Implementation Of Online Heat Exchanger Efficiency Calculation And Fouling Monitoring At Crude Unit

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Abstract: The heat exchangers on crude distillation units need to deliver high heat transfer efficiency and operational reliability. Most of heat exchangers used in crude distillation units are Cross-flow two-stream. The two streams flow at right angles to each other. This flow configuration is intermediate in effectiveness between parallel-flow and counter flow exchangers, but it is often simpler to construct owing to the relative simpler to construct owing to the relative simplicity of the inlet and outlet flow ducts. Use of the "Smart Online Efficiency" online calculation to monitor the heat exchangers performance and efficiency at Crude units in Mina Al-Ahmadi Refinery (MAA) yielded early results when the tool highlighted a fouling event shortly after it occurred. Fouling formation in any heat exchanger will reduce the online-calculated heat exchanger efficiency result and that can noted from the trend of histories efficiency data and from the fouling indicator. This paper looks at the efficiency calculation and fouling monitoring using DCS software application and the result from the case study.

Keywords: DCS, MAA, Smart Online Efficiency, Cross-flow two-stream, Fouling indicator, effectiveness NTU

1. Background

MAA Refinery is one of the largest refineries in the Middle East. It constructed in mid 1950s and officially opened with one crude unit (CDU-1) processing 35,000 BPD. The refinery now processes hundred thousands' barrels of crude, which shared between Crude Distillation Unit No. 3, Crude Distillation Unit No. 4, Crude Distillation Unit No. 5 and EOCENE Crude Unit.

2. Introduction

MAA Refinery is one of those organizations interested in energy efficiency and has had conducting energy saving project in the past two years. The company recognized that for further improvement to be made, areas that have had not been looked at seriously before, like heat exchangers efficiency and fouling, would have to be addressed. Although the refinery had not been experiencing significant fouling problems, the refinery management were keen to install a fouling monitoring tool through the online heat exchanger efficiency and fouling DCS software application, so that the cost of the fouling could monitored on a regular basis.

3. Fouling Problem

Fouling of heat exchangers is one of the major concerns of the prevailing petroleum refinery industry. It normally affects the competence of heat recovery and can critically change the underlying profitability of a refinery over fuel consumption throughout reduction during cleaning operations and due to augmentation of the maintenance costs. Most fouling arises from asphalting deposition from the crude oil onto the metal surfaces of the pre-heat train heat exchangers pipes. This fouling leads to a decline in furnace inlet temperature, by perhaps as much as 30 C (54 F), and a subsequent need to burn extra fuel in the furnace to make up the temperature necessary for efficient distillation. Fouling also causes a significant decrease in the crude unit throughput, cutting production.

The cost associated with fouling in crude pre-heat exchangers categorized as follows:

- Energy costs and environmental impact. This corresponds to the additional fuel required for the furnace due to the reduced heat recovery in the pre-heat train as exchangers foul.
- Pressure drop (pumping power) may also be significant. The use of more fuel leads to additional production of CO_2 with the associated environmental impact.
- Production loss during shutdowns due to fouling.
- Capital expenditure. This includes excess surface area, costs for stronger foundations, provisions for extra space, increased transport and installation costs, cost of anti-fouling equipment, costs of installation of on-line cleaning devices and treatment plants, increased cost of disposal of the (larger) replaced bundles and, finally, the (larger) heat exchangers.
- Maintenance costs. This includes staff and other costs for removing fouling deposits and the cost of chemicals or other operating costs of anti-fouling devices. There are also economic and environmental penalties associated with disposal of cleaning chemicals after cleaning.

4 Fouling Formation and Monitoring

Owing to the enormous costs associated with fouling, a considerable number of fouling mitigation strategies has been developed. Fouling is a function of many variables. For example, fouling in crude oil exchangers affected by the following variables:

- Crude oil composition.
- Inorganic contaminants.
- Process conditions (temperature, pressure and

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flow rate).

- Exchanger and piping configuration.
- Surface temperature.

Therefore, effective control of the variables in certain conditions may minimize fouling. Generally, effective fouling control methods should involve:

- Preventing fouling forming, this can be done by filtering the crude oil from the well to remove sediments as well as by improving the crude desalting process.
- Preventing fouling from adhering to themselves and to heat transfer surfaces, this is main achieved by increasing the shear force on the heat exchanger surface to prevent deposits from forming. If the wall shear stress is above the threshold value for the wall temperature, little or no fouling will register.
- Removal of deposits from the surfaces, this is basically heat exchanger cleaning. This can achieved through mechanical, chemical or supersonic cleaning methods.

5. Heat Exchanger Efficiency Calculation

Preheat train efficiency monitoring accompanied by heat exchanger fouling rates entails utilizing of accurate temperature and the corresponding flow rate measurements. Heat duty computed on both the prevailing shell and tube sides. It is usual to speak about the heat exchange “effectiveness NTU” method, defined as:

Effectiveness NTU (Number of Transfer Units)

Effectiveness = Actual heat transferred from hot stream to cold stream (Q) / Maximum possible heat transfer (Qmax)

Qmax = Maximum possible heat transfer

Qmax = {M*Cp}min*{Th_inlet-Tc_inlet}

Q = Actual heat transfer

Q = {M*Cp}*{Th_inlet-Th_outlt}

OR

Q = {M*Cp}*{Tc_oulet-Tc_inlet}

Where:

Q = actual heat transfer

M = mass flow rate per unit time (kg/hr).

Cp= Specific heat.

Th_inlt = Inlet temperature for hot stream in DigF.

Tc_inlet= Inlet temperature for cold stream in DigF.

6 Specific Heat Calculation

Specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius.

*Cp = {0.388 + 0.00045 * Tout}/(Sp Gr)^0.5*

- Calculate (M * Cp) for cold and hot streams to get (M*Cp)min
- Calculate Qmax from the following equation:

*Qmax = {M*Cp} min*{Th_inlet-Tc_inlet).*

- Calculate the actual heat transfer for cold and hot streams using the following equations:

*Q = {M*Cp* (T_out - T_inlet) cold stream}*

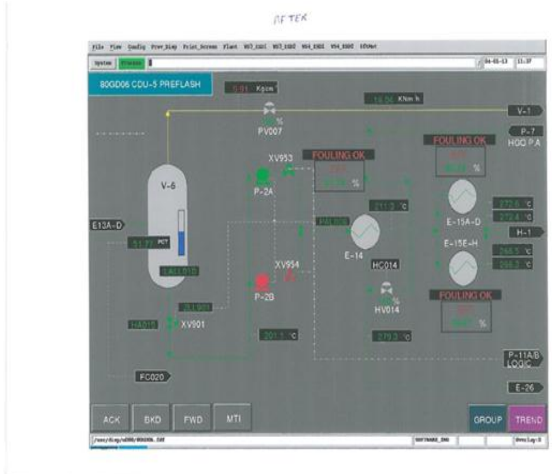
*= { M*Cp* (T _inlet - T_out) hot stream}*

**The actual heat transfer for cold and hot stream should be usually very close therefore; the lowest Q can used to calculate the efficiency.

- Calculate efficiency from the following equation:

*Eff = Q / Qmax * 100%*

The graphic in Fig. 1 is for demonstrating the online efficiency calculations which will shows the efficiency percentage for each heat exchanger every scan (1 minute) and it will shows the fouling indication status with alarm if the fouling is high.



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