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Precipitation and Particles Fouling Effects on Plate Heat Exchangers in Gas Sweetening Unit

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Abstract- The reason of applying heat exchanger is optimizing the usage of heat energy. There are many thermal, pressure and flow limitation for designing heat exchanger. Corrosion, fouling and viscosity have important effect upon designing factors. The plate heat exchanger (PHE) is the most usable type of exchangers. In south pars gas complex (SPGC) we apply this type of exchanger for corrosive liquid such as sour amine (MDEA). Process parameters such as flow velocity, heat flux, and particle concentration were varied over a considerable range. After some years of operation, fouling can happen on the heat transfer surface of the PHE thereby lowering the heat transfer efficiency and increasing the pressure drop. In this paper, we will describe which actions should be estimated to increase the life of plate heat exchanger and having maximums efficiency and investigate fouling effect on plate heat exchanger with a practical experience in gas sweetening unit.

Keywords: *plate heat exchanger,foulingfactor,gassweetening*

I. INTRODUCTION

The Plate Heat Exchanger (PHE) consists of Fixed and Moving Cover Plates, Carrying and Guiding Bars, End Support, corrugated and gasket Heat Transfer Plates, Tightening Bolts/Nuts, and Connection Ports. The corrugated plates are held in between the fixed and moveable cover and are compressed by the tightening bolts. Optional protection shrouds are available on request. The heat exchanger's construction enables it to be easily opened for inspection, cleaning and extension.

Plates are manufactured in standard sizes in virtually any material that can be cold worked. The size, number and arrangement of the plates are contingent upon the duty to be performed. Accordingly, the units are custom designed for each application. Elastomeric gaskets are glued in the gasket groove around the heat transfer surface and the portholes. The gaskets are double around the portholes to prevent leakage between the media. In the event of gasket failure the medium runs straight out of the exchanger [2]. When the unit is tightened, the gasket seals the structure and in conjunction with the portholes, allows fluids to flow in alternate channels and almost always flow counter-currently. The thin fluid interspaced coupled with the corrugated plate design induces turbulence that produces extremely high heat transfer coefficients [5].

II. PLATE WORKING PRINCIPLE USE

A. Working principle

A series of pressed plates with portholes form plate pack of flow channels. The heat exchange media flow through these plates in alternate channels. Usually single-pass plate heat exchangers are used. They are distinguished by the 100% counter-flow of the two media. All of the feed and discharge pipes are connected to the fixed cover plate. This is a particularly maintenance friendly installation. Close temperature differences between the media may demand multi-pass plate heat exchangers. The connection pipes are then attached both to the fixed and movable cover plate [2].

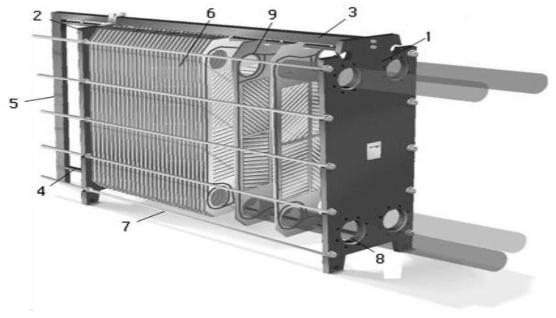

Figure 1. Plate heat exchanger description

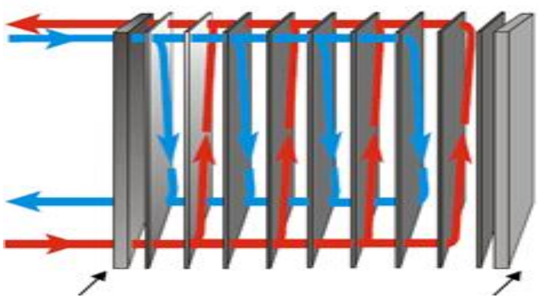

Figure 2. Fixed Cover Plate Movable Cover Plate

III. EXPERIMENTAL CASE STUDY

Calculation of heat duties and fouling factors in lean- rich amine exchangers indicate increasing of fouling factors from specified period of plant startup. There are some possibilities that can be cause of fouling on plate heat exchangers. It is studied in this search as investigation of fouling factors on lean / rich amine exchangers in gas sweetening units.

