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Pre-determination of the Fouling and Cleanliness Factor of the Heat Exchanger

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ABSTRACT

Heat exchanger degradation is a non-periodic non stationary process, which depends upon the variation of parameters w.r.t time. The measurements are associated with gross errors, if they are not properly handled, they may lead to erroneous estimation and prediction of heat exchanger performance. The objective of this paper is to pre-determine the fouling factor and cleanliness factor obtained in the heat exchangers to avoid the degradation and capital cost losses obtained during the heat exchanging process. The performance factor of heat exchangers degrades with time due to scaling or fouling factor. In this paper we have monitored, predicted and diagnosed heat exchanger performance.

Keywords*:* heat exchanger, fouling factor, cleanliness factor, overall heat transfercoofecient**.**

I. Introduction

Thackery et.al.estimated heat exchanger fouling problems were costing US industries on the order of billions per year. The high end of the estimate was proportionally ratioed from a similar UK study.

Nostrand et.al.estimated that a typical refinery is paying $10 million per year for exchanger fouling problem.

All these cost are further multiplied when there are multiple process units at the same location. The biggest cost contributors are production losses, asset utilization, energy consumption and maintenance costs. For reducing the cost there is a solution of monitoring and prevention, there occurs some common problems:

1. Improper sensors for the continuous monitoring of the system.
2. During the calculations, the overall heat transfer coefficients often don't generate accurate and clear results because of noisy and poor quality data.

The detection and the prediction features are discussed in this current paper. Fouling factor is the subject of a future release. The current exchanger types in scope are plate type heat exchangers.

II.Nomenclature

A Heat Transfer surface area
CF Cleanliness factor
Cph,CpcSpecific heat of hot, and cold streams
FF Fouling Factor
LMTD Log mean temperature difference
Mh, mc Mass flow rate of hot and cold streams
Q Heat load
Q_cHeat load by cold stream conditions
Q_hHeat load by hot stream conditions
T_{hi},T_{ho} Hot stream inlet and outlet temperatures
T_{ci},T_{co} Cold stream inlet and outlet temperatures
U_dOverall heat transfer coefficient, fouled
U_c Overall heat transfer coefficient at cleanconditions

III.METHODOLOGY

The primary inputs to this method are temperatures, flows of the hot and cold streams of a heat exchanger. The primary outputs of the fouling detections are heat load, overall heat transfer coefficients, approach temperature and cleanliness factor. Cleanliness factor is the matric to drive the following prediction feature, for which we can predict the next expected cleaning date for an exchanger. The input parameters can be measured with the help of conventional instruments. The data sources can be varied by manual recording of local gauges. The sampling intervals for the heat exchanger conditions vary every five minutes.
Following determinations are:

a. Fouling detection
b. Fouling prediction

IV.DATA RECONCILIATION

The function of data reconciliation is to get a set of measurements that are consisting with the heat balance equation.

$Q_h = M_h C_{ph}(T_{hi}-T_{ho})$ for hot stream
$Q_c = M_c C_{pc}(T_{hi}-T_{ho})$ for cold stream

To enable data reconciliation, all the parameters required by equation must be measured.
Data reconciliation is performed only if all the inputs in the above equation are available,allowing the hot side and cold side heat loads to be calculated independently.

V. FOULING DETECTION

The objective of the fouling detection module is to produce a clear exchanger performance trend, which is reflected only of the changes in the fouling resistance across the heat transfer surface.

The fouling detection module used as inputs, the filtered flows, temperature and pressure.

Critical outputs from fouling detection are heat load, U coefficient, cleanliness factor and approach temperature. The final reported values of U coefficient and cleanliness factor have been corrected for LMTD and flow effects, so that the trends represents a net change in the fouling resistance.

Uc is calculated immediately after the exchanger has been cleaned, at the time of the current cycle.

During the course of run cycle a heat exchanger's performance will degrade from clean to fouled conditions. The speed at which it occurs is dependent on the application and vigilance of the field engineers.

The extent of degradation in performance is expressed by the fouling factor as calculated equation

$FF=1/U_d-1/U_c$

The calculation of U_c and U_d are based on flow rates and temperature of the hot and cold streams.

The cleanliness factor (CF), is an alternate measurement of relative degradation in exchanger performance.

$CF=U_d/U_c \times 100$

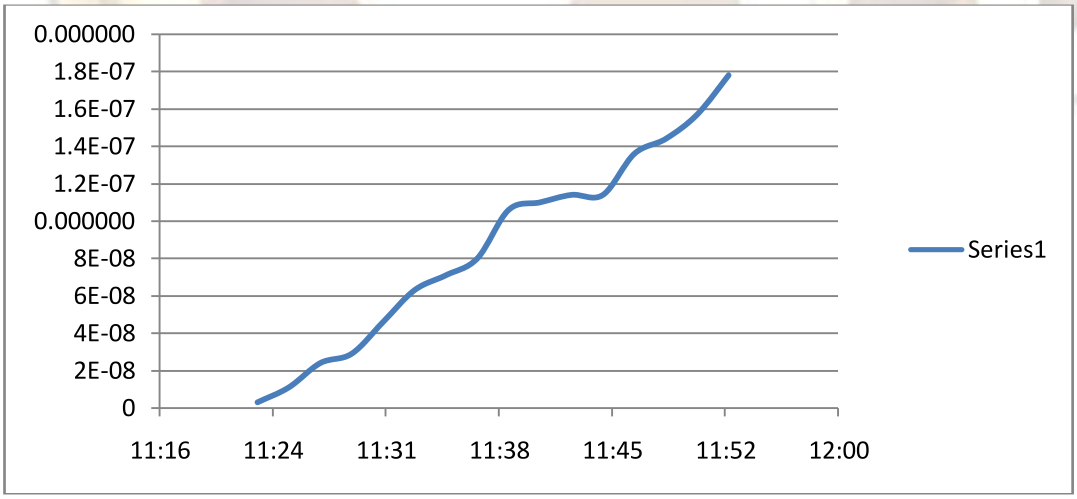
CF is closed to 100 for a clean exchanger and decrease over time as the exchanger fouls.

