Oil and Gas Air Heaters[1]

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Abstract: Most conventional air heaters adopt indirect heat transfer, which uses combustion gases to indirectly heat fresh air by heating surfaces to generate hot air used for material drying and dehumidification. We call them indirect air heaters. However, they have a higher manufacturing cost and lower thermal efficiency, especially when high temperature air is needed. For this reason, a direct air heater applicable for or feed and industrial raw products is put forward, which has advantages such as less production cost, smaller dimensions and higher thermal efficiency. Their design, working principles, characteristics, structure and applications are presented in this article, and brief comparisons are made between the indirect and direct air heater. Finally, the relation of hot-air temperature, oil or gas consumption and fresh airflow is determined based on energy equilibrium.

Key words: air heater; structure; application; energy equilibrium

1. INTRODUCTION

At present, an air-heater burning oil or gas adopts generally indirect heat-transfer, in which combustion gases is used to heat fresh air indirectly to generate hot air used in the technological process of materiel-drying, dehumidification and so on, called it as an indirect air heater. Speaking generally, because the metal of heating-surface in the indirect air heater must bear high working-temperature, highly heat-resistant steel must be used in high temperature area. Furthermore, an indirect hot-air heater has such characteristics as smaller heat-transfer coefficient, more heating surface, more steel consumption, higher first cost, and lower thermal efficiency. Considering the little soot from air heater burning oil or gas, the concept of a direct air heater is put forward, which may be applied for drying feed and industrial raw products, etc.

2. STRUCTURE OF DIRECT AIR HEATER

An indirect air heater uses combustion gases to heat fresh air indirectly, whereas a direct air heater burning oil or gas mixes the combustion gases produced by burning oil or gas with the outdoor air in the mixing room directly to produce hot air, its structure is shown in figure 1.The combustion gases produced by the oil or gas burner in the combustion chamber is mixed with the outdoor air which flows from the front annular aperture board to the back mixing room along the annular passage to gain the required temperature, then the mixture gas or hot air is conveyed to the users through hot air outlet. The temperature of the hot air can be adjusted in some range by adjusting the air-door or adjusting the load of the burner to meet the users' requirements for hot air temperature.

As shown in Fig.1, The combustion chamber is built up with highly heat-resistant materials or with high-temperature-resistant shapeless material on spot. Consolidator is used to keep the stability of the combustion chamber. An aperture board which makes fluid flow distribution more homogeneous is made of heat-resistant steel to prolong the heater life. Thick light thermal-insulator is stuffed between outer casing and outside packing board. Between the combustion chamber brickwork 6 and outer casing, annular cool-air passage is set to lower the temperature of the fireproof brickwork and also the temperature of outer surface of the thermal-insulator, and to prolong the its running life and reduce the radiation loss of

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outer surface.

