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Research Paper

Comparison of threshold models of hydrocarbon fouling formation in preheaters of distillation columns

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1. ABSTRACT

Hydrocarbon fouling of preheat exchangers causes several detrimental impacts on operation, environment, safety, as well as economy of oil refineries. To investigate threshold fouling models, a variety of hydrocarbon fouling data, such as temperature, oil flow, fluid properties and geometries of such exchangers, has been gathered from the literature. The most accurate models for predicting the fouling rate are the Polley, Ebert, and Panchal models, with slopes of 0.352, 0.108, and 0.022, respectively, based on fitted curves on the computational fouling rates in terms of comparable experimental values. The sensitivity analysis indicates that the two factors that profoundly affect the fouling rate are the surface temperature and Reynolds number. Using the Polley's equation, the fouling rate in preheat exchangers may be predicted with the highest degree of accuracy, mean sensitivity analysis of 0.29, based on the consistency of calculated and experimental data.

Keywords: Crude oil, Heat Exchanger, Hydrocarbon Fouling, Sensitivity Analysis, Threshold Equations.

2. INTRODUCTION

Generally, fouling is the accumulation of undesirable, low-conductive materials on the surface of heat devices, including heat exchangers. It may be broadly divided into two categories of organic and inorganic fouling types [1]. The hydrocarbon fouling in preheaters is the main topic of the present research. The development of various types of deposit would result in several negative operational, financial, and environmental effects, necessitating effective methods to forecast hydrocarbon fouling in refinery preheat exchangers [2-4]. Two general threshold and neural network-based correlations are available for this purpose. Threshold hydrocarbon fouling models are the main focus of the current work. There has not been a thorough comparison of threshold models in recent years [5]. To compare the most popular threshold fouling models, this work uses a large laboratory fouling databank related to hydrocarbon fouling in preheaters of distillation unit that has been reported in the literature. Additionally, this study discerns the models' sensitivity analysis to various factors, which might be crucial for constructing the preheat exchangers as efficiently as possible.

3. FOULING DATABANK

As stated before, a large laboratory fouling databank relating to hydrocarbon fouling in preheaters has been collected from the literature. The primary sources of the data were double pipe and shell and tube heat exchangers. The variables of surface and bulk temperatures, equivalent diameter, and crude oil velocity are all included in the databank.

4. RESULTS AND DISCUSSION

4.1. Comparison of threshold hydrocarbon fouling models

The computed fouling rate vs. experimental one is shown in Figure 1 for comparison and selection of the optimal threshold model. As it is seen evidently, the fouling rate is predicted more precisely by the Polley, Ebert, Panchal, and Ma models, respectively. In summary, the Polley model is the most effective threshold model for estimating the rate of hydrocarbon fouling.

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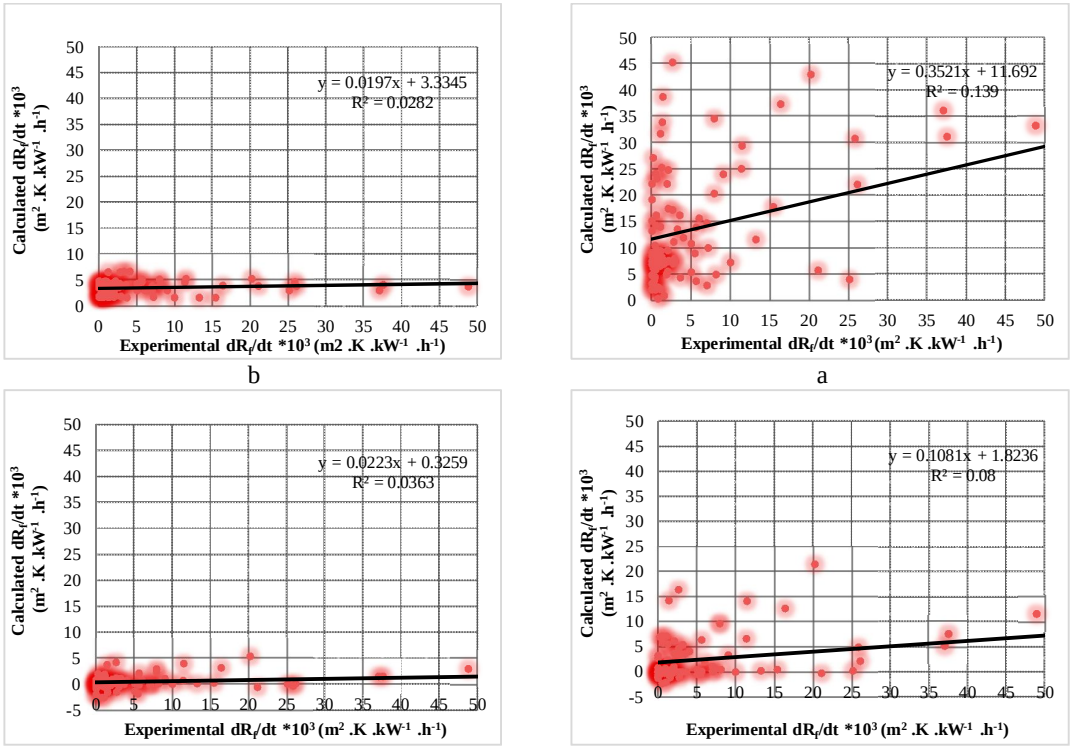

Figure 1. Calculated fouling rate vs. experimental datapoints for the threshold models of a) Polley, b) Ma, c) Ebert, and d) Panchal

4.2. Sensitivity analysis

This study employed the relative sensitivity analysis to ascertain the variable that has the greatest influence on each of the threshold models. The results of the sensitivity analysis indicate that the two factors that are most dominant in predicting the rates of hydrocarbon fouling are the surface temperature and the Reynolds number.

5. CONCLUSIONS

The most accurate threshold model is the Polley model, which has a slope of 0.352, based on the fitted lines that emerged on the experimental fouling data points. Moreover, the most sensitive fouling parameters in preheat train of distillation units are the surface temperature and the Reynolds number.

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