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(54) NUCLEAR STEAM GENERATOR TUBESHEET SHIELD

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NUCLEAR STEAM GENERATOR TUBESHEET SHIELD

ABSTRACT

A nuclear steam generator is provided which includes an integral preheater zone. The upper face of the tubesheet in the preheater zone is provided with ductile cladding which acts as a thermal shield to prevent incoming feed fluid from thermally shocking the tubesheet.

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NUCLEAR STEAM GENERATOR TUBESHEET SHIELD

BACKGROUND OF THE INVENTION

This invention relates to U-tube type heat exchangers, and more particularly, to nuclear steam generators. In U-tube type heat exchanges a first heat exchange fluid is passed into a shell within which a bundle of upstanding U-shaped tubes is disposed, with the ends of the tubes being secured in a tubesheet adjacent the bottom of the heat exchanger. Simultaneously a second heat exchange fluid is passed through the tubes. As the first fluid passes over the outer surfaces of the tubes it comes in an indirect heat exchange relation with the second fluid that is passing through the tubes. When the second fluid is at a higher temperature than the first fluid, the first fluid is thereby heated, and a portion of the first fluid is converted to vapor. Heated first fluid rises within the heat exchanger, and the vapor is thereafter separated from the liquid phase of the heated first fluid. The liquid phase of the heated first fluid is recirculated within the shell, being returned to the lower portion of the steam generator through a downcomer space defined between the inner wall of the heat exchanger shell and the outer wall of a shroud disposed around the tube bundle.

The thermal effectiveness of a U-tube heat exchanger, such as a nuclear steam generator, can sometimes be improved by

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incorporating an integral preheater into the unit. When an integral preheater is employed, relatively cold feedwater is introduced into the heat exchanger just above the tubesheet. Feedwater temperature normally is within a range of from 115°C. to approximately 190°C., whereas the tubesheet temperature may be approximately 260°C. When the relatively cold feedwater impinges upon the tubesheet, it can shock the tubesheet and result in fatigue cracking of the tubesheet.

It has previously been suggested that a plate be disposed above the tubesheet in the preheater zone in order to shield the tubesheet from the incoming feed water. However, when plate-type shields are used, cold feed water can leak from the preheater zone to the boiling zone through clearances existing between the tubes and tube holes formed through the shield. If the tubes are contact rolled into the plate-type shield to preclude such leakage, residual tube stresses can be imposed on the tubing. Furthermore, additional stresses, due to misalignment of tubes, radial differential thermal expansion between the tubesheet and the plate-type shield, and/or out-of-plane bending of the tubesheet because of differential pressure across the tubesheet, can also be introduced when tubes are rolled into a plate-type shield. Another disadvantage of a plate-type shield is that uncertain thermal/hydraulic conditions can exist under the plate-type shield.

The present invention provides a shield for the upper face of the tubesheet which precludes thermal shock of the tubesheet and also avoids leakage and stress problems attendant to plate-type shields.

SUMMARY OF THE INVENTION

In accordance with an illustrative embodiment demonstrating features and advantages of the present invention, there is provided a nuclear steam generator of the type in which a plurality of U-shaped tubes are connected at opposite ends to a tubesheet and extend between inlet and outlet chambers, and the steam generator includes an integral preheater zone adjacent downflow legs of the U-shaped tubes. The improvement comprises a thermal shield disposed adjacent an upper face of the tubesheet within the preheater zone, the shield including ductile cladding material applied directly to the upper face of the tubesheet with the downflow legs of the U-shaped tubes extending through the cladding into the tubesheet. The ductile cladding acts as a thermal shield to prevent incoming feed fluid from thermally shocking the tubesheet, steady-state and transient thermal stress in ligaments of the tubesheet being primarily confined to the cladding material. Because of its ductility and fatigue properties, the cladding absorbs such stresses.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of a nuclear steam generator incorporating the thermal shield of the present invention; and

FIG. 2 is a sectional view of a portion of the steam generator of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 there is shown a nuclear steam generator 10 which includes a cylindrical shell 12 within which a bundle of U-shaped tubes 14 is disposed. Tubes 14 include upflow legs 16 communicating with tubesheet 18 at one end and downflow legs 20 communicating with tubesheet 18 at another end thereof. A header 22 is attached to the underside of tubesheet 18, and together with the underside of tubesheet 18 and a partition plate 24 define an inlet chamber 26 and an outlet chamber 28. An inlet 30 is provided for introducing a heat exchange fluid, such as heavy water, into inlet chamber 26; this fluid is referred to as tubeside fluid. Similarly, an outlet 32 is provided for removal of tubeside heat exchange fluid from outlet chamber 28. An inlet 34 is provided for introducing another heat exchange fluid, referred to as shell-side fluid, into shell 12. The shellside heat exchange fluid, which could be water, for example, passes over the outer surfaces of tubes 14, and a portion of this fluid is vaporized. The heated shellside fluid thereafter rises into the upper section 36 above section 12 within which separators (not shown) are disposed for separating the vapor from the heated fluid. The vapor is ultimately removed from the steam generator 10 through outlet 38, while the liquid phase is recirculated through downcomer space 37 to boiling zone 39.