VI. FOULING PREDICTION

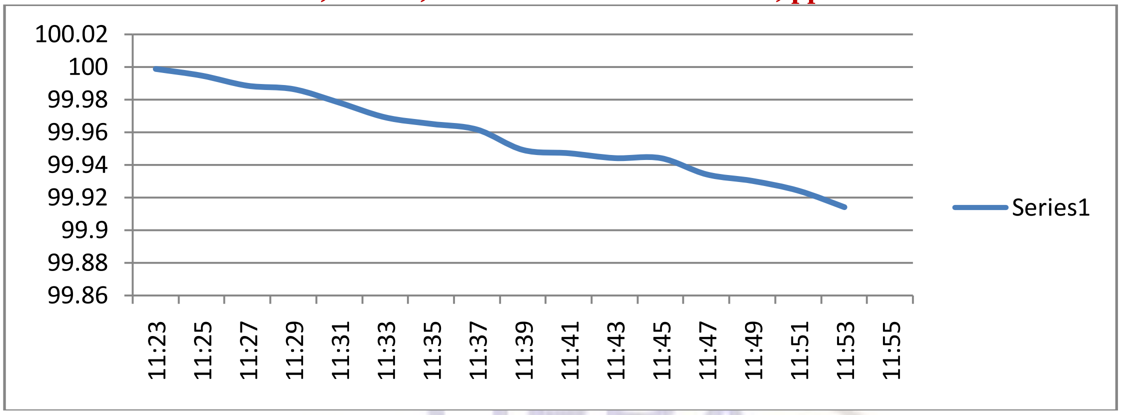
The objective of the fouling prediction module is to fit the performance trend collected in the current run cycle to a best fitting fouling model, and to use that model to forecast performance at future date. For critical exchangers in manufacturing operations, the ability to predict the future is a highly valuable asset. For operational planning, the forecast must be greater than 6 months in advance. By this method the prediction gives a sufficient early warning of degradation to enable control actions to be taken to arrest or reverse the trend. If a fouling treatment program is in place on the exchanger in question, a correction may be effected by changing the dosage or conditions of treatment. In some case a non-chemical solution is recommended, such as re-distributing the coolant flow, repairing a leak, or mechanical cleaning of a plug gage. Once the corrective action have been taken effect, the adaptive predictor will then capture any resultant recovery.

VII.Experimentally proved example

The PHE is used in the process plant where steam is used for water heating and then used for further processes s like CIP(cleaning in place)etc. Any variation in the temperature of the water produces major effect on the CIP process. So it is important for maintain the temperature of the system. By this method my prediction is when the PHE is depleted more than the threshold limit the immediate action for cleaning of the PHE must take to get back the initial results. and applying this method I have reached the date of cleaning the PHE is after 5 months after the initial date. For this prediction I have taken 30 min parametricreadings. And by this prediction I can also find the forecast up to 3 yrs or more in advance.

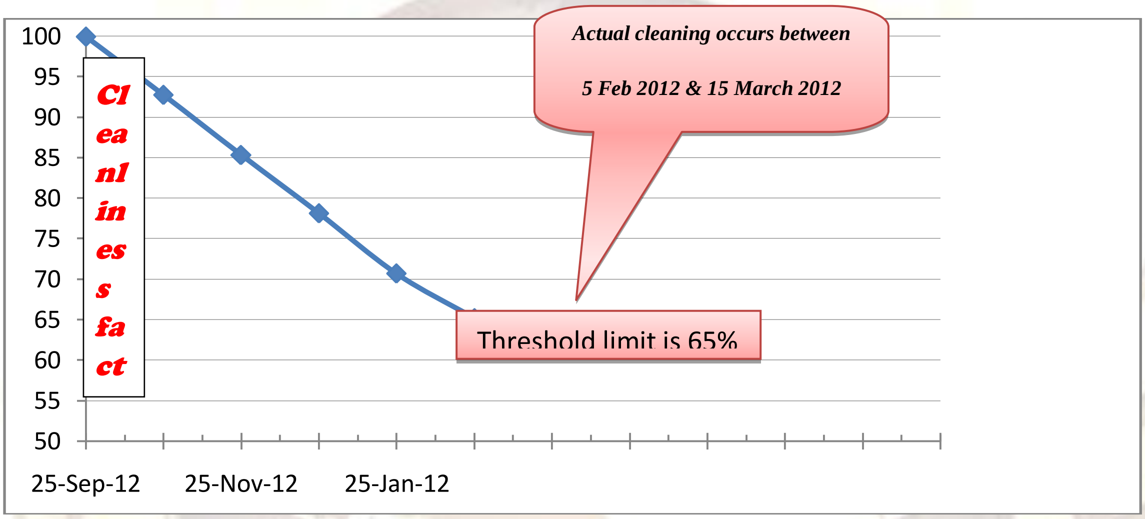


Graph 1:Fouling factor increasing w.r.t time



Graph 2: Clearance factor in % w.r.t time

VIII.Predicted date for cleanliness



The limit for cleanliness is decided 20 days before and 20 days after the due date of limit. For the best performance I recommend to clean the PHE on date.

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