International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 01, January 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

A critical review on effects of Fouling and Fouling Mitigation on Heat Exchanger Surfaces

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ABSTRACT

Heat exchanger perform heating or cooling of one medium by another mediumalong with heat dissipation from surfaces of the equipment. In course of time during operation at high temperature and harsh environment conditions ,the equipment receives deposition which retards capability of the heat exchanging along with the enhanced pressure loss and extended pumping power. Thus accumulation of undesired substances on a surface is defined as fouling. With the development of fouling the heat exchanger may deteriorate to the extent that it must be withdrawn from service for cleaning or replacement. In this present context we review the effect of performance of heat exchanger and evaluate the effect of Fouling on the Heat exchanger surface .The present study focused on fouling phenomena, fouling models and mitigation of fouling.

Keywords :Fouling ,Mitigation of Fouling ,Environment

INTRODUCTION

Occurrence of fouling is observed in the case of natural as well as synthetic systems.The overall efficiency of heat exchanger get influenced by fouling, the process stream and process parameters are influenced by fouling phenomena[1,2]. As a result fouling causes huge economic loss due to its impact on initial cost on heat exchanging operation, operating cost, mitigation measures and performance. Preventive measures of fouling are highly encouraged so as to keep the service of heat exchanger for a longer time.

The present study focused on fouling phenomena, consideration of heat exchanger fouling in design , fouling models, and mitigation of fouling.

A.Fouling

Fouling is the resultant effect of deposition. The process of fouling could be represented by the equation (1.1)

$$\frac{dm_f}{dt} = m_d - m_r$$

where: dm_f , m_d and m_r are net deposition rates, deposition and removal rates respectively[3]. Various deposition and removal processes for a typical system are shown in Figure 1.1.The procedures happening are at the same time and relies upon the working conditions. Generally evacuation rates increments with expanding measures of store though affidavit rates are free of the measure of store however do rely upon the progressions brought about by stores, for example, increment in stream speed and surface harshness[4,5,&7]. In the use of steady divider temperature or consistent warmth exchange coefficient limit conditions, the interface temperature diminishes as stores develop which decreases the affidavit rate. Inception period/time delay in warmth exchanger fouling is viewed as when there is no statement for quite a while after a perfect warmth exchanger has been brought into task.Figure 1.2 illustrates in detail.

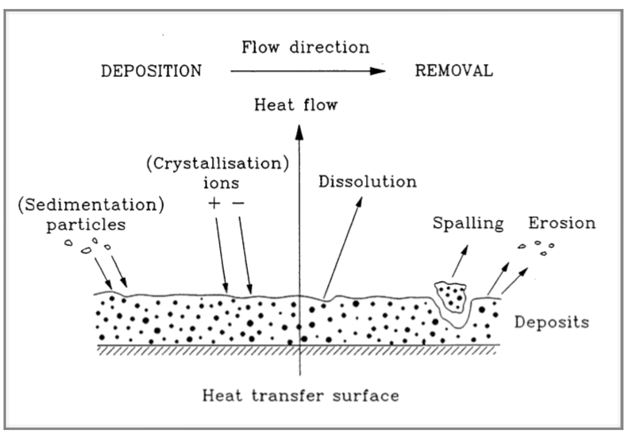

Fig1.1: Various deposition and removal processes during fouling

The initial growth of deposit can cause the heat transfer coefficient to increase rather than decrease resulting in a fouling resistance due to changing flow characteristics near the wall [6]. At the initial stage the deposit penetrates the viscous sub- layer, the resulting turbulence increases the film heat transfer coefficient at the solid/liquid interface by changing flow characteristics near the wall. This increase in heat transfer coefficient may overcome the thermal resistance offered by the deposits and the net heat transfer coefficient may increase.

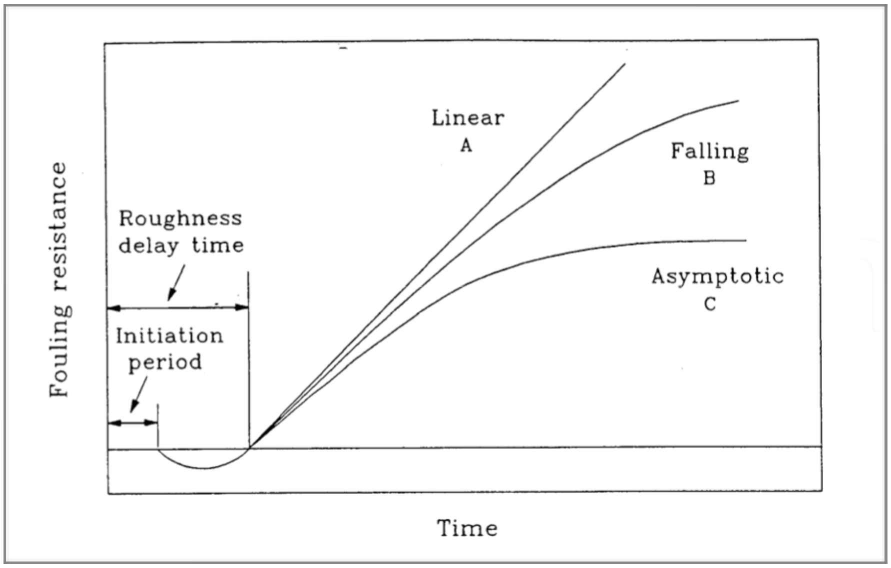

Fig1.2: Typical fouling curves.

