

Mannesmann AG
Mannesmannufer 2
40213 Dusseldorf

K.T.I. Group B.V.
Bredewater 26
NL - 2700 AB Zoetermeer

THIS SHEET HAS BEEN
REPLACED

Arrangement for Indirectly Transferring Heat to a Process Medium

The invention relates to an arrangement for indirectly transferring heat to a process medium, especially for carrying out steam reformation of hydrocarbons, in accordance with the introductory part of Patent Claim 1.

For hydrocarbon steam reformation, arrangements like the example shown in Figs. 5 to 7 in different views and partial sections are often used. The arrangement has a substantially cuboid-shaped heating chamber 1, which can be heated by a plurality of burners 2. The burners 2 are arranged in rows in the roof of the cuboid, and their flame direction is directed vertically upward. Heat exchanger tubes 3 are arranged between the rows of burners on a vertical plane. The process medium for the endothermic chemical reaction can be run through these heat exchanger tubes 3. The process medium is heated primarily by the radiant heat produced during combustion, but partially by means of convection as well. To extract the combustion gasses from the heating chamber 1, waste gas ducts 4 are arranged on the bottom of the heating chamber 1. The waste gas ducts 4, which are closed on top, are arranged parallel to the rows of heat exchanger tubes 3 and the rows of burners 2 and have a substantially rectangular cross-section. The waste gas ducts 4 are made of a refractory-grade material (e.g., built of refractory-grade bricks). Numerous openings 5 are distributed over the axial length of the waste gas ducts 4 in the lower part of their side walls. Through these openings 5, the waste gas can make its way from the heating chamber 1 into the interior of the waste gas ducts 4. The waste gas flows laterally out of the heating chamber 1 through the waste gas ducts 4 and enters a collection duct 8, in which all waste ducts 4 open. The waste gas is



fed from there to a means for using the residual heat still contained in the waste gas, and finally discharged into the open air.

In practical operation of an arrangement of the type shown, it has been found that conditions during heat transfer to the heat exchanger tubes are not uniform. This is reflected by the evidence found during the maintenance of such arrangements. If some of the heat exchanger tubes are exposed to greater heat, these tubes age more rapidly and must be replaced sooner. In this situation, the choice is between either replacing all of the heat exchanger tubes, including those that do not yet need to be replaced, or exchanging only some of the tubes. The latter choice results in more frequent interruptions of operation for maintenance and repair.

Because the heat exchanger tubes are heated largely by radiant heat, it is of decisive importance that the tubes be arranged so that all tubes are exposed to the same conditions with respect to the effects of the heat radiation source. When the waste gas ducts have a rectangular cross-section, this happens as a matter of principle. Figure 8, which shows a disk-shaped section through a heating chamber 1, schematically illustrates such a rectangular duct in greater detail. The openings in the side walls of the waste gas duct 4 for the passage of waste gasses are identified by the reference number 5. Another known form for a waste gas duct 4a is shown in Figure 9. This waste gas duct 4a also has a rectangular cross-section, but its cross-section changes continuously in the direction of the waste gas discharge (collection duct 8). The step-like roof of the waste gas duct 4a is inclined in such a way that the cross-section continuously grows larger in the direction of the collection duct 8. This design of the waste gas duct 4a is intended to ensure that waste gas is extracted uniformly over the axial length of the waste gas duct. This does not happen in the case of the cuboid-shaped waste gas duct 4 in Figure 8, due to pressure loss. However, the shape of the waste gas duct 4a provides no effective improvements in this respect. In both cases, therefore, uneven heating of the heat exchanger tubes occurs.

If it were possible to ensure uniform distribution during the transfer of heat to the heat exchanger tubes, then the heat exchanger tubes could be designed with thinner walls, because the higher wall temperatures that occur in some tubes when there is uneven heat distribution would no longer have to be taken into account. Accordingly, more extreme operating conditions could then be applied or the useful life of the heat exchanger tubes could be extended in normal operation.

