12	12.1875	0.7677	5.7149	0.0123	0.0020	0.0097	0.0201	0.0650	48.5644	26.8644	74.1893	28.4604	28.0291	27.7449
13	13.2500	0.8346	6.2131	0.0123	0.0023	0.0109	0.0210	0.0681	48.8971	27.1971	77.7516	29.0776	28.6247	28.3269
14	14.3125	0.9016	6.7113	0.0123	0.0020	0.0097	0.0201	0.0650	48.8461	27.1461	74.1893	29.6947	29.1929	28.9088
15	15.3750	0.9685	7.2095	0.0054	0.0010	0.0048	0.0092	0.0298	37.8461	16.1461	34.0163	30.3119	29.4535	29.3232
Exit									30.6024	8.9024				

Table 18a Pin0.5_1S Re50k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5207	0.0432	0.2240	33.4957	0.0153	3643.5217	6200.1372	0.0258	528.0162	898.5189	1109.1277	1887.3894	9.4950	16.1575
2	1.7619	0.0678	0.4484	72.4274	0.0237	3612.2815	5865.3434	0.0258	192.3083	312.2554	403.2099	654.7011	3.4518	5.6047
3	1.4952	0.0556	0.4371	76.2564	0.0192	3628.9993	6175.4247	0.0259	203.4243	346.1648	425.7324	724.4638	3.6446	6.2020
4	1.5091	0.0480	0.4544	72.6802	0.0203	3624.8908	5885.8174	0.0259	180.0278	292.3152	376.0763	610.6436	3.2195	5.2276
5	1.4752	0.0448	0.4932	76.2764	0.0190	3629.9511	6177.0444	0.0260	186.4716	317.3165	388.8246	661.6581	3.3286	5.6643
6	1.5154	0.0432	0.5100	72.6739	0.0204	3624.5752	5885.3049	0.0260	179.2532	291.0574	373.0905	605.7956	3.1939	5.1861
7	1.5080	0.0429	0.5286	76.2436	0.0194	3628.3910	6174.3894	0.0261	189.2778	322.0917	393.2379	669.1683	3.3664	5.7286
8	1.5965	0.0429	0.5291	72.5928	0.0215	3620.5309	5878.7382	0.0261	175.8670	285.5592	364.7122	592.1915	3.1222	5.0696
9	1.5951	0.0434	0.5329	76.1565	0.0205	3624.2441	6167.3328	0.0262	185.4380	315.5576	383.8635	653.2160	3.2862	5.5920
10	1.6858	0.0444	0.5211	72.5035	0.0227	3616.0786	5871.5088	0.0262	174.6056	283.5111	360.7865	585.8172	3.0886	5.0150
11	1.7245	0.0466	0.5087	76.0271	0.0222	3618.0897	6156.8599	0.0263	181.4399	308.7541	374.2318	636.8258	3.2037	5.4517
12	1.8414	0.0504	0.4876	72.3479	0.0248	3608.3174	5858.9067	0.0263	179.4827	291.4301	369.5286	600.0119	3.1634	5.1365
13	2.0118	0.0570	0.4609	75.7398	0.0259	3604.4160	6133.5916	0.0264	181.8617	309.4720	373.7545	636.0136	3.1996	5.4448
14	2.3319	0.0690	0.4598	71.8574	0.0314	3583.8518	5819.1815	0.0264	187.1335	303.8529	383.8999	623.3470	3.2865	5.3363
15	0.9024	0.0417	0.2292	33.1139	0.0265	3601.9917	6129.4662	0.0265	478.0841	813.5500	979.0253	1665.9957	8.3812	14.2622
Exit									0				0	

Table 18b Pin0.5_1S Re50k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.5507	-0.1493				
1	0.5000	0.0315	0.2345	0.0054	0.0010	0.0048	0.0092	0.0298	28.7664	7.0664	38.9135	21.8276	21.8063	21.6785
2	1.5625	0.0984	0.7327	0.0123	0.0020	0.0097	0.0201	0.0650	41.6540	19.9540	84.8701	22.4159	22.3637	22.0850
3	2.6250	0.1654	1.2309	0.0123	0.0023	0.0109	0.0210	0.0681	41.2936	19.5936	88.9452	23.0043	22.9478	22.6558
4	3.6875	0.2323	1.7291	0.0123	0.0020	0.0097	0.0201	0.0650	44.4693	22.7693	84.8701	23.5927	23.5053	23.2265
5	4.7500	0.2992	2.2273	0.0123	0.0023	0.0109	0.0210	0.0681	44.2556	22.5556	88.9452	24.1810	24.0894	23.7973
6	5.8125	0.3661	2.7256	0.0123	0.0020	0.0097	0.0201	0.0650	45.6246	23.9246	84.8701	24.7694	24.6468	24.3681
7	6.8750	0.4331	3.2238	0.0123	0.0023	0.0109	0.0210	0.0681	45.1344	23.4344	88.9452	25.3578	25.2310	24.9389
8	7.9375	0.5000	3.7220	0.0123	0.0020	0.0097	0.0201	0.0650	47.1587	25.4587	84.8701	25.9461	25.7884	25.5097
9	9.0000	0.5669	4.2202	0.0123	0.0023	0.0109	0.0210	0.0681	46.6567	24.9567	88.9452	26.5345	26.3726	26.0805
10	10.0625	0.6339	4.7184	0.0123	0.0020	0.0097	0.0201	0.0650	48.3964	26.6964	84.8701	27.1229	26.9300	26.6513
11	11.1250	0.7008	5.2167	0.0123	0.0023	0.0109	0.0210	0.0681	48.2082	26.5082	88.9452	27.7113	27.5142	27.2221
12	12.1875	0.7677	5.7149	0.0123	0.0020	0.0097	0.0201	0.0650	48.9327	27.2327	84.8701	28.2996	28.0716	27.7929
13	13.2500	0.8346	6.2131	0.0123	0.0023	0.0109	0.0210	0.0681	49.1787	27.4787	88.9452	28.8880	28.6558	28.3637
14	14.3125	0.9016	6.7113	0.0123	0.0020	0.0097	0.0201	0.0650	49.1664	27.4664	84.8701	29.4764	29.2132	28.9345
15	15.3750	0.9685	7.2095	0.0054	0.0010	0.0048	0.0092	0.0298	37.7595	16.0595	38.9135	30.0647	29.4688	29.3410
Exit									30.3416	8.6416				

Table 19a Pin0.5_1S Re60k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5291	0.0432	0.2240	38.3845	0.0136	4175.3061	7105.0683	0.0258	601.7315	1023.9593	1263.3804	2149.8793	9.5623	16.2720
2	1.8014	0.0678	0.4484	83.0687	0.0212	4143.0128	6727.1038	0.0258	215.3549	349.6766	451.3596	732.8829	3.4163	5.5470
3	1.5257	0.0556	0.4371	87.4195	0.0172	4160.2478	7079.4438	0.0259	227.4686	387.0806	475.9133	809.8559	3.6021	6.1296
4	1.5481	0.0480	0.4544	83.3220	0.0182	4155.6456	6747.6160	0.0259	199.0568	323.2130	415.7416	675.0491	3.1467	5.1093
5	1.5043	0.0448	0.4932	87.4409	0.0169	4161.2648	7081.1744	0.0260	207.2900	352.7430	432.1821	735.4390	3.2711	5.5664
6	1.5434	0.0432	0.5100	83.3267	0.0182	4155.8800	6747.9966	0.0260	199.2735	323.5649	414.7452	673.4312	3.1391	5.0971
7	1.5333	0.0429	0.5286	87.4119	0.0172	4159.8847	7078.8260	0.0261	210.3430	357.9382	437.0240	743.6785	3.3077	5.6288
8	1.6214	0.0429	0.5291	83.2487	0.0191	4151.9873	6741.6760	0.0261	195.7323	317.8150	405.9633	659.1718	3.0727	4.9891
9	1.6170	0.0434	0.5329	87.3282	0.0182	4155.9012	7072.0473	0.0262	206.5337	351.4560	427.6258	727.6857	3.2366	5.5077
10	1.7062	0.0444	0.5211	83.1638	0.0201	4147.7575	6734.8079	0.0262	194.9732	316.5824	402.9937	654.3500	3.0502	4.9526
11	1.7442	0.0466	0.5087	87.2010	0.0196	4149.8472	7061.7453	0.0263	202.4614	344.5261	417.7511	710.8820	3.1619	5.3805
12	1.8600	0.0504	0.4876	83.0101	0.0219	4140.0898	6722.3577	0.0263	200.6533	325.8054	413.3096	671.1002	3.1283	5.0794
13	2.0279	0.0570	0.4609	86.9174	0.0228	4136.3501	7038.7774	0.0263	203.8548	346.8973	419.1849	713.3219	3.1727	5.3990
14	2.3540	0.0690	0.4598	82.5160	0.0277	4115.4482	6682.3465	0.0264	209.0119	339.3774	429.0548	696.6660	3.2474	5.2729
15	0.8988	0.0417	0.2292	38.0147	0.0231	4135.0830	7036.6211	0.0264	537.3904	914.4707	1101.2613	1874.0032	8.3352	14.1840
Exit									0				0	

Table 19b Pin0.5_1S Re60k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.2263	-0.3737				
1	0.5000	0.0315	0.2345	0.0054	0.0010	0.0048	0.0092	0.0298	28.1842	6.5842	43.2646	21.4822	21.4682	21.3473
2	1.5625	0.0984	0.7327	0.0123	0.0020	0.0097	0.0201	0.0650	40.6388	19.0388	94.3598	22.0258	21.9957	21.7319
3	2.6250	0.1654	1.2309	0.0123	0.0023	0.0109	0.0210	0.0681	40.6732	19.0732	98.8906	22.5694	22.5485	22.2721
4	3.6875	0.2323	1.7291	0.0123	0.0020	0.0097	0.0201	0.0650	44.0450	22.4450	94.3598	23.1131	23.0759	22.8122
5	4.7500	0.2992	2.2273	0.0123	0.0023	0.0109	0.0210	0.0681	43.7961	22.1961	98.8906	23.6567	23.6287	23.3523
6	5.8125	0.3661	2.7256	0.0123	0.0020	0.0097	0.0201	0.0650	45.1083	23.5083	94.3598	24.2004	24.1562	23.8925
7	6.8750	0.4331	3.2238	0.0123	0.0023	0.0109	0.0210	0.0681	44.5310	22.9310	98.8906	24.7440	24.7090	24.4326
8	7.9375	0.5000	3.7220	0.0123	0.0020	0.0097	0.0201	0.0650	46.5248	24.9248	94.3598	25.2876	25.2365	24.9727
9	9.0000	0.5669	4.2202	0.0123	0.0023	0.0109	0.0210	0.0681	45.9416	24.3416	98.8906	25.8313	25.7893	25.5129
10	10.0625	0.6339	4.7184	0.0123	0.0020	0.0097	0.0201	0.0650	47.6424	26.0424	94.3598	26.3749	26.3168	26.0530
11	11.1250	0.7008	5.2167	0.0123	0.0023	0.0109	0.0210	0.0681	47.4097	25.8097	98.8906	26.9186	26.8696	26.5932
12	12.1875	0.7677	5.7149	0.0123	0.0020	0.0097	0.0201	0.0650	48.0678	26.4678	94.3598	27.4622	27.3970	27.1333
13	13.2500	0.8346	6.2131	0.0123	0.0023	0.0109	0.0210	0.0681	48.2705	26.6705	98.8906	28.0058	27.9498	27.6734
14	14.3125	0.9016	6.7113	0.0123	0.0020	0.0097	0.0201	0.0650	48.2428	26.6428	94.3598	28.5495	28.4773	28.2136
15	15.3750	0.9685	7.2095	0.0054	0.0010	0.0048	0.0092	0.0298	36.7229	15.1229	43.2646	29.0931	28.7192	28.5982
Exit									29.3489	7.7489				

Table 20a Pin0.5_1S Re70k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5082	0.0432	0.2240	42.7564	0.0117	4650.8646	7914.3206	0.0258	693.9532	1180.8918	1458.5136	2481.9351	9.6901	16.4896
2	1.7393	0.0678	0.4484	92.6205	0.0184	4619.4018	7500.6274	0.0258	248.1816	402.9781	520.7671	845.5814	3.4599	5.6179
3	1.4968	0.0556	0.4371	97.3938	0.0151	4634.9178	7887.1840	0.0259	256.0194	435.6651	536.3422	912.6871	3.5634	6.0637
4	1.5325	0.0480	0.4544	92.8273	0.0162	4629.7167	7517.3760	0.0259	221.1799	359.1349	462.6062	751.1442	3.0735	4.9905
5	1.4882	0.0448	0.4932	97.4024	0.0150	4635.3258	7887.8784	0.0259	230.1621	391.6640	480.6153	817.8573	3.1931	5.4337
6	1.5254	0.0432	0.5100	92.8344	0.0162	4630.0708	7517.9509	0.0260	221.4505	359.5742	461.6790	749.6387	3.0673	4.9805
7	1.5117	0.0429	0.5286	97.3789	0.0153	4634.2060	7885.9728	0.0260	234.2047	398.5433	487.4837	829.5451	3.2388	5.5114
8	1.5985	0.0429	0.5291	92.7613	0.0169	4626.4240	7512.0295	0.0261	217.8460	353.7215	452.7065	735.0698	3.0077	4.8837
9	1.5903	0.0434	0.5329	97.3003	0.0161	4630.4667	7879.6097	0.0261	230.2527	391.8183	477.7227	812.9350	3.1739	5.4010
10	1.6772	0.0444	0.5211	92.6826	0.0178	4622.4995	7505.6572	0.0261	217.3508	352.9174	450.2334	731.0542	2.9913	4.8570
11	1.7117	0.0466	0.5087	97.1789	0.0173	4624.6909	7869.7810	0.0262	225.6926	384.0584	466.7676	794.2929	3.1011	5.2772
12	1.8214	0.0504	0.4876	92.5384	0.0193	4615.3064	7493.9776	0.0262	223.9831	363.6865	462.4950	750.9637	3.0727	4.9893
13	1.9818	0.0570	0.4609	96.9088	0.0200	4611.8374	7847.9083	0.0263	227.5804	387.2708	469.1767	798.3923	3.1171	5.3044
14	2.2972	0.0690	0.4598	92.0625	0.0243	4591.5752	7455.4448	0.0263	233.1545	378.5782	479.9064	779.2349	3.1884	5.1771
15	0.8598	0.0417	0.2292	42.4048	0.0199	4612.6251	7849.2488	0.0264	604.5550	1028.7641	1242.3995	2114.1764	8.2543	14.0462
Exit									0				0	

Table 20b Pin0.5_1S Re70k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									20.9595	0.0595				
1	0.5000	0.0315	0.2345	0.0054	0.0010	0.0048	0.0092	0.0298	27.3508	6.4508	48.4579	21.1993	21.1917	21.0756
2	1.5625	0.0984	0.7327	0.0123	0.0020	0.0097	0.0201	0.0650	39.7394	18.8394	105.6863	21.7088	21.6983	21.4450
3	2.6250	0.1654	1.2309	0.0123	0.0023	0.0109	0.0210	0.0681	42.1765	21.2765	110.7610	22.2183	22.2292	21.9637
4	3.6875	0.2323	1.7291	0.0123	0.0020	0.0097	0.0201	0.0650	46.4124	25.5124	105.6863	22.7278	22.7357	22.4825
5	4.7500	0.2992	2.2273	0.0123	0.0023	0.0109	0.0210	0.0681	44.6069	23.7069	110.7610	23.2373	23.2666	23.0012
6	5.8125	0.3661	2.7256	0.0123	0.0020	0.0097	0.0201	0.0650	45.5235	24.6235	105.6863	23.7468	23.7732	23.5199
7	6.8750	0.4331	3.2238	0.0123	0.0023	0.0109	0.0210	0.0681	45.0080	24.1080	110.7610	24.2563	24.3040	24.0386
8	7.9375	0.5000	3.7220	0.0123	0.0020	0.0097	0.0201	0.0650	48.0534	27.1534	105.6863	24.7658	24.8106	24.5573
9	9.0000	0.5669	4.2202	0.0123	0.0023	0.0109	0.0210	0.0681	47.9078	27.0078	110.7610	25.2753	25.3415	25.0760
10	10.0625	0.6339	4.7184	0.0123	0.0020	0.0097	0.0201	0.0650	47.5275	26.6275	105.6863	25.7848	25.8480	25.5947
11	11.1250	0.7008	5.2167	0.0123	0.0023	0.0109	0.0210	0.0681	47.6631	26.7631	110.7610	26.2943	26.3789	26.1135
12	12.1875	0.7677	5.7149	0.0123	0.0020	0.0097	0.0201	0.0650	47.3983	26.4983	105.6863	26.8038	26.8855	26.6322
13	13.2500	0.8346	6.2131	0.0123	0.0023	0.0109	0.0210	0.0681	47.7722	26.8722	110.7610	27.3133	27.4163	27.1509
14	14.3125	0.9016	6.7113	0.0123	0.0020	0.0097	0.0201	0.0650	47.7569	26.8569	105.6863	27.8228	27.9229	27.6696
15	15.3750	0.9685	7.2095	0.0054	0.0010	0.0048	0.0092	0.0298	35.8383	14.9383	48.4579	28.3323	28.1551	28.0390
Exit									28.5720	7.6720				

Table 21a Pin0.5_1S Re80k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5025	0.0432	0.2240	47.9555	0.0104	5216.3971	8876.6804	0.0258	847.9838	1443.0038	1783.7584	3035.4004	10.4672	17.8119
2	1.7258	0.0678	0.4484	103.9605	0.0163	5184.9823	8418.9733	0.0258	287.5655	466.9267	603.9800	980.6961	3.5442	5.7548
3	1.6192	0.0556	0.4371	109.1418	0.0146	5193.9988	8838.5654	0.0258	260.2439	442.8538	545.7638	928.7198	3.2026	5.4498
4	1.6798	0.0480	0.4544	104.0065	0.0159	5187.2746	8422.6954	0.0259	219.0141	355.6182	458.6023	744.6429	2.6911	4.3696
5	1.5559	0.0448	0.4932	109.2051	0.0140	5197.0090	8843.6880	0.0259	243.1962	413.8440	508.4661	865.2507	2.9837	5.0773
6	1.5736	0.0432	0.5100	104.1128	0.0149	5192.5745	8431.3010	0.0259	238.4455	387.1694	497.7794	808.2557	2.9210	4.7429
7	1.5622	0.0429	0.5286	109.1988	0.0141	5196.7107	8843.1803	0.0260	250.4229	426.1417	521.9941	888.2710	3.0631	5.2124
8	1.6941	0.0429	0.5291	103.9922	0.0160	5186.5613	8421.5372	0.0260	222.7171	361.6308	463.5431	752.6655	2.7201	4.4167
9	1.7061	0.0434	0.5329	109.0549	0.0154	5189.8613	8831.5247	0.0261	229.3100	390.2141	476.5472	810.9347	2.7964	4.7586
10	1.7032	0.0444	0.5211	103.9831	0.0161	5186.1101	8420.8047	0.0261	238.5215	387.2928	494.9464	803.6556	2.9044	4.7159
11	1.7561	0.0466	0.5087	109.0049	0.0159	5187.4821	8827.4761	0.0261	242.7591	413.1003	502.9849	855.9234	2.9515	5.0226
12	1.8229	0.0504	0.4876	103.8634	0.0172	5180.1359	8411.1041	0.0262	251.5299	408.4148	520.3784	844.9502	3.0536	4.9582
13	1.9933	0.0570	0.4609	108.7677	0.0180	5176.1961	8808.2708	0.0262	253.0042	430.5342	522.6475	889.3829	3.0669	5.2190
14	2.3120	0.0690	0.4598	103.3743	0.0219	5155.7448	8371.4998	0.0263	258.6395	419.9587	533.4928	866.2444	3.1306	5.0832
15	0.8521	0.0417	0.2292	47.6058	0.0176	5178.3686	8811.9678	0.0263	689.8978	1173.9908	1420.9295	2417.9787	8.3381	14.1888
Exit									0				0	

