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(54) **Heat exchanger**

(57) A tube-nest heat exchanger with bypass for process fluid output temperature control comprises a chamber (14) traversed by an exchange fluid and closed at opposite ends by a pair of tube plates (12,13) with a tube nest (11) between them. The tube-nest tubes are traversed by the process fluid and are in contact externally with the exchange fluid in the chamber. Between the tube plates (12,13) is at least one bypass tube (17) made up of an external shell (18) in contact with the exchange fluid and a thermally insulating layer (19) on the inner wall to surround an internal passage (20) traversed by the process fluid. The material of the external shell of the bypass tube and the material of the tube-nest tubes are mutually different and chosen with different thermal expansion coefficients such that the functions $\Delta L_t(T)$ and $\Delta L_b(T)$ of the lengthening starting from the length under assembly conditions as a function of temperature and respectively of the tube-nest tubes and the bypass tube shell identify at said respective mean operating temperatures T_{et} and T_{eb}, values $\Delta L_t(T_{et})$ and $\Delta L_b(T_{eb})$ such that $|1-\Delta L_t(T_{et})/\Delta L_b(T_{eb})|<=0.15$. This produces reduced stress on the welds between tubes and tube plates and allows realization of more economical and stronger exchangers.

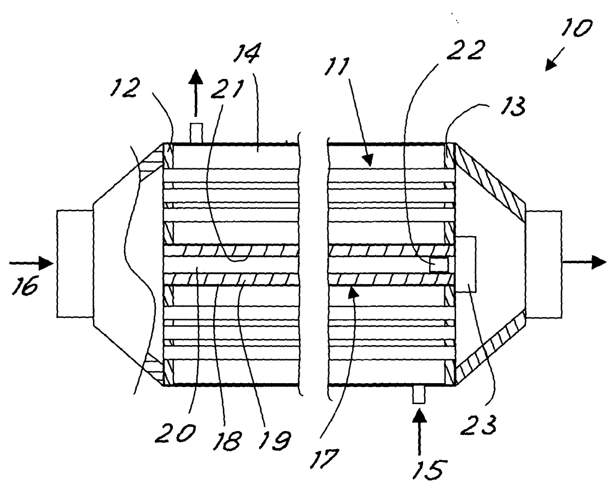

Fig.1

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Description

[0001] The present invention relates to a heat exchanger with improved structural characteristics.

[0002] In particular, an exchanger of the type with tube plates and with tube nest arranged between the plates and with process fluid output temperature control is described. This structure realizes known exchangers for example with the name 'Waste Heat Boiler' or 'Process Gas Cooler'. Use is generally for the realization of steam generators for various plants (ammonium, methanol, hydrogen etc) for which process gas output temperature control is required. Said control is obtained by means of a bypass tube carrying the gas in variable proportion from the exchanger input directly to its output. A controlled valve adjusts the quantity of process gas passing through the bypass so as to regulate the desired exchanger output fluid temperature.

[0003] To function, the bypass tube must be insulated thermally inside for metallurgical reasons and hence its external shell in contact with the water constituting the exchange fluid circulating in the exchanger takes on a temperature very close to that of the fluid on the jacket side.

[0004] In the prior art the bypass duct is realized with the same material as the other tubes of the nest. But being cold in normal operation as compared with the exchange tubes of the tube nest, it lengthens less as compared with the tubes of the nest. Thus tensions are created on the weld between the tube and the tube-nest in the zone contiguous to the bypass. The stress is the higher the longer tubes. This involves among other things a limit to the length of the tubes usable and hence to the efficiency and economic character of the exchanger.

[0005] The prior art solutions proposed heretofore aimed at realizing stronger joints or those having solutions a suitable to absorbing more stress. Said solutions are however unsatisfactory and led to complicating the exchanger and making it still less economical.

[0006] The general purpose of the present invention is to remedy the above-mentioned shortcomings by making available an exchanger with improved structure in a simple and economical manner allowing greatly reducing the stresses produced by the bypass duct and the incidence of the length of the tubes on the stresses produced by the bypass duct so as to be able also to realize exchangers with longer and therefore more economical tubes.

