AIR HEATER FOR THOROUGH UTILIZATION OF THE HEAT OF WASTE GASES

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Most industrial furnaces are usually operated in such a way that the heat is utilized at a high temperature level; a large amount of heat goes to waste with the stack gases, which are an important secondary energy source.

As is well known, a considerable amount of fuel can be saved by extensive application of air heaters because these permit recirculation of waste gas heat to the furnace, and more complete burning of the fuel. The amount of fuel saved depends on the degree to which the heat of the waste gases is utilized; the higher this degree, the higher will be the temperature of the air supplied to the furnace. However, a high degree of utilization implies a large surface area in the air heater, and this increases the cost of heat utilization.

A previous paper [1] provides technical solutions which make it possible thoroughly to utilize the heat of waste gases by employing a minimum amount of metal and heating the air by means of a granular carrier.

The present paper gives detailed description of the most up-to-date design of an air heater for thorough utilization of the heat contained in any volume of stack gas passed through the air heater; in addition, several design points are discussed.

A nonmetallic inert granular material—the heat carrier—which satisfies definite specifications and is circulated in the installation provides the surface via which heat is taken up and transmitted in these heat exchangers.

The air heater consists of sections with parallel inlets and outlets for the stack gases and air, so that the hydraulic resistance of the gases moving through the heat carrier is kept as low as possible.

The figure shows an air heater with two parallel stack gas inlets (sections I and III) and two air inlets (sections II and IV). A larger number of sections may be used when larger amounts of stack gas and air have to be handled. This design permits thorough utilization of the waste gas heat.

The stack gases from the furnace or boiler are piped to the air heater; this consists of a vertical shaft 1 which, by means of the horizontal diaphragms 2, is divided into four sections; each section is provided with overflow tubes 3.

Spouts 4, connecting at their ends with collectors 5 fixed on the outside of the shaft, are mounted in each section; the other ends of the spouts suspend freely in the shaft.

All free space in the shaft is filled with an inert granular material—the heat carrier—which is collected at the shaft bottom at point 7, raised by means of bucket elevator 6, and discharged into the top of the shaft, so that it is circulated at a constant rate.

To ensure uniform flow of the granular material throughout the cross section of the shaft, a group of hoppers levelling out the flow of the heat carrier 8 is mounted near the shaft bottom.

The stack gases from the furnace or boiler 9 enter the vertical space 10, from which they flow into collector 5 and further into the spouts 4.

From these spouts the stack gases enter the bed of granular heat carrier, delivering their heat in passing through the bed; subsequently, they are pumped off to the atmosphere, via aperture 11 and vertical gas compartment 10, by means of pump 12.

Cold air is supplied by fan 13 via air pipeline 14 and collector 5 and spout 4, being warmed up during its passage through the bed of heated carrier.

Via aperture 11 the heated air is led through the vertical space 14; on leaving the heater, it is fed to the furnace or boiler.

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Fig. 1. Diagram of the air heater and its connections with the pipelines: 1) shaft; 2) horizontal diaphragm; 3) overflow tubes; 4) spout; 5) collector; 6) bucket elevator; 7) outflow tube; 8) flow equalizer; 9) furnace or boiler; 10) vertical space; 11) apertures in the shaft; 12) pump for stack gases; 13) ventilator; 14) air inlets. Pipelines and flows: A) hot gases from the furnace or boiler to sections I and III (via the spouts); B) cooled gases from sections I and III; C) cold air supplied by the fan to sections II and IV (via spouts); D) heated air from sections II and IV to the furnace or boiler; E) stack gases discharged into the atmosphere (start line).

It should be noted that the surface area participating in the heat exchange between the carrier and the gases equals the area of the carrier granules above the spouts 4 in the sections.

It is easily calculated that, if the carrier particles are spheres of 10 mm diameter, the cross section of the shaft measures $3 \times 3$ m, and the bed height above the spouts equals 0.6 m, the exchanging surface area in a section will exceed 1500 m$^2$.

Since the stack gases and the heat carrier flow countercurrently in this installation, their heat capacities are nearly equal, and the exchanging surface area and the heat exchange coefficients* are large, it is quite understandable that heat exchange will take place at various small temperature differences, i.e., the air will be heated to a

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* The coefficient of heat transmission from stack gases to spherical surfaces ranges from 60 to 90 kcal/h $\cdot$ m$^2$ $\cdot$ °C under the conditions considered.