Table 21b Pin0.5_1S Re80k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.0901	0.7901				
1	0.5000	0.0315	0.2345	0.0054	0.0022	0.0053	0.0085	0.0302	29.8885	9.5885	19.4628	21.4339	21.4699	21.2800
2	1.5625	0.0984	0.7327	0.0123	0.0041	0.0097	0.0180	0.0640	40.8420	20.5420	41.2401	22.1644	22.2747	21.8723
3	2.6250	0.1654	1.2309	0.0123	0.0051	0.0122	0.0194	0.0690	40.8128	20.5128	44.4864	22.8949	23.1428	22.7088
4	3.6875	0.2323	1.7291	0.0123	0.0041	0.0097	0.0180	0.0640	42.4189	22.1189	41.2401	23.6254	23.9476	23.5452
5	4.7500	0.2992	2.2273	0.0123	0.0051	0.0122	0.0194	0.0690	43.4592	23.1592	44.4864	24.3559	24.8157	24.3816
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0097	0.0211	0.0748	44.7649	24.4649	48.1965	25.0864	25.7562	25.2860
7	6.8750	0.4331	3.2238	0.0123	0.0051	0.0122	0.0194	0.0690	44.5415	24.2415	44.4864	25.8169	26.6243	26.1903
8	7.9375	0.5000	3.7220	0.0123	0.0041	0.0097	0.0180	0.0640	46.9623	26.6623	41.2401	26.5474	27.4291	27.0267
9	9.0000	0.5669	4.2202	0.0123	0.0051	0.0122	0.0194	0.0690	46.0947	25.7947	44.4864	27.2779	28.2972	27.8631
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0097	0.0211	0.0748	47.7722	27.4722	48.1965	28.0084	29.2377	28.7675
11	11.1250	0.7008	5.2167	0.0123	0.0051	0.0122	0.0194	0.0690	48.1542	27.8542	44.4864	28.7389	30.1058	29.6718
12	12.1875	0.7677	5.7149	0.0123	0.0041	0.0097	0.0180	0.0640	49.0480	28.7480	41.2401	29.4694	30.9106	30.5082
13	13.2500	0.8346	6.2131	0.0123	0.0051	0.0122	0.0194	0.0690	49.2051	28.9051	44.4864	30.1999	31.7787	31.3446
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0097	0.0211	0.0748	49.2118	28.9118	48.1965	30.9304	32.7192	32.2490
15	15.3750	0.9685	7.2095	0.0054	0.0022	0.0053	0.0085	0.0302	40.1469	19.8469	19.4628	31.6609	33.0990	32.9091
Exit									32.0047	11.7047				

Table 22a Pin1_2S Re20k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7196	0.0746	0.0043	18.7432	0.0370	2203.5239	3469.4074	0.0258	260.6304	410.3577	547.8582	862.5925	9.9217	15.6215
2	2.2388	0.1093	-0.0055	39.0013	0.0543	2163.9145	3158.4175	0.0258	115.8561	169.1019	243.0038	354.6848	4.4008	6.4233
3	1.8088	0.0883	-0.0024	42.6776	0.0407	2195.0956	3456.1372	0.0259	122.5085	192.8874	256.3977	403.6935	4.6434	7.3109
4	1.7553	0.0785	0.0179	39.4848	0.0426	2190.7390	3197.5700	0.0259	116.5692	170.1426	243.4377	355.3181	4.4087	6.4348
5	1.8054	0.0759	0.0483	42.6810	0.0406	2195.2700	3456.4118	0.0260	114.9156	180.9325	239.4652	377.0335	4.3367	6.8281
6	1.8957	0.0750	0.0602	46.3009	0.0393	2198.1325	3749.5556	0.0261	111.7024	190.5410	232.2671	396.1992	4.2064	7.1752
7	1.8965	0.0751	0.0760	42.5899	0.0426	2190.5849	3449.0352	0.0261	116.9899	184.1984	242.7380	382.1865	4.3960	6.9214
8	2.0939	0.0756	0.0775	39.1462	0.0508	2171.9548	3170.1529	0.0262	106.3909	155.2866	220.2729	321.5070	3.9891	5.8225
9	2.0541	0.0764	0.0830	42.4324	0.0462	2182.4799	3436.2741	0.0262	115.9859	182.6177	239.6246	377.2845	4.3396	6.8326
10	2.1872	0.0771	0.0686	46.0093	0.0454	2184.2897	3725.9427	0.0263	110.5198	188.5238	227.8445	388.6552	4.1263	7.0385
11	2.2755	0.0796	0.0592	42.2110	0.0511	2171.0923	3418.3445	0.0263	111.8238	176.0645	230.0422	362.1971	4.1661	6.5594
12	2.4477	0.0836	0.0434	38.7924	0.0594	2152.3251	3141.5017	0.0264	109.9325	160.4559	225.6715	329.3868	4.0869	5.9652
13	2.6742	0.0920	0.0160	41.8122	0.0601	2150.5829	3386.0529	0.0264	113.1577	178.1647	231.8007	364.9658	4.1979	6.6095
14	3.2017	0.1103	0.0134	44.9948	0.0664	2136.1279	3643.7887	0.0265	116.8470	199.3166	238.8529	407.4332	4.3256	7.3786
15	1.3852	0.0688	0.0203	18.0776	0.0712	2125.2748	3346.2056	0.0266	250.4458	394.3222	510.8716	804.3578	9.2519	14.5669
Exit									0				0	

Table 22b Pin1_2S Re20k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									20.8275	0.6275				
1	0.5000	0.0315	0.2345	0.0054	0.0022	0.0053	0.0085	0.0302	29.0988	8.8988	24.9049	21.1269	21.1504	20.9890
2	1.5625	0.0984	0.7327	0.0123	0.0041	0.0097	0.0180	0.0640	40.3593	20.1593	52.7715	21.7630	21.8345	21.4925
3	2.6250	0.1654	1.2309	0.0123	0.0051	0.0122	0.0194	0.0690	40.3365	20.1365	56.9256	22.3991	22.5726	22.2036
4	3.6875	0.2323	1.7291	0.0123	0.0041	0.0097	0.0180	0.0640	41.7754	21.5754	52.7715	23.0352	23.2567	22.9146
5	4.7500	0.2992	2.2273	0.0123	0.0051	0.0122	0.0194	0.0690	42.7072	22.5072	56.9256	23.6713	23.9947	23.6257
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0097	0.0211	0.0748	43.7476	23.5476	61.6731	24.3074	24.7943	24.3945
7	6.8750	0.4331	3.2238	0.0123	0.0051	0.0122	0.0194	0.0690	43.4429	23.2429	56.9256	24.9435	25.5323	25.1633
8	7.9375	0.5000	3.7220	0.0123	0.0041	0.0097	0.0180	0.0640	45.8757	25.6757	52.7715	25.5796	26.2165	25.8744
9	9.0000	0.5669	4.2202	0.0123	0.0051	0.0122	0.0194	0.0690	44.7988	24.5988	56.9256	26.2157	26.9545	26.5855
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0097	0.0211	0.0748	46.4006	26.2006	61.6731	26.8518	27.7540	27.3542
11	11.1250	0.7008	5.2167	0.0123	0.0051	0.0122	0.0194	0.0690	46.8646	26.6646	56.9256	27.4879	28.4920	28.1230
12	12.1875	0.7677	5.7149	0.0123	0.0041	0.0097	0.0180	0.0640	47.6386	27.4386	52.7715	28.1240	29.1762	28.8341
13	13.2500	0.8346	6.2131	0.0123	0.0051	0.0122	0.0194	0.0690	47.8785	27.6785	56.9256	28.7601	29.9142	29.5452
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0097	0.0211	0.0748	48.0436	27.8436	61.6731	29.3962	30.7138	30.3140
15	15.3750	0.9685	7.2095	0.0054	0.0022	0.0053	0.0085	0.0302	38.5320	18.3320	24.9049	30.0323	31.0366	30.8752
Exit									30.3317	10.1317				

Table 23a Pin1_2S Re30k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6682	0.0746	0.0043	24.2367	0.0268	2849.3736	4486.2858	0.0257	357.4262	562.7609	752.0196	1184.0409	9.7992	15.4286
2	2.1970	0.1093	-0.0055	50.5745	0.0416	2806.0347	4095.6465	0.0258	150.8915	220.2391	316.8693	462.4978	4.1290	6.0266
3	1.7756	0.0883	-0.0024	55.1500	0.0312	2836.6048	4466.1816	0.0258	158.1384	248.9860	331.4571	521.8730	4.3190	6.8002
4	1.7126	0.0785	0.0179	51.0589	0.0325	2832.9082	4134.8707	0.0259	151.1675	220.6419	316.2459	461.5879	4.1208	6.0147
5	1.7559	0.0759	0.0483	55.1697	0.0308	2837.6149	4467.7719	0.0259	149.0663	234.7022	311.2610	490.0746	4.0559	6.3859
6	1.8268	0.0750	0.0602	59.8463	0.0296	2841.2001	4846.4949	0.0260	146.1507	249.3026	304.5977	519.5801	3.9690	6.7704
7	1.8215	0.0751	0.0760	55.1041	0.0320	2834.2424	4462.4620	0.0260	153.2068	241.2212	318.7032	501.7922	4.1528	6.5386
8	2.0193	0.0756	0.0775	50.7522	0.0383	2815.8949	4110.0383	0.0261	138.7408	202.5041	288.0696	420.4621	3.7537	5.4788
9	1.9627	0.0764	0.0830	54.9629	0.0345	2826.9805	4451.0282	0.0261	152.1265	239.5204	315.2715	496.3891	4.1081	6.4682
10	2.0892	0.0771	0.0686	59.5839	0.0339	2828.7460	4825.2507	0.0262	144.7020	246.8315	299.3251	510.5861	3.9003	6.6532
11	2.1808	0.0796	0.0592	54.7448	0.0383	2815.7612	4433.3636	0.0262	145.3167	228.7985	300.0370	472.4026	3.9096	6.1556
12	2.3381	0.0836	0.0434	50.4333	0.0443	2798.2016	4084.2135	0.0263	143.3905	209.2907	295.5100	431.3220	3.8506	5.6203
13	2.5614	0.0920	0.0160	54.3642	0.0450	2796.1852	4402.5417	0.0263	146.2564	230.2779	300.8576	473.6948	3.9203	6.1725
14	3.0839	0.1103	0.0134	58.5892	0.0500	2781.5212	4744.6951	0.0264	149.1644	254.4434	306.2725	522.4371	3.9909	6.8076
15	1.2811	0.0688	0.0203	23.6239	0.0514	2777.3237	4372.8445	0.0264	326.7571	514.4730	669.6785	1054.3963	8.7262	13.7393
Exit									0				0	

Table 23b Pin1_2S Re30k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									20.5982	0.7982				
1	0.5000	0.0315	0.2345	0.0054	0.0022	0.0053	0.0085	0.0302	28.4712	8.6712	29.2790	20.8672	20.8792	20.7387
2	1.5625	0.0984	0.7327	0.0123	0.0041	0.0097	0.0180	0.0640	39.9270	20.1270	62.0398	21.4386	21.4745	21.1768
3	2.6250	0.1654	1.2309	0.0123	0.0051	0.0122	0.0194	0.0690	40.0706	20.2706	66.9235	22.0100	22.1166	21.7955
4	3.6875	0.2323	1.7291	0.0123	0.0041	0.0097	0.0180	0.0640	41.3935	21.5935	62.0398	22.5814	22.7119	22.4143
5	4.7500	0.2992	2.2273	0.0123	0.0051	0.0122	0.0194	0.0690	42.2801	22.4801	66.9235	23.1528	23.3541	23.0330
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0097	0.0211	0.0748	43.0835	23.2835	72.5048	23.7242	24.0498	23.7019
7	6.8750	0.4331	3.2238	0.0123	0.0051	0.0122	0.0194	0.0690	42.7230	22.9230	66.9235	24.2957	24.6919	24.3708
8	7.9375	0.5000	3.7220	0.0123	0.0041	0.0097	0.0180	0.0640	45.1446	25.3446	62.0398	24.8671	25.2872	24.9895
9	9.0000	0.5669	4.2202	0.0123	0.0051	0.0122	0.0194	0.0690	43.9067	24.1067	66.9235	25.4385	25.9293	25.6083
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0097	0.0211	0.0748	45.4357	25.6357	72.5048	26.0099	26.6250	26.2772
11	11.1250	0.7008	5.2167	0.0123	0.0051	0.0122	0.0194	0.0690	45.9414	26.1414	66.9235	26.5813	27.2672	26.9461
12	12.1875	0.7677	5.7149	0.0123	0.0041	0.0097	0.0180	0.0640	46.5969	26.7969	62.0398	27.1528	27.8625	27.5648
13	13.2500	0.8346	6.2131	0.0123	0.0051	0.0122	0.0194	0.0690	46.8015	27.0015	66.9235	27.7242	28.5046	28.1835
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0097	0.0211	0.0748	47.0092	27.2092	72.5048	28.2956	29.2003	28.8525
15	15.3750	0.9685	7.2095	0.0054	0.0022	0.0053	0.0085	0.0302	37.0952	17.2952	29.2790	28.8670	29.4812	29.3408
Exit									29.1359	9.3359				

Table 24a Pin1_2S Re40k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6512	0.0746	0.0043	28.6278	0.0222	3365.6055	5299.0833	0.0257	442.6085	696.8789	931.9680	1467.3663	9.5312	15.0067
2	2.1934	0.1093	-0.0055	59.8464	0.0354	3320.4661	4846.5029	0.0258	179.5965	262.1364	377.5157	551.0162	3.8608	5.6352
3	1.7874	0.0883	-0.0024	65.1361	0.0267	3350.2318	5274.8777	0.0258	185.4994	292.0654	389.2576	612.8789	3.9809	6.2679
4	1.7140	0.0785	0.0179	60.3258	0.0276	3347.0646	4885.3258	0.0259	177.9205	259.6901	372.7173	544.0127	3.8118	5.5636
5	1.7539	0.0759	0.0483	65.1696	0.0262	3351.9565	5277.5932	0.0259	175.2453	275.9205	366.4889	577.0299	3.7481	5.9013
6	1.8070	0.0750	0.0602	70.6978	0.0249	3356.3764	5725.2782	0.0259	173.3732	295.7384	361.9584	617.4255	3.7017	6.3144
7	1.7975	0.0751	0.0760	65.1260	0.0269	3349.7138	5274.0621	0.0260	181.7793	286.2081	378.8657	596.5169	3.8746	6.1006
8	1.9942	0.0756	0.0775	60.0456	0.0321	3331.5197	4862.6367	0.0260	164.2963	239.8045	341.8490	498.9577	3.4961	5.1028
9	1.9251	0.0764	0.0830	64.9984	0.0288	3343.1502	5263.7278	0.0261	181.0222	285.0161	376.0154	592.0293	3.8455	6.0547
10	2.0456	0.0771	0.0686	70.4592	0.0282	3345.0497	5705.9571	0.0261	172.1962	293.7308	357.0806	609.1050	3.6518	6.2293
11	2.1392	0.0796	0.0592	64.7843	0.0320	3332.1380	5246.3894	0.0262	172.1138	270.9900	356.3107	561.0046	3.6440	5.7374
12	2.2845	0.0836	0.0434	59.7553	0.0368	3315.4146	4839.1299	0.0262	170.5097	248.8734	352.3986	514.3558	3.6040	5.2603
13	2.4991	0.0920	0.0160	64.4243	0.0373	3313.6233	5217.2383	0.0263	173.6948	273.4792	358.3816	564.2652	3.6652	5.7707
14	3.0140	0.1103	0.0134	69.4909	0.0416	3299.0779	5627.5388	0.0263	176.2926	300.7185	363.1352	619.4330	3.7138	6.3349
15	1.2097	0.0688	0.0203	28.0693	0.0413	3299.9423	5195.6979	0.0263	401.0558	631.4549	824.7379	1298.5345	8.4346	13.2801
Exit									0				0	0

Table 24b Pin1_2S Re40k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									20.3926	0.3926				
1	0.5000	0.0315	0.2345	0.0054	0.0022	0.0053	0.0085	0.0302	27.6795	7.6795	37.0845	20.6487	20.6739	20.5332
2	1.5625	0.0984	0.7327	0.0123	0.0041	0.0097	0.0180	0.0640	40.2499	20.2499	78.5789	21.1927	21.2698	20.9718
3	2.6250	0.1654	1.2309	0.0123	0.0051	0.0122	0.0194	0.0690	40.3995	20.3995	84.7645	21.7368	21.9127	21.5912
4	3.6875	0.2323	1.7291	0.0123	0.0041	0.0097	0.0180	0.0640	41.6778	21.6778	78.5789	22.2809	22.5086	22.2106
5	4.7500	0.2992	2.2273	0.0123	0.0051	0.0122	0.0194	0.0690	42.2000	22.2000	84.7645	22.8250	23.1515	22.8300
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0097	0.0211	0.0748	42.5491	22.5491	91.8338	23.3691	23.8479	23.4997
7	6.8750	0.4331	3.2238	0.0123	0.0051	0.0122	0.0194	0.0690	42.1452	22.1452	84.7645	23.9132	24.4908	24.1694
8	7.9375	0.5000	3.7220	0.0123	0.0041	0.0097	0.0180	0.0640	44.4316	24.4316	78.5789	24.4572	25.0867	24.7888
9	9.0000	0.5669	4.2202	0.0123	0.0051	0.0122	0.0194	0.0690	43.0393	23.0393	84.7645	25.0013	25.7296	25.4082
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0097	0.0211	0.0748	44.4214	24.4214	91.8338	25.5454	26.4261	26.0778
11	11.1250	0.7008	5.2167	0.0123	0.0051	0.0122	0.0194	0.0690	45.0134	25.0134	84.7645	26.0895	27.0689	26.7475
12	12.1875	0.7677	5.7149	0.0123	0.0041	0.0097	0.0180	0.0640	45.7058	25.7058	78.5789	26.6336	27.6649	27.3669
13	13.2500	0.8346	6.2131	0.0123	0.0051	0.0122	0.0194	0.0690	45.7284	25.7284	84.7645	27.1777	28.3077	27.9863
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0097	0.0211	0.0748	46.2674	26.2674	91.8338	27.7218	29.0042	28.6560
15	15.3750	0.9685	7.2095	0.0054	0.0022	0.0053	0.0085	0.0302	36.0636	16.0636	37.0845	28.2658	29.2854	29.1448
Exit									28.5219	8.5219				

Table 25a Pin1_2S Re50k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5772	0.0746	0.0043	36.5073	0.0156	4291.9461	6757.5894	0.0257	610.4493	961.1411	1286.2217	2025.1322	10.8883	17.1435
2	2.2069	0.1093	-0.0055	76.3721	0.0281	4237.3642	6184.7937	0.0258	222.3504	324.5393	467.7296	682.6912	3.9595	5.7792
3	1.7988	0.0883	-0.0024	82.9658	0.0212	4267.2890	6718.7672	0.0258	228.6534	360.0106	480.2053	756.0743	4.0651	6.4004
4	1.7207	0.0785	0.0179	76.8583	0.0219	4264.3404	6224.1678	0.0258	219.8471	320.8855	460.9605	672.8112	3.9022	5.6956
5	1.7326	0.0759	0.0483	83.0319	0.0204	4270.6922	6724.1255	0.0259	220.4231	347.0521	461.4190	726.4956	3.9061	6.1501
6	1.7519	0.0750	0.0602	90.0819	0.0191	4276.6351	7295.0476	0.0259	222.9740	380.3471	466.0036	794.9050	3.9449	6.7292
7	1.7390	0.0751	0.0760	83.0255	0.0205	4270.3610	6723.6041	0.0260	234.2230	368.7798	488.7231	769.4854	4.1372	6.5140
8	1.9252	0.0756	0.0775	76.6538	0.0245	4252.9932	6207.6057	0.0260	212.9225	310.7786	443.5623	647.4170	3.7549	5.4806
9	1.8435	0.0764	0.0830	82.9210	0.0217	4264.9880	6715.1443	0.0260	236.4453	372.2787	491.7732	774.2877	4.1630	6.5546
10	1.9520	0.0771	0.0686	89.8819	0.0213	4267.1384	7278.8482	0.0261	226.0619	385.6144	469.4228	800.7374	3.9738	6.7785
11	2.0494	0.0796	0.0592	82.7151	0.0242	4254.3970	6698.4690	0.0261	224.8156	353.9680	466.0875	733.8460	3.9456	6.2123
12	2.1932	0.0836	0.0434	76.3857	0.0279	4238.1201	6185.8970	0.0262	222.2139	324.3401	459.9575	671.3471	3.8937	5.6832
13	2.3821	0.0920	0.0160	82.3825	0.0281	4237.2874	6671.5303	0.0262	228.4160	359.6367	472.0414	743.2203	3.9960	6.2916
14	2.9101	0.1103	0.0134	88.9237	0.0317	4221.6513	7201.2568	0.0263	227.6352	388.2981	469.6793	801.1749	3.9760	6.7822
15	1.1250	0.0688	0.0203	35.9594	0.0303	4227.5425	6656.1871	0.0263	542.1478	853.6016	1116.8366	1758.4384	9.4544	14.8858
Exit									0				0	