Turning to FIG. 2, a more detailed sectional view of the cylindrical shell 12 of steam generator 10 is shown.

Adjacent inlet 34 is a preheater or economizer zone 40. The preheater zone 40 is defined by the inner wall of a generally semi-cylindrical section of shroud 42, a section 43 of the upper face of tubesheet 18, and a first plate 44. Plate 44 extends across a diametrial tube-free zone 46 formed between upflow legs 16 and downflow legs 20 of U-tubes 14, and is welded to shroud 42 along its side edges. A second plate 48 is also disposed within zone 46, being closer to upflow legs 16 than is first plate 44. Plate 48 is also welded to shroud 42, but extends beyond shroud 42 to shell 12.

Feed water at a temperature within a range of from 115°C. to approximately 190°C is introduced through inlet 34 into preheater zone 40. The tubesheet 18 and shell 12 are at a temperature of approximately 260°C. during normal full load operation of the steam generator 10. However, it should be understood that the temperatures of the tubesheet and the feedwater can vary during transient conditions, and these "normal" temperatures are used herein only to illustrate possible temperature differences between the feedwater and the tubesheet. A thermal shield 50 is disposed above section 43 of the upper face of tubesheet 18 in the preheater zone 40. Thermal shield 50 comprises a weld deposit of ductile Ni-Cr-Fe alloy having a finished thickness of approximately 6.35mm. The weld deposit, or cladding, is applied to the tubesheet before holes are formed in the tubesheet for receiving the ends of U-tubes 14. Therefore a tight fit is assured between the thermal shield 50 and the tubes 14. Since the cladding is applied directly to the face of the tubesheet, thereby eliminating any space between the cladding and the tubesheet face, leakage of feed water from the preheater zone 40 to the boiling zone 39 is not possible. Although in the preferred embodiment a Ni-Cr-Fe alloy material is used as cladding, other weld material having similar ductility and fatigue properties can be employed.

In operation relatively cold feedwater is introduced through inlet 34 into the preheater zone 40 of steam generator 10. Relatively hot fluid, such as heavy water, is introduced through inlet 30 into chamber 26. The hot fluid rises through upflow legs 16 of U-tubes 14, coming in contact with the colder shellside fluid and giving off a portion of its heat thereto. The tubeside fluid is then returned through downflow legs 20 and empties into chamber 28 from which it is removed through outlet 32. The incoming feed water falls within shell 12 on to thermal shield 50 disposed above section 43 of the upper face of tubesheet 18 in preheater zone 40. Shield 50 acts to prevent the relatively cold shellside fluid from thermally shocking tubesheet 18. After the colder fluid is preheated within zone 40, it rises and continues to absorb additional heat as it contacts the outer surfaces of U-tubes 14. Upon rising into upper section 36, vapor is separated from the heated shellside fluid, and is later removed through outlet 38. Separated shellside liquid is recirculated through downcomer space 37 to boiling zone 39.

A latitude of modification, change and substitution is intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention herein.

WHAT IS CLAIMED IS:

1. A nuclear steam generator of the type in which a plurality of U-shaped tubes are connected at opposite ends to a tubesheet and extend between inlet and outlet chambers, said steam generator including an integral preheater zone adjacent downflow legs of said U-shaped tubes, the improvement comprising a thermal shield disposed adjacent an upper face of said tubesheet within said preheater zone, said shield including ductile cladding material applied directly to said upper face of said tubesheet, said downflow legs of said U -shaped tubes extending through said cladding into said tubesheet.

2. The improvement of claim 1 in which said ductile cladding material comprises a weld deposit having a thickness of at least approximately 6.35 mm.

