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(54) A heat exchanger with a silicon carbide set of tubes and tube plates in enamelled steel

(57) A heat exchanger comprising a set of tubes (11) consisting of silicon carbide (SiC) tubes mounted between two tube plates (12,21) in enamelled steel by means of a pressure seal system (22-24) along which the tube (11) may slide to compensate for thermal expansions.

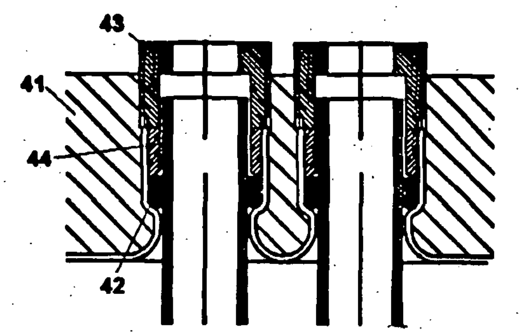

Fig. 4

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Description

Field of the invention

[0001] The present invention relates to a heat with a set of tubes and tube plates and more particularly a heat exchanger suited for the treatment of highly corrosive fluids or the ones for which a high level of purity must be ensured.

State of the art

[0002] Heat exchanger are known for processing highly corrosive fluids or fluids with special purity requirements, wherein the tube plates are of a suitable material, such as solid PTFE. The tubes are sealed with the plate by means of threaded ring nuts, directly tightened in a threading provided in the PTFE. This solution presents drawbacks connected with the not satisfactory mechanical resistance of the plates, especially at high temperatures, which limits the possible applications of the exchanger and renders frequent maintenance necessary.

[0003] A possible alternative is the use of PTFE coated steel plates; the coating is necessarily thin, which renders it not always sufficiently impermeable, and unsuitable for providing a proper sealing for the tubes passing through the plate.

[0004] This requires complicate construction for properly fixing and sealing the tubes, and a relevant danger of seepage of the circulating fluid is anyway present.

Summary of the invention

[0005] The above mentioned problems have been solved, according to the present invention, with a heat exchanger comprising a set of tubes consisting of SiC tubes mounted between two tube plates in enamelled steel by means of a pressure seal system on the outer surface of each tube, in which the tube can axially slide therein to compensate for thermal expansions.

Brief description of the drawings

[0006] In the attached figures are represented:

- Figure 1: overall view of the exchanger according to the invention where (11) is the set of tubes with silicon carbide tubes, (12) are the tube plates in enamelled steel, (14) is the central shell in enamelled steel, and (13) are the end distributors;
- Figure 2: a detail of the tube plate in PTFE according to the prior art, double ○ ring seal (24), threaded ring nut (22) with threading (23) on the PTFE;
- Figure 3: a detail of the double tube plate according to the prior art, in PTFE coated steel, where (32) is the coating in PTFE, (33) ○ ring seal, (34) locking through screw, (35) through holes;
- Figure 4: a detail of the single tube plate (41) according to the invention, with O ring seal (42), threaded ring nut (43), and intermediate bushing (44);
- Figure 5: a detail of the double tube plate according to the invention, with O ring seal (51) on the inner plate and an O ring (52) on the outer plate, a single locking ring nut (53), intermediate bushing (54) hole (55) for the conveyance of possible fluid leakages;
- Figure 6: a detail of the double tube plate according to the invention, with O ring seal (62) on the inner plate (61), O ring seal (67) on the outer plate (65) locking bushing (66), steel ring nut (63), intermediate bushing (64), elastic seal system support L-profile (68);
- Figure 7: a detail of the double tube plate with locking screw (74) of the two plates with gasket (73) between the plates.

Detailed description of preferred embodiments

[0007] In Fig.1 is briefly represented a heat exchanger according to the present invention, comprising a set of tubes in silicon carbide (SiC) (11) and tube plates in enamelled steel (12) as the essential members. Depending on the plates which may be enamelled indifferently on one or both the two faces, both the central shell (14) and the end distributors (13) may be provided in enamelled steel.

[0008] A characteristic and original aspect of the heat exchanger according to the invention is represented by the enamelled tube plates substituting the traditional ones in PTFE (PolyTetraFluoroEthylene) see Fig. 2 reference 21 or the ones in PFTE-coated steel (see Fig.3 reference31).

[0009] Another original aspect is represented by the seal systems between the end of the SiC tube and the tube plate (see. Fig. 4, 5, 6). These seal systems, especially studied for the various embodiments of enamelled tube plates (enamelling only on the distributor side face, only on that of the shell side or on both), can also be adopted for traditional tube plates with tubes in SiC or in glass and represent an improvement with respect to the traditional solutions.