[0007] In view of this purpose it was sought to provide in accordance with the present invention a tube-nest heat exchanger with bypass for process fluid output temperature control comprising a chamber traversed by an exchange fluid and closed at opposite ends by a pair of tube plates with a tube nest between them and the tube-nest tubes being traversed by the process fluid and being in contact externally with the exchange fluid in the chamber with there being between the tube plates in addition at least one bypass tube made up of an external shell in contact with the exchange fluid and a thermally insulating layer on the inner wall to surround an internal passage traversed by the process fluid so that under operating conditions when the tube-nest tubes are at a first average temperature T_{et} the external shell of the bypass tube is at a second average temperature T_{eb} lower than the first, characterized in that the material of the external shell of the bypass tube and the material of the tube-nest tubes are mutually different and chosen with different thermal expansion coefficients such that the functions $\Delta L_t(T)$ and $\Delta L_b(T)$ of the lengthening starting from the length under assembly conditions as a function of temperature and respectively of the tube-nest tubes and the bypass tube shell while identifying at said respective mean operating temperatures T_{et} and T_{eb}, values $\Delta L_t(T_{et})$ and $\Delta L_b(T_{eb})$ such that $|1-\Delta L_t(T_{et})/\Delta L_b(T_{eb})|<=0.15$.

[0008] To clarify the explanation of the innovative principles of the present invention and its advantages compared with the prior art there is described below with the aid of the annexed drawings a possible embodiment thereof by way of non-limiting example applying said principles. In the drawings:

FIG 1 shows a partially cross sectioned diagrammatic view of an exchanger of the type complying with the present invention; and

FIG 2 shows a graph of sizing parameters of the exchanger of FIG 1.

[0009] With reference to the figures, FIG 1 shows a heat exchanger indicated as a whole by reference number 10 and having a tube nest 11 between tube plates 12 and 13. The pair of plates closes a chamber 14 traversed by an exchange fluid 15 while the tubes of the tube nest 11 are traversed by the process fluid 16 and are in contact externally with the exchange fluid in the chamber.

[0010] The exchanger also comprises a bypass 17 for control of process fluid output temperature. Said bypass 17 comprises in turn an external shell 18 in contact with the exchange fluid and a thermally insulating layer 19 on the internal wall to surround an internal passage 20 traversed by the process fluid. In this manner, under operating conditions the tube-nest tubes are at a first average temperature T_{et} while the bypass tube external shell is at a second average temperature T_{eb} which is lower than the first.

[0011] The internal passage 20 of the bypass traversed by the process fluid can be advantageously separated from the thermally insulating layer by means of an internal duct 21. This allows protecting the insulating material from the aggressive action of the process fluid. If the internal duct 21 is used, it can be realized with a known telescopic union 22 so as to allow appropriate lengthenings caused by its linear expansion.

[0012] For output fluid temperature control the bypass tube has advantageously a mouth at its process fluid output end equipped with a known adjustable valve 23 for flow choking. The material of the external shell 18 of the bypass tube and the material of the tube-nest tubes 11 are mutually different and are chosen with different thermal expansion coefficients.

[0013] As shown diagrammatically in FIG 2, two functions $\Delta L_t(T)$ and $\Delta L_b(T)$ of the lengthening can be defined as a function of temperature respectively of the tube-nest tubes and of the bypass tube shell starting from the length which they have under rest condition, i.e. under assembly conditions. Under these conditions the stress can be considered minimal. The curves of the two functions (ideally two straight lines) intersect mutually at assembly temperature T_M (for example at surrounding temperature of 25°C). The inclination of the two straight lines is a function of the linear expansion coefficients of the two materials chosen and of the length of the tubes at rest.

[0014] In accordance with the principles of the present invention the materials of the tubes must be chosen with expansion coefficients such that the above-mentioned functions $\Delta L_t(T)$ and $\Delta L_b(T)$ identify at said mean operating temperatures T_{et} and T_{eb} of tubes and bypass values $\Delta L_t(T_{et})$ and $\Delta L_b(T_{eb})$ such that $|1-\Delta L_t(T_{et})/ \Delta L_b(T_{eb})|<=x$ with at most equal to 0.15.

