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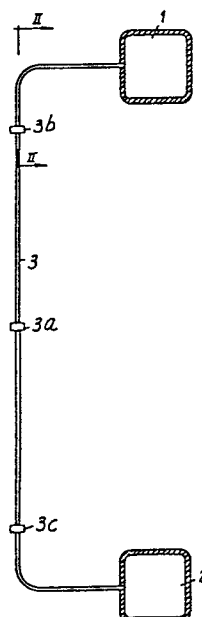
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⑤④ **Heat exchanger structure particularly for nuclear plants.**

⑤⑦ To reduce costs both through material and labour savings of a nuclear plant heat exchanger, the latter comprises two quadrangular cross-section headers (1, 2) coupled by a yoke-like tube nest (3) which is cold pre-deformed in such a way as to minimize the primary stresses of thermal origin developed during the operation of the exchanger.



HEAT EXCHANGER STRUCTURE PARTICULARLY FOR NUCLEAR PLANTS

The invention relates to a heat exchanger structure particularly for nuclear plants.

It is known that in the design of heat exchangers intended for operation in very drastic conditions due to high pressures or temperatures being involved, technicians are called upon to overcome considerable difficulties. Particularly in the case of nuclear plants, where for example a sodium-air exchanger is provided which operates at a high temperature, the calculation standards which the designer is forced to follow are so exacting that, notwithstanding the sophisticated and highly laborious crosschecking calculations which are carried out, the prior art requires construction techniques which often show considerable complexity.

This results mainly from the fact that said standards require that crosschecks be made in the operating condition bearing in mind the several overlapping loads which, albeit with a modest degree of likelihood, could occur simultaneously; thus, to the primary stresses of thermal origin brought about by material deformations as the temperature increases from ambient temperature to operative temperature, the stresses are to be added due to seismic phenomena, those deriving from thermal transients, creep stresses, and others yet, thereby complex and costly constructions are required effective to resist thereagainst.

This invention is aimed at providing a heat exchanger structure particularly for nuclear plants,

wherein constructional techniques of great simplicity can be adopted to reduce costs both through material and labour savings.

5 Within the proposed aim, it is an object of the invention to provide a heat exchanger structure which can bring about a simplification in the crosschecking calculations.

10 According to one aspect of the present invention the proposed aim and cited object are achieved by a heat exchanger structure particularly for nuclear plants, characterized in that it comprises at least one pair of headers connected by a tube nest, said tube nest having a cold pre-deformed structure, such as to minimize, in the operating condition thereof, 15 the primary stresses of thermal origin.

 It will be appreciated that according to one embodiment the said pre-tensioning effecting cold pre-deformation is opposite to the thermal deformation or stresses caused in the operative temperature conditions. 20

 The solution stems from the consideration that the strain pattern or distribution induced by the primary stresses of thermal origin alone, in the operating condition, is close to the limit conditions imposed by the cold condition standards, thereby, by 25 imparting the tube nest with cold pre-stressing so as to substantially induce said strain pattern, one will achieve in the hot operating condition a minimization of such primary stresses, thus leaving an ample margin for subsequent verifications which take into account 30

the seismic phenomena, thermal transients, etc., which in the cold condition, as is apparent, were not to be accounted for.

5 The possibility derives from the foregoing of adopting specially advantageous construction forms, such as having a cross-section of quadrangular, instead of circular, shape for the headers, as better specified hereinafter.

10 Further features and advantages will be more clearly apparent from the description of a preferred, though not exclusive, embodiment of the invention, as illustrated by way of example and not of limitation in the accompanying drawings, where:

15 Figure 1 is a schematical side elevation view of the invention;

Figure 2 is a sectional view taken in the plane II-II of Figure 1, showing for reference purposes a single tube of the tube nest;

20 Figure 3 is a detail view of the mounting of one tube of the tube nest to the header.

25 With reference to the above-mentioned views, indicated at 1 and 2 are the two headers with quadrangular cross-section connected by a tube nest formed by generally yoke-like or U-like tubes such as 3, with the web portion of the U-shape or centrally thereof having a substantial extension. The tubes are, as previously mentioned, subjected to cold pre-stressing, the stress whereof is substantially relieved as the exchanger is operated at a high temperature, thanks
30 to deformation of the materials. The temperature of

of the cold, pre-stressing may be the room temperature or any other low temperature suitable to create the desired stress relieving effect in operative conditions.

