SAFETY, DIAGNOSIS, AND REPAIR

REPAIRING HEAT EXCHANGERS WITH PRESSED-ON PROTECTIVE TUBES

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The initial parts of heat-exchange pipes are repaired by pressing short thin-walled tubes into them. Long protective tubes can be used over the entire length of the heat-transfer pipes (tube in tube).

Most of the working damage to heat exchanger (HE) tubes is local, represented by erosion in the initial parts of the tubes, pitching or corrosion cracking in the shoulder region and damage to areas of emergence from the tube grid and so on. Tubes with such defects are required to be gradually taken out of commission and the tube bundle or entire equipment replaced.

The Prometei center has devised an effective technology for repairing heat-exchanger tubes, which is placed on the mechanical pressing of protective tubes into the defective parts. We consider that technology in repairing a large HE for the nitrogen industry.

Repairing Heat-Exchange Tubes for a Carbamide Production Stripper. The stripper is a film evaporator used to distill off unreacted gases in the making of carbamide. It works at high temperatures (210°C) and pressures (15 MPa) in a corrosive medium: a two-phase flow of molten carbamide and gases (NH₃ and CO₂). Plants in the Russian nitrogen industry use strippers designed by the Italian firm of Snamprogetti. The heat-exchanger pipes and lining of the high-pressure chamber are made of titanium. Corrosion and erosion occur within the pipes over relatively short parts at the top of the chamber under the tube grid and near the junction with the ends of the distributing tubes. For example, with an average corrosion rate within the tubes of 0.05–0.15 mm/yr, the damage rate in these local areas attains 0.2 mm/yr [1].

The stripper is a very large vessel: length 15 m, diameter 2.5 m, and mass about 100 tons, and it governs the entire cycle in the production of carbamide. The usual practice in repairing strippers is to shorten the heat-exchange tubes or replace all the tubes by new ones after 8–12 years of use. A major repair of the stripper with complete replacement of the heat-exchange tubes was carried out by the Italian firm of Siai-Lerici at the Prometei center in collaboration with the NIJK company at the end of the 1990s for the Togliattiazot Company [2]. However, the method is very expensive and involves demounting the equipment and withdrawing the stripper from use for a prolonged period.

The Prometei center had the task of repairing the titanium stripper (without dismounting the apparatus), which was undertaken by the Japanese company of Kobe Steel Ltd. in the short period of planned shutdown of the production at the Novomoskovskii Azot company.

Foreign experience was used in deciding on restoring the tubes on the scheme shown in Fig. 1. It was proposed to enlarge the internal diameter of the tubes from 20 to 22 mm to a depth of 1000 mm and then insert thin-walled titanium tubes with pressing of the tube into the surrounding tube throughout the length. The equipment contained 1856 tubes (Ø27 × 3.5 × 6800 mm), of which about 50% had considerable corrosion and erosion damage to depths of 400–800 mm under the top tube grid, whose thickness was 400 mm.
There was also major damage to the initial part of each tube to a depth of about 50 mm, so for the first group it was proposed to install long protective tubes (1000 mm), while for the second group there were proposed short (70 mm) ones, which were designed to restore the heat-transfer tube wall thickness.

In the preparations for repair, the necessary number of thin-walled integral-rolled protective titanium tubes were fabricated, a technology was developed, and special equipment, tools, and accessories were designed and produced. The most complicated task was that of turning the titanium heat-transfer tubes; in the mechanical working of deep holes it is important to provide stable removal of the swarf from the cutting zone. The traditional technology for deep drilling and turning in the present case was ineffective, in the main because of the special properties of titanium. In particular, much heat is produced in cutting titanium, and the swarf has a tendency to stick to the cutting tool. This problem was resolved by an essentially new technology for turning with the use of turning heads of novel design. Two transportable turning systems were developed, which were equipped with a special pneumatic drive, a reliable hydraulic system, and other necessary devices. It provided for automatic deep turning (1000 mm) in two heat-transfer tubes simultaneously within the stripper chamber with a rate of about 50 mm/min. For turning tubes to a smaller depth (70 mm), a manual form of this technology was employed.

The protective tubes were pressed mechanically into the machine heat-transfer tubes by means of a specially designed tube expander, which provided continuous feed of the protective tubes throughout the length with a speed of 200–300 mm/min. This development was extremely effective, since it enabled one to produce a complete closure of the gap between the inserted protective tube and the heat-transfer tube without especial effort on the part of the operator, and where the outside diameter of the heat-transfer tube was not increased, while there was close contact between the pair tube in tube.

For this technology to be successful, one needs to have the best geometry for the tubes, including the diameter and wall thickness of the protective tubes. The effective diameter of the heat-transfer tubes is almost unaltered by the repair.

The final stage of the development was the production of a new sealing unit (distributive tube) without a tailpiece, which is a cause of erosion in the initial parts of the tubes.