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Heat Exchanger Fouling and Cleaning: Fundamentals and Applications

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Chemical Cleaning of Oil Refinery Heat Exchangers – The Need for a Joint Effort

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CHEMICAL CLEANING OF OIL REFINERY HEAT EXCHANGERS -- THE NEED FOR A JOINT EFFORT

EXTENDED ABSTRACT

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INTRODUCTION

One component of the high cost of fouling to oil refineries is the maintenance money spent to clean fouled heat exchangers and the associated lost production while the exchanger is out of service. This presentation will highlight some specific fouling situations in oil refineries which can benefit from chemical cleaning. Cooperative efforts are needed between refinery operators, researchers, and chemical suppliers to develop the proper solvents and to find the optimum procedures to use them for cleaning.

HIGH COST OF TRADITIONAL MECHANICAL CLEANING

Large shell-and-tube heat exchangers (Figure 1) usually require disassembly of both ends and internals, removal of the tube bundle, transportation to a cleaning facility and cleaning, reassembly, and leak testing. This process can take between 3-14 days, depending on several factors like exchanger size and weight, severity of fouling, whether specialty equipment is required to extract the tube bundle etc. In the worst cases the cost for the mechanical work is as high as 40-50k$ per exchanger. A penalty of up to ten-times that cost could also be incurred, depending on the duration of outage and if production is affected while the cleaning takes place. As a result there is an obviously large incentive to develop cleaning methods which minimize or eliminate the mechanical costs and which can be carried out in short periods of time (one day or less).

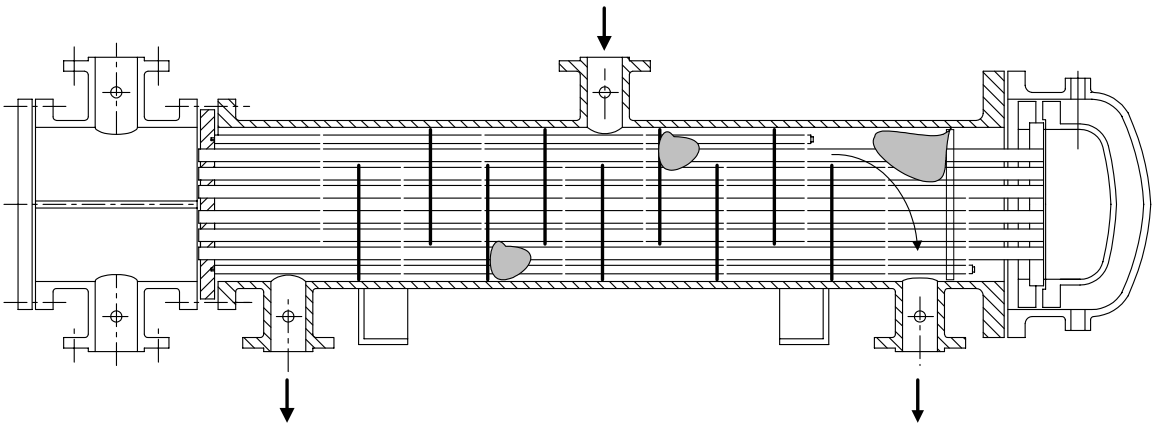

Fig. 1 Details of a typical shell-and-tube heat exchanger

CHEMICAL CLEANING AS AN ALTERNATIVE

Chemical cleaning is one technique to achieve the objectives of cheaper and quicker maintenance on fouled heat exchangers. It is broadly defined as cleaning a fouled heat exchanger using a chemical to dissolve some or all of the constituents of the solid foulant deposit. Typically, cleaning will be performed by flowing the solvent chemical through the exchanger (circulating or once-through) without the need for disassembly.

Current attempts to chemically clean heat exchange equipment have been successful in a limited number of cases, and even then, the benefits are sustained for only a relatively short amount of time compared to the alternative method of dismantling and washing with a high pressure water jet. The usual method is to circulate hydrocarbon streams like naphtha, kerosene, or gas oil, in the hope that the foulant deposit which is expected to be mostly organic can be dissolved and washed away. As seen in the results plotted below (Fig. 2), which are very typical for such

methods, the chemical cleaning (referred to as LCO Soak in the plot) is not very effective.