The object of the invention is to further develop an arrangement of the type indicated in the introductory part of Patent Claim 1 in such a way as to ensure the most uniform possible distribution of heat during the transfer of heat to the heat exchanger tubes.

The object is attained according to the invention by means of the characterizing features of Patent Claim 1. Advantageous further developments of the invention are indicated in the subclaims 2 to 4.

The invention is explained below in greater detail in reference to the drawings. The drawings show:

Fig. 1 A disk-shaped section through a heating chamber with a waste gas duct according to the invention;

Fig. 2 A modification of the embodiment in Fig. 1;

Fig. 3 A profile of the vertical components of the waste gas rate in the vicinity of a row of heat exchanger tubes along a waste gas duct, as a function of the height above the floor of the heating chamber, in an arrangement according to the invention;

Fig. 4 A comparative depiction like that in Fig. 3 for an arrangement with conventional waste gas duct;

and as the prior art:

Fig. 5 A side view of a steam reformation arrangement (partially in section);

Fig. 6 A top view of the arrangement in Fig. 5 (in partial section);

Fig. 7 A frontal view of the arrangement in Fig. 5 (in partial section);

Fig. 8 A schematic disk-shaped section through a heating chamber with a cuboid-shaped gas duct;

Fig. 9 A disk-shaped section through a heating chamber with an inclined waste gas duct.

The object of the invention is attained with surprisingly simple means. An especially simple embodiment of the invention is shown schematically in Fig. 1 in the form of a disk-shaped section through a heating chamber along a waste gas duct 4. A series of flow bodies in the form of flow baffles 6 is simply arranged in the interior of the waste gas duct 4. The flow baffles 6 are flat bodies running substantially horizontally in the axial direction (flow direction) of the waste gas duct 4 and having thinner walls compared with the duct cross-section. The flow baffles 6 extend across the entire width of the waste gas duct 4 between its longitudinal walls. The flow baffles 6 are made of a heat-resistant material suitable for the conditions of use, such as a refractory-grade material or a heat-resistant metal material; thus, the term "flow baffle" does not necessarily refer to metal materials only. Rather, the term is meant to indicate the fact that the waste gas flow inside of the waste gas duct 4 is influenced in the sense of being evened out in the axial direction. The length of each flow baffle 6 equals only a small fraction of the total axial length of the waste gas duct 4. The individual flow baffles 6 are arranged, as a whole, in a step-like fashion, with the steps leading downward in the direction of the collection duct 8. Advantageously, the individual directly adjacent flow baffles 6 overlap each other slightly. The waste gas flows through the waste gas openings 5 arranged as in Fig. 5, i.e., located close to the floor of the heating chamber 1, and reaches the interior of the waste gas duct 4. There, the waste gas flows upward and is deflected horizontally by the flow baffles 6 located in the area of each opening. In this way, a horizontal flow in the direction of the collection duct 8 is produced quite uniformly over the entire cross-section in the interior of the waste gas duct 4.

Figure 2 shows a modification of the embodiment in Figure 1. The embodiment in Figure 2 differs only in that the individual flow baffles 6a are connected, on their face sides that face away from the collection duct 8, to a somewhat vertical dividing baffle 6b. The dividing baffle 6b extends down to the floor of the waste gas duct 4. As a result, a forced orientation of the waste gas flow is achieved from the start, because the

waste gas that flows in between two directly adjacent dividing baffles 6b is completely enclosed by the wall of the waste gas duct 4 and these two dividing baffles 6b. The waste gas can then flow only through the axial opening located between the two flow baffles 6a associated with the two dividing walls 6b, i.e., the waste gas must necessarily assume a horizontal flow. However, the embodiment in Figure 2 provides no significant improvements compared to that in Figure 1. In an extreme case of the present invention, it would be possible for the waste gas duct to comprise a plurality of individual tubular conduits, each of which leads from one of the waste gas openings to the collection duct. To this extent, the concept of the flow body in the framework of the invention also encompasses such an embodiment, although this embodiment is less preferred due to the associated constructive expense.