Table 25b Pin1_2S Re50k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									20.1468	0.1468				
1	0.5000	0.0315	0.2345	0.0054	0.0022	0.0053	0.0085	0.0302	27.5920	7.5920	43.0678	20.4015	20.4251	20.2860
2	1.5625	0.0984	0.7327	0.0123	0.0041	0.0097	0.0180	0.0640	41.0745	21.0745	91.2571	20.9427	21.0147	20.7199
3	2.6250	0.1654	1.2309	0.0123	0.0051	0.0122	0.0194	0.0690	41.1339	21.1339	98.4408	21.4839	21.6508	21.3328
4	3.6875	0.2323	1.7291	0.0123	0.0041	0.0097	0.0180	0.0640	42.5779	22.5779	91.2571	22.0251	22.2404	21.9456
5	4.7500	0.2992	2.2273	0.0123	0.0051	0.0122	0.0194	0.0690	42.9324	22.9324	98.4408	22.5663	22.8765	22.5584
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0097	0.0211	0.0748	43.1859	23.1859	106.6506	23.1075	23.5656	23.2210
7	6.8750	0.4331	3.2238	0.0123	0.0051	0.0122	0.0194	0.0690	42.6964	22.6964	98.4408	23.6487	24.2016	23.8836
8	7.9375	0.5000	3.7220	0.0123	0.0041	0.0097	0.0180	0.0640	44.9022	24.9022	91.2571	24.1899	24.7912	24.4964
9	9.0000	0.5669	4.2202	0.0123	0.0051	0.0122	0.0194	0.0690	43.3728	23.3728	98.4408	24.7311	25.4273	25.1093
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0097	0.0211	0.0748	44.6865	24.6865	106.6506	25.2723	26.1164	25.7718
11	11.1250	0.7008	5.2167	0.0123	0.0051	0.0122	0.0194	0.0690	45.3278	25.3278	98.4408	25.8135	26.7524	26.4344
12	12.1875	0.7677	5.7149	0.0123	0.0041	0.0097	0.0180	0.0640	45.9667	25.9667	91.2571	26.3547	27.3420	27.0472
13	13.2500	0.8346	6.2131	0.0123	0.0051	0.0122	0.0194	0.0690	46.0744	26.0744	98.4408	26.8959	27.9781	27.6601
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0097	0.0211	0.0748	46.5195	26.5195	106.6506	27.4371	28.6672	28.3226
15	15.3750	0.9685	7.2095	0.0054	0.0022	0.0053	0.0085	0.0302	36.0287	16.0287	43.0678	27.9783	28.9454	28.8063
Exit									28.2329	8.2329				

Table 26a Pin1_2S Re60k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5707	0.0746	0.0043	42.4971	0.0133	4996.1394	7866.3286	0.0257	694.8238	1093.9871	1465.0875	2306.7530	10.9042	17.1685
2	2.2969	0.1093	-0.0055	88.9602	0.0252	4935.7924	7204.2092	0.0257	245.1744	357.8530	516.1286	753.3336	3.8414	5.6068
3	1.8636	0.0883	-0.0024	96.5771	0.0189	4967.3804	7821.0482	0.0258	252.7929	398.0178	531.3039	836.5281	3.9543	6.2260
4	1.7914	0.0785	0.0179	89.4658	0.0196	4963.8439	7245.1527	0.0258	241.5163	352.5137	506.7823	739.6918	3.7718	5.5053
5	1.7882	0.0759	0.0483	96.6526	0.0182	4971.2607	7827.1576	0.0259	244.0953	384.3235	511.3669	805.1377	3.8060	5.9924
6	1.7997	0.0750	0.0602	104.8509	0.0169	4977.7935	8491.0776	0.0259	247.9183	422.8969	518.5391	884.5196	3.8593	6.5832
7	1.7804	0.0751	0.0760	96.6603	0.0181	4971.6585	7827.7840	0.0259	261.0111	410.9572	545.0461	858.1649	4.0566	6.3871
8	1.9608	0.0756	0.0775	89.2964	0.0215	4954.4453	7231.4348	0.0260	239.2031	349.1373	498.7051	727.9025	3.7117	5.4176
9	1.8690	0.0764	0.0830	96.5718	0.0190	4967.1038	7820.6126	0.0260	266.4511	419.5222	554.6239	873.2450	4.1279	6.4993
10	1.9724	0.0771	0.0686	104.6782	0.0185	4969.5944	8477.0916	0.0261	255.9772	436.6436	531.9710	907.4316	3.9593	6.7537
11	2.0744	0.0796	0.0592	96.3663	0.0211	4956.5372	7803.9757	0.0261	253.9953	399.9108	527.0107	829.7685	3.9224	6.1757
12	2.2150	0.0836	0.0434	89.0421	0.0243	4940.3364	7210.8416	0.0261	251.9039	367.6752	521.8399	761.6698	3.8839	5.6689
13	2.4139	0.0920	0.0160	96.0269	0.0245	4939.0777	7776.4860	0.0262	257.5319	405.4792	532.6518	838.6503	3.9644	6.2418
14	2.9379	0.1103	0.0134	103.7127	0.0275	4923.7585	8398.9051	0.0262	258.0261	440.1387	532.8284	908.8941	3.9657	6.7646
15	1.1226	0.0688	0.0203	41.9452	0.0261	4931.2515	7764.1639	0.0263	612.5461	964.4425	1262.9184	1988.4416	9.3995	14.7994
Exit									0				0	

Table 26b Pin1_2S Re60k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									19.4176	-0.5824				
1	0.5000	0.0315	0.2345	0.0054	0.0022	0.0053	0.0085	0.0302	26.7302	6.7302	48.5033	19.6588	19.6848	19.5512
2	1.5625	0.0984	0.7327	0.0123	0.0041	0.0097	0.0180	0.0640	40.8001	20.8001	102.7745	20.1713	20.2511	19.9680
3	2.6250	0.1654	1.2309	0.0123	0.0051	0.0122	0.0194	0.0690	41.2787	21.2787	110.8648	20.6838	20.8619	20.5565
4	3.6875	0.2323	1.7291	0.0123	0.0041	0.0097	0.0180	0.0640	42.7312	22.7312	102.7745	21.1963	21.4281	21.1450
5	4.7500	0.2992	2.2273	0.0123	0.0051	0.0122	0.0194	0.0690	43.3466	23.3466	110.8648	21.7088	22.0389	21.7335
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0097	0.0211	0.0748	43.4850	23.4850	120.1108	22.2213	22.7007	22.3698
7	6.8750	0.4331	3.2238	0.0123	0.0051	0.0122	0.0194	0.0690	42.9735	22.9735	110.8648	22.7338	23.3115	23.0061
8	7.9375	0.5000	3.7220	0.0123	0.0041	0.0097	0.0180	0.0640	45.0971	25.0971	102.7745	23.2463	23.8778	23.5946
9	9.0000	0.5669	4.2202	0.0123	0.0051	0.0122	0.0194	0.0690	43.4396	23.4396	110.8648	23.7588	24.4886	24.1832
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0097	0.0211	0.0748	44.6343	24.6343	120.1108	24.2713	25.1503	24.8195
11	11.1250	0.7008	5.2167	0.0123	0.0051	0.0122	0.0194	0.0690	45.5251	25.5251	110.8648	24.7838	25.7611	25.4557
12	12.1875	0.7677	5.7149	0.0123	0.0041	0.0097	0.0180	0.0640	45.8764	25.8764	102.7745	25.2963	26.3274	26.0443
13	13.2500	0.8346	6.2131	0.0123	0.0051	0.0122	0.0194	0.0690	46.1886	26.1886	110.8648	25.8088	26.9382	26.6328
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0097	0.0211	0.0748	46.3566	26.3566	120.1108	26.3213	27.6000	27.2691
15	15.3750	0.9685	7.2095	0.0054	0.0022	0.0053	0.0085	0.0302	35.1717	15.1717	48.5033	26.8338	27.8672	27.7336
Exit									27.0750	7.0750				

Table 27a Pin1_2S Re70k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5064	0.0746	0.0043	47.9969	0.0104	5642.7198	8884.3575	0.0256	797.9561	1256.3671	1686.3180	2655.0763	11.0266	17.3612
2	2.2670	0.1093	-0.0055	100.5076	0.0221	5576.4775	8139.3436	0.0257	270.3240	394.5609	570.3932	832.5374	3.7297	5.4439
3	1.8764	0.0883	-0.0024	108.9884	0.0169	5605.7450	8826.1413	0.0257	272.1906	428.5590	573.4472	902.8820	3.7497	5.9038
4	1.8034	0.0785	0.0179	100.9711	0.0175	5602.1979	8176.8847	0.0258	260.1442	379.7027	547.2258	798.7227	3.5782	5.2227
5	1.8196	0.0759	0.0483	109.0452	0.0164	5608.6663	8830.7409	0.0258	259.2063	408.1155	544.4165	857.1736	3.5599	5.6049
6	1.8221	0.0750	0.0602	118.2886	0.0152	5615.7501	9579.2984	0.0258	264.0995	450.4987	553.8446	944.7435	3.6215	6.1776
7	1.8013	0.0751	0.0760	109.0635	0.0162	5609.6104	8832.2274	0.0259	277.1590	436.3817	580.3437	913.7404	3.7948	5.9748
8	1.9755	0.0756	0.0775	100.7990	0.0192	5592.6496	8162.9483	0.0259	255.9469	373.5762	535.1104	781.0393	3.4990	5.1071
9	1.8741	0.0764	0.0830	108.9907	0.0169	5605.8632	8826.3275	0.0259	284.8383	448.4727	594.6079	936.1991	3.8881	6.1217
10	1.9684	0.0771	0.0686	118.1424	0.0164	5608.8075	9567.4558	0.0260	275.4403	469.8437	574.1160	979.3222	3.7541	6.4037
11	2.0901	0.0796	0.0592	108.7747	0.0189	5594.7518	8808.8327	0.0260	269.7395	424.6998	561.3813	883.8844	3.6708	5.7796
12	2.2075	0.0836	0.0434	100.5670	0.0215	5579.7775	8144.1603	0.0261	271.1250	395.7300	563.4112	822.3467	3.6841	5.3772
13	2.4244	0.0920	0.0160	108.4404	0.0219	5577.5596	8781.7639	0.0261	273.6806	430.9050	567.8634	894.0903	3.7132	5.8463
14	2.9199	0.1103	0.0134	117.1909	0.0243	5563.6333	9490.3981	0.0261	277.6912	473.6832	575.3168	981.3704	3.7619	6.4171
15	1.0637	0.0688	0.0203	47.4396	0.0219	5577.2023	8781.2014	0.0262	668.8930	1053.1596	1383.7195	2178.6407	9.0480	14.2459
Exit									0				0	

Table 27b Pin1_2S Re70k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									19.0478	-1.4522				
1	0.5000	0.0315	0.2345	0.0054	0.0022	0.0053	0.0085	0.0302	26.3550	5.8550	54.6981	19.2766	19.3073	19.1775
2	1.5625	0.0984	0.7327	0.0123	0.0041	0.0097	0.0180	0.0640	40.8069	20.3069	115.9007	19.7629	19.8573	19.5823
3	2.6250	0.1654	1.2309	0.0123	0.0051	0.0122	0.0194	0.0690	41.0237	20.5237	125.0242	20.2492	20.4505	20.1539
4	3.6875	0.2323	1.7291	0.0123	0.0041	0.0097	0.0180	0.0640	42.5399	22.0399	115.9007	20.7355	21.0005	20.7255
5	4.7500	0.2992	2.2273	0.0123	0.0051	0.0122	0.0194	0.0690	43.2622	22.7622	125.0242	21.2218	21.5937	21.2971
6	5.8125	0.3661	2.7256	0.0123	0.0010	0.0097	0.0211	0.0748	43.2790	22.7790	135.4511	21.7081	22.2364	21.9151
7	6.8750	0.4331	3.2238	0.0123	0.0051	0.0122	0.0194	0.0690	42.8807	22.3807	125.0242	22.1944	22.8296	22.5330
8	7.9375	0.5000	3.7220	0.0123	0.0041	0.0097	0.0180	0.0640	45.0079	24.5079	115.9007	22.6807	23.3796	23.1046
9	9.0000	0.5669	4.2202	0.0123	0.0051	0.0122	0.0194	0.0690	43.3130	22.8130	125.0242	23.1670	23.9728	23.6762
10	10.0625	0.6339	4.7184	0.0123	0.0010	0.0097	0.0211	0.0748	44.4267	23.9267	135.4511	23.6533	24.6155	24.2942
11	11.1250	0.7008	5.2167	0.0123	0.0051	0.0122	0.0194	0.0690	45.4151	24.9151	125.0242	24.1396	25.2088	24.9122
12	12.1875	0.7677	5.7149	0.0123	0.0041	0.0097	0.0180	0.0640	45.5420	25.0420	115.9007	24.6259	25.7587	25.4838
13	13.2500	0.8346	6.2131	0.0123	0.0051	0.0122	0.0194	0.0690	45.9277	25.4277	125.0242	25.1123	26.3520	26.0554
14	14.3125	0.9016	6.7113	0.0123	0.0010	0.0097	0.0211	0.0748	46.0423	25.5423	135.4511	25.5986	26.9947	26.6733
15	15.3750	0.9685	7.2095	0.0054	0.0022	0.0053	0.0085	0.0302	34.3977	13.8977	54.6981	26.0849	27.2542	27.1245
Exit									26.3137	5.8137				

Table 28a Pin1_2S Re80k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.4411	0.0746	0.0043	54.2570	0.0081	6378.6768	10043.1081	0.0256	901.1438	1418.8342	1906.5824	3001.8785	11.0492	17.3968
2	2.2131	0.1093	-0.0055	113.6876	0.0191	6307.7486	9206.6960	0.0256	299.7417	437.4985	633.2442	924.2738	3.6698	5.3564
3	1.8097	0.0883	-0.0024	123.2145	0.0145	6337.4548	9978.2048	0.0257	305.0595	480.3106	643.5354	1013.2346	3.7295	5.8720
4	1.7491	0.0785	0.0179	114.1516	0.0151	6333.4918	9244.2704	0.0257	290.4686	423.9636	611.8599	893.0616	3.5459	5.1756
5	1.7753	0.0759	0.0483	123.2490	0.0142	6339.2278	9980.9964	0.0258	287.6184	452.8498	604.9726	952.5182	3.5060	5.5201
6	1.7692	0.0750	0.0602	133.6819	0.0131	6346.5457	10825.8835	0.0258	294.2180	501.8745	617.9534	1054.0997	3.5812	6.1088
7	1.7567	0.0751	0.0760	123.2675	0.0141	6340.1813	9982.4975	0.0258	306.4927	482.5671	642.7992	1012.0754	3.7252	5.8653
8	1.9309	0.0756	0.0775	113.9698	0.0167	6323.4031	9229.5451	0.0259	283.2161	413.3780	593.1205	865.7099	3.4373	5.0170
9	1.8262	0.0764	0.0830	123.1980	0.0146	6336.6070	9976.8699	0.0259	314.5345	495.2287	657.7552	1035.6233	3.8119	6.0017
10	1.9138	0.0771	0.0686	133.5373	0.0141	6339.6795	10814.1712	0.0259	305.1839	520.5800	637.2793	1087.0655	3.6932	6.2999
11	2.0416	0.0796	0.0592	122.9826	0.0163	6325.5293	9959.4283	0.0260	297.3161	468.1186	619.9547	976.1072	3.5928	5.6568
12	2.1377	0.0836	0.0434	113.7630	0.0184	6311.9303	9212.7996	0.0260	301.7748	440.4660	628.3464	917.1250	3.6414	5.3150
13	2.3544	0.0920	0.0160	122.6698	0.0188	6309.4394	9934.0951	0.0261	303.1126	477.2452	630.2255	992.2783	3.6523	5.7505
14	2.8301	0.1103	0.0134	132.6210	0.0209	6296.1776	10739.9659	0.0261	307.9755	525.3420	639.4182	1090.7141	3.7056	6.3210
15	0.9761	0.0688	0.0203	53.7220	0.0178	6315.7842	9944.0848	0.0261	759.7602	1196.2283	1575.1555	2480.0531	9.1285	14.3726
Exit									0				0	

Table 28b Pin1_2S Re80k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.5340	1.6340				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0069	0.0116	0.0300	31.6604	10.7604	16.6777	22.8221	22.8456	22.6898
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0139	0.0250	0.0645	43.3860	22.4860	35.8530	23.4345	23.5156	23.1806
3	2.6250	0.1654	1.2309	0.0123	0.0015	0.0157	0.0266	0.0686	45.8757	24.9757	38.1204	24.0468	24.2279	23.8717
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0139	0.0250	0.0645	47.7359	26.8359	35.8530	24.6592	24.8978	24.5629
5	4.7500	0.2992	2.2273	0.0123	0.0015	0.0157	0.0266	0.0686	47.2278	26.3278	38.1204	25.2715	25.6101	25.2540
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0139	0.0250	0.0645	47.5805	26.6805	35.8530	25.8839	26.2801	25.9451
7	6.8750	0.4331	3.2238	0.0123	0.0015	0.0157	0.0266	0.0686	47.5897	26.6897	38.1204	26.4962	26.9924	26.6362
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0139	0.0250	0.0645	49.4387	28.5387	35.8530	27.1085	27.6623	27.3274
9	9.0000	0.5669	4.2202	0.0123	0.0015	0.0157	0.0266	0.0686	49.0807	28.1807	38.1204	27.7209	28.3747	28.0185
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0139	0.0250	0.0645	50.6091	29.7091	35.8530	28.3332	29.0446	28.7096
11	11.1250	0.7008	5.2167	0.0123	0.0015	0.0157	0.0266	0.0686	50.4117	29.5117	38.1204	28.9456	29.7569	29.4008
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0139	0.0250	0.0645	51.5414	30.6414	35.8530	29.5579	30.4269	30.0919
13	13.2500	0.8346	6.2131	0.0123	0.0015	0.0157	0.0266	0.0686	51.3811	30.4811	38.1204	30.1703	31.1392	30.7830
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0139	0.0250	0.0645	51.2108	30.3108	35.8530	30.7826	31.8091	31.4742
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0069	0.0116	0.0300	41.8614	20.9614	16.6777	31.3949	32.1208	31.9650
Exit									31.6831	10.7831				

Table 29a Fin0.125_1S Re20k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.8737	0.0875	-0.0681	15.8040	0.0524	1359.3417	2925.3544	0.0259	153.8020	330.9877	321.9615	692.8733	5.6385	12.1343
2	2.7102	0.1282	-0.1714	33.1428	0.0756	1326.0564	2683.9824	0.0259	66.4640	134.5253	138.8791	281.0960	2.4322	4.9228
3	2.4099	0.1038	-0.1835	35.7105	0.0632	1343.8072	2891.9237	0.0260	61.5609	132.4814	128.4003	276.3223	2.2487	4.8392
4	2.3010	0.0921	-0.1712	33.5520	0.0642	1342.4292	2717.1216	0.0260	58.1725	117.7431	121.1131	245.1370	2.1211	4.2931
5	2.1824	0.0886	-0.1505	35.9380	0.0573	1352.3684	2910.3476	0.0261	61.5938	132.5522	128.0044	275.4702	2.2417	4.8243
6	2.1999	0.0877	-0.1396	33.6531	0.0614	1346.4760	2725.3125	0.0261	62.0591	125.6096	128.7386	260.5713	2.2546	4.5634
7	2.2182	0.0876	-0.1207	35.9023	0.0582	1351.0229	2907.4520	0.0262	64.0492	137.8362	132.6280	285.4204	2.3227	4.9986
8	2.4032	0.0886	-0.1256	33.4498	0.0670	1338.3410	2708.8469	0.0262	59.9343	121.3090	123.8845	250.7464	2.1696	4.3913
9	2.4042	0.0895	-0.1170	35.7163	0.0631	1344.0233	2892.3888	0.0263	62.9229	135.4124	129.8290	279.3969	2.2737	4.8931
10	2.5624	0.0908	-0.1363	33.2907	0.0715	1331.9728	2695.9574	0.0263	59.7943	121.0257	123.1534	249.2666	2.1568	4.3654
11	2.6272	0.0939	-0.1428	35.4933	0.0689	1335.6324	2874.3312	0.0263	62.2206	133.9011	127.9222	275.2935	2.2403	4.8212
12	2.8845	0.0992	-0.1541	32.9685	0.0805	1319.0835	2669.8692	0.0264	60.0033	121.4487	123.1442	249.2480	2.1566	4.3651
13	3.1537	0.1090	-0.1688	34.9668	0.0827	1315.8195	2831.6931	0.0264	62.0354	133.5024	127.0887	273.4998	2.2257	4.7898
14	3.7951	0.1304	-0.1564	32.0579	0.1059	1282.6493	2596.1252	0.0265	62.7882	127.0855	128.4034	259.8928	2.2487	4.5515
15	1.6525	0.0815	-0.0557	15.0252	0.0991	1292.3616	2781.2107	0.0265	123.4759	265.7249	252.0654	542.4542	4.4144	9.5000
Exit									0				0	

