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EQUIPMENT

CAUSES OF REFINERY EQUIPMENT FAILURE AND MEANS FOR ELIMINATING FAILURES

M. L. Medvedeva

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The petroleum refining and petrochemical industry, both here and abroad, incurs major losses due to corrosion damage, amounting to 10-12% of the production cost in refineries. About 60% of all premature failures of equipment are due to corrosion of various elements of the equipment.

Primary crude oil distillation units require the greatest amounts of metal in their construction. In other countries, these units operate for 3-5 years between shutdowns for maintenance; in our country, the average run is only 11-12 months. In atmospheric—vacuum tubestill units, up to 20 unscheduled repair operations must be performed annually [1]. The weakest point in these process units from the standpoint of corrosion resistance is the condenser/cooler equipment. Costs for maintenance and repair of this equipment, on the average, account for 25-30% of the total maintenance and repair costs for all types of major equipment [2].

Of the various types of condensing and cooling equipment in atmospheric—vacuum tubestill units, the condenser/coolers on the overhead line from the atmospheric tower are the most susceptible to corrosion damage. The head fractions of the crude that are condensed in the tubes contain hydrogen sulfide and hydrogen chloride (formed as a result of conversion of organic sulfur and chlorine compounds present in the original crude), along with moisture. This combination produces acids and sharply increases the corrosivity of the working medium in the equipment. Anticorrosion measures specified in standardization documents include alkalization and inhibition of the head fraction, and also the use of condenser/cooler tubes made of 08Kh22N6T stainless steel or LAM8Sh 77-2-0.05 brass. The advantages and disadvantages of these measures have been discussed thoroughly in [3].

The author has followed the operation and maintenance of atmospheric—vacuum tubestill units in a number of refineries. Carbon steel tubes are used in most of this equipment, in combination with various protective measures in the process itself, including pretreatment of the crude with caustic and the injection of a sodium carbonate or ammonia solution into the head fraction. However, preliminary treatment of the crude with caustic will quite often result in the formation of salt plugs in the piping and plugging of the heat exchanger tubes by salt deposits.

To combat these undesirable effects, the Volgograd Special Design Bureau developed a system of corrosion protection in which condensate from barometric boxes with a low salt content is used to prepare the caustic solution. Implementation of this technique in a number of refineries in our country has eliminated the problem of salt deposition in the process lines and heat- exchanger tubes. In some cases, however, the service life of the condenser/cooler equipment operating on the head fraction from the atmospheric tower was reduced to 1.5-2 months.

From our analysis we have been able to relate the failures to the very marked increases of hydrogen sulfide and hydrogen chloride contents in the head fraction, obviously as a consequence of the high contents of these corrosive components in the condensate from the barometric box (most of the hydrogen sulfide and hydrogen chloride enters the condensate when the head fraction is condensed and the hydrocarbon part of the condensate is separated from the water).

When such a condensate is used as the solvent in preparing the caustic solution, all of the corrosive components in the condensate are brought back into the feed to the distillation unit, with the end result a sharp increase of corrosivity. Therefore, this method should be prohibited, and consideration should be given to the use of steam condensate from the power generating station or waste-heat boilers as the solvent for the caustic.

I. M. Gubkin State Academy of Oil and Gas (GANG). Translated from Khimiya i Tekhnologiya Topliv i Masel, No. 6, p. 16, June, 1994.

The problem of corrosion protection of equipment in thermal cracking units has for the most part been solved successfully [3-5]. Nonetheless, breakdowns still occur in the operation of these units because of the failure of furnace coils in the linear sections and particularly in the bends. These failures can be attributed to corrosive—abrasive wear. It had been considered previously that the principal abrasive agents are carbenes and carboids, along with coke particles formed in the course of feedstock conversion [4]. The main factor in coil failure has not yet been identified. The steels recommended for coil fabrication, 15KhM, 12MKh, and Kh5M, do not always ensure reliable operation of the furnaces.

In operating tests on visbreaker furnace coils at the Mazheikyai refinery and thermal cracking furnace coils at the Novo-Ufa refinery, the author demonstrated that the cause of failure is corrosive—abrasive wear, with the abrasive factor predominant. Coke particles, which have a Mohs hardness of approximately 1, do not have any abrasive effect on the tube wall.

In delayed coking units, highly abrasive particles of aluminosilicate cracking catalyst enter the furnace with the 320-410°C aromatic cut that is one of the feedstock components. These particles have a Mohs hardness of 5-6 and a size of 50-80 μm; with a flow velocity of 6 m/sec or higher in the coil, the particles are actively abrasive. Such particles have been found in particularly large quantities in the breakdown products of the most highly damaged sections of the coil (radiant section bends).

The corrosive agent of the working medium, as shown by the investigation, is hydrogen sulfide. The most severe damage is observed in the bends of the radiant section of the coil, where, as indicated by calculations, the content of hydrogen sulfide is the highest. The breakdown products also include iron and iron sulfides, with practically no iron oxides.

We propose the following measures for increasing the reliability of furnace operation in thermal cracking units:

Eliminate the entry of abrasive material into the working medium (to do this, consideration must be given to the possibility of replacing the aromatic cut by hydrogen-rich gas);

In processing feedstocks containing sulfur compounds (more than 0.1% sulfur), use coils made of Kh9M steel, which is more resistant to high-temperature hydrogen sulfide corrosion than the Kh5M, 15KhM, and 12MKh steels.

Protecting the tube bends in the furnaces of existing units by wear-resistant, corrosion-resistant hardfacing (the hardfacing material and the technology of its application have been already been selected).

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