The invention eliminates the uneven flow of waste gas from the interior of the heating chamber 1 previously found in an embodiment of the waste gas duct 4 as in Figure 8 (or a waste gas duct 4a as in Figure 9). The pressure losses that occur in the waste gas duct 4 or 4a resulted in the previous design in a clearly stronger waste gas flow in the part of the heating chamber 1 closer to the collection duct 8. In the regions farther from the collection duct 8, the waste gas flow was markedly weaker, so that non-uniformities developed in heat distribution.

The effectiveness of the inventive measure of installing flow bodies in the waste gas duct can be seen by analyzing the waste gas flow in the flow profile shown in Figure 3. This drawing (in which parameter values are recorded) shows the vertical components of the waste gas flow rate in the immediate vicinity of a heat exchanger tube row 3 in a cross-section parallel to the plane of the heat exchanger tube row 3. Lines of equal flow rate as a function of the location L along the length L_1 of the waste gas duct and of the height H from the floor of the heating chamber (total height H_1) have been recorded.

The negative flow rate values indicate that in the immediate vicinity of the heat exchanger tubes in the upper half of the heating chamber, the combustion waste gas flows from bottom to top, because roller-like flows form between two





rows of heat exchanger tubes and are directed downward in the middle (in the area of a burner plane). Not until the lower half of the heating chamber does the combustion waste gas flow downward along the heat exchanger tubes to the openings in the side wall of particular waste gas duct. Clearly, only slight differences occur in the vertical components of the flow rate occur in the direction of the waste gas duct at a constant height above the floor of the heating chamber, which is a measure of the intensity of the heat transfer taking place by means of convection.

In contrast, as Fig. 4 (reflecting a corresponding analysis) shows, the differences are very marked in a heating chamber with a conventional waste gas duct embodied as in Fig. 8. The lower right part of this drawing shows the area with the most positive (i.e., downwardly directed) vertical speed components by far. This means that the strongest mass flow of the combustion waste gas in the heating chamber cross-section is present in the immediate vicinity of the waste gas duct output from the heating chamber. This in turn must mean that considerably greater heating of the heat exchanger tubes takes place in this area than in the other regions, due to the intensive convection.



Patent Claims

THIS SHEET HAS BEEN
REPLACED

1. Arrangement for indirectly transferring heat to a flowing process medium, especially for carrying out steam reformation of hydrocarbons, with a heating chamber (1), which can be heated from above by burners (2) arranged in multiple rows and through which run, on vertical longitudinal planes, a plurality of rows of heat exchanger tubes (3) through which the process medium can be conducted, whereby the combustion waste gasses of the burners (2) can be extracted laterally from the heating chamber (1) through waste gas ducts (4) arranged on the floor of the heating chamber (1) parallel to each other and to the rows of heat exchanger tubes (3), and whereby the waste gas ducts (4) are made of refractory-grade material and have a substantially rectangular cross-section constant in the axial direction and are equipped on their longitudinal sides in the region near the floor with openings (5) distributed over their entire axial length for the passage of waste gasses out of the heating chamber (1) into the interior of each respective waste gas duct (4), characterized by the fact that to equalize the flow conditions of the waste gas, flow bodies are arranged in the interior of the waste gas ducts (4) in the region of the lower part of the row of heat exchanger tubes (3).
2. Arrangement as in Claim 1, characterized by the fact that the flow bodies have, by section, flow baffles (6, 6a) running substantially horizontally, and are arranged in a step-like configuration relative to each other, whereby the step-like form is directed downward in the direction of the lateral output of the waste gas duct (4).
3. Arrangement as in Claim 2, characterized by the fact that the individual directly adjacent flow baffles (6, 6a) partially overlap each other.





4. Arrangement as in one of the Claims 2 or 3,
characterized by the fact
that each flow body has a dividing baffle (6b) extending out of the floor at a
substantially right angle to the longitudinal direction of the waste gas duct (4),
which dividing baffle (6b) is connected to the flow baffle (6a) in question on the
side facing away from the side of the waste gas extraction.

THIS SHEET HAS BEEN
REPLACED

This Sheet Has Been Replaced