The linear fouling curve is obtained for very strong deposits where the removal is negligible and in the case where the removal rate is constant and deposition is faster than removal. The falling rate curve is obtained from decrease in deposition and deposits with lower mechanical strength[8,9]. The combined effect with time causes the net deposition or fouling rate to fall. Asymptotic fouling curve has been most commonly reported for different types of fouling. The removal rate increases with time for weak deposits and can eventually become equal to the deposition rate.

Linear fouling curves have been presented by many authors for crystallization fouling .For the constant heat flux situation, the net driving force may decrease with fouling. Asymptotic behaviour for crystallization fouling has reported by various authors[10].Cooper et al. [11] found asymptotic behaviour for calcium phosphate fouling (with some particulate fouling from suspended solids). For particulate fouling, asymptotic behaviour is attained because particles do not adhere strongly to the wall and can be removed easily .

B. Heat exchanger type, geometry and process fluid influencing fouling .

Shell and tube heat exchangers are utilized most ordinarily however they are not especially reasonable for fouling conditions. Fouling can be diminished with extraordinary confuse and tube structure. A few examinations have demonstrated that finned tubes foul not exactly plain tubes. Non-uniform warm development prompts bring down store quality and thus less deposition. The tubes with longitudinal sections outwardly had less particulate fouling (by alumina particles) than the plain tubes. Fluidized-bed heat exchangers are utilized in a few applications to diminish or even kill fouling totally. Fluidized particles expel stores from the heat exchange surface. They likewise improve the heat exchange effectiveness as they interfere with the gooey sub-layer. These heat exchangers have been utilized effectively to lessen fouling by hard, following silica stores . Graphite heat exchangers are likewise answered to have less fouling[12]. Coordinate contact heat exchange might be another choice to decrease fouling . Properties of the procedure liquid, for example, the nature and convergence of the disintegrated constituents or suspended particles, nearness of any living life forms, arrangement pH and so forth influence fouling fundamentally.

C. Fouling models

A number of models have been proposed for different types of fouling. Analysis and model improvement is still progressing as there are difficulties due to the complex nature of deposit formation and lack of reproducible measurement of fouling resistance.

Most of the models have been simplified with many assumptions .

- Surface roughness is neglected.
- Change in surface roughness with deposit formation is also neglected.
- Only one type of fouling is only considered.
- Changes in physical properties of the fluids are neglected.
- The fouling layer is assumed to be homogeneous.

D.Fouling mitigation

Bott [13] indicated that the added substances utilized act in various courses, for example, (a) sequestering specialists, (b) limit operators, (c) precious stone modifiers and (d) dispersants. A portion of the regular water added substances are EDTA (sequestering specialist), polyphosphates and poly-phosphonates (edge operators) and poly-carboxylic corrosive and its subsidiaries (sequestering and edge treatment). Sequestering operators, for example, EDTA complex emphatically with the scaling actions, for example, Ca^{++}, Mg^{++}, and Cu^{++} in return with Na^{+}, accordingly averting scaling just as expelling any scale framed already. They are utilized successfully as anti-scalants in kettle feed water treatment. Gilmour [14] revealed that the debasement of heat exchange execution due to fouling in shell and cylinder warm exchangers happens chiefly because of poor shell-side plan. As of late various strategies have been created to control fouling. These techniques can be delegated: (1) concoction strategies, (2) mechanical techniques and (3) changing the period of the arrangement. By including outside synthetics in an answer, decrease of fouling is accomplished by concoction techniques for fouling alleviation. Compound added substances created by numerous organizations have been broadly used to alleviate fouling in the mechanical segment. Different added substances can be utilized to avoid scaling . Crystal altering specialists (for example Polycarboxylic corrosive) misshape the crystal propensity and hinder the arrangement of vast crystals. The misshaped crystals don't settle on the warmth exchange surface, they stay suspended in the mass arrangement. In the event that their fixation increments past a specific limit, particulate fouling may occur. This is forestalled either by utilizing procedures to limit particulate fouling or utilizing scattering operators alongside crystal altering specialists.

Summary and Conclusions :

Heat flux situation, the net driving force may decrease with fouling. asymptotic behaviour fouling occurs due to no strong adhere with the walls Crystal altering specialists misshape the crystal propensity and hinder the arrangement of vast crystals. The irregular shaped crystals don't settle on the warmth exchange surface, they stay suspended in the mass arrangement which the fouling may occur. Improving the heat exchange effectiveness can be done by interfere with the gooey sub-layer in the region.

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