Feb. 6, 1971 J. W. SCHROEDER ET AL 3,562,887

EXPLOSIVE EXPANSION OF LINER SLEEVES

Filed May 8, 1968

FIG. 1

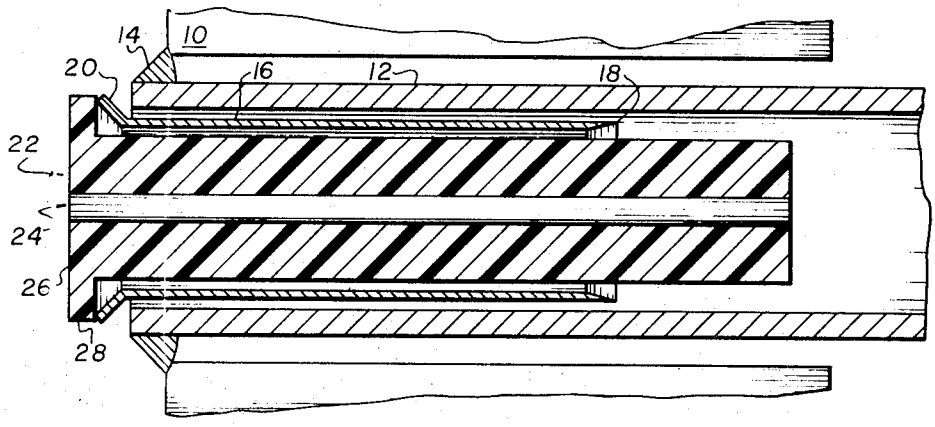
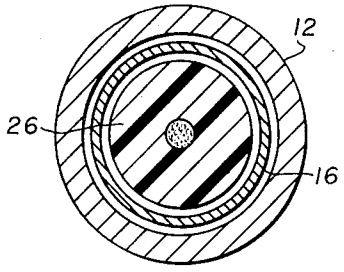


FIG. 2



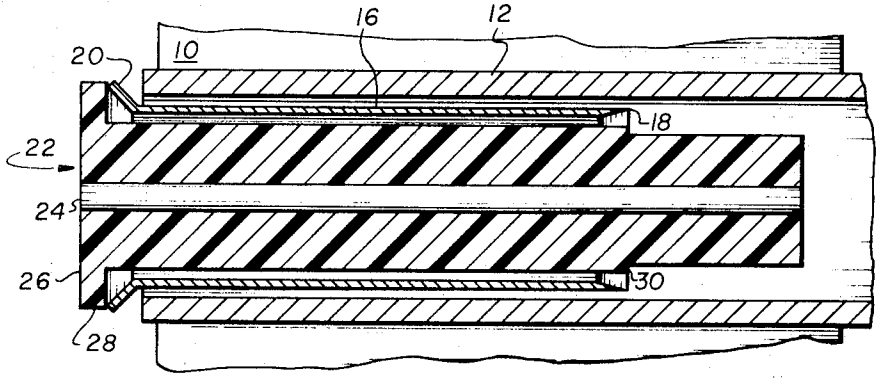


FIG. 3

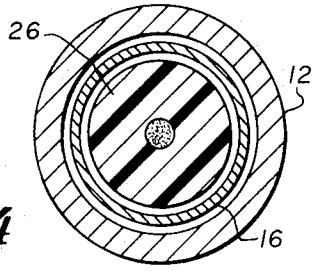


FIG. 4

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EXPLOSIVE EXPANSION OF LINER SLEEVES

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ABSTRACT OF THE DISCLOSURE

By use of an explosive charge together with an accompanying medium two concentric tubes may be expanded at the same time, with the inner tube or liner sleeve expanding and locking to the outer tube and the outer tube expanding into a tube hole in a tubesheet or heat transfer medium. In cases where the inner tube does not extend the full length that must be expanded in the outer tube the medium or explosive may be shaped to provide the proper force required at each section.

BACKGROUND

Corrosion-erosion is a phenomenon which combines a corrosive medium with high flow rates so that the corrosive medium reaches new surface. For ferritic tubes this occurs frequently with many feedwater heaters under operating conditions. It also occurs for other materials. The occurrence generally depends upon the particular feedwater treatment and rate of flow.

Since it is difficult and expensive to change these conditions for many heaters various methods of lining the initial portion of the tubes with corrosion resistant material have been tried.

The methods which have been tried include tube into tubesheet expansion and then electrochemical plating, or electrochemical plating of tubes and subsequent tube into tubesheet expansion. In either case, this allows corrosion resistant material which has poor heat conduction to be used at the point of maximum corrosion.

Electrochemical plating has the possibility that corrosive elements can be washed into other parts of the boiler system, and cause damage.

Tubes have been mechanically expanded, and kinetically expanded into tubesheets. In either case, subsequent mechanical expansion of an insert is very difficult. Sleeve inserts must be designed with a feather edge on the trailing side so as to reduce turbulence. This feather edge requires special equipment for the mechanical expansion to the tube. The result, even if special equipment is used, is questionable. In addition, mechanical cold work would probably damage the insert surface.

In mechanical expansion of a tube into tubesheet, a space is left near the weld of the tube to the face of the tubesheet. This is done because in mechanical expansion, the direct compression of the tube on the tubesheet surface causes tube elongation. If an insert is then mechanically rolled into the tube, it will close up this gap and put an axial load on the weld. In addition, it will put an axial load on the previously rolled portion and possibly open the seal.

Kinetic expansion of inserts into both previously kinetically and mechanically rolled tubes is excellent for rework and can be so carried out as not to close the gap near the weld. It does however, for a new heater, require two steps, namely, expansion of the tube into tubesheet, and expansion of insert into tube.

