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REGENERATIVE HEAT EXCHANGER

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This invention relates to a regenerative heat exchange apparatus of the type commonly employed as air preheaters in boiler installations to impart heat from the combustion gases generated in the boiler to combustion supporting air supplied to the boiler and the invention has particular relation to an improved heat exchanger of this type embodying a fluidized medium.

The invention in general comprises a heat exchanger embodying a rotor that is rotatable about its axis within a stationary casing. The rotor contains numerous generally axially extending spaced plates, or the like, which form the regenerative material of the heat exchanger and which have a stream of hot gases passed thereover at one location and a stream of gases to be heated passed thereover at another location with the casing being provided with means for directing the passage of these streams of gases through the rotor in a generally axial direction and in contact with the plates. Each of the surfaces of the plates has a body of discrete material retained in contact therewith and which is fluidized by the gas flow through the rotor. The rotor is continuously rotated about its axis and as the plates traverse the location at which the hot gas stream passes through the rotor the discrete material associated with these plates is fluidized by this gas stream and the plates are heated with the effective rate of heat exchange between the plates and the gas stream being greatly increased by this fluidized medium. After being heated these plates then traverse the location where the gas to be heated, such as air, passes through the rotor. This gas flow also fluidizes the discrete material associated with these plates and the plates impart or give up heat to this gas stream with the rate of heat exchange here again being greatly increased by the fluidized medium. With this organization the capacity of a rotary regenerative heat exchanger is greatly increased over that heretofore obtainable thereby permitting a substantial reduction in the size of such a heat exchanger of a given capacity.

The technique of fluidization involves passing a gas through a body of discrete material at such a velocity that the body of material assumes an agitated state resembling a boiling liquid with the particles of the material moving rapidly within the mass and the mass being in what is termed a pseudo-liquid condition. When in this fluidized state the material is not carried along with the fluidizing gas and although the body of material is expanded so that it occupies considerably more volume than when in the non-fluidized state the fluidizing gas passes through the body of material and leaves the same at what is termed a disengaging zone. This type of fluidization is sometimes referred to as "dense phase" fluidization and it is to be understood that when the term fluidization is used throughout this application reference is had to this type of fluidization. When a body of discrete material is in this fluidized condition or state the body of material has many of the properties of a liquid and results in extremely high rates of heat transfer between the fluidizing gas and a heat exchange surface

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which is in contact with the fluidized material with these rates of heat exchange being in the order of 30 or 40 B. t. u./hr./sq. ft./° F. and above, with rates as high as 100 B. t. u./hr./sq. ft./° F. being obtainable depending upon the make up of the discrete material and the size of the particles thereof. However, the material must be fluidized to obtain these high rates of heat transfer and if the gas velocity is either too low or too high to produce fluidization these high rates will not be realized. In the present invention such a fluidized body or mass is employed in a novel manner to greatly increase the capacity of a rotary regenerative type heat exchanger. It is an object of this invention to provide an improved rotary regenerative type heat exchanger embodying a fluidized medium.

Other and further objects of the invention will become apparent to those skilled in the art as the description proceeds.

With the aforementioned objects in view, the invention comprises an arrangement, construction and combination of the elements of the inventive organization in such a manner as to attain the results desired as hereinafter more particularly set forth in the following detailed description of an illustrative embodiment, said embodiment being shown by the accompanying drawing wherein:

Figure 1 is a transverse sectional view through a rotary regenerative heat exchanger embodying the present invention.

Figure 2 is a sectional view taken along line 2—2 of Fig. 1 showing the disposition of the plates of the rotor and the openings in the casing for directing the streams of gases through the rotor.

Figure 3 is a sectional view taken along line 3—3 of Fig. 2 and showing the detailed construction of the plates of the rotor.

Figure 4 is a view similar to that of Fig. 3 but showing a modified form of construction.

Referring now to the drawing, wherein like reference characters are used throughout to designate like elements, the rotary regenerative heat exchanger disclosed therein comprises a rotor 10 having a hub portion 12 that is rotatably journaled to the stationary upright shaft 14. Extending radially outward of the hub portion 12 are the closely spaced axially disposed plates 16 which form the regenerative material of the heat exchanger and which are connected at their outer ends to the annulus 18. The rotor 10 is mounted within the stationary housing 20 which is provided with a pair of aligned openings 22 for directing a heating gas through the rotor and a pair of aligned openings 24 for directing a gas to be heated through the rotor. Through a suitable driving mechanism, such as ring gear 26, pinion 28 and motor 30, the rotor 10 is continuously rotated about its central axis so that the passages formed between the regenerative mass, i. e., between plates 16, are first brought into register with the aligned openings 22 for the flow of a heating gas such as flue gas, therethrough in the direction indicated by arrows 32 and are then brought into registry with the aligned openings 24 and accordingly into the stream of gas to be heated, such as air, which is directed through these openings as indicated by arrows 34. In passing through the stream of heating gases the regenerative mass is heated with a major portion of this heat being given up by this mass to the gases to be heated during the passage through the latter gas stream.

