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Review Paper

Mineral Scale Management in Shell & Tube Heat Exchangers of Oil and Gas Industries

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1. ABSTRACT

Shell & tube heat exchangers are known as one of the most important devices in the oil, gas, and energy industries. Alongside their design, their maintenance would also be of prime importance when they are prone to mineral scale formation. According to the field reports, the mineral scaling can be formed in heat exchangers due to the presence of fluid precursors at different operating conditions as well heat transfer surface conditions. Thus, in-depth knowledge of the best management methods to control scale formation in heat exchangers is indispensable for engineers. In this paper, various methods of controlling mineral scale formation, including removal and inhibition, i.e., conventional physical and chemical methods, and ultrasonic technology have been examined for an industrial case study. Moreover, several statistics from the field reports have been examined to prove that the utilization of ultrasonic would clean the exchanger under study. The results show that scale management especially the use of ultrasonic technology would lead to an increase in the efficiency of heat exchangers as well as a significant reduction in operating costs.

Keywords: Heat Exchangers, Mineral Scale Management, Scale Removal Methods of Mechanical and Chemical Ones, Ultrasonic Technology.

2. INTRODUCTION

Heat exchangers are known as devices that provide heat transfer between two or several fluids with different temperatures. Heat exchangers are generally employed in a wide range of applications, including electricity generation, chemical, and food industries as well as environmental engineering, waste heat recovery, air conditioning, refrigeration, and space applications. The presence of various process fluids though at different operating conditions of temperature and pressure along with heat transfer surfaces would make a potential situation for precipitation and deposition of mineral scales.

The scale phenomenon induces large operating costs in addition to maintenance and cleaning costs which all may come with a high penalty cost. Generally, the removal techniques to combat the mineral scales, which mostly concentrate on the removal of mineral deposition after formation, include chemical and physical methods. Offline and online techniques of the aforementioned methods would be applied based on the operating conditions [1].

The use of chemical agents, known as scale inhibitors, are viable option that have attracted interest from the oil and gas industry. Scale inhibitors can generally mitigate precipitation and deposition under different mechanisms. It should be noted that all such methods, would be applied to control scale formation with regard to the operating conditions and economic issues. Therefore, the optimum decision must be made by the industrial managers to recover the unit efficiency with the minimum possible associated costs.

A new method that is gaining increased attention recently by both researchers and engineers is based on the utilization of ultrasonic waves. It was purposed to deal with mineral precipitates and deposits in the heat exchangers of industrial units. Heat exchangers and ultrasonic transducers are directly connected to make a common vibration system. This vibration commonly leads to induce significant tension between the heat transfer surfaces of heat exchangers and mineral precipitants and deposits [2].

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In this paper, the common mechanical and chemical removal approaches have been examined. In addition, the ultrasound application in anti-precipitation transducers and liquid phase sonification has been investigated..

3. MECHANICAL AND CHEMICAL REMOVAL METHODS

In general, the well-known techniques to deal with mineral deposits in heat exchangers, both in shell and tube sides, can be divided into two categories: i) mechanical, and ii) chemical. On the other hand, the mechanical or chemical cleaning processes may be performed while the unit is still working (online). Nonetheless in most cases, it is necessary to clean the heat exchangers of the decommissioned unit, which in this case is known as offline cleaning. In some cases, the combination of these methods may be necessary. Each cleaning method which is summarized in Table 1 [3], has its advantages and disadvantages according to the construction material of the heat exchangers.

Table 1. Different methods for scale control

No.	Online techniques	Offline techniques
1	Use and control of appropriate additives Inhibitors Antiscalant Dispersants Acids	Chemical cleaning
2	Online Cleanings Sponge balls Brushes Sonic horns Soot blowers Chains and scrapers Thermal shock Air bumping	Disassembly and manual cleaning Lances Liquid jet Steam Air jet Mechanical Cleaning Drills Scrapers

4. APPLICATION OF ULTRASONIC TECHNOLOGY IN HEAT EXCHANGERS

The impact of ultrasonic waves on crystallization processes have been studied for more than two decades. Therefore, ultrasonic technology is now sufficiently advanced to reliably deal with the problems caused by mineral scale formation. The application could be divided into two approaches; removal and inhibition of mineral scales by employing the ultrasonic anti-precipitation transducer in heat exchangers and liquid phase sonification, respectively.

The ultrasonic anti-precipitation transducers are commonly installed in the inlet pipe of heat exchangers through a flange and a control valve (Figure 1). The key advantage of this method is that there is no need to stop production, even when the ultrasonic anti-precipitation devices need repair and service [4].

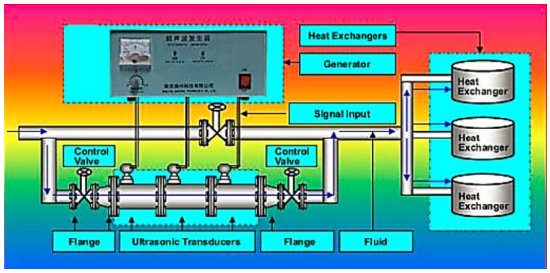

Figure 1. The schematic of the anti-precipitation transducer [4]

Furthermore, initially the method of liquid phase sonification was used to mitigate deposit formation on metal surfaces as such that an ultrasonic probe was directly placed in the fluid tank to inhibit or remove the heavy deposits of limestone that covered the tank inner walls [5]. In the technical explanation of this method, it should be emphasized that the main effect of cleaning and removing scales is achieved by the vibrations of the heat transfer surfaces. In this process, the impact of cavitation is the primary cause of deposit removal. Finally, there are two types of sonification. i.e., direct and indirect which can generally be used with respect to type of liquid phase and probe exposure.

5. CONCLUSIONS

This paper reports the conventional methods of mineral scale control in heat exchangers, which includes online and offline physical and chemical cleaning in the oil and gas industries. Ultrasonic technology was also discussed in this work as one of the novel methods to combat mineral scales. The method can be considered as a viable option to manage scale formations on the heat transfer surfaces. Conclusively, applying the ultrasonic-based technology would be interesting to save energy and costs as well as the environment based on the following results:

- During a long time, a constant heat transfer rate, without any decrease in the operating performance, would be achieved.
- The temperature difference between the process fluid and the refrigerant could be increased without forming deposits on the heat transfer surface.
- The need for continuous cleaning could be eliminated.
- The required unit shutdowns for cleaning could be profoundly fewer which could result in significant reduction of maintenance costs.

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