An advantageous structural symmetry is achieved
5 by securing the tubes such as 3 with a retaining action in all directions via the support 3a located substantially in the middle of the web portion of the U-shape of the tubes and by means of the supports 3b and 3c arranged
10 symmetrically offset with respect to the support 3a on the web portion of the U-shape, near the elbows thereof and providing retention only perpendicularly to the plane in which the U-like tubes extend, while allowing axial movement in the axial direction of the tubes and in a direction parallel to said plane in which
15 the tubes extend (plane in which Fig. 1 is located) and perpendicular to the tubes themselves. For the purpose the holes of support 3b have an elongated shape in the last mentioned direction. Assuming that the exchanger in question transports the hot fluid
20 through the interior of the headers and tubes of the tube nest which are swept across the exterior wall by the cold fluid, e.g. ambient air, there may occur two conditions of operation; a first condition, which we will call isothermal, when no cold fluid is directed
25 into the exchanger and accordingly the exchanger is at a uniform temperature throughout, and a second condition, which we will call of power removal, which occurs when cold fluid is directed into the exchanger interior in the interspace between the tubes so that the inlet
30 header, which we assume to be the one indicated at 1,

will be at a higher temperature than the cooled tubes 3 and related supports.

To also achieve minimal primary stresses of thermal origin in the perpendicular direction to the plane containing the yokes, provision is then made to reduce the longitudinal drilling pitch 4 (or distance between the holes) on the header 1 for connecting the tubes such as 3 with respect to the drilling pitch 5 on the support 3b, so that the resulting pre-stressing of the tubes in the cold condition is substantially cancelled, along with its related stresses, in the power removal conditions of operation thanks to the greater expansion of the header 1 over the support 3b.

In the instance of an exchanger wherein it is the cold fluid that flows through the interior of the headers and tubes swept exteriorly by the hot fluid, it will, of course, be the pitch 5 which is decreased relatively to the pitch 4.

One of the main advantages to be derived from the low stress values occurring at the connection sections of the tube nest tubes to the headers resides in the possibility of adopting quadrangular cross-section headers, i.e. formed by flat radiused plates, instead of the usual circular cross-section headers which have a much higher rigidity than the flat plates, and which must be used of necessity, owing to the high stresses, on the exchangers fabricated in accordance with the prior art.

The quadrangular cross-section appreciably facilitates the construction of the header supports and

allows the geometry of the tube nest tubes to be simplified.

The connecting lugs such as 6 of the headers to the tubes 3 may then be formed by milling the flat plates such as 1a of the headers, instead of extruding them as is required in the case of circular cross-section headers.

For the purpose the starting plate 1a has an initial thickness equal to the sum of the projecting length of lug 6 and the final thickness of plate 1a and by milling the excess thickness corresponding to the length of the lug 6 is removed, except for the portion which will form the lug 6 which thus is an integral part of the plate 1a. This affords savings in the heat treatment which otherwise would be necessary after the extrusion and the fabrication of the end section of the lugs is possible with the same thickness as the tubes such as 3, thus enabling said tubes to be welded directly i.e. in abutment relationship onto the lugs, with attendant elimination of the intermediate stub pipe which is required where the lugs are obtained by extrusion for the purpose of providing gradual transition from the tube thickness to that of the end section of the lug which is much larger; the connection, therefore, reduces itself to making a single weld, which in addition may be effected in ideal conditions with the IBW (Internal Bore Welding) method, contrary to what happens in the case of the circular cross-section header owing to the continued adjustments involved.

Another feature to be pointed out is that the

ample margin left for strength checks in the operating condition, by virtue of the primary stresses of thermal origin having been minimized, allows for easier calculations, with appreciable savings in designing time,
5 which may normally require even a few months.

The invention just described is susceptible to many modifications and variations, all of which fall within the scope of the inventive concept; further, all the details may be replaced with other technically
10 equivalent elements.

In practicing the invention, the materials used, as well as the shapes and dimensions, may be any ones contingent on individual requirements.