Each of the plates 16 has a screen 36 spaced from its opposed surfaces 38 and 40 (Fig. 3) with the screens having laterally extending edge portions 42 secured to the plates 16 so as to form with the plate enclosed compartment 44. Within each of the compartments 44 is provided a body of discrete material 46 which is retained

within the compartment by screen 36 and which is fluidized by the streams of gas flowing through openings 22 and openings 24 as the various plates are brought into register with these openings. By retaining this body of discrete material in the form of a thin layer in contact with the opposed surfaces 38 and 40 of each of the plates 16 the rate of heat transfer between the plates and the heating gases as well as the plates and the gases to be heated is greatly increased with this rate being many times that which would prevail in the absence of the fluidized medium whereby the capacity of an air heater of a given physical dimension may be greatly increased.

In the embodiment of Fig. 3 screens 36 are parallel with surfaces 38 and 40 of plate 16, while in the embodiment of Fig. 4 screens 36 are undulated with the undulations extending transversely of the direction of the gas flow through the openings 22 and the openings 24. With the parallel screens 36 the gas flow through the discrete material 46 in the compartments 44 will be somewhat less than that with the use of undulated screens 36 and therefore in certain installations one of these arrangements may be preferable to the other.

Since fluidization of a discrete material which is of a particular particle size occurs between a maximum velocity above which the material is no longer fluidized but is carried along with the gas and a minimum velocity below which fluidization does not occur the velocity of the gases flowing through the discrete material 46 in the compartments 44 must be within these limits. In order to increase the range of gas flows through openings 22 and openings 24 which will produce fluidization, the individually operated dampers 48 are provided at the inlet of each of the pair of aligned openings 22 and 24 in order to control the effective cross sectional area of the gas streams passing through these openings thereby varying the velocity of the gas flow and enabling this velocity to be increased so that it will effect fluidization of the material 46 when it would otherwise, without the use of these dampers, be below the limit required to effect this fluidization. Thus when dampers 48 are open and the velocity of the gas stream approaches the lower limit required for fluidization one or more of the dampers may be closed thereby restricting the area of the gas stream resulting in increasing the velocity of the gas stream so that it is well within the range required for fluidization.

With the use of the novel organization, in a typical air preheater for a boiler wherein the heating gas is hot combustion gases and the gas to be heated is relatively cold air the heat transfer rate between each of these gases and the regenerative material may be increased from a rate of approximately 8 B. t. u./hr./sq. ft./° F. which prevails in the heretofore known air heaters of this type, to a rate of 30 or 40 B. t. u./hr./sq. ft./° F. or better thus greatly reducing the size of the air heaters required for a given capacity.

This large increase in heat exchange rate with the use of a fluidized mass of discrete material is a result of the very high rate of heat transfer between the fluidizing medium and the discrete material and also the high rate of heat transfer between this material and the plate, or the like, with which this material is in contact, with this latter being a consequence of the discrete fluidized material breaking down the insulating gas layer that shrouds

the surface of the plate. It should be noted that since the discrete material has mass it will also act as regenerative material in the rotary regenerative air heater of this invention and since the heat exchange rate between this fluidized discrete material and the gas streams which fluidizes the same is extremely high this material will act as very efficient regenerative material.

In accordance with this invention it is essential that the discrete material be fluidized by the stream of heating gas and the stream of gases to be heated (this being combustion gases and air, respectively, in a boiler installation) and the particle size must be chosen relative to the velocity of these streams of gases to assure that fluidization will be obtained. If fluidization is not obtained the heat exchange rate will only be that heretofore obtained with rotary regenerative heat exchangers which is far below that obtained with fluidization.

While I have illustrated and described a preferred embodiment of my novel organization it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes as fall within the purview of my invention.

What I claim is:

1. A rotary regenerative heat exchanger comprising a rotor rotated about its axis within a stationary casing and having its axis generally vertical, said rotor being formed with arcuately restricted passages that extend vertically therethrough and said rotor containing numerous vertically extending closely spaced metallic plates that form at least a major portion of the regenerative material of the heat exchanger, said rotor having a stream of heating gas directed upwardly through one portion thereof and a stream of gas to be heated upwardly through another portion, screens disposed over the vertical surfaces of the plates in spaced relation therewith forming with the vertical surface of the plates a narrow chamber, the screens being spaced from the plates substantially less than half the distance the plates are spaced apart so that there is an unobstructed passageway portion between adjacent screens of adjacent plates, said narrow chambers having disposed therein a discrete material of such a particle size that it is retained within the chamber by the screen but is fluidized by the passage of the heating and the heated gas upwardly therethrough.

2. The organization of claim 1 wherein said screens are undulated in a manner so that the undulations extend generally transversely of the direction of the heating and the heated gas flow through the rotor.

3. The organization of claim 1 including adjustable damper means operative to vary the effective area through which the heating gases and the gases to be heated are passed.

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