USING PRODUCT SPECIFIC SIMULATION MODELS IN A TOOL FOR MANUAL COMMISSIONING OF AIR HANDLING UNITS

JÖRGEN ERIKSSON   ÅF-INSTALLATION AB   GOTHENBURG, SWEDEN

ABSTRACT
This short paper describes an outline of a tool for manual commissioning of air handling units. The prototype tool is implemented EES professional version that can generate standalone programs. The idea is to use the benefit of simulation models in manual procedures. By combining measurements with simulations the value of the measurements will increase. The tool is made with modularity as one important issue. It should be easy to exchange different parts of the tool with new developments when necessary. The tool is supposed to be installed in a tablet PC that can easily be carried around in the building during the commissioning process.

INTRODUCTION

This paper describes an outline of a tool for initial commissioning of AHUs based on product specific simulation models. The prototype-tool will be developed using EES professional version that can generate standalone programs. The tool will among others contain following characteristics:

♦ A model of an air-handling unit (AHU) based on simulation models that simulate the AHU with high accuracy.
♦ Predefined tests to be performed on the AHU for comparison between simulations and measurements.
♦ Automatic calculation of important performance metrics.
♦ Possibility to define and carry out own not predefined tests.
♦ Possibility to store the test results for later use.
♦ Possibility to calibrate models based on test data.

In this prototype tool, only steady state performance will be studied.

There exists a comprehensive amount of work that directly or indirect deals with the matter in this article. Below is a short list of existing tools and other work in line with this study divided in three subcategories. However, this list just gives a glance of the work.

Field tools
The existing tool, that has the most similarities with the one described in this paper is the HVAC Service assistant.[1]. This tool for commercial rooftop HVAC units is implemented in a handheld computer and is used to collect data (pressure, temperature…), perform evaluation of system performance, and managing service records etc.

Manufacturer of district heating substations chillers have for a period of time delivered tools to aid performance testing along with their equipment.

An example of this is a Swedish manufacturer of Plate Heat exchangers and prefabricated district heating substations. Their tool named IQ-optimizer [2] is a tool based on a handheld computer to be connected to the substation. This tool includes viewing dynamic data and adjusting control curves

In this section it is also important to mention a recent study that covers a lot in this subject, "Methods for automated and continuous commissioning of building systems " [3], this study gives an excellent overview of existing tools and methods for manual and automatic commissioning.

Manufacturers of chillers have a long tradition of field tools customised to the specific chillers for fault detection and diagnoses. [3]

Test protocols
To be able to find out if something is wrong with the equipment, it is necessary to look at data from a large part of the working range of the equipment. To do this it is need for some test sequences. In the " Commissioning Test Protocol Library " [4], test protocols and some active tests are given. More information about this can be found in the Functional Testing Guide. [5]

Simulation models for performance testing
A workshop paper about model-based diagnostics [6] gives a description how firs principle models can be used for detecting faults in air handling units.

An example of how to use models of individual components for fault detection is presented in another paper [7]. In this paper there is a discussion about how to perform calibration using manufacturers data.

THE STRUCTURE OF THE TOOL

The tool is made as modular as possible, just the structure is defined and can be filled using libraries with a number of different tests, models and measures of performance. The tests to be used and performance metrics to calculate depend on the models used. The structure of the tool is described in figure 1 and 2.

Over All Structure

The tool is structured in three parts, Template program, libraries and data management. In the template program there is support for data input and result visualisation. There are libraries of common models, product specific models, tests and metrics of performance. The data management is an aid for handling different projects.

Data Input

The parameters of the models and the data measured are put into the model using the graphic interface, see figure 3.

Modelling

Almost all air-handling units are built in the same way, having the same components, only the performance of the components differs. If product specific simulation models are used, a model of an AHU can be built quickly using a template AHU model by just change the components to the ones preferred. In EES this means just changing the name of e.g. the coil module.
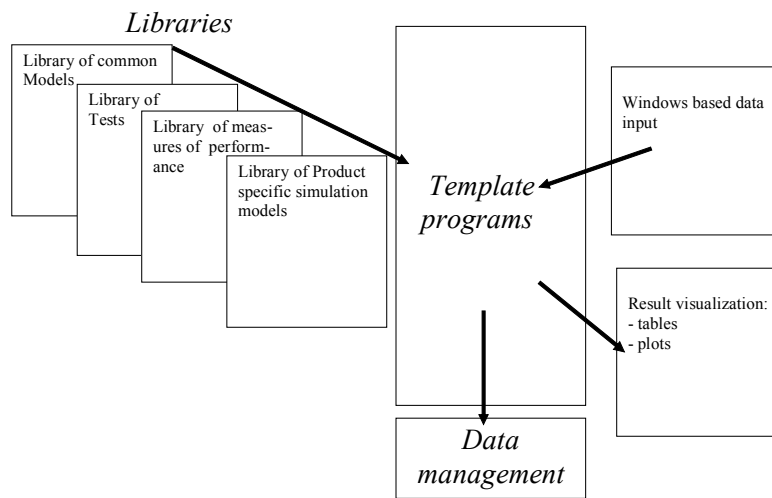