3. The improvement of claim 1 in which said cladding material comprises Ni-Cr-Fe alloy.

4. A nuclear steam generator comprising:

(a) a generally cylindrical shell,

(b) a plurality of U-shaped tubes disposed within said shell, the ends of said U-shaped tubes disposed adjacent the bottom of said shell,

(c) a tubesheet disposed adjacent the bottom of said shell, said tubesheet having holes formed therethrough for receiving said ends of said U-shaped tubes,

(d) a header disposed below said tubesheet and connected to said tubesheet, said header including inlet and outlet chambers,

(e) means for introducing a first heated fluid to said inlet chamber of said header,

(f) means for removing said first fluid from said outlet chamber of said header,

(g) means for introducing a relatively cold heat exchange fluid into said shell,

(h) means defining a preheater zone within said shell adjacent said inlet means for introducing said relatively cold fluid into said shell, said means including a semi-cylindrical shroud disposed within said shell, and a plate extending across the upper face of said tubesheet, connected at opposite ends thereof to the inner walls of said shell, and

(i) a thermal shield disposed above said tubesheet within said preheater zone, said thermal shield comprising cladding applied directly to the upper face of said tubesheet, said cladding comprising a Ni-Cr-Fe alloy.

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FIG. 1.

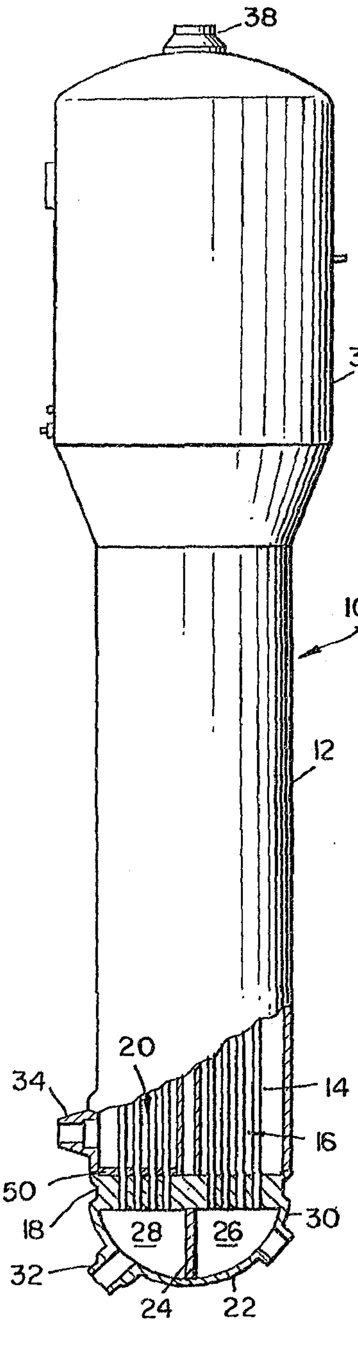
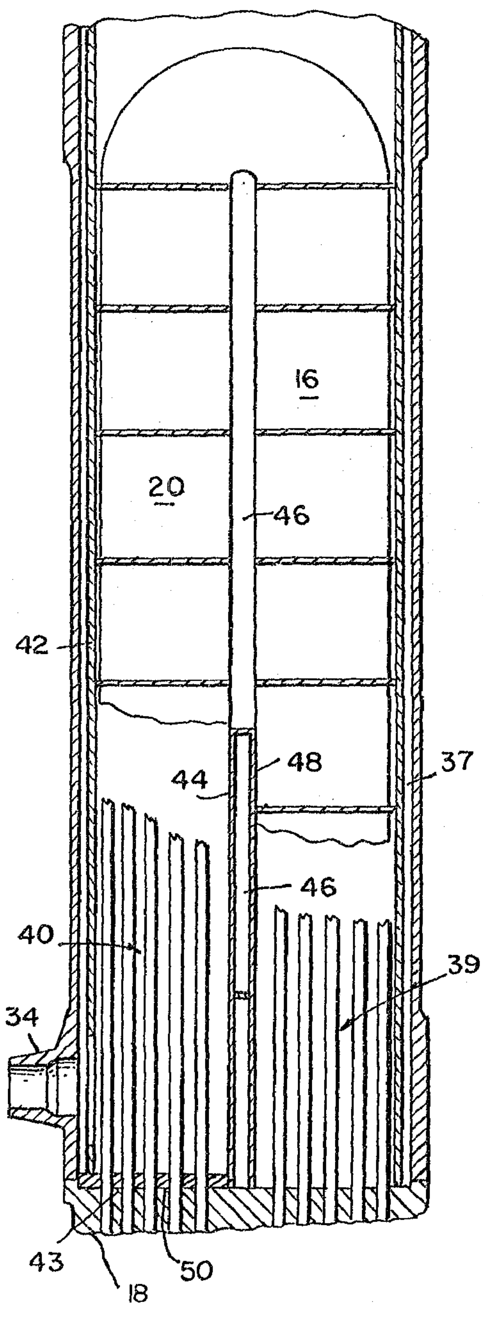


FIG. 2.



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