Table 29b Fin0.125_1S Re20k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.8587	1.4587				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0069	0.0116	0.0300	31.9854	10.5854	20.1657	23.1222	23.1222	22.9904
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0139	0.0250	0.0645	44.3318	22.9318	43.3514	23.6821	23.6886	23.4054
3	2.6250	0.1654	1.2309	0.0123	0.0015	0.0157	0.0266	0.0686	46.6428	25.2428	46.0930	24.2421	24.2909	23.9898
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0139	0.0250	0.0645	48.7614	27.3614	43.3514	24.8020	24.8574	24.5741
5	4.7500	0.2992	2.2273	0.0123	0.0015	0.0157	0.0266	0.0686	47.7999	26.3999	46.0930	25.3620	25.4597	25.1585
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0139	0.0250	0.0645	47.9287	26.5287	43.3514	25.9219	26.0261	25.7429
7	6.8750	0.4331	3.2238	0.0123	0.0015	0.0157	0.0266	0.0686	47.6865	26.2865	46.0930	26.4818	26.6284	26.3272
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0139	0.0250	0.0645	49.4346	28.0346	43.3514	27.0418	27.1948	26.9116
9	9.0000	0.5669	4.2202	0.0123	0.0015	0.0157	0.0266	0.0686	48.9662	27.5662	46.0930	27.6017	27.7971	27.4960
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0139	0.0250	0.0645	50.5738	29.1738	43.3514	28.1617	28.3636	28.0804
11	11.1250	0.7008	5.2167	0.0123	0.0015	0.0157	0.0266	0.0686	50.4144	29.0144	46.0930	28.7216	28.9659	28.6647
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0139	0.0250	0.0645	51.7395	30.3395	43.3514	29.2816	29.5323	29.2491
13	13.2500	0.8346	6.2131	0.0123	0.0015	0.0157	0.0266	0.0686	51.7720	30.3720	46.0930	29.8415	30.1346	29.8335
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0139	0.0250	0.0645	51.8744	30.4744	43.3514	30.4014	30.7011	30.4178
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0069	0.0116	0.0300	41.9698	20.5698	20.1657	30.9614	30.9646	30.8328
Exit									31.2249	9.8249				

Table 30a Fin0.125_1S Re30k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.8584	0.0875	-0.0681	19.3073	0.0426	1660.6734	3573.8316	0.0259	187.3674	403.2217	391.8754	843.3306	5.1543	11.0922
2	2.7674	0.1282	-0.1714	40.5841	0.0638	1623.7843	3286.5938	0.0259	78.6348	159.1594	164.1896	332.3252	2.1596	4.3710
3	2.4376	0.1038	-0.1835	43.6554	0.0529	1642.7776	3535.3193	0.0260	73.3359	157.8216	152.8715	328.9851	2.0107	4.3271
4	2.3494	0.0921	-0.1712	41.0020	0.0542	1640.5060	3320.4391	0.0260	68.4702	138.5861	142.4925	288.4095	1.8742	3.7934
5	2.1888	0.0886	-0.1505	43.9042	0.0475	1652.1416	3555.4709	0.0261	73.6314	158.4576	152.9801	329.2190	2.0121	4.3302
6	2.1866	0.0877	-0.1396	41.1649	0.0504	1647.0226	3333.6289	0.0261	74.8415	151.4816	155.2378	314.2064	2.0418	4.1327
7	2.1828	0.0876	-0.1207	43.9102	0.0474	1652.3666	3555.9551	0.0262	77.9248	167.6970	161.3673	347.2686	2.1224	4.5676
8	2.3585	0.0886	-0.1256	40.9929	0.0544	1640.1419	3319.7021	0.0262	73.2440	148.2483	151.4253	306.4899	1.9917	4.0312
9	2.3492	0.0895	-0.1170	43.7439	0.0510	1646.1062	3542.4825	0.0262	77.0488	165.8118	159.0304	342.2394	2.0917	4.5014
10	2.5137	0.0908	-0.1363	40.8377	0.0580	1633.9325	3307.1340	0.0263	72.9041	147.5602	150.2296	304.0698	1.9759	3.9994
11	2.5805	0.0939	-0.1428	43.5126	0.0560	1637.4027	3523.7522	0.0263	75.4815	162.4390	155.2871	334.1837	2.0425	4.3955
12	2.8546	0.0992	-0.1541	40.4969	0.0658	1620.2957	3279.5327	0.0264	72.1482	146.0303	148.1879	299.9373	1.9491	3.9450
13	3.1418	0.1090	-0.1688	42.9513	0.0682	1616.2806	3478.2967	0.0264	73.7000	158.6051	151.1294	325.2361	1.9878	4.2778
14	3.8165	0.1304	-0.1564	39.5350	0.0880	1581.8098	3201.6359	0.0265	73.6652	149.1007	150.8131	305.2508	1.9836	4.0149
15	1.6205	0.0815	-0.0557	18.5452	0.0804	1595.1203	3432.7590	0.0265	144.8996	311.8294	296.1701	637.3693	3.8955	8.3832
Exit									0				0	

Table 30b Fin0.125_1S Re30k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.8355	1.0355				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0069	0.0116	0.0300	31.6370	9.8370	23.6381	23.0726	23.0677	22.9516
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0139	0.0250	0.0645	43.9870	22.1870	50.8161	23.5764	23.5668	23.3173
3	2.6250	0.1654	1.2309	0.0123	0.0015	0.0157	0.0266	0.0686	46.0032	24.2032	54.0299	24.0802	24.0975	23.8322
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0139	0.0250	0.0645	47.4418	25.6418	50.8161	24.5841	24.5967	24.3471
5	4.7500	0.2992	2.2273	0.0123	0.0015	0.0157	0.0266	0.0686	46.5620	24.7620	54.0299	25.0879	25.1274	24.8620
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0139	0.0250	0.0645	46.5040	24.7040	50.8161	25.5917	25.6265	25.3770
7	6.8750	0.4331	3.2238	0.0123	0.0015	0.0157	0.0266	0.0686	46.4398	24.6398	54.0299	26.0956	26.1573	25.8919
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0139	0.0250	0.0645	48.0953	26.2953	50.8161	26.5994	26.6564	26.4068
9	9.0000	0.5669	4.2202	0.0123	0.0015	0.0157	0.0266	0.0686	47.5507	25.7507	54.0299	27.1032	27.1871	26.9218
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0139	0.0250	0.0645	49.0619	27.2619	50.8161	27.6070	27.6862	27.4367
11	11.1250	0.7008	5.2167	0.0123	0.0015	0.0157	0.0266	0.0686	48.9890	27.1890	54.0299	28.1109	28.2170	27.9516
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0139	0.0250	0.0645	50.3010	28.5010	50.8161	28.6147	28.7161	28.4665
13	13.2500	0.8346	6.2131	0.0123	0.0015	0.0157	0.0266	0.0686	50.4367	28.6367	54.0299	29.1185	29.2468	28.9815
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0139	0.0250	0.0645	50.7310	28.9310	50.8161	29.6223	29.7460	29.4964
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0069	0.0116	0.0300	40.8482	19.0482	23.6381	30.1262	29.9781	29.8621
Exit									30.3633	8.5633				

Table 31a Fin0.125_1S Re40k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7929	0.0875	-0.0681	22.8452	0.0335	########	4228.6988	0.0259	229.4348	493.7522	479.9293	1032.8260	5.0193	10.8017
2	2.6719	0.1282	-0.1714	48.1442	0.0526	########	3898.8345	0.0259	94.3758	191.0199	197.1189	398.9753	2.0616	4.1726
3	2.3297	0.1038	-0.1835	51.7002	0.0431	########	4186.8033	0.0260	88.7429	190.9781	185.0767	398.2920	1.9356	4.1655
4	2.1910	0.0921	-0.1712	48.6251	0.0431	########	3937.7797	0.0260	85.1140	172.2736	177.2438	358.7474	1.8537	3.7519
5	2.0437	0.0886	-0.1505	51.9862	0.0378	########	4209.9661	0.0261	91.0988	196.0481	189.4244	407.6485	1.9811	4.2634
6	2.0266	0.0877	-0.1396	48.7896	0.0399	########	3951.0973	0.0261	93.3468	188.9371	193.8104	392.2788	2.0269	4.1026
7	2.0385	0.0876	-0.1207	51.9913	0.0377	########	4210.3832	0.0261	96.1680	206.9572	199.3719	429.0559	2.0851	4.4872
8	2.2044	0.0886	-0.1256	48.6117	0.0434	########	3936.6944	0.0262	90.4810	183.1366	187.3042	379.1100	1.9589	3.9649
9	2.1868	0.0895	-0.1170	51.8431	0.0405	########	4198.3776	0.0262	95.4095	205.3247	197.2149	424.4139	2.0626	4.4387
10	2.3401	0.0908	-0.1363	48.4761	0.0460	########	3925.7097	0.0262	90.4014	182.9755	186.5877	377.6597	1.9514	3.9497
11	2.4092	0.0939	-0.1428	51.6207	0.0446	########	4180.3687	0.0263	93.0407	200.2271	191.7526	412.6589	2.0054	4.3158
12	2.6722	0.0992	-0.1541	48.1439	0.0526	########	3898.8085	0.0263	88.8238	179.7823	182.7930	369.9790	1.9117	3.8694
13	2.9526	0.1090	-0.1688	51.0772	0.0546	########	4136.3565	0.0264	90.1607	194.0293	185.2724	398.7133	1.9377	4.1699
14	3.6152	0.1304	-0.1564	47.2009	0.0711	########	3822.4420	0.0264	89.4671	181.0844	183.5781	371.5683	1.9199	3.8860
15	1.4965	0.0815	-0.0557	22.1415	0.0633	########	4098.4523	0.0264	177.6196	382.2442	363.9270	783.1845	3.8061	8.1909
Exit									0				0	0

Table 31b Fin0.125_1S Re40k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.7524	1.0524				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0069	0.0116	0.0300	31.5945	9.8945	27.6178	22.9714	22.9664	22.8594
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0139	0.0250	0.0645	44.4170	22.7170	59.3716	23.4369	23.4265	23.1964
3	2.6250	0.1654	1.2309	0.0123	0.0015	0.0157	0.0266	0.0686	46.1989	24.4989	63.1263	23.9024	23.9157	23.6711
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0139	0.0250	0.0645	47.5107	25.8107	59.3716	24.3679	24.3758	24.1457
5	4.7500	0.2992	2.2273	0.0123	0.0015	0.0157	0.0266	0.0686	46.7356	25.0356	63.1263	24.8334	24.8650	24.6204
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0139	0.0250	0.0645	46.7180	25.0180	59.3716	25.2990	25.3250	25.0950
7	6.8750	0.4331	3.2238	0.0123	0.0015	0.0157	0.0266	0.0686	47.0214	25.3214	63.1263	25.7645	25.8142	25.5696
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0139	0.0250	0.0645	49.0395	27.3395	59.3716	26.2300	26.2743	26.0443
9	9.0000	0.5669	4.2202	0.0123	0.0015	0.0157	0.0266	0.0686	48.6029	26.9029	63.1263	26.6955	26.7635	26.5189
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0139	0.0250	0.0645	50.1665	28.4665	59.3716	27.1610	27.2236	26.9936
11	11.1250	0.7008	5.2167	0.0123	0.0015	0.0157	0.0266	0.0686	49.6746	27.9746	63.1263	27.6265	27.7128	27.4682
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0139	0.0250	0.0645	50.5255	28.8255	59.3716	28.0920	28.1729	27.9429
13	13.2500	0.8346	6.2131	0.0123	0.0015	0.0157	0.0266	0.0686	50.2908	28.5908	63.1263	28.5575	28.6621	28.4175
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0139	0.0250	0.0645	50.4959	28.7959	59.3716	29.0230	29.1222	28.8921
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0069	0.0116	0.0300	40.1600	18.4600	27.6178	29.4885	29.3362	29.2292
Exit									29.7076	8.0076				

Table 32a Fin0.125_1S Re50k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7979	0.0875	-0.0681	26.8198	0.0289	########	4964.4233	0.0259	267.5208	575.7149	559.7660	1204.6374	4.8392	10.4141
2	2.7398	0.1282	-0.1714	56.6317	0.0461	########	4586.1736	0.0259	108.0004	218.5965	225.6696	456.7627	1.9509	3.9487
3	2.3604	0.1038	-0.1835	60.7660	0.0374	########	4920.9726	0.0260	102.5570	220.7066	213.9994	460.5347	1.8500	3.9813
4	2.2066	0.0921	-0.1712	57.1650	0.0372	########	4629.3583	0.0260	98.8297	200.0345	205.9374	416.8241	1.7803	3.6034
5	2.0679	0.0886	-0.1505	61.0584	0.0328	########	4944.6592	0.0260	104.9061	225.7618	218.2983	469.7861	1.8872	4.0613
6	2.0541	0.0877	-0.1396	57.3175	0.0346	########	4641.7064	0.0261	107.0680	216.7091	222.4908	450.3288	1.9234	3.8931
7	2.0983	0.0876	-0.1207	61.0281	0.0332	########	4942.2017	0.0261	108.0364	232.4985	224.1954	482.4770	1.9382	4.1710
8	2.2969	0.0886	-0.1256	57.0746	0.0387	########	4622.0405	0.0261	100.1150	202.6361	207.4726	419.9314	1.7936	3.6303
9	2.2898	0.0895	-0.1170	60.8365	0.0363	########	4926.6858	0.0262	104.4994	224.8867	216.2627	465.4054	1.8696	4.0234
10	2.4495	0.0908	-0.1363	56.9221	0.0413	########	4609.6875	0.0262	98.9970	200.3733	204.5960	414.1091	1.7687	3.5800
11	2.4829	0.0939	-0.1428	60.6435	0.0393	########	4911.0528	0.0262	103.5028	222.7420	213.6168	459.7113	1.8467	3.9742
12	2.7044	0.0992	-0.1541	56.6671	0.0456	########	4589.0416	0.0263	101.0666	204.5622	208.3052	421.6166	1.8008	3.6449
13	2.9476	0.1090	-0.1688	60.1787	0.0467	########	4873.4179	0.0263	104.1979	224.2377	214.4675	461.5421	1.8541	3.9900
14	3.5976	0.1304	-0.1564	55.7739	0.0606	########	4516.7073	0.0264	103.9236	210.3449	213.6133	432.3604	1.8467	3.7378
15	1.4486	0.0815	-0.0557	26.1692	0.0525	########	4843.9805	0.0264	210.9240	453.9164	432.9646	931.7561	3.7430	8.0550
Exit									0				0	

Table 32b Fin0.125_1S Re50k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.6186	1.0186				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0069	0.0116	0.0300	31.7038	10.1038	31.7662	22.8412	22.8315	22.7251
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0139	0.0250	0.0645	45.4221	23.8221	68.2898	23.3140	23.2891	23.0603
3	2.6250	0.1654	1.2309	0.0123	0.0015	0.0157	0.0266	0.0686	47.4127	25.8127	72.6086	23.7869	23.7756	23.5323
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0139	0.0250	0.0645	48.8935	27.2935	68.2898	24.2597	24.2332	24.0044
5	4.7500	0.2992	2.2273	0.0123	0.0015	0.0157	0.0266	0.0686	47.7011	26.1011	72.6086	24.7325	24.7197	24.4764
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0139	0.0250	0.0645	47.4479	25.8479	68.2898	25.2054	25.1773	24.9485
7	6.8750	0.4331	3.2238	0.0123	0.0015	0.0157	0.0266	0.0686	47.4372	25.8372	72.6086	25.6782	25.6638	25.4205
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0139	0.0250	0.0645	49.0474	27.4474	68.2898	26.1511	26.1213	25.8926
9	9.0000	0.5669	4.2202	0.0123	0.0015	0.0157	0.0266	0.0686	48.3343	26.7343	72.6086	26.6239	26.6079	26.3646
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0139	0.0250	0.0645	49.9414	28.3414	68.2898	27.0968	27.0654	26.8366
11	11.1250	0.7008	5.2167	0.0123	0.0015	0.0157	0.0266	0.0686	49.7815	28.1815	72.6086	27.5696	27.5519	27.3087
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0139	0.0250	0.0645	51.0233	29.4233	68.2898	28.0424	28.0095	27.7807
13	13.2500	0.8346	6.2131	0.0123	0.0015	0.0157	0.0266	0.0686	51.1396	29.5396	72.6086	28.5153	28.4960	28.2528
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0139	0.0250	0.0645	51.5411	29.9411	68.2898	28.9881	28.9536	28.7248
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0069	0.0116	0.0300	40.5762	18.9762	31.7662	29.4610	29.1665	29.0600
Exit									29.6835	8.0835				

Table 33a Fin0.125_1S Re60k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.8163	0.0875	-0.0681	30.9500	0.0257	2662.0923	5728.9228	0.0259	300.3709	646.4095	628.7460	1353.0851	4.8377	10.4109
2	2.8815	0.1282	-0.1714	65.4083	0.0422	2617.0132	5296.9222	0.0259	118.3735	239.5920	247.4348	500.8163	1.9038	3.8534
3	2.4968	0.1038	-0.1835	70.1117	0.0344	2638.3445	5677.8166	0.0260	111.6721	240.3226	233.0992	501.6382	1.7935	3.8597
4	2.3432	0.0921	-0.1712	65.9466	0.0343	2638.5502	5340.5137	0.0260	107.1112	216.7966	223.2656	451.8970	1.7178	3.4770
5	2.1623	0.0886	-0.1505	70.4462	0.0298	2650.9319	5704.9051	0.0260	115.4159	248.3793	240.2397	517.0050	1.8485	3.9779
6	2.1269	0.0877	-0.1396	66.1629	0.0311	2647.2047	5358.0308	0.0261	119.0155	240.8914	247.3865	500.7186	1.9034	3.8526
7	2.1435	0.0876	-0.1207	70.4651	0.0295	2651.6419	5706.4330	0.0261	121.8644	262.2567	252.9552	544.3692	1.9463	4.1885
8	2.3065	0.0886	-0.1256	65.9833	0.0338	2640.0175	5343.4837	0.0261	115.3031	233.3773	239.0030	483.7500	1.8389	3.7221
9	2.2748	0.0895	-0.1170	70.3338	0.0313	2646.7003	5695.7987	0.0262	121.9092	262.3531	252.3453	543.0566	1.9416	4.1784
10	2.4381	0.0908	-0.1363	65.8517	0.0357	2634.7514	5332.8249	0.0262	115.3336	233.4390	238.4033	482.5362	1.8343	3.7127
11	2.5023	0.0939	-0.1428	70.1063	0.0345	2638.1381	5677.3724	0.0262	118.7714	255.6006	245.1699	527.6149	1.8864	4.0596
12	2.7637	0.0992	-0.1541	65.5261	0.0405	2621.7243	5306.4577	0.0263	114.0829	230.9077	235.1667	475.9853	1.8094	3.6623
13	3.0510	0.1090	-0.1688	69.5575	0.0420	2617.4885	5632.9338	0.0263	115.6934	248.9765	238.1577	512.5243	1.8324	3.9435
14	3.7469	0.1304	-0.1564	64.5428	0.0549	2582.3852	5226.8339	0.0264	114.5031	231.7580	235.3830	476.4231	1.8111	3.6657
15	1.4907	0.0815	-0.0557	30.2756	0.0469	2604.0836	5604.0859	0.0264	234.2798	504.1789	480.9456	1035.0129	3.7005	7.9636
Exit									0				0	

Table 33b Fin0.125_1S Re60k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.3242	0.7242				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0069	0.0116	0.0300	31.3042	9.7042	35.2622	22.5303	22.5237	22.4240
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0139	0.0250	0.0645	45.1805	23.5805	75.8052	22.9684	22.9525	22.7381
3	2.6250	0.1654	1.2309	0.0123	0.0015	0.0157	0.0266	0.0686	46.7968	25.1968	80.5992	23.4064	23.4084	23.1805
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0139	0.0250	0.0645	47.7712	26.1712	75.8052	23.8444	23.8372	23.6228
5	4.7500	0.2992	2.2273	0.0123	0.0015	0.0157	0.0266	0.0686	46.8730	25.2730	80.5992	24.2824	24.2932	24.0652
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0139	0.0250	0.0645	46.8014	25.2014	75.8052	24.7204	24.7220	24.5076
7	6.8750	0.4331	3.2238	0.0123	0.0015	0.0157	0.0266	0.0686	47.1793	25.5793	80.5992	25.1585	25.1779	24.9500
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0139	0.0250	0.0645	49.1784	27.5784	75.8052	25.5965	25.6067	25.3923
9	9.0000	0.5669	4.2202	0.0123	0.0015	0.0157	0.0266	0.0686	48.6853	27.0853	80.5992	26.0345	26.0627	25.8347
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0139	0.0250	0.0645	50.2766	28.6766	75.8052	26.4725	26.4915	26.2771
11	11.1250	0.7008	5.2167	0.0123	0.0015	0.0157	0.0266	0.0686	49.7463	28.1463	80.5992	26.9106	26.9474	26.7194
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0139	0.0250	0.0645	50.6219	29.0219	75.8052	27.3486	27.3762	27.1618
13	13.2500	0.8346	6.2131	0.0123	0.0015	0.0157	0.0266	0.0686	50.3516	28.7516	80.5992	27.7866	27.8321	27.6042
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0139	0.0250	0.0645	50.7380	29.1380	75.8052	28.2246	28.2610	28.0466
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0069	0.0116	0.0300	39.6284	18.0284	35.2622	28.6626	28.4604	28.3607
Exit									28.8688	7.2688				