[0010] The improvement achieved with the present invention overcomes the drawbacks of the above mentioned prior art exchangers and in particular (with reference to figure 2 for the plate in solid PTFE and figure 3 for the plate in PTFE-coated steel):

- The plate in solid PTFE (Fig.2, reference21), normally of the glass fiber filled type, can be used up to a maximum temperature of 165°C, beyond which a rapid decline in the mechanical resistance values of this material is observed.

[0011] In addition, being PTFE essentially a plastic material, the tube plate may deform over time and bend under pressure, subjecting the ends of the SiC tubes (particularly the most exterior ones with respect to the set of tubes) to flexing stress beyond their ultimate stress. For this reason in practice they do not exceed ϕ 300 mm.

- For sealing the tubes on the glass-filled solid PTFE tube plates threaded ring nuts (22) also in glass-filled PTFE are provided, which press a gasket generally of a double O ring type (24). The threading (23) on the PTFE (plastic material) tends to loosen with time the higher the temperature as well as the amplitude and the frequency of the thermal cycles. Accordingly, frequent inspections of the locking moment of the PTFE ring nuts are required to avoid leakages from the sealing.
- The PTFE coated steel plates (Fig.3, reference 31) are not subjected to permanent progressive deformations. However, being the coating (32) necessarily thin, it has certain porosity and as a consequence is not completely impermeable. Furthermore, in this low thickness neither the threading required for the locking ring nuts of the O ring gasket nor the housings for the gaskets themselves can be formed, as it is however possible to do for the plates in solid PTFE. One must therefore resort to the solution represented by the double plate with O ring (33) in the intermediate area. To allow for the tightening of the O rings between the two plates through screws (34) passing through holes in the plate, are used and thus the PTFE coating is drilled accordingly. In correspondence of such holes (35) an appropriate seal system must be provided, which will however constitute a point of discontinuity in the coating with a danger of seepage of the circulating fluid.

[0012] With the enamelled tube plate the following advantages may be achieved:

- The coating is not porous, but perfectly impermeable and cleanable like glass;
- The high mechanical resistance of the steel plate allows the use of large-sized plates, well beyond 300 mm diameter;
- It is suitable to be easily implemented in a double embodiment with enamelling on one or on both faces and with an intermediate circuit for leakage collection (see Fig.7 reference 71) delimited on the circumference of the O ring gasket reference 73 with a drainage hole (72) in the lower part, wherein an appropriate device for signalling the leakage itself may be screwed thereto (for example a manometer with min/max pressure contacts). In this way, the fluids are prevented from entering into contact with each other, an event to be avoided with chemically incompatible fluids or fluids which must not contaminate each another. The collected fluid allows for an immediate identification of whether the leakage is on the tube side or the shell side.
- All the threaded couplings for the locking ring nuts are metallic and therefore much more reliable than those in PTFE.

[0013] With the new sealing systems between the end of the SiC tube and the tube plate the basic needs are considered, which are however met by the traditional seal systems (generally made with fluoro-elastomer O ring gaskets of Kalrez^R and Viton^R type or FEP-coated Silicone (C_2F_4/C_3F_6 copolymer), or other materials with high corrosion resistance), and that is:

- accomplish the pressure seal between tube and tube plate,
- prevent direct contact of the tube with the tube plate (both elements in rigid material) in such a way as to avoid breakage due to localised peaks of stress,
- allow the sliding of the tube (in the hole of the tube plate) for the automatic compensation of the different expansion between set of tubes and shell of the exchanger,
- prevent that the sum of subsequent translations of the tube, which may also occur always in the same direction, may cause the tube itself to unthread from the hole of the plate. This is achieved by a "translation limiter" consisting in the reduction in diameter of the ring nut head (reference 43, 53, 66), which prevents the tube from exiting beyond the ring nut itself.

[0014] Fig.4 shows the embodiment of the exchanger with a single tube plate (41), with enamelling on the shell side, in which the O ring seal gaskets (42) are locked by the threaded ring nut (43) by means of the intermediate bushing (44).

[0015] The following new prerogatives for the double tube plates are further added.

[0016] For the double tube plate enamelled only on the inner face (shell side) Fig.5, the seal on the inner (by O ring reference 51) and the outer (by O ring reference 52) tube plate can be simultaneously achieved by a single locking of the threaded ring nut (53) by means of the intermediate bushing (54) in steel or in PEEK (phenylpolyetherketones of Du Pont), which is fitted with holes (55) for conveying possible fluid leakages to the outside.

[0017] For the double tube plate enamelled on both sides (Fig.6), the two seals on the tube are separate. For the inner plate (shell side) (61) the seal is implemented by means of a double O ring gasket (62) pressed by an intermediate bushing in steel or in PEEK (64) by the screwing of a steel ring nut (63) in the corresponding thread provided in the tube plate.