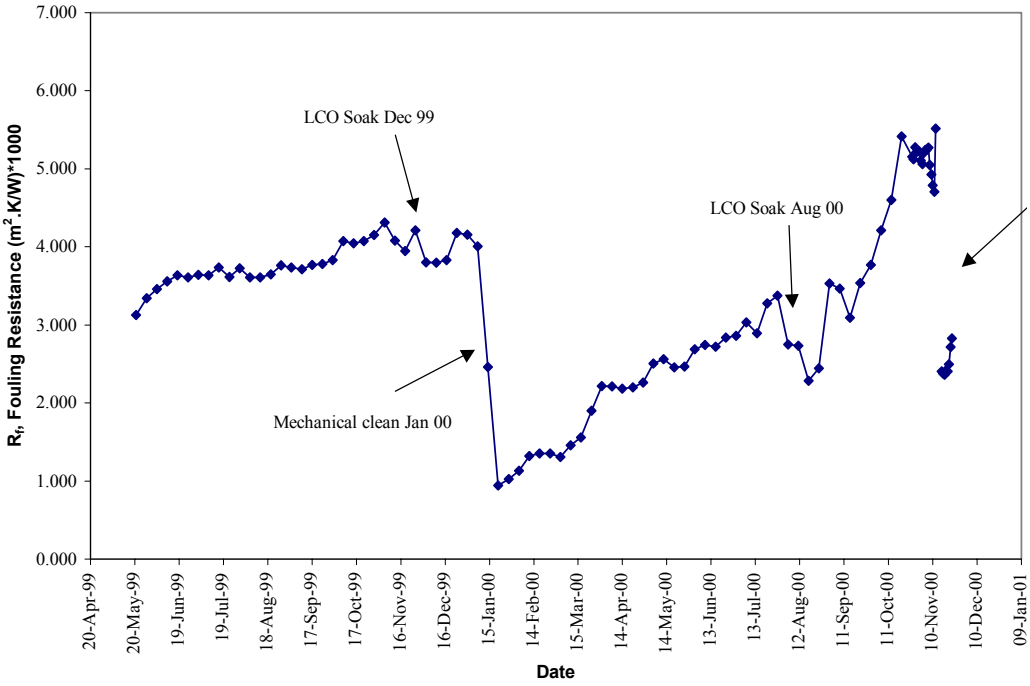

Fig. 2 Effect of Cleaning on Heat Exchanger Fouling Factors

The ineffectiveness of chemical cleaning in the above situation can be attributed to two main reasons. First, the inadequacy of the LCO as a solvent for the degraded organic material in the foulant as well as for the inorganic materials (such as iron sulfide), the latter of which may be within the deposit. Secondly, the inability to circulate a sufficiently large volumetric flow of the solvent due to the small connections used for circulation, and to get the solvent to cover the quiescent zones such as those shown on the shellside of Fig. 1

To realize the substantial benefits that effective chemical cleaning can provide, research and development is required in the following areas: (1) Determination of which types of solvents can dissolve the various types of foulant material as briefly described below, and which can be circulated safely in oil refinery equipment, (2) Procedures and equipment to ensure adequate distribution of the solvent to all areas of the fouled equipment, and (3) Understanding of the fouling process so that the cleaning can be performed at the optimum intervals considering cost, effectiveness, and time required.

Specific situations where large cost savings can be realized include: Fouling of crude oil due to organic (e.g., asphaltenes) as well as inorganic (salts, corrosion) precursors; fouling of FCC slurries due to fine catalyst particulates as well as coking; fouling of heavy hydrocrabon streams (resids) due to corrosion and coking; and fouling of mid-range hydrocrabons due to polymerization. A cooperative effort between refiners, universities, vendors, and chemical companies is needed to develop or identify chemicals that can be used for these fouling situations. The research objectives should include establishing protocols for such chemicals to be used at the right time to obtain the maximum benefit at the lowest possible cost.

CONCLUSIONS

Chemical cleaning of oil refinery heat exchangers has the potential of large economic benefits but joint research and development between the refiners and chemical companies is required before this benefit can be realized.