Table 34a Fin0.125_1S Re70k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7813	0.0875	-0.0681	34.4809	0.0222	2965.7951	6382.5027	0.0259	338.0265	727.4458	708.2238	1524.1243	4.7533	10.2293
2	2.8505	0.1282	-0.1714	72.9547	0.0376	2918.9461	5908.0445	0.0259	131.4125	265.9832	274.9726	556.5538	1.8455	3.7354
3	2.4329	0.1038	-0.1835	78.1664	0.0302	2941.4450	6330.1004	0.0259	125.7545	270.6284	262.7910	565.5360	1.7637	3.7956
4	2.2398	0.0921	-0.1712	73.5654	0.0295	2943.3808	5957.5011	0.0260	123.0163	248.9892	256.7348	519.6398	1.7231	3.4876
5	2.0890	0.0886	-0.1505	78.5103	0.0259	2954.3867	6357.9513	0.0260	130.7794	281.4421	272.5819	586.6066	1.8295	3.9371
6	2.0702	0.0877	-0.1396	73.7350	0.0273	2950.1667	5971.2360	0.0260	133.6068	270.4247	278.1143	562.9127	1.8666	3.7780
7	2.1209	0.0876	-0.1207	78.4784	0.0263	2953.1863	6355.3679	0.0261	134.1089	288.6073	278.7983	599.9845	1.8712	4.0268
8	2.3181	0.0886	-0.1256	73.4871	0.0306	2940.2471	5951.1585	0.0261	124.6825	252.3616	258.8672	523.9559	1.7374	3.5166
9	2.3062	0.0895	-0.1170	78.2931	0.0286	2946.2128	6340.3609	0.0261	130.0713	279.9183	269.7073	580.4203	1.8102	3.8955
10	2.4686	0.0908	-0.1363	73.3366	0.0326	2934.2271	5938.9737	0.0262	123.2659	249.4944	255.2672	516.6693	1.7132	3.4677
11	2.4990	0.0939	-0.1428	78.1002	0.0310	2938.9562	6324.7443	0.0262	128.6997	276.9665	266.1773	572.8235	1.7865	3.8446
12	2.7239	0.0992	-0.1541	73.0813	0.0359	2924.0111	5918.2962	0.0262	125.6381	254.2958	259.5121	525.2612	1.7417	3.5253
13	2.9652	0.1090	-0.1688	77.6341	0.0368	2921.4147	6286.9943	0.0263	129.4664	278.6166	267.0772	574.7602	1.7925	3.8576
14	3.6422	0.1304	-0.1564	72.1629	0.0480	2887.2682	5843.9274	0.0263	128.2469	259.5760	264.2233	534.7967	1.7734	3.5893
15	1.4134	0.0815	-0.0557	33.8487	0.0401	2911.4210	6265.4876	0.0263	265.5009	571.3679	546.3055	1175.6700	3.6666	7.8906
Exit									0				0	

Table 34b Fin0.125_1S Re70k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.0780	0.5780				
1	0.5000	0.0315	0.2345	0.0054	0.0006	0.0069	0.0116	0.0300	30.9778	9.4778	39.2648	22.2583	22.2741	22.1760
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0139	0.0250	0.0645	45.4273	23.9273	84.4099	22.6416	22.6957	22.4849
3	2.6250	0.1654	1.2309	0.0123	0.0015	0.0157	0.0266	0.0686	47.3735	25.8735	89.7482	23.0248	23.1440	22.9199
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0139	0.0250	0.0645	48.5680	27.0680	84.4099	23.4080	23.5657	23.3549
5	4.7500	0.2992	2.2273	0.0123	0.0015	0.0157	0.0266	0.0686	47.2883	25.7883	89.7482	23.7913	24.0140	23.7898
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0139	0.0250	0.0645	46.8055	25.3055	84.4099	24.1745	24.4356	24.2248
7	6.8750	0.4331	3.2238	0.0123	0.0015	0.0157	0.0266	0.0686	46.8543	25.3543	89.7482	24.5578	24.8839	24.6598
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0139	0.0250	0.0645	48.2188	26.7188	84.4099	24.9410	25.3056	25.0947
9	9.0000	0.5669	4.2202	0.0123	0.0015	0.0157	0.0266	0.0686	47.5664	26.0664	89.7482	25.3243	25.7539	25.5297
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0139	0.0250	0.0645	48.9865	27.4865	84.4099	25.7075	26.1755	25.9647
11	11.1250	0.7008	5.2167	0.0123	0.0015	0.0157	0.0266	0.0686	48.9869	27.4869	89.7482	26.0907	26.6238	26.3997
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0139	0.0250	0.0645	50.1388	28.6388	84.4099	26.4740	27.0454	26.8346
13	13.2500	0.8346	6.2131	0.0123	0.0015	0.0157	0.0266	0.0686	50.2434	28.7434	89.7482	26.8572	27.4937	27.2696
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0139	0.0250	0.0645	50.7779	29.2779	84.4099	27.2405	27.9154	27.7046
15	15.3750	0.9685	7.2095	0.0054	0.0006	0.0069	0.0116	0.0300	39.2259	17.7259	39.2648	27.6237	28.1115	28.0134
Exit									27.8040	6.3040				

Table 35a Fin0.125_1S Re80k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7615	0.0875	-0.0681	38.5034	0.0194	3311.7805	7127.0763	0.0258	379.8145	817.3752	796.4232	1713.9326	4.8323	10.3992
2	2.8949	0.1282	-0.1714	81.5150	0.0343	3261.4486	6601.2810	0.0259	143.1356	289.7113	299.7944	606.7938	1.8190	3.6817
3	2.5031	0.1038	-0.1835	87.2451	0.0279	3283.0814	7065.3147	0.0259	134.8359	290.1719	282.0885	607.0650	1.7116	3.6833
4	2.3224	0.0921	-0.1712	82.0875	0.0275	3284.3561	6647.6465	0.0259	130.5393	264.2158	272.7884	552.1328	1.6551	3.3500
5	2.1346	0.0886	-0.1505	87.6136	0.0238	3296.9494	7095.1592	0.0260	140.3135	301.9599	292.8800	630.2889	1.7770	3.8242
6	2.0793	0.0877	-0.1396	82.3306	0.0246	3294.0824	6667.3329	0.0260	145.5565	294.6113	303.4788	614.2513	1.8413	3.7269
7	2.1011	0.0876	-0.1207	87.6471	0.0234	3298.2090	7097.8699	0.0260	147.9248	318.3398	308.0667	662.9712	1.8692	4.0225
8	2.2419	0.0886	-0.1256	82.1680	0.0266	3287.5754	6654.1625	0.0260	141.2324	285.8591	293.7960	594.6530	1.7826	3.6080
9	2.2150	0.0895	-0.1170	87.5332	0.0247	3293.9237	7088.6476	0.0261	148.0936	318.7030	307.7205	662.2261	1.8671	4.0180
10	2.3605	0.0908	-0.1363	82.0495	0.0280	3282.8330	6644.5637	0.0261	141.0209	285.4311	292.6935	592.4214	1.7759	3.5945
11	2.4371	0.0939	-0.1428	87.3111	0.0272	3285.5661	7070.6618	0.0261	143.4986	308.8143	297.5000	640.2311	1.8051	3.8846
12	2.6859	0.0992	-0.1541	81.7240	0.0318	3269.8117	6618.2082	0.0262	138.1717	279.6641	286.1338	579.1443	1.7361	3.5139
13	2.9643	0.1090	-0.1688	86.7839	0.0330	3265.7293	7027.9723	0.0262	139.6436	300.5182	288.8567	621.6305	1.7526	3.7717
14	3.6605	0.1304	-0.1564	80.7495	0.0434	3230.8193	6539.2862	0.0262	137.2630	277.8250	283.6138	574.0438	1.7208	3.4830
15	1.3888	0.0815	-0.0557	37.8760	0.0354	3257.8218	7010.9550	0.0262	280.7922	604.2753	579.5242	1247.1579	3.5162	7.5671
Exit									0				0	

Table 35b Fin0.125_1S Re80k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.5478	1.1478				
1	0.5000	0.0315	0.2345	0.0054	0.0007	0.0042	0.0089	0.0303	31.5340	10.1340	13.2482	22.7538	22.7900	22.6689
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0077	0.0188	0.0637	42.6575	21.2575	27.8890	23.1915	23.2998	23.0449
3	2.6250	0.1654	1.2309	0.0123	0.0016	0.0097	0.0204	0.0692	45.0197	23.6197	30.2817	23.6292	23.8534	23.5766
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0077	0.0188	0.0637	47.5362	26.1362	27.8890	24.0669	24.3632	24.1083
5	4.7500	0.2992	2.2273	0.0123	0.0016	0.0097	0.0204	0.0692	47.5805	26.1805	30.2817	24.5046	24.9168	24.6400
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0077	0.0188	0.0637	49.0357	27.6357	27.8890	24.9424	25.4266	25.1717
7	6.8750	0.4331	3.2238	0.0123	0.0016	0.0097	0.0204	0.0692	48.4720	27.0720	30.2817	25.3801	25.9802	25.7034
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0077	0.0188	0.0637	50.0612	28.6612	27.8890	25.8178	26.4901	26.2351
9	9.0000	0.5669	4.2202	0.0123	0.0016	0.0097	0.0204	0.0692	50.1761	28.7761	30.2817	26.2555	27.0436	26.7668
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0077	0.0188	0.0637	51.3060	29.9060	27.8890	26.6932	27.5535	27.2985
11	11.1250	0.7008	5.2167	0.0123	0.0016	0.0097	0.0204	0.0692	50.7879	29.3879	30.2817	27.1309	28.1070	27.8303
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0077	0.0188	0.0637	51.7833	30.3833	27.8890	27.5686	28.6169	28.3620
13	13.2500	0.8346	6.2131	0.0123	0.0016	0.0097	0.0204	0.0692	51.6917	30.2917	30.2817	28.0063	29.1704	28.8937
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0077	0.0188	0.0637	50.4570	29.0570	27.8890	28.4441	29.6803	29.4254
15	15.3750	0.9685	7.2095	0.0054	0.0007	0.0042	0.0089	0.0303	41.0073	19.6073	13.2482	28.8818	29.9225	29.8014
Exit									29.0878	7.6878				

Table 36a Fin0.25_2S Re20k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7659	0.0853	-0.0985	12.4823	0.0578	1397.6964	2310.5075	0.0259	159.1866	263.1486	333.3013	550.9746	5.7201	9.4559
2	2.4328	0.1261	-0.2482	25.4562	0.0872	1354.0556	2061.5037	0.0259	69.5602	105.9030	145.4538	221.4484	2.4963	3.8005
3	2.1548	0.1020	-0.2536	28.1269	0.0712	1377.9003	2277.7829	0.0259	64.4165	106.4858	134.5230	222.3777	2.3087	3.8165
4	2.1276	0.0911	-0.2539	25.7614	0.0763	1370.2906	2086.2210	0.0260	58.3866	88.8916	121.7723	185.3941	2.0899	3.1817
5	2.0564	0.0871	-0.2232	28.2253	0.0679	1382.7211	2285.7521	0.0260	59.9206	99.0537	124.8097	206.3208	2.1420	3.5409
6	2.1636	0.0860	-0.2138	25.7254	0.0776	1368.3742	2083.3032	0.0260	56.7947	86.4680	118.1456	179.8727	2.0276	3.0870
7	2.1212	0.0854	-0.1911	28.1605	0.0701	1379.5451	2280.5020	0.0261	59.7414	98.7575	124.1150	205.1724	2.1301	3.5212
8	2.2688	0.0860	-0.1971	25.6202	0.0814	1362.7793	2074.7851	0.0261	56.2124	85.5815	116.6328	177.5695	2.0017	3.0475
9	2.3208	0.0872	-0.1899	27.9609	0.0766	1369.7702	2264.3432	0.0261	57.2633	94.6610	118.6603	196.1553	2.0365	3.3664
10	2.4397	0.0887	-0.2126	25.4494	0.0875	1353.6919	2060.9500	0.0262	54.9994	83.7347	113.8226	173.2911	1.9534	2.9740
11	2.4830	0.0921	-0.2222	27.7987	0.0820	1361.8228	2251.2055	0.0262	57.5655	95.1605	118.9803	196.6842	2.0419	3.3755
12	2.7323	0.0976	-0.2345	25.1567	0.0980	1338.1252	2037.2502	0.0262	55.2608	84.1327	114.0707	173.6687	1.9577	2.9805
13	3.0161	0.1078	-0.2494	27.2656	0.0996	1335.7058	2208.0320	0.0263	56.3938	93.2236	116.2605	192.1881	1.9953	3.2983
14	3.5092	0.1289	-0.2376	24.3798	0.1258	1296.8015	1974.3362	0.0263	58.9108	89.6898	121.2946	184.6669	2.0817	3.1693
15	1.4968	0.0812	-0.0953	11.7515	0.1130	1315.8599	2175.2250	0.0263	108.5198	179.3921	223.1523	368.8892	3.8298	6.3309
Exit									0				0	

Table 36b Fin0.25_2S Re20k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.6710	1.3710				
1	0.5000	0.0315	0.2345	0.0054	0.0007	0.0042	0.0089	0.0303	31.3427	10.0427	16.3960	22.8530	22.8774	22.7742
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0077	0.0188	0.0637	42.5349	21.2349	34.5154	23.2399	23.3118	23.0946
3	2.6250	0.1654	1.2309	0.0123	0.0016	0.0097	0.0204	0.0692	44.6227	23.3227	37.4766	23.6267	23.7834	23.5476
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0077	0.0188	0.0637	47.0247	25.7247	34.5154	24.0135	24.2178	24.0006
5	4.7500	0.2992	2.2273	0.0123	0.0016	0.0097	0.0204	0.0692	47.0321	25.7321	37.4766	24.4003	24.6895	24.4537
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0077	0.0188	0.0637	48.4183	27.1183	34.5154	24.7871	25.1239	24.9067
7	6.8750	0.4331	3.2238	0.0123	0.0016	0.0097	0.0204	0.0692	47.7713	26.4713	37.4766	25.1740	25.5956	25.3597
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0077	0.0188	0.0637	49.2211	27.9211	34.5154	25.5608	26.0300	25.8128
9	9.0000	0.5669	4.2202	0.0123	0.0016	0.0097	0.0204	0.0692	49.4178	28.1178	37.4766	25.9476	26.5016	26.2658
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0077	0.0188	0.0637	50.4118	29.1118	34.5154	26.3344	26.9360	26.7188
11	11.1250	0.7008	5.2167	0.0123	0.0016	0.0097	0.0204	0.0692	49.8847	28.5847	37.4766	26.7213	27.4077	27.1719
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0077	0.0188	0.0637	50.7873	29.4873	34.5154	27.1081	27.8421	27.6249
13	13.2500	0.8346	6.2131	0.0123	0.0016	0.0097	0.0204	0.0692	50.9006	29.6006	37.4766	27.4949	28.3138	28.0779
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0077	0.0188	0.0637	49.6553	28.3553	34.5154	27.8817	28.7482	28.5310
15	15.3750	0.9685	7.2095	0.0054	0.0007	0.0042	0.0089	0.0303	40.1372	18.8372	16.3960	28.2685	28.9545	28.8514
Exit									28.4506	7.1506				

Table 37a Fin0.25_2S Re30k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7581	0.0853	-0.0985	15.6379	0.0462	1751.0379	2894.6102	0.0259	206.2561	340.9584	431.7266	713.6797	5.4935	9.0812
2	2.4300	0.1261	-0.2482	32.0854	0.0704	1706.6758	2598.3560	0.0259	88.4515	134.6643	184.9298	281.5493	2.3531	3.5826
3	2.1245	0.1020	-0.2536	35.3521	0.0567	1731.8529	2862.8958	0.0259	82.4850	136.3545	172.2572	284.7554	2.1919	3.6234
4	2.0901	0.0911	-0.2539	32.4253	0.0606	1724.7540	2625.8794	0.0260	74.9528	114.1131	156.3479	238.0343	1.9894	3.0289
5	2.0174	0.0871	-0.2232	35.4592	0.0538	1737.1027	2871.5742	0.0260	76.7550	126.8824	159.9238	264.3672	2.0349	3.3639
6	2.1191	0.0860	-0.2138	32.3963	0.0614	1723.2106	2623.5296	0.0260	72.9210	111.0198	151.7616	231.0519	1.9311	2.9400
7	2.0699	0.0854	-0.1911	35.4067	0.0552	1734.5276	2867.3173	0.0261	76.7581	126.8874	159.5647	263.7736	2.0304	3.3564
8	2.2052	0.0860	-0.1971	32.3103	0.0639	1718.6351	2616.5636	0.0261	72.6379	110.5888	150.8275	229.6298	1.9192	2.9219
9	2.2633	0.0872	-0.1899	35.2133	0.0604	1725.0526	2851.6544	0.0261	73.4997	121.5011	152.4432	252.0011	1.9398	3.2066
10	2.3692	0.0887	-0.2126	32.1462	0.0686	1709.9077	2603.2764	0.0261	71.0172	108.1213	147.1268	223.9956	1.8721	2.8502
11	2.4091	0.0921	-0.2222	35.0675	0.0643	1717.9135	2839.8528	0.0262	74.1648	122.6005	153.4732	253.7038	1.9529	3.2282
12	2.6448	0.0976	-0.2345	31.8706	0.0766	1695.2480	2580.9576	0.0262	71.5921	108.9965	147.9814	225.2966	1.8830	2.8668
13	2.9416	0.1078	-0.2494	34.5350	0.0785	1691.8243	2796.7252	0.0262	72.2824	119.4888	149.2392	246.7048	1.8990	3.1392
14	3.4187	0.1289	-0.2376	31.0967	0.0990	1654.0836	2518.2862	0.0263	75.9676	115.6580	156.6705	238.5255	1.9935	3.0351
15	1.4343	0.0812	-0.0953	14.9618	0.0875	1675.3307	2769.4599	0.0263	141.1556	233.3418	290.7813	480.6856	3.7000	6.1165
Exit									0				0	

Table 37b Fin0.25_2S Re30k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.6294	1.3294				
1	0.5000	0.0315	0.2345	0.0054	0.0007	0.0042	0.0089	0.0303	31.5279	10.2279	20.1856	22.8062	22.8257	22.7276
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0077	0.0188	0.0637	43.5103	22.2103	42.4928	23.1818	23.2390	23.0324
3	2.6250	0.1654	1.2309	0.0123	0.0016	0.0097	0.0204	0.0692	45.5465	24.2465	46.1384	23.5575	23.6878	23.4634
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0077	0.0188	0.0637	48.0049	26.7049	42.4928	23.9332	24.1011	23.8945
5	4.7500	0.2992	2.2273	0.0123	0.0016	0.0097	0.0204	0.0692	47.7382	26.4382	46.1384	24.3088	24.5499	24.3255
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0077	0.0188	0.0637	49.0022	27.7022	42.4928	24.6845	24.9632	24.7565
7	6.8750	0.4331	3.2238	0.0123	0.0016	0.0097	0.0204	0.0692	48.2169	26.9169	46.1384	25.0602	25.4120	25.1876
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0077	0.0188	0.0637	49.4893	28.1893	42.4928	25.4358	25.8253	25.6186
9	9.0000	0.5669	4.2202	0.0123	0.0016	0.0097	0.0204	0.0692	49.7190	28.4190	46.1384	25.8115	26.2740	26.0496
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0077	0.0188	0.0637	50.6028	29.3028	42.4928	26.1871	26.6873	26.4807
11	11.1250	0.7008	5.2167	0.0123	0.0016	0.0097	0.0204	0.0692	50.0598	28.7598	46.1384	26.5628	27.1361	26.9117
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0077	0.0188	0.0637	50.9939	29.6939	42.4928	26.9385	27.5494	27.3428
13	13.2500	0.8346	6.2131	0.0123	0.0016	0.0097	0.0204	0.0692	51.2329	29.9329	46.1384	27.3141	27.9982	27.7738
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0077	0.0188	0.0637	50.0103	28.7103	42.4928	27.6898	28.4115	28.2048
15	15.3750	0.9685	7.2095	0.0054	0.0007	0.0042	0.0089	0.0303	40.0488	18.7488	20.1856	28.0655	28.6078	28.5097
Exit									28.2422	6.9422				