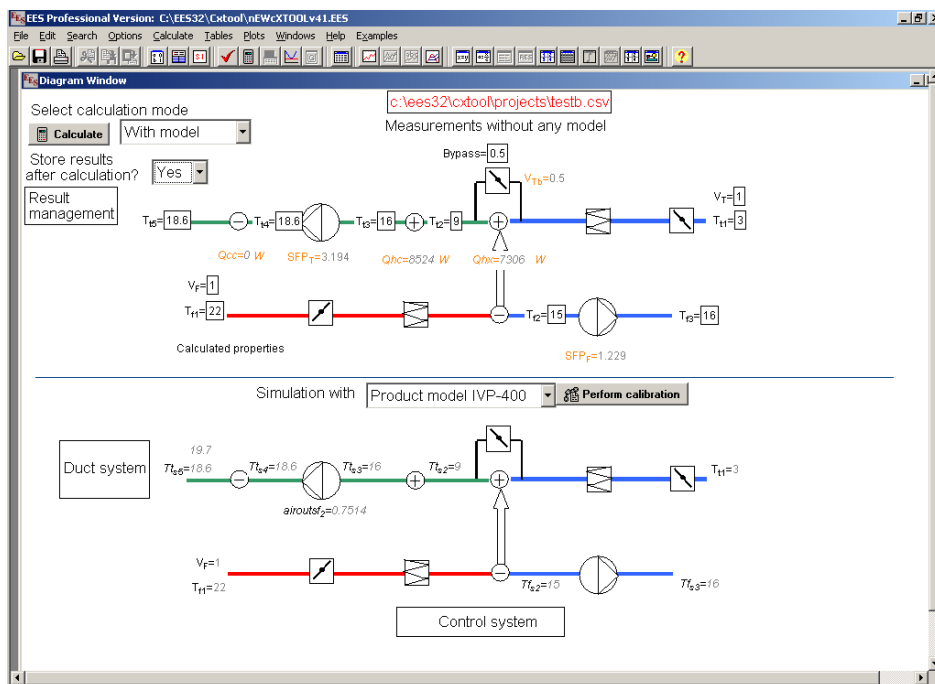Figure 1.   Structure of the tool

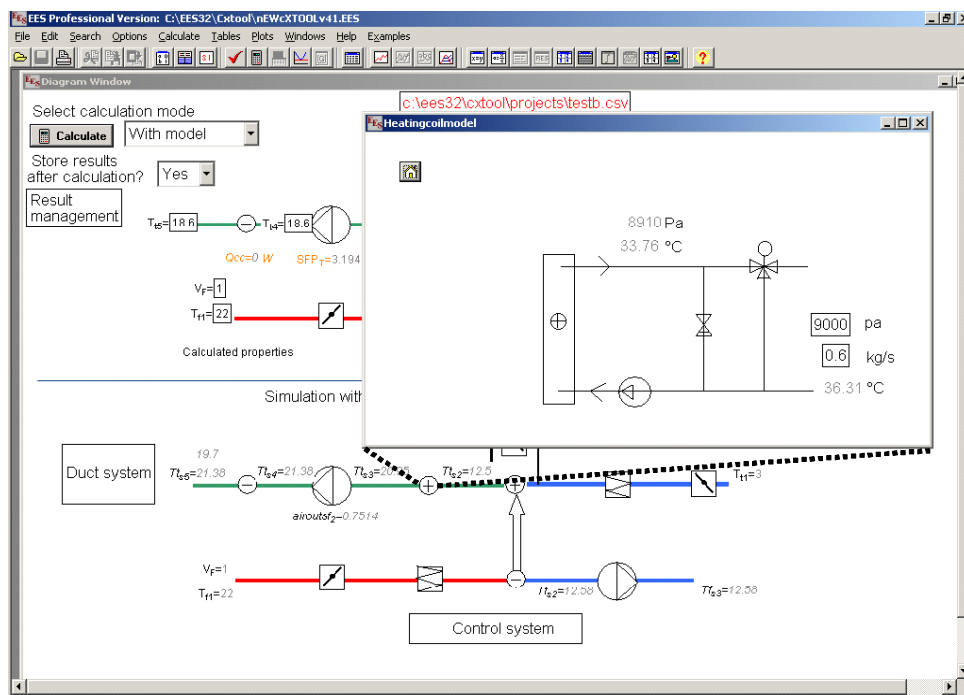Figure 2.   Example of one template program.

