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(19)

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(54) IMPROVEMENTS IN OR RELATING TO HEAT EXCHANGERS

(71) We, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, London, a British Authority, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to heat exchangers and more particularly but not exclusively, to heat exchangers suited for use with high temperature gas cooled reactors where the useful heat of the reacter is used as process heat.

An object of the invention is the provision of a heat exchanger construction which though of necessity of large size for use with a process heat nuclear reactor, is of much ligher weight than existing constructions of heat exchanger and is better able to withstand the operating temperature (up to c. 1000°C).

This object is achieved by construction a heat exchanger as regards its essential elements, from carbon fibre reinforced carbon materials. Such materials are able to withstand high temperatures better than conventional heat exchangers constructed from metal and it may well be that a heat exchanger according to the present invention would weigh only one third that of conventional heat exchanger.

In order that the present invention may be clearly understood, a method of fabricating a heat exchanger in accordance with the present invention, will now be described by way of example with reference to the two figures of the diagrammatic drawings filed with the provisional specification in which Figure 1 shows how a carbon tube may be heated and Figure 2 shows such a tube formed into a helical tube for use in a heat exchanger suitable for use with helium.

Referring now to the drawings, a heat exchanger tube 1 reinforced with carbon fibres is made from carbon filaments, tape or cloth, using carbon-fibre pre-impregnated with say a phenolic resin, and the filaments, tape or cloth is/are wound upon or aluminium or similar metal mandrel and allowed to get hard at ambient temperature (c. 20°C) or to a B stage condition, that is, to a condition at which the resin starts to polymerise. When set, the tube is removed from the mandrel, the chosen resin being solid at 20°C. The tube may conveniently be 1/2″ O/D and 1/16″ wall thickness.

After removal from the mandrel, the tube is filled with free flowing graphite powder 2 having a median particle size of about 100 μm. The powder is packed by tamping and then each end of the tube is plugged with a graphite electrode 3, the electrodes 3 being connectable to an electric supply (not shown). The tube is heated electrically to about 80°C by passing an electric current through the graphite powder and a heating time of about five minutes is sufficient to render the tube suitable for forming onto another mandrel. The heating can, of course, by carried out otherwise than by electric heating; for example, it may be heated for five minutes in an oven and in this case the graphite powder would be used as a "filler" to prevent the tube collapsing whilst being heated and when later wound on a mandrel (or other shaping device).

Figure 2 shows the heated tube 1 wound upon a forming mandrel 4 in the form of a right circular section cylinder. This gives the tube a helical wound form though other shapes may be made. After winding the now helical tube is removed from the mandrel 4 and heated slowly, either electrically or in an oven, to a temperature of about 180°C to complete the cross-linking of the polymer. Next, the graphite electrode 3 (plugs) are removed and the graphite powder, still in powder form, extracted. This may be done by forcing a hollow flexible metal tube (not shown) through the bore of the tube 1 and blowing air through the flexible tube so that the graphite powder is discharged around the outside of the flexible tube into a container.

When the electrodes and graphite powder have been removed, the tube is next placed in a carbonising oven and the resin reduced to a char (or a glassy carbon). Heating should be at a slow rate, that is, it should not exceed a temperature rise of 5°C per hour, and the temperature should finally reach about 800 to 1000°C. On completion of the carbonisation stage, the tube is placed in a chemical vapour deposition furnace where it is infiltrated with a cracked hydrocarbon gas, such as methane, propene, or xylene, in order to render it impermeable to gases.

In making a heat exchanger using a tube or bundle of tubes as described above, a tube header plate would also be made of carbon based material and one suitable form is manufactured from carbon powder, of particle size less than 0.10 μm, chopped carbon fibre (e.g. about 1/2 mm long) and phenolic or polyimide resin, the mixture being pressed to form an artefact moulded with through holes to receive the tube or bundle of tubes. The header plate would be heated to carbonise the resin in much the same manner as used in forming the tube 1 and the final step in making the heat exchanger component is to braze the ends of the tube or tubes into the header plate (or plates) to make a pressure tight joint.

Alternatively, a pressure tight joint can be made mechanically by forming screw threads on the inside of the through holes in the header plate and on the engaging end portion of the tube during the manufacture thereof.

Alternative inert conductive particles may be used in place of the graphite powder to fill the tube.

WHAT WE CLAIM IS:—

1. A heat exchanger comprising a heat exchanger tube or bundle of tubes associated with a tube header plate, wherein the tube or tubes comprises or comprise carbon fibre reinforced carbon material.

2. A heat exchanger as claimed in Claim 1, wherein the tube or at least one of the tubes has a portion of curved form in a direction along the length of said tube or said one of the tubes.

3. A heat exchanger as claimed in Claim 1 or Claim 2, wherein the tube header plate comprises chopped carbon fibre reinforced carbon material.

4. A heat exchanger as claimed in any one of the preceding Claims, wherein the carbon material is formed from carbonisation of a thermosetting plastics material.

5. A heat exchanger as claimed in Claim 4, wherein the plastics material comprises a phenolic resin.

6. A heat exchanger as claimed in any one of the preceding CLaims, wherein the tube(s) and the header plate are adapted for association by screw thread means.

7. A heat exchanger as claimed in any one of the preceding Claims and rendered substantially impermeable to gases by an infiltration treatment of the carbon material using a cracked hydrocarbon gas.

8. A heat exchanger having a header plate associated with a tube or tubes substantially as hereinbefore described with reference to the drawings filed with the provisional specification.

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1506489 PROVISIONAL SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1.

FIG. 2.