[0015] Still better, it was found advantageous that x be at most 0.07 and expediently not over 0.05.

[0016] Choosing the materials and sizing the exchanger as above-mentioned, it was found that the forces on the welds between plates and tubes are greatly reduced (even more than 20% compared with known devices) and this allows using more economical fastening solutions and/or realizing much longer exchangers than those of the prior art.

[0017] For comparison with $\Delta L_{Lbo}(T_{eb})$, the value which would be had with the prior art is indicated.

[0018] Use of the principles of the present invention allows designing WHB and Gas Coolers with longer tubes; while with the prior art, WBH and Gas Coolers are realized with tubes 6 to 8 meters long, with the technology of the present invention it is possible to utilize tubes 12 meters long and more. The apparatuses will thus have smaller diameter and will be much more economical.

[0019] It is now clear that the predetermined purposes of the present invention have been achieved.

[0020] Naturally the above description of an embodiment applying the innovative principles of the present invention is given by way of non-limiting example of said principles within the scope of the exclusive right claimed here. Various materials with suitable characteristics can be used advantageously by choosing them in accordance with the present invention. For example, for the bypass it was found advantageous to use a series 800 nickel alloy and in particular ALLOY 825 while the tubes of the exchanger are made of a chrome-molybdenum alloy.

Claims

1. Tube-nest heat exchanger with bypass for process fluid output temperature control comprising a chamber (14) traversed by an exchange fluid and closed at opposite ends by a pair of tube plates (12,13) with a tube nest (11) between them and the tube-nest tubes being traversed by the process fluid and being in contact externally with the exchange fluid in the chamber with there being between the tube plates (12,13) in addition at least one bypass tube (17) made up of an external shell (18) in contact with the exchange fluid and a thermally insulating layer (19) on the inner wall to surround an internal passage (20) traversed by the process fluid so that under operating conditions when the tube-nest tubes are at a first average temperature T_{et} the external shell of the bypass tube is at a second average temperature T_{eb} lower than the first, **characterized in that** the material of the external shell of the bypass tube and the material of the tube-nest tubes are mutually different and chosen with different thermal expansion coefficients such that the functions $\Delta L_t(T)$ and $\Delta L_b(T)$ of the lengthening starting from the length under assembly conditions as a function of temperature and respectively of the tube-nest tubes and the bypass tube shell while identifying at said respective mean operating temperatures T_{et} and T_{eb}, values $\Delta L_t(T_{et})$ and $\Delta L_b(T_{eb})$ such that $|1-\Delta L_t(T_{et})/\Delta L_b(T_{eb})|<=0.15$.

2. Exchanger in accordance with claim 1 **characterized in that** the coefficients are chosen so that $|1-\Delta L_t(T_{et})/ \Delta L_b(T_{eb})|<=0.07$ and preferably $|1-\Delta L_t(T_{et})/\Delta L_b(T_{eb})|<=0.05$.

3. Exchanger in accordance with claim 1 **characterized in that** the internal passage traversed by the process fluid is separated from the thermally insulating layer by means of a telescopic duct (21).

4. Exchanger in accordance with claim 1 **characterized in that** for temperature control the bypass tube has its mouth at its process fluid output end which is equipped with a adjustable flow-choking valve (23).

5. Exchanger in accordance with claim 1 **characterized in that** the bypass tube is made of a nickel alloy.

6. Exchanger in accordance with claim 5 **characterized in that** the nickel alloy is a series 800 nickel alloy.

7. Exchanger in accordance with claim 6 **characterized in that** the nickel alloy is ALLOY 825.

8. Exchanger in accordance with claim 1 **characterized in that** the tube-nest tubes of the exchanger are made of a chrome-molybdenum alloy.