SUMMARY

The main object of the present invention is to provide

corrosion erosion resistant surface at inlet end of feedwater heater tube. Accordingly a corrosive resistant liner sleeve shorter than the thickness of the tube sheet is inserted in a tube within the tube sheet. An insert having a central portion with grains of explosive distributed therealong and excluded in a force transmitting annular portion of polyethylene or the like, is inserted in the liner sleeve. The sleeve preferably tapered toward the inner end thereof to form a thin edge. The explosive is detonated, and the liner sleeve is expanded and locked inside the tube, and the tube is simultaneously expanded and locked inside the tube sheet hole. In the drawings:

FIG. 1 is a section through a tube sheet longitudinally of a tube therein, illustrating the method and apparatus for explosive expansion of a liner sleeve into the tube and tube sheet, according to the preferred embodiment of the present invention;

FIG. 2 is a transverse section through the structure shown in FIG. 1;

FIG. 3 is a view similar to FIG. 1, showing a modification; and

FIG. 4 is a transverse section through the structure shown in FIG. 3.

As shown in FIGS. 1 and 2, a tube sheet **10** has a base receiving a tube **12** of carbon steel or other material subject to corrosion. Generally the tube is inserted within the tube sheet with a clearance of .006 inch, plus or minus. One end of the tube **12** is welded as at **14** to one surface of the tube sheet.

A liner sleeve **16** of corrosion resistant material such as stainless steel, is inserted inside the tube **12**. This liner sleeve **16** is shorter than the thickness of tube sheet **10**, and is tapered in thickness toward the inner end thereof to form a thin edge **18**. The outer end to the sleeve **16** is preferably flanged outward as at **20**, forming a stop to gauge the distance the end **18** extends into the tube **18**.

For generating the explosive force an insert **22** has an external diameter by which it can be inserted into the liner sleeve **16**, and a length so that when it is positioned within the tube **12**, the insert **22** is at least substantially coextensive with the area of overlap between the liner sleeve **16** and the tube **12**. In essence, the insert **22** comprises a central axial portion **24** which contains a predetermined number of grains of explosive, generally from 25 grains per foot to 40 grains per foot, uniformly disposed along the insert axis. For a detonating fuse, a known material can be used, consisting of grains of explosive embedded in a fiber or plastic body.

Encompassing the axial portion **24** is an annular tubular force transmitting portion **26** which occupies the space between the center portion and tube inside surface. In practice, the annular force transmitting portion **26** is extruded and is then cut to desired insert length. The center portion **22** is then inserted into the force transmitting portion **26**.

A preferred transmitting medium for the force transmitting portion **26** is polyethylene, or another thermoplastic hardenable resin having essentially the same properties as polyethylene. Some examples of suitable mediums other than polyethylene are polyvinyl acetate, polyvinyl butyrals, polystyrene, nylon, Teflon, polyester resins, Delrin, Lexon, polypropylene and Tygon. These materials have essentially the same flexibility, formability, resiliency, density, and at least about as high a melting point as polyethylene.

The force transmitting portion **26** has a flange **28** at the outer end thereof, to gauge the extent of the insert **22** into the hole of tube sheet **10**. In the form of the invention shown in FIGS. 3 and 4 the tube **12** is not welded to the tube sheet **10**, because the expansion of the tube into the hole of the tube sheet **10** is adequate for some low

pressure installations. Also, the inner end of the force transmitting portion **26** is shaped as at **30** for variation of the forming power to suit work.

What is claimed is:

1. Apparatus for simultaneously expanding a liner sleeve within a tube in turn within a tube sheet,

said liner sleeve extending inward from one end of said tube end for a length materially shorter than the thickness of the tube sheet, said apparatus comprising

an insert comprising a central axial portion including a predetermined number of grains of explosive uniformly dispersed along the axis of the insert;

an annular tubular force transmitting portion encompassing the center portion;

the annular portion being formed to make a close fit with the inside of said liner sleeve; and

means to position the insert within the tube whereby length dimension thereof is coextensive with a major portion of the area of overlap between the liner sleeve and the tube.

2. Apparatus for expanding a liner sleeve within a tube in turn within a tube sheet as claimed in claim **1**, in which the tube extends through the tube sheet and one end thereof is adjacent to one surface of the tube sheet, said insert includes a length dimension approximately equal to the thickness of the tube sheet, and said annular portion being a thermoplastic hardenable resin of the class consisting of polyethylene and resins having essentially the same qualities.

3. Apparatus for expanding a liner sleeve within a tube in turn within a tube sheet as claimed in claim **1**, in which the thickness of the liner sleeve is tapered toward the inner end thereof to form a thin edge.

4. A method of expanding a liner sleeve within a tube inturn within a tube sheet comprising the steps of

positioning the tube within a tube sheet hole to define an area of overlap between the tube sheet and tube;

positioning the liner within the tube to define a smaller

area of overlap between the liner and tube, positioning a cylindrical explosive insert within the liner wherein the insert is coextensive with the major portion of both overlaps;

the explosive insert including a central axial portion comprising a predetermined number of grains of explosive uniformly disposed along the axis of the insert, and an annular tubular force transmitting portion between the center portion and the tube inside surface;

the insert outside surface defining a close fit with the inside surface of the liner;

the annular portion being a thermoplastic hardenable resin of the class consisting of polyethylene and resins having essentially the same qualities; and

detonating said explosive insert such that said liner and tube are simultaneously expanded within said tube sheet hole.

5. A method as claimed in claim **4** in which said tube is welded to said tube sheet prior to the positioning of the liner therein.

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29—421, 470.1; 228—3