[0018] For the outer tube plate (distributor side) (65), the use of a ring nut for the locking of every single tube not being possible, the required pressure for pressing the O ring seals (67) has been provided by means of a special bushing in glass-filled PEEK or PTFE (66), being pressed by the tube plate. This pressure is applied during the coupling step of the two single plates by the locking of the screws located on an outer peripheral circumference of the enamelled area to avoid any point of discontinuity in the coating (see fig.7 reference 74). The type of seal is characterised by a high degree of elasticity in the axial direction made by means of a mechanical spring system or an adequate number of overlapping O ring gaskets (68), in addition to those provided for pressure seal.

[0019] An underlying L-profile ring (69) ensures support to this elastic system regardless of the position of the underlying seal ring nut on the inner plate.

Claims

1. A heat exchanger comprising a set of tubes consisting of SiC tubes mounted between two tube plates in enamelled steel by means of a pressure seal system on the outer surface of each tube, in which the tube can axially slide therein to compensate for thermal expansions.

2. The heat exchanger according to claim 1, in which each of the two tube plates can be single or double, being the single plate enamelled only on the inner face thereof (shell side) and the double tube plate enamelled only on the inner face (shell side), or on both faces.

3. The heat exchanger according to claims 1 and 2, in which the members of the seal system between tubes and tube plate are adapted for chemically and thermally resisting to the circulating fluids the normal operating conditions of the exchanger.

4. The heat exchanger according to claims 2 and 3 with single tube plate (fig.4) in which the seal between the ends of the tubes and the tube plate is obtained by a double ○ ring gasket (42) pressed, by means of an intermediate bushing in steel or in PEEK (44), by screwing of a steel ring nut (43) in the corresponding threading provided on the tube plate.

5. The heat exchanger according to claims 2 and 3 with double tube plate with enamelling only on the inner face (shell side) (fig.5), wherein the seals between the ends of the tubes and the two plates forming the double tube plate are obtained with double ○ ring gaskets (51) and (52) simultaneously pressed by screwing a steel ring nut (53) in the corresponding threading provided in the outer non-enamelled tube plate, which acts on the intermediate bushing in steel or in PEEK (54), being the bushing suitably drilled (55) to allow for possible leakages to be conveyed outside.

6. The heat exchanger according to claims 2 and 3 with double tube plate with enamelling on both faces (fig.6) in which the seals between the ends of the tubes and the two plates forming the double tube plate are obtained through double ○ ring gaskets pressed in a different way: the seal (62) on the inner plate (shell side) in the same way as described in claim 4, the seal (67) on the outer plate (distributor side) by means of the locking of the screws provided in such a way as to make the two plates integral to one another, being these screws distributed over a peripheral circumference of the tube plate which is located beyond the enamelled area to avoid any points of discontinuity in the coating.

7. The heat exchanger according to claim 6 wherein the seals between the ends of the tubes and the outer enamelled plate are ensured by an elastic system indifferently formed by a series of overlapping O ring gaskets (fig.6, reference 68) or a mechanical spring, which rest on an L-profile ring (69) which can also be adapted to ensure pressing required for each single seal following the locking of the peripheral screws which fix the two plates forming the double tube plate one to the other.