Table 38a Fin0.25_2S Re40k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7740	0.0853	-0.0985	19.4116	0.0383	2173.5996	3593.1396	0.0259	249.2156	411.9740	521.7205	862.4470	5.4004	8.9274
2	2.5530	0.1261	-0.2482	39.9398	0.0601	2124.4634	3234.4234	0.0259	104.5067	159.1079	218.5350	332.7121	2.2621	3.4440
3	2.2187	0.1020	-0.2536	43.9197	0.0481	2151.5695	3556.7219	0.0259	97.8475	161.7500	204.3815	337.8596	2.1156	3.4972
4	2.1794	0.0911	-0.2539	40.3134	0.0513	2144.3342	3264.6760	0.0260	89.0808	135.6225	185.8625	282.9693	1.9239	2.9291
5	2.0788	0.0871	-0.2232	44.0596	0.0451	2158.4222	3568.0501	0.0260	92.1247	152.2898	191.9995	317.3910	1.9874	3.2854
6	2.1694	0.0860	-0.2138	40.3235	0.0511	2144.8700	3265.4918	0.0260	88.2019	134.2844	183.6196	279.5546	1.9007	2.8937
7	2.1080	0.0854	-0.1911	44.0304	0.0457	2156.9944	3565.6897	0.0260	93.1476	153.9807	193.7004	320.2027	2.0050	3.3145
8	2.2282	0.0860	-0.1971	40.2646	0.0524	2141.7391	3260.7250	0.0261	89.0408	135.5616	184.9551	281.5879	1.9145	2.9148
9	2.2896	0.0872	-0.1899	43.8488	0.0496	2148.0965	3550.9808	0.0261	89.8502	148.5298	186.4298	308.1839	1.9298	3.1901
10	2.3862	0.0887	-0.2126	40.1067	0.0562	2133.3377	3247.9343	0.0261	87.3757	133.0265	181.0952	275.7112	1.8745	2.8539
11	2.4252	0.0921	-0.2222	43.7132	0.0526	2141.4553	3540.0023	0.0262	91.1374	150.6577	188.6834	311.9092	1.9531	3.2286
12	2.6650	0.0976	-0.2345	39.8278	0.0627	2118.5064	3225.3540	0.0262	88.0676	134.0800	182.1270	277.2822	1.8852	2.8702
13	2.9774	0.1078	-0.2494	43.1610	0.0645	2114.4011	3495.2795	0.0262	88.3994	146.1315	182.6120	301.8727	1.8903	3.1247
14	3.4645	0.1289	-0.2376	39.0283	0.0815	2075.9794	3160.6082	0.0263	93.0075	141.6008	191.9202	292.1920	1.9866	3.0245
15	1.4271	0.0812	-0.0953	18.7585	0.0707	2100.4656	3472.2430	0.0263	175.2816	289.7549	361.2953	597.2509	3.7398	6.1823
Exit									0				0	0

Table 38b Fin0.25_2S Re40k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.5209	1.3209				
1	0.5000	0.0315	0.2345	0.0054	0.0007	0.0042	0.0089	0.0303	31.6154	10.4154	25.0675	22.7019	22.7113	22.6161
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0077	0.0188	0.0637	44.0494	22.8494	52.7700	23.0864	23.1121	22.9117
3	2.6250	0.1654	1.2309	0.0123	0.0016	0.0097	0.0204	0.0692	45.3340	24.1340	57.2972	23.4709	23.5473	23.3297
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0077	0.0188	0.0637	46.9964	25.7964	52.7700	23.8555	23.9482	23.7477
5	4.7500	0.2992	2.2273	0.0123	0.0016	0.0097	0.0204	0.0692	46.5289	25.3289	57.2972	24.2400	24.3834	24.1658
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0077	0.0188	0.0637	47.3179	26.1179	52.7700	24.6245	24.7842	24.5838
7	6.8750	0.4331	3.2238	0.0123	0.0016	0.0097	0.0204	0.0692	46.6931	25.4931	57.2972	25.0091	25.2194	25.0018
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0077	0.0188	0.0637	47.9802	26.7802	52.7700	25.3936	25.6202	25.4198
9	9.0000	0.5669	4.2202	0.0123	0.0016	0.0097	0.0204	0.0692	48.3361	27.1361	57.2972	25.7781	26.0554	25.8378
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0077	0.0188	0.0637	49.1612	27.9612	52.7700	26.1627	26.4562	26.2558
11	11.1250	0.7008	5.2167	0.0123	0.0016	0.0097	0.0204	0.0692	48.7693	27.5693	57.2972	26.5472	26.8914	26.6738
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0077	0.0188	0.0637	49.8470	28.6470	52.7700	26.9318	27.2923	27.0919
13	13.2500	0.8346	6.2131	0.0123	0.0016	0.0097	0.0204	0.0692	50.3615	29.1615	57.2972	27.3163	27.7275	27.5099
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0077	0.0188	0.0637	49.2300	28.0300	52.7700	27.7008	28.1283	27.9279
15	15.3750	0.9685	7.2095	0.0054	0.0007	0.0042	0.0089	0.0303	38.9450	17.7450	25.0675	28.0854	28.3187	28.2235
Exit									28.2663	7.0663				

Table 39a Fin0.25_2S Re50k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7899	0.0853	-0.0985	24.2776	0.0315	2718.4658	4493.8484	0.0259	304.9823	504.1609	638.6637	1055.7638	5.4238	8.9661
2	2.6336	0.1261	-0.2482	50.1364	0.0499	2666.8327	4060.1622	0.0259	127.2163	193.6824	266.0988	405.1264	2.2598	3.4405
3	2.2073	0.1020	-0.2536	55.0900	0.0385	2698.7882	4461.3197	0.0259	123.4407	204.0577	257.9063	426.3404	2.1903	3.6207
4	2.0967	0.0911	-0.2539	50.6733	0.0397	2695.3941	4103.6460	0.0260	116.4771	177.3324	243.0794	370.0802	2.0643	3.1429
5	1.9823	0.0871	-0.2232	55.3150	0.0346	2709.8103	4479.5402	0.0260	121.5765	200.9760	253.4324	418.9447	2.1523	3.5579
6	2.0331	0.0860	-0.2138	50.7369	0.0385	2698.7764	4108.7954	0.0260	118.9236	181.0571	247.6202	376.9933	2.1029	3.2016
7	1.9864	0.0854	-0.1911	55.3109	0.0347	2709.6088	4479.2070	0.0260	124.9590	206.5675	259.8913	429.6218	2.2071	3.6486
8	2.1070	0.0860	-0.1971	50.6630	0.0399	2694.8442	4102.8088	0.0261	119.3117	181.6480	247.8645	377.3653	2.1050	3.2048
9	2.1777	0.0872	-0.1899	55.1196	0.0380	2700.2365	4463.7138	0.0261	119.7021	197.8774	248.3938	410.6155	2.1095	3.4871
10	2.2672	0.0887	-0.2126	50.5028	0.0430	2686.3235	4089.8363	0.0261	116.8044	177.8307	242.1066	368.5991	2.0561	3.1303
11	2.3156	0.0921	-0.2222	54.9816	0.0404	2693.4802	4452.5451	0.0262	121.2072	200.3656	250.9489	414.8392	2.1312	3.5230
12	2.5628	0.0976	-0.2345	50.2072	0.0486	2670.6009	4065.8991	0.0262	116.5427	177.4323	241.0193	366.9437	2.0469	3.1163
13	2.8943	0.1078	-0.2494	54.4030	0.0505	2665.1312	4405.6819	0.0262	115.6479	191.1755	238.8993	394.9202	2.0288	3.3539
14	3.3768	0.1289	-0.2376	49.3932	0.0640	2627.3027	3999.9791	0.0263	122.0347	185.7937	251.8094	383.3713	2.1385	3.2558
15	1.3456	0.0812	-0.0953	23.7220	0.0537	2656.2498	4391.0002	0.0263	244.5994	404.3431	504.1458	833.3946	4.2815	7.0776
Exit									0				0	

Table 39b Fin0.25_2S Re50k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									22.2029	0.9029				
1	0.5000	0.0315	0.2345	0.0054	0.0007	0.0042	0.0089	0.0303	31.3609	10.0609	26.6394	22.3721	22.3805	22.2917
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0077	0.0188	0.0637	44.1986	22.8986	56.0789	22.7315	22.7542	22.5673
3	2.6250	0.1654	1.2309	0.0123	0.0016	0.0097	0.0204	0.0692	46.0278	24.7278	60.8900	23.0909	23.1600	22.9571
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0077	0.0188	0.0637	48.2617	26.9617	56.0789	23.4503	23.5338	23.3469
5	4.7500	0.2992	2.2273	0.0123	0.0016	0.0097	0.0204	0.0692	47.7809	26.4809	60.8900	23.8097	23.9396	23.7367
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0077	0.0188	0.0637	48.8002	27.5002	56.0789	24.1692	24.3133	24.1264
7	6.8750	0.4331	3.2238	0.0123	0.0016	0.0097	0.0204	0.0692	47.9350	26.6350	60.8900	24.5286	24.7191	24.5162
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0077	0.0188	0.0637	48.9245	27.6245	56.0789	24.8880	25.0929	24.9060
9	9.0000	0.5669	4.2202	0.0123	0.0016	0.0097	0.0204	0.0692	49.4198	28.1198	60.8900	25.2474	25.4987	25.2958
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0077	0.0188	0.0637	50.1397	28.8397	56.0789	25.6069	25.8724	25.6855
11	11.1250	0.7008	5.2167	0.0123	0.0016	0.0097	0.0204	0.0692	49.7784	28.4784	60.8900	25.9663	26.2782	26.0753
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0077	0.0188	0.0637	50.6980	29.3980	56.0789	26.3257	26.6520	26.4651
13	13.2500	0.8346	6.2131	0.0123	0.0016	0.0097	0.0204	0.0692	51.1786	29.8786	60.8900	26.6851	27.0578	26.8549
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0077	0.0188	0.0637	49.8257	28.5257	56.0789	27.0445	27.4315	27.2446
15	15.3750	0.9685	7.2095	0.0054	0.0007	0.0042	0.0089	0.0303	39.1670	17.8670	26.6394	27.4040	27.6090	27.5203
Exit									27.5731	6.2731				

Table 40a Fin0.25_2S Re60k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7597	0.0853	-0.0985	25.8797	0.0285	2897.8566	4790.3962	0.0258	322.3846	532.9283	675.7703	1117.1042	5.1634	8.5356
2	2.6398	0.1261	-0.2482	53.4390	0.0471	2842.5074	4327.6209	0.0259	132.4122	201.5931	277.2601	422.1191	2.1185	3.2253
3	2.2678	0.1020	-0.2536	58.6222	0.0372	2871.8265	4747.3663	0.0259	125.2054	206.9749	261.8892	432.9244	2.0011	3.3079
4	2.2028	0.0911	-0.2539	53.8760	0.0393	2865.7510	4363.0086	0.0259	115.5014	175.8469	241.3334	367.4218	1.8440	2.8074
5	2.0826	0.0871	-0.2232	58.8074	0.0342	2880.9011	4762.3673	0.0260	120.1817	198.6703	250.8448	414.6671	1.9167	3.1684
6	2.1520	0.0860	-0.2138	53.9269	0.0384	2868.4558	4367.1265	0.0260	116.4570	177.3019	242.8116	369.6724	1.8553	2.8246
7	2.0839	0.0854	-0.1911	58.8061	0.0342	2880.8352	4762.2585	0.0260	123.0789	203.4596	256.3451	423.7596	1.9587	3.2379
8	2.1796	0.0860	-0.1971	53.8992	0.0389	2866.9849	4364.8871	0.0260	119.2762	181.5940	248.1610	377.8166	1.8962	2.8868
9	2.2635	0.0872	-0.1899	58.6265	0.0372	2872.0366	4747.7136	0.0261	118.8148	196.4106	246.9386	408.2100	1.8868	3.1191
10	2.3451	0.0887	-0.2126	53.7337	0.0418	2858.1837	4351.4876	0.0261	116.5042	177.3737	241.8799	368.2540	1.8482	2.8138
11	2.3993	0.0921	-0.2222	58.4907	0.0394	2865.3855	4736.7188	0.0261	120.3331	198.9205	249.5649	412.5513	1.9069	3.1522
12	2.6361	0.0976	-0.2345	53.4427	0.0470	2842.7048	4327.9215	0.0261	116.6368	177.5756	241.6434	367.8939	1.8464	2.8110
13	2.9716	0.1078	-0.2494	57.9184	0.0488	2837.3491	4690.3724	0.0262	115.8412	191.4950	239.7418	396.3131	1.8318	3.0282
14	3.4407	0.1289	-0.2376	52.6381	0.0614	2799.9071	4262.7635	0.0262	122.9044	187.1178	254.0917	386.8460	1.9415	2.9558
15	1.3555	0.0812	-0.0953	25.2839	0.0509	2831.1449	4680.1163	0.0262	240.6817	397.8668	497.0601	821.6813	3.7980	6.2783
Exit									0				0	

Table 40b Fin0.25_2S Re60k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.9922	0.6922				
1	0.5000	0.0315	0.2345	0.0054	0.0007	0.0042	0.0089	0.0303	30.9163	9.6163	29.7716	22.1478	22.1559	22.0740
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0077	0.0188	0.0637	43.7670	22.4670	62.6725	22.4786	22.5007	22.3283
3	2.6250	0.1654	1.2309	0.0123	0.0016	0.0097	0.0204	0.0692	45.4522	24.1522	68.0494	22.8094	22.8750	22.6878
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0077	0.0188	0.0637	47.5606	26.2606	62.6725	23.1402	23.2197	23.0473
5	4.7500	0.2992	2.2273	0.0123	0.0016	0.0097	0.0204	0.0692	46.9302	25.6302	68.0494	23.4710	23.5940	23.4068
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0077	0.0188	0.0637	47.7246	26.4246	62.6725	23.8018	23.9387	23.7663
7	6.8750	0.4331	3.2238	0.0123	0.0016	0.0097	0.0204	0.0692	46.8407	25.5407	68.0494	24.1325	24.3130	24.1259
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0077	0.0188	0.0637	47.8209	26.5209	62.6725	24.4633	24.6577	24.4854
9	9.0000	0.5669	4.2202	0.0123	0.0016	0.0097	0.0204	0.0692	48.5124	27.2124	68.0494	24.7941	25.0320	24.8449
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0077	0.0188	0.0637	49.2913	27.9913	62.6725	25.1249	25.3768	25.2044
11	11.1250	0.7008	5.2167	0.0123	0.0016	0.0097	0.0204	0.0692	48.9675	27.6675	68.0494	25.4557	25.7511	25.5639
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0077	0.0188	0.0637	49.7953	28.4953	62.6725	25.7865	26.0958	25.9234
13	13.2500	0.8346	6.2131	0.0123	0.0016	0.0097	0.0204	0.0692	50.2541	28.9541	68.0494	26.1172	26.4701	26.2829
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0077	0.0188	0.0637	48.7947	27.4947	62.6725	26.4480	26.8148	26.6424
15	15.3750	0.9685	7.2095	0.0054	0.0007	0.0042	0.0089	0.0303	38.2375	16.9375	29.7716	26.7788	26.9786	26.8967
Exit									26.9345	5.6345				

Table 41a Fin0.25_2S Re70k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.7218	0.0853	-0.0985	29.0498	0.0242	3252.8326	5377.2007	0.0258	370.9713	613.2462	778.1367	1286.3243	5.0945	8.4217
2	2.5854	0.1261	-0.2482	60.0872	0.0413	3196.1321	4866.0025	0.0258	150.1352	228.5757	314.6076	478.9794	2.0598	3.1359
3	2.2091	0.1020	-0.2536	65.8403	0.0325	3225.4311	5331.9039	0.0259	142.4486	235.4792	298.2061	492.9593	1.9524	3.2274
4	2.1390	0.0911	-0.2539	60.5336	0.0341	3219.8784	4902.1555	0.0259	131.8519	200.7400	275.7510	419.8215	1.8054	2.7486
5	2.0085	0.0871	-0.2232	66.0409	0.0295	3235.2591	5348.1504	0.0259	137.9098	227.9762	288.1366	476.3137	1.8865	3.1185
6	2.0595	0.0860	-0.2138	60.6131	0.0329	3224.1068	4908.5931	0.0260	134.7709	205.1841	281.3021	428.2730	1.8417	2.8039
7	1.9904	0.0854	-0.1911	66.0589	0.0293	3236.1432	5349.6119	0.0260	142.5099	235.5806	297.1637	491.2362	1.9456	3.2162
8	2.0847	0.0860	-0.1971	60.5879	0.0333	3222.7648	4906.5500	0.0260	137.9751	210.0624	287.4260	437.5963	1.8818	2.8650
9	2.1844	0.0872	-0.1899	65.8650	0.0321	3226.6441	5333.9091	0.0260	136.0400	224.8854	283.1177	468.0169	1.8536	3.0641
10	2.2699	0.0887	-0.2126	60.4027	0.0362	3212.9151	4891.5542	0.0261	132.9495	202.4111	276.4155	420.8333	1.8097	2.7552
11	2.3246	0.0921	-0.2222	65.7247	0.0342	3219.7712	5322.5476	0.0261	136.9424	226.3771	284.4393	470.2017	1.8622	3.0784
12	2.5480	0.0976	-0.2345	60.1246	0.0407	3198.1226	4869.0331	0.0261	133.2062	202.8019	276.4093	420.8238	1.8097	2.7552
13	2.8719	0.1078	-0.2494	65.1775	0.0422	3192.9607	5278.2277	0.0261	132.2859	218.6796	274.2327	453.3292	1.7954	2.9680
14	3.3078	0.1289	-0.2376	59.3648	0.0528	3157.7081	4807.5034	0.0262	141.3057	215.1331	292.6461	445.5438	1.9160	2.9170
15	1.2800	0.0812	-0.0953	28.4916	0.0430	3190.3249	5273.8705	0.0262	278.4186	460.2489	576.0493	952.2571	3.7714	6.2345
Exit									0				0	

Table 41b Fin0.25_2S Re70k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.6617	-0.2383				
1	0.5000	0.0315	0.2345	0.0054	0.0007	0.0042	0.0089	0.0303	30.4215	8.5215	33.2989	21.8127	21.8263	21.7440
2	1.5625	0.0984	0.7327	0.0123	0.0013	0.0077	0.0188	0.0637	43.2506	21.3506	70.0979	22.1336	22.1728	21.9995
3	2.6250	0.1654	1.2309	0.0123	0.0016	0.0097	0.0204	0.0692	44.6375	22.7375	76.1118	22.4544	22.5490	22.3609
4	3.6875	0.2323	1.7291	0.0123	0.0013	0.0077	0.0188	0.0637	46.4417	24.5417	70.0979	22.7753	22.8955	22.7223
5	4.7500	0.2992	2.2273	0.0123	0.0016	0.0097	0.0204	0.0692	45.8385	23.9385	76.1118	23.0962	23.2717	23.0836
6	5.8125	0.3661	2.7256	0.0123	0.0013	0.0077	0.0188	0.0637	46.5519	24.6519	70.0979	23.4171	23.6182	23.4450
7	6.8750	0.4331	3.2238	0.0123	0.0016	0.0097	0.0204	0.0692	45.6388	23.7388	76.1118	23.7380	23.9944	23.8063
8	7.9375	0.5000	3.7220	0.0123	0.0013	0.0077	0.0188	0.0637	46.5180	24.6180	70.0979	24.0588	24.3409	24.1677
9	9.0000	0.5669	4.2202	0.0123	0.0016	0.0097	0.0204	0.0692	47.0051	25.1051	76.1118	24.3797	24.7171	24.5290
10	10.0625	0.6339	4.7184	0.0123	0.0013	0.0077	0.0188	0.0637	47.6586	25.7586	70.0979	24.7006	25.0636	24.8904
11	11.1250	0.7008	5.2167	0.0123	0.0016	0.0097	0.0204	0.0692	47.3389	25.4389	76.1118	25.0215	25.4399	25.2518
12	12.1875	0.7677	5.7149	0.0123	0.0013	0.0077	0.0188	0.0637	48.2662	26.3662	70.0979	25.3423	25.7864	25.6131
13	13.2500	0.8346	6.2131	0.0123	0.0016	0.0097	0.0204	0.0692	49.0068	27.1068	76.1118	25.6632	26.1626	25.9745
14	14.3125	0.9016	6.7113	0.0123	0.0013	0.0077	0.0188	0.0637	47.7181	25.8181	70.0979	25.9841	26.5091	26.3358
15	15.3750	0.9685	7.2095	0.0054	0.0007	0.0042	0.0089	0.0303	37.2476	15.3476	33.2989	26.3050	26.6737	26.5914
Exit									26.4560	4.5560				