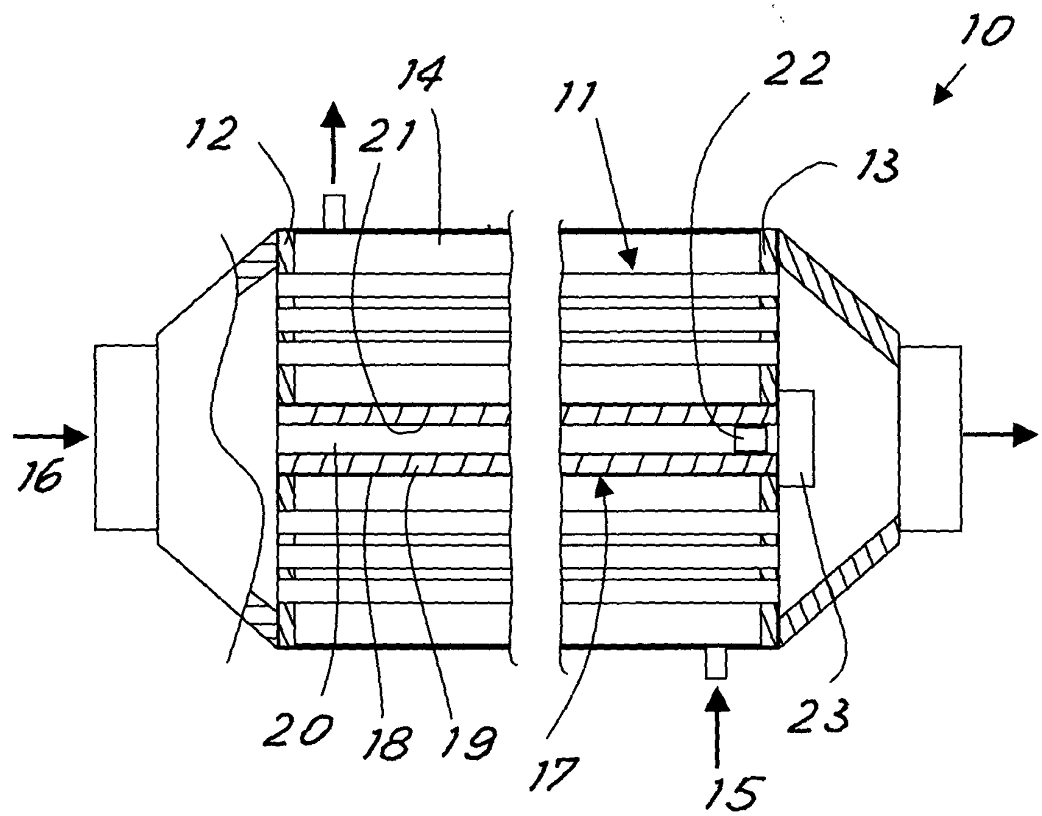
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Fig.1

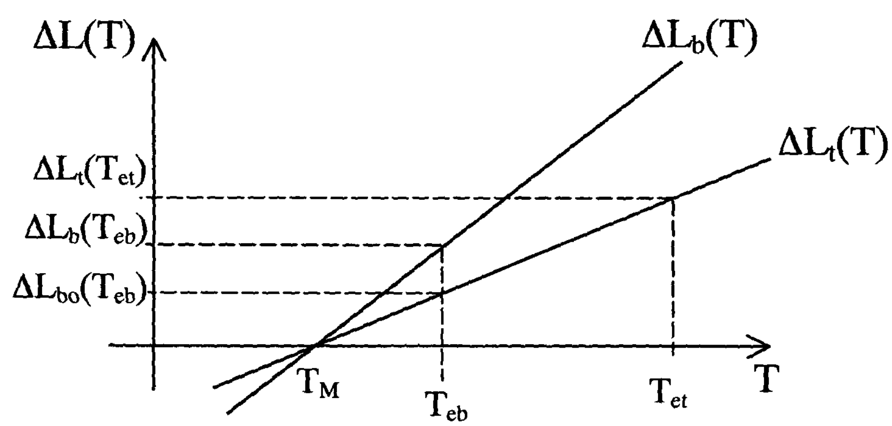
ΔL(T)
ΔL_b(T)
ΔL_t(T)
ΔL_t(T_et)
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Fig.2