CLAIMS

- 1 1. A heat exchanger structure particularly for
2 nuclear plants, characterized in that it comprises
3 at least one pair of headers (1,2) connected by a
4 tube nest (3), said tube nest having a cold-pre-deformed
5 structure, such as to minimize, in the operating condi-
6 tion thereof, the primary stresses of thermal origin.
- 1 2. A heat exchanger structure particularly for
2 nuclear plants, characterized in that it comprises
3 two substantially parallel headers (1,2) of quadrangular
4 cross-section connected by a tube nest (3) formed by
5 yoke-like tubes with remarkable extension of the central
6 leg, being cold pre-deformed so as to minimize, in the
7 operating condition, the primary stresses of thermal
8 origin.
- 1 3. An exchanger structure according to one or
2 more of the preceding claims, characterized in that
3 the yoke-like tubes (3) are retained in all directions
4 by means of supports (3a) at the substantially middle
5 area, and are retained in the normal direction to the
6 plane containing the yoke by means of supports (3b,3c)
7 at two areas arranged symmetrically with respect to the
8 middle area substantially at the end of the central leg.
- 1 4. An exchanger structure according to one or
2 more of the preceding claims, characterized in that
3 the lugs (6) for providing connection between the
4 yoke-like tubes (3) and headers (1,2), as formed by
5 milling from the plates of said headers (1,2) and
6 integral therewith, have at the end section thereof a
7 thickness such as to allow direct abutment connection

8 to said tubes.

1 5. An exchanger structure according to one or
2 more of the preceding claims, characterized in that
3 the weldments between the lugs (6) and yoke-like
4 tubes (3) are effected with the IBW method.

1 6. An exchanger structure according to one or
2 more of the preceding claims, containing the hot
3 fluid inside the headers (1,2) and tubes (3), character-
4 ized in that the longitudinal pitch (4) of the connec-
5 tion holes on the inlet header (1) with the yoke-like
6 tubes (3) is reduced over the pitch (5) of said tubes
7 (3) at the supports (3b).

1 7. An exchanger structure according to one or
2 more of the preceding claims, containing the cold
3 fluid inside the headers (1,2) and tubes (3), charac-
4 terized in that the longitudinal pitch (4) of the con-
5 nection holes on the inlet header with the yoke-like
6 tubes (3) is increased over the pitch (5) of said
7 tubes (3) at the supports (3b,3c).

1 8. A heat exchanger structure particularly for
2 nuclear plants, according to the preceding claims,
3 and substantially as herein described and illustrated.

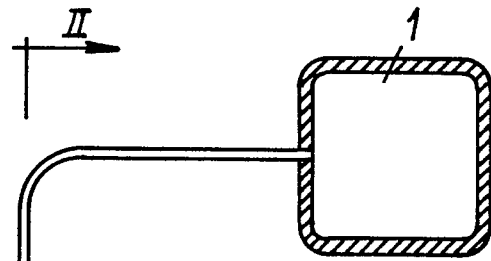
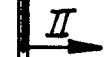


Fig. 1

3b



3

3a

3c

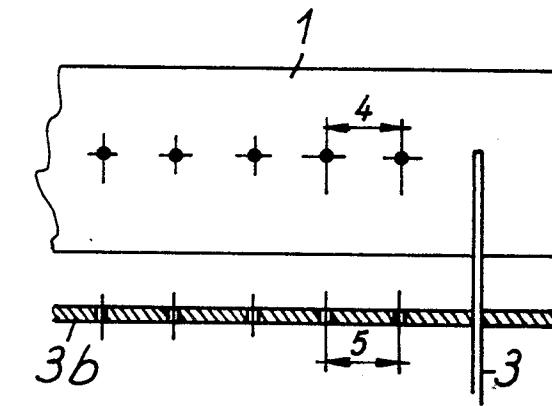


Fig. 2

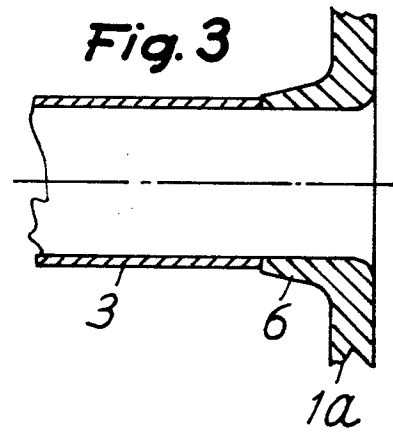


Fig. 3