Table 41a Fin0.25_2S Re80k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6284	0.0853	-0.0985	32.6705	0.0189	3658.2575	6047.4017	0.0258	424.9421	702.4643	892.2374	1474.9420	5.3584	8.8578
2	2.4446	0.1261	-0.2482	67.6534	0.0349	3598.5902	5478.7314	0.0258	170.4116	259.4459	357.4648	544.2281	2.1468	3.2684
3	2.0649	0.1020	-0.2536	74.0470	0.0271	3627.4666	5996.5017	0.0258	163.5245	270.3194	342.6895	566.4940	2.0580	3.4021
4	1.9823	0.0911	-0.2539	68.1156	0.0283	3623.1785	5516.1662	0.0259	153.0942	233.0808	320.5247	487.9879	1.9249	2.9306
5	1.8612	0.0871	-0.2232	74.2506	0.0245	3637.4440	6012.9952	0.0259	159.9419	264.3971	334.5413	553.0244	2.0091	3.3212
6	1.9070	0.0860	-0.2138	68.1910	0.0272	3627.1873	5522.2695	0.0259	156.7845	238.6991	327.6243	498.7969	1.9676	2.9955
7	1.8365	0.0854	-0.1911	74.2753	0.0241	3638.6518	6014.9918	0.0259	166.1417	274.6460	346.8469	573.3666	2.0830	3.4434
8	1.9210	0.0860	-0.1971	68.1770	0.0274	3626.4422	5521.1350	0.0260	161.4682	245.8299	336.7694	512.7200	2.0225	3.0792
9	2.0005	0.0872	-0.1899	74.1114	0.0263	3630.6202	6001.7149	0.0260	160.4665	265.2644	334.3621	552.7282	2.0080	3.3194
10	2.0719	0.0887	-0.2126	68.0261	0.0296	3618.4164	5508.9161	0.0260	157.6101	239.9561	328.0987	499.5191	1.9704	2.9999
11	2.1195	0.0921	-0.2222	73.9923	0.0278	3624.7896	5992.0765	0.0260	162.4193	268.4926	337.7894	558.3938	2.0286	3.3535
12	2.3401	0.0976	-0.2345	67.7579	0.0334	3604.1498	5487.1957	0.0261	157.2226	239.3661	326.6721	497.3471	1.9618	2.9868
13	2.6728	0.1078	-0.2494	73.4391	0.0351	3597.6851	5947.2704	0.0261	154.1189	254.7712	319.9204	528.8548	1.9213	3.1761
14	3.0916	0.1289	-0.2376	67.0064	0.0441	3564.1767	5426.3380	0.0261	163.9911	249.6710	340.0917	517.7781	2.0424	3.1095
15	1.1509	0.0812	-0.0953	32.1480	0.0346	3599.7500	5950.6839	0.0261	328.9659	543.8077	681.5796	1126.7074	4.0932	6.7665
Exit									0				0	

Table 41b Fin0.25_2S Re80k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.75815347	0.558153465				
1	0.5	0.031496	0.234457	0.005402409	0.00035282	0.00381048	0.008860063	0.030269176	29.8381	8.638053507	10.16488613	21.92249017	21.94181634	21.8499849
2	1.5625	0.098425	0.732677	0.012348362	0.00064516	0.00696773	0.01867093	0.063786643	40.1058	18.90580594	21.42060198	22.27170567	22.3288516	22.13533397
3	2.625	0.165354	1.230897	0.012348362	0.00080645	0.00870966	0.020251572	0.069186687	42.6536	21.45361468	23.23402543	22.62092117	22.74865246	22.53875203
4	3.6875	0.232283	1.729118	0.012348362	0.00064516	0.00696773	0.01867093	0.063786643	45.6158	24.41579876	21.42060198	22.97013668	23.13568772	22.94217009
5	4.75	0.299213	2.227338	0.012348362	0.00080645	0.00870966	0.020251572	0.069186687	45.5705	24.370503	23.23402543	23.31935218	23.55548858	23.34558815
6	5.8125	0.366142	2.725558	0.012348362	0.00064516	0.00696773	0.01867093	0.063786643	47.2216	26.0215552	21.42060198	23.66856768	23.94252384	23.74900621
7	6.875	0.433071	3.223779	0.012348362	0.00080645	0.00870966	0.020251572	0.069186687	47.0003	25.80030604	23.23402543	24.01778318	24.3623247	24.15242427
8	7.9375	0.5	3.721999	0.012348362	0.00064516	0.00696773	0.01867093	0.063786643	48.9202	27.72020421	21.42060198	24.36699868	24.74935996	24.55584233
9	9	0.566929	4.220219	0.012348362	0.00080645	0.00870966	0.020251572	0.069186687	48.2931	27.09305545	23.23402543	24.71621418	25.16916082	24.95926039
10	10.0625	0.633858	4.71844	0.012348362	0.00064516	0.00696773	0.01867093	0.063786643	49.2908	28.09084431	21.42060198	25.06542968	25.55619608	25.36267845
11	11.125	0.700787	5.21666	0.012348362	0.00080645	0.00870966	0.020251572	0.069186687	48.7750	27.5749774	23.23402543	25.41464518	25.97599694	25.76609651
12	12.1875	0.767717	5.71488	0.012348362	0.00064516	0.00696773	0.01867093	0.063786643	49.5343	28.33426918	21.42060198	25.76386068	26.3630322	26.16951457
13	13.25	0.834646	6.213101	0.012348362	0.00080645	0.00870966	0.020251572	0.069186687	48.8931	27.69309547	23.23402543	26.11307619	26.78283306	26.57293263
14	14.3125	0.901575	6.711321	0.012348362	0.00064516	0.00696773	0.01867093	0.063786643	47.4077	26.20765693	21.42060198	26.46229169	27.16986832	26.97635069
15	15.375	0.968504	7.209542	0.005402409	0.00035282	0.00381048	0.008860063	0.030269176	39.0354	17.83543276	10.16488613	26.81150719	27.35353119	27.26169975
Exit									26.97584389	5.775843894				

Table 42a Fin0.125_2S Re20k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6768	0.0757	0.0233	9.4881	0.0666	1070.8809	1756.2671	0.0258	135.2880	221.8752	283.9667	465.7113	4.8133	7.8940
2	2.1266	0.1191	-0.1245	19.2940	0.0993	1033.3731	1562.4774	0.0258	57.9437	87.6118	121.4957	183.7035	2.0594	3.1138
3	1.9409	0.0994	-0.1913	21.2931	0.0835	1051.4302	1724.3674	0.0259	52.4857	86.0777	109.9369	180.2988	1.8635	3.0561
4	1.9165	0.0864	-0.1929	19.5041	0.0895	1044.6228	1579.4871	0.0259	46.1290	69.7479	96.5217	145.9424	1.6361	2.4738
5	1.8210	0.0807	-0.1456	21.4131	0.0784	1057.3532	1734.0814	0.0259	47.5190	77.9322	99.3269	162.8982	1.6836	2.7612
6	1.8809	0.0767	-0.1153	19.5397	0.0878	1046.5323	1582.3743	0.0259	44.4331	67.1836	92.7802	140.2852	1.5727	2.3779
7	1.8622	0.0751	-0.0755	21.3719	0.0801	1055.3185	1730.7443	0.0260	45.9183	75.3070	95.7821	157.0846	1.6235	2.6626
8	2.0046	0.0747	-0.0654	19.4160	0.0936	1039.9049	1572.3536	0.0260	42.3531	64.0386	88.2540	133.4415	1.4959	2.2619
9	1.9865	0.0755	-0.0602	21.2475	0.0855	1049.1791	1720.6757	0.0260	44.5004	72.9816	92.6327	151.9195	1.5702	2.5751
10	2.1033	0.0780	-0.0873	19.3173	0.0982	1034.6206	1564.3636	0.0260	42.7081	64.5753	88.8100	134.2822	1.5054	2.2761
11	2.1524	0.0823	-0.1165	21.0817	0.0926	1040.9890	1707.2437	0.0261	44.5623	73.0830	92.5703	151.8172	1.5691	2.5734
12	2.3886	0.0893	-0.1424	19.0320	0.1115	1019.3395	1541.2584	0.0261	42.8827	64.8394	88.9897	134.5538	1.5084	2.2807
13	2.6196	0.1000	-0.1484	20.6144	0.1127	1017.9161	1669.4037	0.0261	44.6846	73.2837	92.6336	151.9211	1.5702	2.5751
14	3.0198	0.1186	-0.0872	18.4008	0.1410	985.5298	1490.1376	0.0262	47.0524	71.1440	97.4421	147.3342	1.6517	2.4974
15	1.2605	0.0691	0.0283	8.9043	0.1240	1004.9980	1648.2178	0.0262	82.2157	134.8354	170.0882	278.9483	2.8831	4.7283
Exit									0				0	

Table 42a Fin0.125_2S Re20k Part1

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.6354	0.3354				
1	0.5000	0.0315	0.2345	0.0054	0.0004	0.0038	0.0089	0.0303	29.7744	8.4744	13.5917	21.7871	21.8071	21.7212
2	1.5625	0.0984	0.7327	0.0123	0.0006	0.0070	0.0187	0.0638	40.8726	19.5726	28.6421	22.1095	22.1690	21.9880
3	2.6250	0.1654	1.2309	0.0123	0.0008	0.0087	0.0203	0.0692	43.2693	21.9693	31.0668	22.4319	22.5615	22.3653
4	3.6875	0.2323	1.7291	0.0123	0.0006	0.0070	0.0187	0.0638	46.3227	25.0227	28.6421	22.7543	22.9234	22.7425
5	4.7500	0.2992	2.2273	0.0123	0.0008	0.0087	0.0203	0.0692	45.7728	24.4728	31.0668	23.0767	23.3160	23.1197
6	5.8125	0.3661	2.7256	0.0123	0.0006	0.0070	0.0187	0.0638	47.3780	26.0780	28.6421	23.3991	23.6779	23.4969
7	6.8750	0.4331	3.2238	0.0123	0.0008	0.0087	0.0203	0.0692	46.9871	25.6871	31.0668	23.7215	24.0704	23.8741
8	7.9375	0.5000	3.7220	0.0123	0.0006	0.0070	0.0187	0.0638	48.9596	27.6596	28.6421	24.0439	24.4323	24.2513
9	9.0000	0.5669	4.2202	0.0123	0.0008	0.0087	0.0203	0.0692	48.1702	26.8702	31.0668	24.3663	24.8248	24.6286
10	10.0625	0.6339	4.7184	0.0123	0.0006	0.0070	0.0187	0.0638	49.2192	27.9192	28.6421	24.6887	25.1867	25.0058
11	11.1250	0.7008	5.2167	0.0123	0.0008	0.0087	0.0203	0.0692	48.6630	27.3630	31.0668	25.0111	25.5793	25.3830
12	12.1875	0.7677	5.7149	0.0123	0.0006	0.0070	0.0187	0.0638	49.6167	28.3167	28.6421	25.3335	25.9412	25.7602
13	13.2500	0.8346	6.2131	0.0123	0.0008	0.0087	0.0203	0.0692	49.1536	27.8536	31.0668	25.6559	26.3337	26.1374
14	14.3125	0.9016	6.7113	0.0123	0.0006	0.0070	0.0187	0.0638	47.8964	26.5964	28.6421	25.9783	26.6956	26.5147
15	15.3750	0.9685	7.2095	0.0054	0.0004	0.0038	0.0089	0.0303	38.8082	17.5082	13.5917	26.3007	26.8673	26.7815
Exit									26.4524	5.1524				

Table 43a Fin0.125_2S Re30k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6644	0.0757	0.0233	12.9273	0.0489	1459.0541	2392.8792	0.0258	182.6703	299.5831	383.5765	629.0734	4.8805	8.0041
2	2.2060	0.1191	-0.1245	26.4361	0.0770	1415.8969	2140.8599	0.0258	75.4617	114.0994	158.3040	239.3583	2.0142	3.0455
3	1.9922	0.0994	-0.1913	29.0747	0.0641	1435.6755	2354.5379	0.0258	68.8990	112.9958	144.3977	236.8152	1.8373	3.0132
4	1.9690	0.0864	-0.1929	26.6731	0.0687	1428.5905	2160.0527	0.0259	60.6146	91.6503	126.9133	191.8950	1.6148	2.4416
5	1.8292	0.0807	-0.1456	29.2376	0.0589	1443.7216	2367.7335	0.0259	63.6109	104.3232	133.0591	218.2196	1.6930	2.7766
6	1.8852	0.0767	-0.1153	26.7569	0.0658	1433.0763	2166.8354	0.0259	59.7640	90.3642	124.8924	188.8395	1.5891	2.4027
7	1.8537	0.0751	-0.0755	29.2132	0.0597	1442.5143	2365.7536	0.0259	62.0020	101.6846	129.4453	212.2929	1.6470	2.7011
8	2.0001	0.0747	-0.0654	26.6420	0.0698	1426.9232	2157.5317	0.0260	57.2700	86.5932	119.4516	180.6128	1.5199	2.2981
9	1.9697	0.0755	-0.0602	29.0972	0.0634	1436.7864	2356.3598	0.0260	60.3593	98.9905	125.7749	206.2735	1.6003	2.6246
10	2.0899	0.0780	-0.0873	26.5522	0.0730	1422.1135	2150.2594	0.0260	57.9733	87.6566	120.6878	182.4820	1.5356	2.3218
11	2.1349	0.0823	-0.1165	28.9319	0.0687	1428.6265	2342.9773	0.0260	60.4023	99.0611	125.6248	206.0273	1.5984	2.6214
12	2.3870	0.0893	-0.1424	26.2551	0.0833	1406.1994	2126.1970	0.0261	57.9082	87.5582	120.3230	181.9304	1.5310	2.3148
13	2.6357	0.1000	-0.1484	28.4312	0.0848	1403.9000	2302.4253	0.0261	59.7463	97.9852	124.0242	203.4024	1.5780	2.5880
14	3.0659	0.1186	-0.0872	25.5761	0.1070	1369.8372	2071.2168	0.0261	62.4980	94.4979	129.6131	195.9771	1.6492	2.4935
15	1.2379	0.0691	0.0283	12.3538	0.0911	1394.3259	2286.7237	0.0261	111.4797	182.8290	230.9760	378.8054	2.9389	4.8198
Exit									0				0	

Table 43b Fin0.125_2S Re30k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									21.4710	0.4710				
1	0.5000	0.0315	0.2345	0.0054	0.0004	0.0038	0.0089	0.0303	29.8444	8.8444	16.7962	21.6105	21.6352	21.5531
2	1.5625	0.0984	0.7327	0.0123	0.0006	0.0070	0.0187	0.0638	41.7445	20.7445	35.3948	21.9068	21.9812	21.8082
3	2.6250	0.1654	1.2309	0.0123	0.0008	0.0087	0.0203	0.0692	43.9121	22.9121	38.3912	22.2031	22.3564	22.1688
4	3.6875	0.2323	1.7291	0.0123	0.0006	0.0070	0.0187	0.0638	46.9351	25.9351	35.3948	22.4994	22.7024	22.5294
5	4.7500	0.2992	2.2273	0.0123	0.0008	0.0087	0.0203	0.0692	45.9550	24.9550	38.3912	22.7958	23.0776	22.8900
6	5.8125	0.3661	2.7256	0.0123	0.0006	0.0070	0.0187	0.0638	47.4549	26.4549	35.3948	23.0921	23.4236	23.2506
7	6.8750	0.4331	3.2238	0.0123	0.0008	0.0087	0.0203	0.0692	46.8560	25.8560	38.3912	23.3884	23.7988	23.6112
8	7.9375	0.5000	3.7220	0.0123	0.0006	0.0070	0.0187	0.0638	48.8263	27.8263	35.3948	23.6847	24.1448	23.9718
9	9.0000	0.5669	4.2202	0.0123	0.0008	0.0087	0.0203	0.0692	47.8956	26.8956	38.3912	23.9810	24.5200	24.3324
10	10.0625	0.6339	4.7184	0.0123	0.0006	0.0070	0.0187	0.0638	48.8564	27.8564	35.3948	24.2773	24.8660	24.6930
11	11.1250	0.7008	5.2167	0.0123	0.0008	0.0087	0.0203	0.0692	48.2811	27.2811	38.3912	24.5736	25.2413	25.0536
12	12.1875	0.7677	5.7149	0.0123	0.0006	0.0070	0.0187	0.0638	49.2901	28.2901	35.3948	24.8700	25.5872	25.4142
13	13.2500	0.8346	6.2131	0.0123	0.0008	0.0087	0.0203	0.0692	48.9593	27.9593	38.3912	25.1663	25.9625	25.7748
14	14.3125	0.9016	6.7113	0.0123	0.0006	0.0070	0.0187	0.0638	47.8183	26.8183	35.3948	25.4626	26.3084	26.1354
15	15.3750	0.9685	7.2095	0.0054	0.0004	0.0038	0.0089	0.0303	38.2931	17.2931	16.7962	25.7589	26.4726	26.3905
Exit									25.8984	4.8984				

Table 44a Fin0.125_2S Re40k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6924	0.0757	0.0233	16.1037	0.0412	1817.5642	2980.8433	0.0258	220.7405	362.0191	463.7624	760.5801	4.8015	7.8746
2	2.3455	0.1191	-0.1245	33.0493	0.0663	1770.0930	2676.4103	0.0258	89.2286	134.9151	187.2977	283.1973	1.9392	2.9321
3	2.0859	0.0994	-0.1913	36.3054	0.0543	1792.7184	2940.0956	0.0258	82.5797	135.4325	173.1878	284.0316	1.7931	2.9407
4	2.0478	0.0864	-0.1929	33.3470	0.0579	1786.0382	2700.5196	0.0259	73.0915	110.5155	153.1533	231.5704	1.5857	2.3975
5	1.8681	0.0807	-0.1456	36.5231	0.0487	1803.4700	2957.7285	0.0259	77.8727	127.7129	163.0277	267.3688	1.6879	2.7682
6	1.9141	0.0767	-0.1153	33.4807	0.0541	1793.1974	2711.3445	0.0259	73.6038	111.2902	153.9548	232.7822	1.5940	2.4101
7	1.8663	0.0751	-0.0755	36.5249	0.0486	1803.5577	2957.8724	0.0259	76.8532	126.0409	160.6098	263.4034	1.6629	2.7271
8	2.0125	0.0747	-0.0654	33.3822	0.0569	1787.9262	2703.3743	0.0259	71.1142	107.5259	148.4856	224.5127	1.5373	2.3245
9	1.9716	0.0755	-0.0602	36.4196	0.0514	1798.3614	2949.3502	0.0260	75.1994	123.3286	156.8773	257.2821	1.6242	2.6637
10	2.0850	0.0780	-0.0873	33.3098	0.0589	1784.0454	2697.5065	0.0260	72.5839	109.7481	151.2881	228.7502	1.5663	2.3683
11	2.1282	0.0823	-0.1165	36.2630	0.0554	1790.6289	2936.6687	0.0260	75.5303	123.8713	157.2914	257.9611	1.6285	2.6708
12	2.3846	0.0893	-0.1424	33.0101	0.0674	1767.9967	2673.2405	0.0260	72.3992	109.4689	150.6388	227.7684	1.5596	2.3582
13	2.6462	0.1000	-0.1484	35.7450	0.0689	1765.0479	2894.7154	0.0261	74.1834	121.6624	154.2160	252.9175	1.5967	2.6186
14	3.0922	0.1186	-0.0872	32.3025	0.0874	1730.0982	2615.9374	0.0261	77.3896	117.0144	160.7406	243.0425	1.6642	2.5163
15	1.2231	0.0691	0.0283	15.5731	0.0728	1757.6728	2882.6202	0.0261	140.2306	229.9811	291.0089	477.2607	3.0129	4.9413
Exit									0				0	0

Table 44b Fin0.125_2S Re40k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									20.9582	0.0582				
1	0.5000	0.0315	0.2345	0.0054	0.0004	0.0038	0.0089	0.0303	29.6938	8.7938	21.6939	21.0865	21.1197	21.0390
2	1.5625	0.0984	0.7327	0.0123	0.0006	0.0070	0.0187	0.0638	42.7043	21.8043	45.7159	21.3590	21.4599	21.2898
3	2.6250	0.1654	1.2309	0.0123	0.0008	0.0087	0.0203	0.0692	44.7056	23.8056	49.5861	21.6315	21.8290	21.6444
4	3.6875	0.2323	1.7291	0.0123	0.0006	0.0070	0.0187	0.0638	47.7531	26.8531	45.7159	21.9040	22.1692	21.9991
5	4.7500	0.2992	2.2273	0.0123	0.0008	0.0087	0.0203	0.0692	46.3166	25.4166	49.5861	22.1765	22.5382	22.3537
6	5.8125	0.3661	2.7256	0.0123	0.0006	0.0070	0.0187	0.0638	47.6923	26.7923	45.7159	22.4490	22.8784	22.7083
7	6.8750	0.4331	3.2238	0.0123	0.0008	0.0087	0.0203	0.0692	47.0105	26.1105	49.5861	22.7215	23.2475	23.0630
8	7.9375	0.5000	3.7220	0.0123	0.0006	0.0070	0.0187	0.0638	49.0167	28.1167	45.7159	22.9940	23.5877	23.4176
9	9.0000	0.5669	4.2202	0.0123	0.0008	0.0087	0.0203	0.0692	48.0273	27.1273	49.5861	23.2665	23.9567	23.7722
10	10.0625	0.6339	4.7184	0.0123	0.0006	0.0070	0.0187	0.0638	49.0682	28.1682	45.7159	23.5390	24.2970	24.1268
11	11.1250	0.7008	5.2167	0.0123	0.0008	0.0087	0.0203	0.0692	48.4828	27.5828	49.5861	23.8115	24.6660	24.4815
12	12.1875	0.7677	5.7149	0.0123	0.0006	0.0070	0.0187	0.0638	49.6279	28.7279	45.7159	24.0840	25.0062	24.8361
13	13.2500	0.8346	6.2131	0.0123	0.0008	0.0087	0.0203	0.0692	49.3024	28.4024	49.5861	24.3565	25.3752	25.1907
14	14.3125	0.9016	6.7113	0.0123	0.0006	0.0070	0.0187	0.0638	48.3198	27.4198	45.7159	24.6290	25.7155	25.5454
15	15.3750	0.9685	7.2095	0.0054	0.0004	0.0038	0.0089	0.0303	37.9668	17.0668	21.6939	24.9015	25.8769	25.7962

