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METALS AND STRENGTH ANALYSIS

A Technology for Fixing Thin-Walled Tubes in the Profiled Holes Drilled in the Tube Sheets of Heat Exchangers

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Abstract—A device for fixing tubes in the profiled holes drilled in the tube sheets of heat exchangers by pressing them using an elastic element is developed. The use of this device allows good quality to be ensured in pressing the tubes simultaneously in the smooth and conical segments of the hole in the tube sheet and in subsequently welding the obtained connection.

Keywords: press expansion, heat exchanger, fixing tubes in tube sheets

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Adequate consideration of the climatic conditions under which the equipment being manufactured will operate is one of the main requirements set forth in designing and producing any articles relating to construction of machinery and equipment, including those in the field of power engineering. This factor is especially important for the equipment of facilities, including those of the nuclear power industry located in regions with hot climate, with a high content of microelements in water of the coastal zone, geothermal sources, etc. After solving the corrosion resistance problem by using appropriate materials, another no less important problem has to be solved. Relatively high temperature of cooling water facilitates rapid growth of biological and mineral deposits on the washed surfaces of condenser tubes, which drastically degrade the performance characteristics of the entire set of equipment. The ball cleaning technology is widely used as a means to prevent the growth of such deposits.

For making the cleaning process maximally efficient, the holes in the tube sheets must have the geometrical parameters at which the cleaning balls will stably enter into the heat-transfer tubes.

A hole with a conical segment is the recommended shape. As a ball enters into this segment, it tightly and reliably closes the tube hole and the pressure difference forces it to pass through the tube. Not only does such shape of the entrance hole create favorable conditions for the ball to enter into it, but it also excludes the possibility of ball surface being damaged as a result of its rubbing against the beads and ripple on the seam through which the tube is welded to the tube sheet.

The following factors must be taken into account in selecting the method and working out the technology for fixing tubes in tube sheets: the intricate shape of the tube hole and scatter of the diameters of supplied tubes.

The widely used technology for mechanically expanding tubes with $d < 25$ mm in holes with a conical segment will consist of two stages: expanding in the cylindrical segment and then in the conical segment. Use of expanding tools allowing these operations to be carried out simultaneously is impossible because they have been developed for tubes with diameters equal to or larger than 25 mm. But in that case, measures have to be provided at the heat exchanger design stage to ensure that the aperture angle of the tube sheet hole was consistent with the inclination angle of rollers in the expansion tool. It should be pointed out that fixation of tubes in holes with a conical segment in a stagewise manner involves certain difficulties. When a tube is expanded in the conical segment, the tube wall is inflected in the zone of transition from this segment to the cylindrical part, as a result of which it separates from the hole walls over a certain length in both the conical and cylindrical segments. Therefore, it is important to ensure tight contact between the tube wall and the tube hole surface near the tube sheet's outer plane, which is necessary for properly making the next operation of welding the connection between the tube and tube sheet. When the conical segment is being expanded, the already expanded cylindrical segment hinders axial deformation of the tube toward the tube bundle, a factor that additionally deteriorates the tightness of the connection, due to which the cylindrical segment in these connections has to be additionally expanded. As a result, the labor intensity of fixing the tube ends increases by 40–50% [1].

When the mechanical expansion method is used for fixing tubes in tube sheets, scatter of the outer diameter of tubes generates the need to assemble the tube bundle in a selective manner; i.e., holes are drilled in