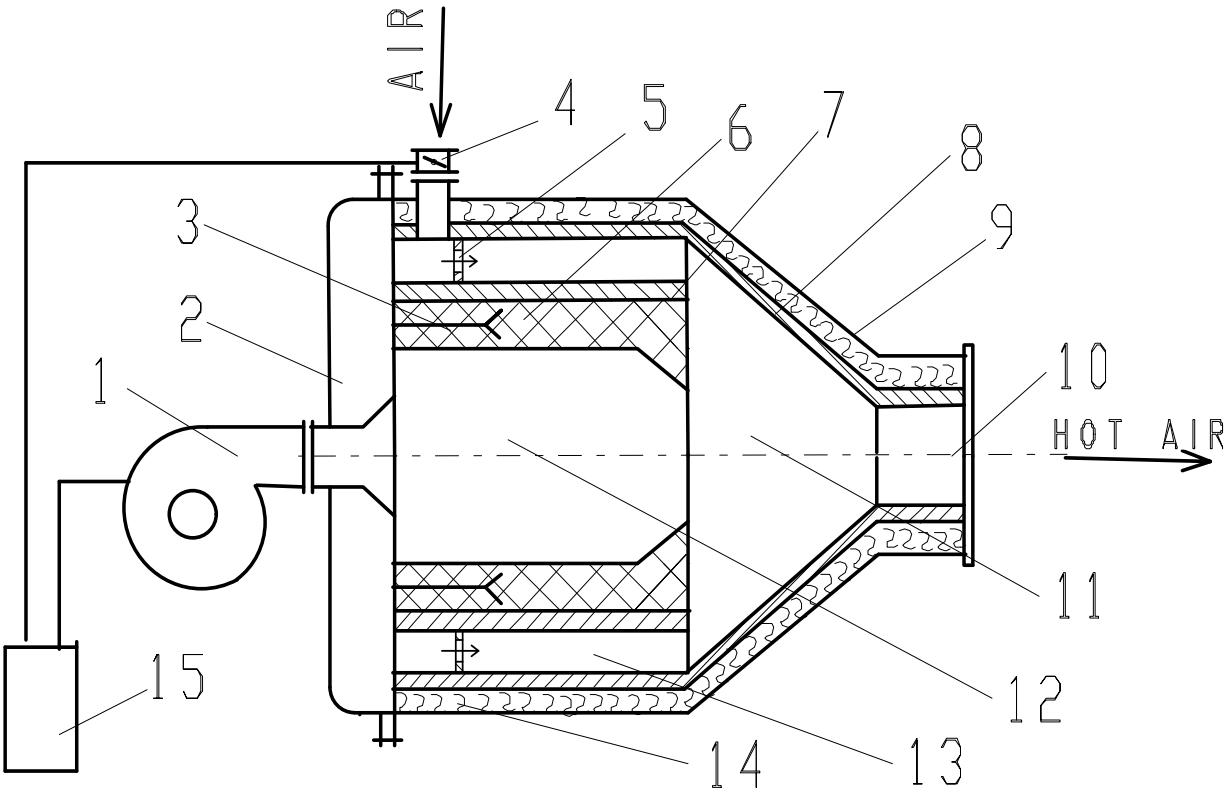

Fig.1 Structure of direct air heater

1-Oil or gas burner; 2-front casing; 3-Consolidator; 4-fresh air door; 5-aperture boar; 6-fire-resistent material; 7-inner casing; 8-outer casing; 9-outside packing board; 10-hot air outlet; 11-mixing room; 12- combustion chamber; 13-fresh air passage; 14- light thermal-insulator; 15-control panel

Compared with an indirect hot-air heater burning oil or gas, the direct air heater has characteristics as following: (1) hot combustion gases is mixed with fresh air directly, which saves the expensive metal used for heating surface;(2)There is no high temperature corrosion of the heating surface, as the combustion chamber made of highly heat-resistant material; (3)The temperature rises fast ,because of the little heat storage capacity; (4)Its thermal efficiency is high, and oil or gas is saved by 10%～20%; (5)Its structure is simple, and steel consumption is less, which reduces the first cost by 30%～60%;(6) It is convenient to adjust the hot air temperature according to users' requirements in some range by adjusting air door or controlling panel.

3. VOLUMETRIC COMPOSITION OF HOT AIR

The hot air from the direct air heater burning oil or gas is really the mixture of outdoor fresh air and hot combustion gases. The dust of original combustion gases is enough little to neglect it, so the hot air is composed of nitrogen, carbon dioxide, sulphur dioxide and oxygen etc. The volumetric composition of hot air is decided by the volume of the fresh air mixed with, which depends on the needed temperature of the hot air. The lower the hot air temperature is, the more the fresh air is needed, and the less the volumetric composition of the harmful gas, such as carbon dioxide and sulphur dioxide.

The volumetric composition of the hot air generated by a 116 kW (10×10^4 Cal/h) direct air heater burning light oil can be obtained by approximate calculation, its design parameters are: rated heat load 116 kW, the temperature of hot air = 220 . The composition is shown in tab.1. The excessive air coefficient is taken as1.0 to simplify the

calculation.

Tab. 1 Comparison of the gas volumetric composition of hot air of the direct air heater burning oil and original combustion gases

Items	The volumetric composition before mixing/%	The volumetric composition after mixing/%
CO_2	0.2517	0.01401
SO_2	0.0018	0.000015
H_2O	0.1215	0.01472
N_2	0.6393	0.77173
O_2	0.0000	0.18453

4. TEMPERATURE OF HOT AIR

There are many factors that influence the temperature of outlet hot air, among them the main ones includes the oil consumption, mixed fresh air flow and its temperature. The hot air temperature may be counted by energy equilibrium.

If The density of combustion gases and fresh air in standard condition is taken respectively as 1.34 kg/m^3 and 1.29 kg/m^3, the theoretical combustion gases volume V_y^0 as 11.799 m^3/kg, fresh air temperature as 20 , and at the same time the specific heat of smoke gas and fresh air is considered constant, the simple relation of the hot air temperature t_{rk}, oil consumption B and fresh air volume V_k can be obtained according to energy equilibrium:

$$t_{rk} = \frac{22682 + 20V_k / B}{12 + V_k / B} \qquad (1)$$

5. DISCUSSION

Compared with the indirect air heater, the cleanness of hot air generated by the direct air heater is lower, but in some places such as carton drying, underground dehumidification, material drying and vegetable house heating etc, where the high cleanness of hot air is not needed, and supplied fuel is oil or gas, this kind of direct air heater is recommended to generate hot air to reduce the first cost and operation fee to a great extent. Whereas in other places where strict requirements for the cleanness and gas composition of hot air is needed, and direct air heater burning oil or gas should be not used propositionally.

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