Table 45a Fin0.125_2S Re50k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6886	0.0757	0.0233	21.0053	0.0317	2370.7874	3888.1408	0.0257	275.4378	451.7238	579.5874	950.5355	4.8179	7.9015
2	2.4717	0.1191	-0.1245	43.2442	0.0541	2316.1257	3502.0207	0.0258	108.5073	164.0648	228.1390	344.9499	1.8964	2.8674
3	2.1747	0.0994	-0.1913	47.4114	0.0439	2341.1243	3839.4927	0.0258	101.4611	166.3983	213.1502	349.5708	1.7718	2.9059
4	2.1271	0.0864	-0.1929	43.5888	0.0465	2334.5811	3529.9257	0.0258	90.3156	136.5587	189.5810	286.6497	1.5759	2.3828
5	1.9054	0.0807	-0.1456	47.6807	0.0384	2354.4214	3861.3004	0.0258	97.5315	159.9537	204.5612	335.4846	1.7004	2.7888
6	1.9400	0.0767	-0.1153	43.7759	0.0424	2344.6022	3545.0778	0.0258	92.8803	140.4365	194.6474	294.3101	1.6180	2.4465
7	1.8855	0.0751	-0.0755	47.7007	0.0380	2355.4048	3862.9131	0.0259	96.9742	159.0398	203.0619	333.0258	1.6880	2.7683
8	2.0342	0.0747	-0.0654	43.6817	0.0445	2339.5558	3537.4475	0.0259	89.9045	135.9371	188.1054	284.4185	1.5637	2.3643
9	1.9891	0.0755	-0.0602	47.5970	0.0401	2350.2879	3854.5212	0.0259	94.9196	155.6701	198.4373	325.4414	1.6495	2.7053
10	2.1093	0.0780	-0.0873	43.6066	0.0461	2335.5342	3531.3667	0.0259	91.4849	138.3267	191.1019	288.9493	1.5886	2.4019
11	2.1530	0.0823	-0.1165	47.4331	0.0434	2342.1937	3841.2467	0.0260	94.9359	155.6969	198.1504	324.9708	1.6472	2.7014
12	2.4237	0.0893	-0.1424	43.2922	0.0530	2318.6930	3505.9026	0.0260	90.7730	137.2503	189.3084	286.2375	1.5737	2.3794
13	2.6905	0.1000	-0.1484	46.8956	0.0543	2315.6518	3797.7173	0.0260	92.8270	152.2382	193.4357	317.2387	1.6080	2.6371
14	3.1635	0.1186	-0.0872	42.5524	0.0692	2279.0700	3445.9919	0.0260	96.2009	145.4574	200.3049	302.8643	1.6651	2.5176
15	1.2074	0.0691	0.0283	20.4865	0.0557	2312.2285	3792.1031	0.0260	176.9759	290.2442	368.1937	603.8454	3.0607	5.0195
Exit									0				0	

Table 45b Fin0.125_2S Re50k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									20.3422	-0.4578				
1	0.5000	0.0315	0.2345	0.0054	0.0004	0.0038	0.0089	0.0303	29.4453	8.6453	23.9269	20.4725	20.5009	20.4216
2	1.5625	0.0984	0.7327	0.0123	0.0006	0.0070	0.0187	0.0638	43.2591	22.4591	50.4215	20.7495	20.8354	20.6682
3	2.6250	0.1654	1.2309	0.0123	0.0008	0.0087	0.0203	0.0692	45.2176	24.4176	54.6901	21.0265	21.1982	21.0168
4	3.6875	0.2323	1.7291	0.0123	0.0006	0.0070	0.0187	0.0638	48.2115	27.4115	50.4215	21.3034	21.5327	21.3654
5	4.7500	0.2992	2.2273	0.0123	0.0008	0.0087	0.0203	0.0692	46.5315	25.7315	54.6901	21.5804	21.8954	21.7141
6	5.8125	0.3661	2.7256	0.0123	0.0006	0.0070	0.0187	0.0638	47.7610	26.9610	50.4215	21.8574	22.2299	22.0627
7	6.8750	0.4331	3.2238	0.0123	0.0008	0.0087	0.0203	0.0692	46.9633	26.1633	54.6901	22.1343	22.5927	22.4113
8	7.9375	0.5000	3.7220	0.0123	0.0006	0.0070	0.0187	0.0638	48.9490	28.1490	50.4215	22.4113	22.9272	22.7599
9	9.0000	0.5669	4.2202	0.0123	0.0008	0.0087	0.0203	0.0692	47.9572	27.1572	54.6901	22.6883	23.2900	23.1086
10	10.0625	0.6339	4.7184	0.0123	0.0006	0.0070	0.0187	0.0638	49.0006	28.2006	50.4215	22.9652	23.6244	23.4572
11	11.1250	0.7008	5.2167	0.0123	0.0008	0.0087	0.0203	0.0692	48.4958	27.6958	54.6901	23.2422	23.9872	23.8058
12	12.1875	0.7677	5.7149	0.0123	0.0006	0.0070	0.0187	0.0638	49.7549	28.9549	50.4215	23.5192	24.3217	24.1545
13	13.2500	0.8346	6.2131	0.0123	0.0008	0.0087	0.0203	0.0692	49.5128	28.7128	54.6901	23.7961	24.6845	24.5031
14	14.3125	0.9016	6.7113	0.0123	0.0006	0.0070	0.0187	0.0638	48.6231	27.8231	50.4215	24.0731	25.0189	24.8517
15	15.3750	0.9685	7.2095	0.0054	0.0004	0.0038	0.0089	0.0303	37.7760	16.9760	23.9269	24.3501	25.1777	25.0983
Exit									24.4804	3.6804				

Table 46a Fin0.125_2S Re60k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.6774	0.0757	0.0233	23.2495	0.0283	2624.0825	4303.5501	0.0257	292.4501	479.6243	616.5211	1011.1074	4.6685	7.6565
2	2.5496	0.1191	-0.1245	47.8718	0.0506	2563.9768	3876.7758	0.0257	113.9058	172.2275	239.9278	362.7749	1.8168	2.7471
3	2.2355	0.0994	-0.1913	52.4546	0.0409	2590.1477	4247.8964	0.0257	107.0703	175.5975	225.3422	369.5659	1.7064	2.7985
4	2.1753	0.0864	-0.1929	48.2461	0.0431	2584.0242	3907.0878	0.0258	96.0316	145.2014	201.9422	305.3400	1.5292	2.3121
5	1.9308	0.0807	-0.1456	52.7593	0.0353	2605.1937	4272.5721	0.0258	104.4122	171.2382	219.3834	359.7934	1.6613	2.7245
6	1.9529	0.0767	-0.1153	48.4685	0.0387	2595.9360	3925.0986	0.0258	100.2153	151.5272	210.3908	318.1144	1.5932	2.4089
7	1.8894	0.0751	-0.0755	52.8006	0.0345	2607.2356	4275.9209	0.0258	105.0077	172.2149	220.2695	361.2466	1.6680	2.7355
8	2.0366	0.0747	-0.0654	48.3848	0.0404	2591.4533	3918.3207	0.0258	97.6518	147.6511	204.6700	309.4644	1.5498	2.3434
9	1.9913	0.0755	-0.0602	52.6987	0.0364	2602.2035	4267.6681	0.0259	102.9806	168.8903	215.6605	353.6877	1.6331	2.6783
10	2.1118	0.0780	-0.0873	48.3096	0.0419	2587.4256	3912.2307	0.0259	99.3811	150.2659	207.9509	314.4252	1.5747	2.3809
11	2.1623	0.0823	-0.1165	52.5277	0.0395	2593.7614	4253.8229	0.0259	102.7084	168.4440	214.7361	352.1717	1.6261	2.6668
12	2.4440	0.0893	-0.1424	47.9775	0.0485	2569.6337	3885.3291	0.0259	97.9440	148.0930	204.6064	309.3683	1.5494	2.3426
13	2.7216	0.1000	-0.1484	51.9685	0.0498	2566.1465	4208.5339	0.0260	99.7852	163.6498	208.2813	341.5857	1.5772	2.5866
14	3.2114	0.1186	-0.0872	47.2101	0.0637	2528.5359	3823.1885	0.0260	102.9955	155.7309	214.8055	324.7895	1.6266	2.4594
15	1.2012	0.0691	0.0283	22.7257	0.0502	2564.9634	4206.5936	0.0260	191.0461	313.3197	398.1155	652.9178	3.0147	4.9441
Exit									0				0	

Table 46b Fin0.125_2S Re60k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									19.2393	-1.7607				
1	0.5000	0.0315	0.2345	0.0054	0.0004	0.0038	0.0089	0.0303	28.5691	7.5691	28.5550	19.3750	19.3959	19.3176
2	1.5625	0.0984	0.7327	0.0123	0.0006	0.0070	0.0187	0.0638	43.2289	22.2289	60.1744	19.6633	19.7260	19.5609
3	2.6250	0.1654	1.2309	0.0123	0.0008	0.0087	0.0203	0.0692	45.2534	24.2534	65.2687	19.9516	20.0840	19.9050
4	3.6875	0.2323	1.7291	0.0123	0.0006	0.0070	0.0187	0.0638	48.4141	27.4141	60.1744	20.2400	20.4141	20.2490
5	4.7500	0.2992	2.2273	0.0123	0.0008	0.0087	0.0203	0.0692	46.5210	25.5210	65.2687	20.5283	20.7721	20.5931
6	5.8125	0.3661	2.7256	0.0123	0.0006	0.0070	0.0187	0.0638	47.8680	26.8680	60.1744	20.8167	21.1021	20.9371
7	6.8750	0.4331	3.2238	0.0123	0.0008	0.0087	0.0203	0.0692	47.1572	26.1572	65.2687	21.1050	21.4602	21.2812
8	7.9375	0.5000	3.7220	0.0123	0.0006	0.0070	0.0187	0.0638	49.0696	28.0696	60.1744	21.3933	21.7902	21.6252
9	9.0000	0.5669	4.2202	0.0123	0.0008	0.0087	0.0203	0.0692	47.7291	26.7291	65.2687	21.6817	22.1482	21.9692
10	10.0625	0.6339	4.7184	0.0123	0.0006	0.0070	0.0187	0.0638	48.7140	27.7140	60.1744	21.9700	22.4783	22.3133
11	11.1250	0.7008	5.2167	0.0123	0.0008	0.0087	0.0203	0.0692	48.0057	27.0057	65.2687	22.2584	22.8363	22.6573
12	12.1875	0.7677	5.7149	0.0123	0.0006	0.0070	0.0187	0.0638	49.1489	28.1489	60.1744	22.5467	23.1664	23.0014
13	13.2500	0.8346	6.2131	0.0123	0.0008	0.0087	0.0203	0.0692	48.9224	27.9224	65.2687	22.8350	23.5244	23.3454
14	14.3125	0.9016	6.7113	0.0123	0.0006	0.0070	0.0187	0.0638	47.9549	26.9549	60.1744	23.1234	23.8545	23.6895
15	15.3750	0.9685	7.2095	0.0054	0.0004	0.0038	0.0089	0.0303	36.5888	15.5888	28.5550	23.4117	24.0111	23.9328
Exit									23.5474	2.5474				

Table 47a Fin0.125_2S Re70k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5959	0.0757	0.0233	27.9591	0.0209	3155.6331	5175.3042	0.0256	343.2204	562.8887	725.9482	1190.5701	4.7114	7.7269
2	2.5222	0.1191	-0.1245	57.6522	0.0419	3087.8058	4668.8139	0.0256	131.0300	198.1196	276.9015	418.6797	1.7971	2.7173
3	2.2192	0.0994	-0.1913	63.0495	0.0340	3113.3145	5105.9009	0.0257	123.0475	201.8004	259.8063	426.0877	1.6862	2.7653
4	2.1756	0.0864	-0.1929	57.9989	0.0362	3106.3733	4696.8884	0.0257	110.2564	166.7095	232.5968	351.6903	1.5096	2.2825
5	1.9138	0.0807	-0.1456	63.3549	0.0293	3128.3934	5130.6305	0.0257	120.3568	197.3876	253.6845	416.0478	1.6464	2.7002
6	1.9458	0.0767	-0.1153	58.2286	0.0323	3118.6791	4715.4949	0.0257	115.2876	174.3168	242.7894	367.1016	1.5757	2.3825
7	1.8890	0.0751	-0.0755	63.3797	0.0289	3129.6191	5132.6408	0.0257	120.1286	197.0134	252.7654	414.5405	1.6405	2.6904
8	2.0307	0.0747	-0.0654	58.1437	0.0337	3114.1318	4708.6194	0.0258	112.5199	170.1319	236.5512	357.6694	1.5352	2.3213
9	1.9590	0.0755	-0.0602	63.3097	0.0300	3126.1612	5126.9696	0.0258	120.0180	196.8321	252.0969	413.4441	1.6361	2.6833
10	2.0739	0.0780	-0.0873	58.1006	0.0345	3111.8189	4705.1221	0.0258	116.3557	175.9318	244.1935	369.2247	1.5848	2.3963
11	2.1055	0.0823	-0.1165	63.1632	0.0323	3118.9265	5115.1046	0.0258	121.1359	198.6655	254.0068	416.5764	1.6485	2.7036
12	2.3720	0.0893	-0.1424	57.8024	0.0394	3095.8509	4680.9783	0.0259	116.3758	175.9622	243.8155	368.6531	1.5824	2.3926
13	2.6425	0.1000	-0.1484	62.6261	0.0405	3092.4086	5071.6147	0.0259	118.5403	194.4086	248.1369	406.9497	1.6104	2.6411
14	3.1084	0.1186	-0.0872	57.0660	0.0517	3056.4094	4621.3422	0.0259	123.0858	186.1078	257.4308	389.2396	1.6707	2.5262
15	1.1053	0.0691	0.0283	27.4497	0.0387	3098.1412	5081.0164	0.0259	235.1165	385.5960	491.3185	805.7727	3.1887	5.2295
Exit									0				0	

Table 47b Fin0.125_2S Re70k Part2

Section	X_center (inch)	X/L	X/Dh	Cu Area (m^2, heated)	Loss area (m^2)	Fin area (m^2)	Total area (m^2)	Area ratio (section/whole)	T (C)	ΔT (C)	q (W)	T_bulk_int (C)	T_bulk_exit_eng (C)	T_bulk_eng (C)
Inlet									18.8158	-2.1842				
1	0.5000	0.0315	0.2345	0.0054	0.0004	0.0038	0.0089	0.0303	28.4626	7.4626	32.3712	18.9515	18.9762	18.8960
2	1.5625	0.0984	0.7327	0.0123	0.0006	0.0070	0.0187	0.0638	44.0581	23.0581	68.2162	19.2397	19.3140	19.1451
3	2.6250	0.1654	1.2309	0.0123	0.0008	0.0087	0.0203	0.0692	45.9912	24.9912	73.9912	19.5280	19.6805	19.4973
4	3.6875	0.2323	1.7291	0.0123	0.0006	0.0070	0.0187	0.0638	49.1046	28.1046	68.2162	19.8162	20.0184	19.8494
5	4.7500	0.2992	2.2273	0.0123	0.0008	0.0087	0.0203	0.0692	46.9426	25.9426	73.9912	20.1045	20.3848	20.2016
6	5.8125	0.3661	2.7256	0.0123	0.0006	0.0070	0.0187	0.0638	48.2483	27.2483	68.2162	20.3927	20.7227	20.5538
7	6.8750	0.4331	3.2238	0.0123	0.0008	0.0087	0.0203	0.0692	47.6516	26.6516	73.9912	20.6810	21.0892	20.9059
8	7.9375	0.5000	3.7220	0.0123	0.0006	0.0070	0.0187	0.0638	49.7527	28.7527	68.2162	20.9692	21.4270	21.2581
9	9.0000	0.5669	4.2202	0.0123	0.0008	0.0087	0.0203	0.0692	48.4850	27.4850	73.9912	21.2575	21.7935	21.6103
10	10.0625	0.6339	4.7184	0.0123	0.0006	0.0070	0.0187	0.0638	49.7356	28.7356	68.2162	21.5457	22.1314	21.9624
11	11.1250	0.7008	5.2167	0.0123	0.0008	0.0087	0.0203	0.0692	49.0419	28.0419	73.9912	21.8339	22.4978	22.3146
12	12.1875	0.7677	5.7149	0.0123	0.0006	0.0070	0.0187	0.0638	50.3337	29.3337	68.2162	22.1222	22.8357	22.6668
13	13.2500	0.8346	6.2131	0.0123	0.0008	0.0087	0.0203	0.0692	50.0856	29.0856	73.9912	22.4104	23.2021	23.0189
14	14.3125	0.9016	6.7113	0.0123	0.0006	0.0070	0.0187	0.0638	49.1261	28.1261	68.2162	22.6987	23.5400	23.3711
15	15.3750	0.9685	7.2095	0.0054	0.0004	0.0038	0.0089	0.0303	36.9839	15.9839	32.3712	22.9869	23.7003	23.6202
Exit									23.1226	2.1226				

Table 48a Fin0.125_2S Re80k Part1

Section	q_loss_net (W)	m	c	q_net (W)	%Power Loss	q" (W/m2)	q" (W/m2) (Smooth Channel)	Kf (W/m/K)	HTC (W/m2/K) (Total area)	HTC (W/m2/K) (Smooth Channel)	Nu (Total area)	Nu (Smooth Channel)	Nu/Nu0 (Total area)	Nu/Nu0 (Smooth Channel)
Inlet														
1	0.5879	0.0757	0.0233	31.7833	0.0182	3587.2513	5883.1671	0.0256	377.1638	618.5565	798.7636	1309.9890	4.7731	7.8279
2	2.6210	0.1191	-0.1245	65.5952	0.0384	3513.2268	5312.0577	0.0256	141.5577	214.0376	299.5321	452.8976	1.7899	2.7063
3	2.2925	0.0994	-0.1913	71.6987	0.0310	3540.4020	5806.3333	0.0256	133.7858	219.4114	282.8406	463.8645	1.6901	2.7719
4	2.2352	0.0864	-0.1929	65.9809	0.0328	3533.8862	5343.2951	0.0256	120.6581	182.4371	254.8654	385.3607	1.5230	2.3027
5	1.9478	0.0807	-0.1456	72.0434	0.0263	3557.4217	5834.2459	0.0257	132.5509	217.3862	279.7433	458.7849	1.6716	2.7415
6	1.9750	0.0767	-0.1153	66.2412	0.0290	3547.8250	5364.3707	0.0257	127.3651	192.5782	268.5659	406.0761	1.6048	2.4265
7	1.9261	0.0751	-0.0755	72.0651	0.0260	3558.4943	5836.0050	0.0257	131.9395	216.3836	277.9707	455.8777	1.6610	2.7241
8	2.0817	0.0747	-0.0654	66.1345	0.0305	3542.1084	5355.7271	0.0257	123.0606	186.0697	259.0402	391.6731	1.5479	2.3405
9	2.0161	0.0755	-0.0602	71.9751	0.0272	3554.0501	5828.7165	0.0258	130.5316	214.0746	274.5292	450.2335	1.6405	2.6904
10	2.1536	0.0780	-0.0873	66.0626	0.0316	3538.2604	5349.9088	0.0258	125.5150	189.7808	263.7505	398.7952	1.5761	2.3830
11	2.1908	0.0823	-0.1165	71.8004	0.0296	3545.4250	5814.5710	0.0258	130.3086	213.7088	273.5874	448.6891	1.6348	2.6812
12	2.4779	0.0893	-0.1424	65.7383	0.0363	3520.8911	5323.6463	0.0258	124.8036	188.7051	261.8037	395.8516	1.5644	2.3654
13	2.7588	0.1000	-0.1484	71.2324	0.0373	3517.3761	5768.5703	0.0258	127.0950	208.4385	266.3813	436.8708	1.5918	2.6106
14	3.2473	0.1186	-0.0872	64.9689	0.0476	3479.6814	5261.3364	0.0259	131.6695	199.0865	275.7319	416.9113	1.6477	2.4913
15	1.1326	0.0691	0.0283	31.2385	0.0350	3525.7688	5782.3345	0.0259	251.8958	413.1144	527.0476	864.3690	3.1494	5.1651
Exit									0				0	

Table 48b Fin0.125_2S Re80k Part2