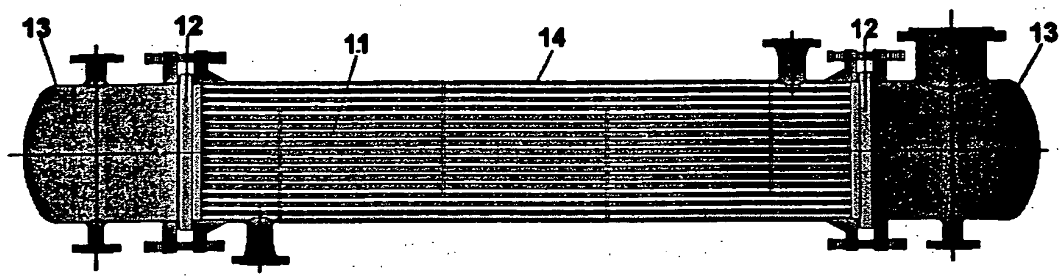

Fig.1

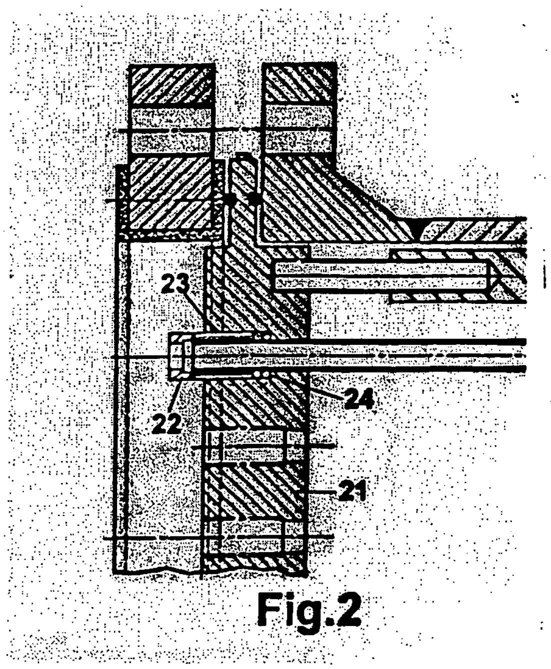

Fig.2

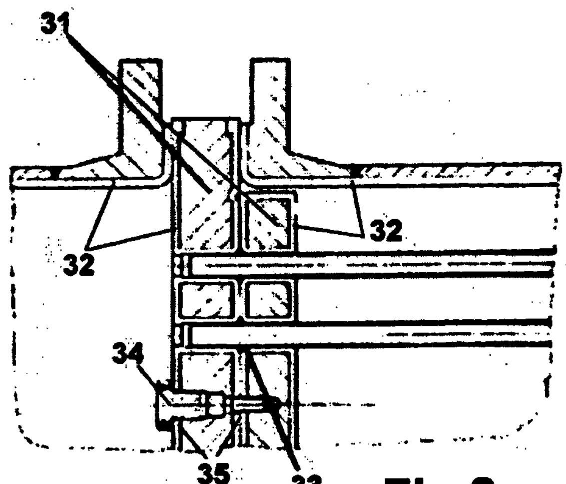

Fig.3

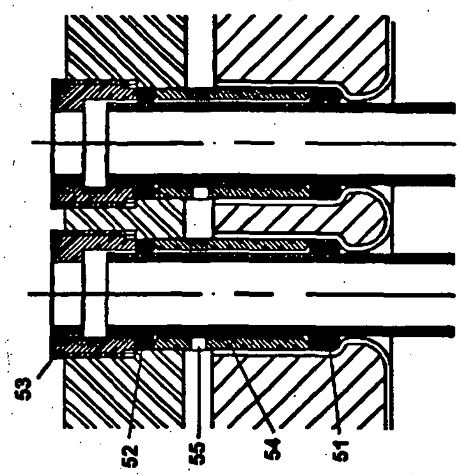

Fig.5

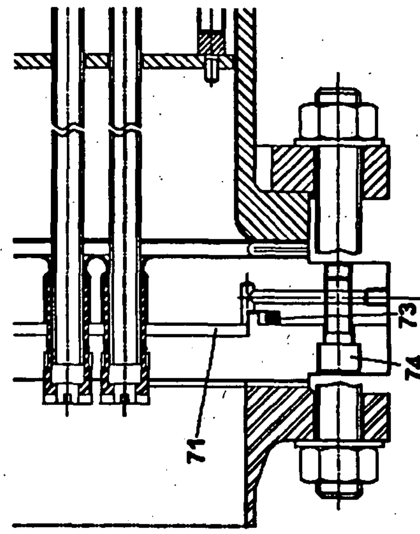

Fig.7

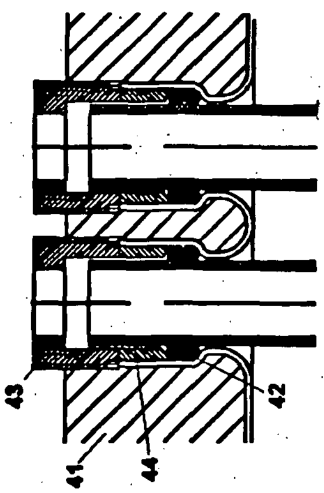

Fig. 4

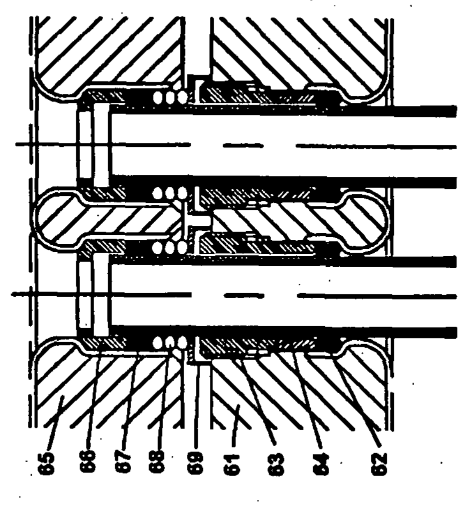

Fig.6