Figure 3.   When clicking on one component an input window is opened.

Calculation of Performance Metrics

The performance metrics interesting for evaluation of an AHU, are to be defined and calculated. For every component different metrics are determined. For the heating coil following measures can be applicable:

♦ *Temperature efficiency*: to detect fouling
♦ *Heating power*: to confirm the design and selection of coil
♦ *Pressure drop*: to detect fouling
♦ *Valve position*: to confirm the control
♦ *Temperature rise on air side and temperature fall on water side*: to check if the air and water flow correspond to the design.

Result and Data Management

The results of the calculations are stored together with the input data using the data management module of the tool.

Model Calibration

It doesn't matter how accurate the models are made. When a system is built in reality, the components will not behave as stated in the catalogue data. When a system e.g. an air handling unit is commissioned and said to work properly, measurements from the Cx process can be used for calibration of the models to make the simulation model behave as the studied system.

Predefined Tests

The tool have a number of pre defined tests included to help the cx-agent to perform his checking of the AHU. The tests are connected to the AHU tested, not all tests can be performed on all units. But as stated before most of the AHUs are similar so most tests can be performed on most units. If not all criteria for the test are fulfilled it will not be performed and an error massage will be printed on the screen. Some test demands that the data reading must be undertaken not before a certain time after the start of the test.

In this prototype version of the tool, only a limited number of tests are predefined. All the tests in this version will be based on temperature readings.

THE SIMULATION MODEL

The simulation model of the AHU is based on a number of component models. To enhance the modularity of the tool, each model is stored in the EES library as a module. The modules are structured in a certain way as shown below, using a simple fan model as an example.. The fan model is pressure dependent; hence the output pressure is located in the {Links-in} section and the ingoing mass flow in the {Links-out} section.

```
Module Fan(AirIn[1..5] ; Airout[1..5] ; Parameters[1..3] ; properties[1..2] ; other[1] )
{Abstract}
"A model of a fan with automatic calculation of the temperature rise the notation for the input and
output links is  [ Pressure, massflow, Temperature, Humidity, Pollution ]. The notation for Parame-
ters is [ nominal pressure, nominal massflow, fan efficiency ] "
{
Declaration of variables

type        name        role    def     min     max     description
Temp        Tin         in      20      -30     45      temperature of incoming air to fan
Temp        Tout        out     20      -30     45      temperature of outgoing air from fan
pressure    dP          out     800     5       10000   pressure rise
volflow     m           out     3       0       10000   airflow
}
{
Declaration of parameters

type        name        role    def     min     max     description
generic     eta         S_P     0.7     0.1     0.90    fan efficiency
pressure    p0          S_P     800     5       10000   nominal pressure
volflow     m0          S_P     3       0       10000   nominal airflow
}
{Parameters}
p0=parameters[1]
m0=parameters[2]
eta=parameters[3]
{Links-in}
"Array airin"
Pin=AirIn[1]: Tin=AirIn[3]: Hum=AirIn[4]: Poll=AirIn[5]
"Array airin end"
"Array airout"
Pout=airout[1]
"Array airout end"
"Array other"
control=other[1]
"Array other end"
{Property calculation}
Ar=DENSITY(Air;T=Tin;P=101300)
Acp=CP(Air;T=Tin)
"Array properties"
properties[1]=ar
properties[2]=acp
"Array properties end"
{Equations}
"Pressure rise of fan"
dP=p0*((m0-m/control)/m0)**2
Pout=Pin+dP
"Temperature rise of fan"
Tout=Tin+DP/(eta*Acp*Ar)
{links-out}
"Array airout"
 airout[2]=m: airout[3]=Tout: airout[4]=Hum: airout[5]=Poll
"Array airout end"
"Array airin"
Airin[2]=m
"Array airin end"
end{ fan }
```

IMPLEMENTATION OF THE TOOL IN THE CX PROCESS.

One great issue to solve is to make the professionals to use computer-aided tools. To enhance the use of the tool in practise the tool is implemented in a tablet PC. If other tools used by the professionals, such as templates for protocols and checklists also are implemented in PC-format the possibility for use of simulation based tools in Cx will increase.

FUTURE WORK

A lot of work remains before the prototype tool is finished. Some of the work to be performed in the near future are market analysis, development of product specific simulation model of an Air handler, implementation of a calibration routine into the tool,

CONCLUSIONS

This is so far a limited study, but the conclusions are still that this is one possible way of creating a tool that can be an important part of the initial commissioning of HVAC subsystems. There exist similar tools but the approach in this study is different in many ways, but mainly in the use of product specific simulation models.

ACKNOWLEDGEMENT

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