Welded plate heat exchangers provide a large heat transfer area in a very compact space. In gas sweetening units, there are three parallel plate & frame heat exchangers, which are caused to exchange heat between lean amine outlet from bottom of regenerators and rich amine inlet to regenerators [3]. The lean - rich amine exchangers preheat the rich amine solution and reduce the heat duty of the reboilers. They also cool the lean amine and reduce the heat duty of the lean amine trim coolers. The rich amine usually passed through heat exchanger with a low inlet velocity to reduce corrosion. This low velocity sometimes causes fouling in the rich amine sides of the heat exchangers when solid particulates are present. The change of temperature of inlet and outlet on lean / rich amine streams have compared with design case in order to determine the performance of plate heat exchangers which are affected on the performance of amine regenerators

Inlet and outlet daily average temperatures of lean - rich amine streams have been used to calculate LMTD, heat duties, overall heat transfer coefficients and fouling factors of lean-rich amine exchangers. Different flow rates of amine circulation have been used since plant startup (from 255 m3/h to 135m3/h).

Q: Heat Exchanged

LMTD: Logarithmic Mean Temperature Difference

U: Overall heat transfer coefficient (c: clean, d: dirt)

D_T: Temperature difference

F: Correction factor

Rf: Fouling factor

T_L: Lean Amine Temperature

T_R: Rich Amine Temperature

There are not any flow indicators on inlet and outlet streams of heat exchangers but there is a flow indicator on discharge lines of amine pumps. Hence, the amount of dissolved H2S, dissolved hydrocarbon and selective CO2 absorption should be considered for rich amine flow rate through plate heat exchangers. Therefore, the mass flow rate coefficient ((mass flow rate of rich amine to plate heat exchangers) / (amine circulation flow rate)) is considered for this purpose according to mass balance of design case with an acceptable accuracy.

The amount of exchanged heat is calculated as below:

$$Q = m * Cp * DT$$

According to the inlet and outlet daily average temperatures of lean and rich streams on plate heat exchangers, Logarithmic Mean Temperature Difference (LMTD) is calculated by following formula:

$$DT_h = T_{Lin} - T_{Rout}$$

$$DT_c = T_{Lout} - T_{Rin}$$

$$LMTD = (DT_h - DT_c) / Ln (DT_h / DT_c)$$

Now, dirt overall heat transfer coefficient (U_d) and clean overall heat transfer coefficient (U_c) are calculated as follows:

$$U = Q / (A * F * LMTD)$$

In figures 3, 4, 5, fouling factor trends versus different amine flow rate at four amine plant plate heat exchanger were illustrate

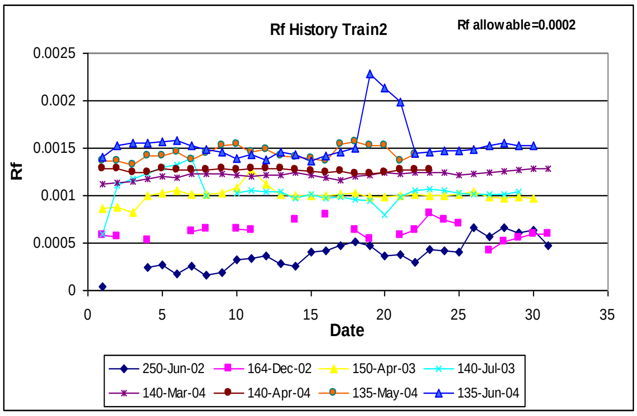

Figure 3. Fouling factor trends in different amine flow rate (train 1)

Use LMTD and exchanged heat (Q_C) of design case for calculation of clean overall heat transfer coefficient. Fouling is defined as any undesirable deposits on the heat transfer surface, which increase resistance to both heat transfer and fluid flow. Fouling factor of lean / rich amine exchanger is calculated as below:

$$Rf = (1/ U_d - 1/ U_c)$$

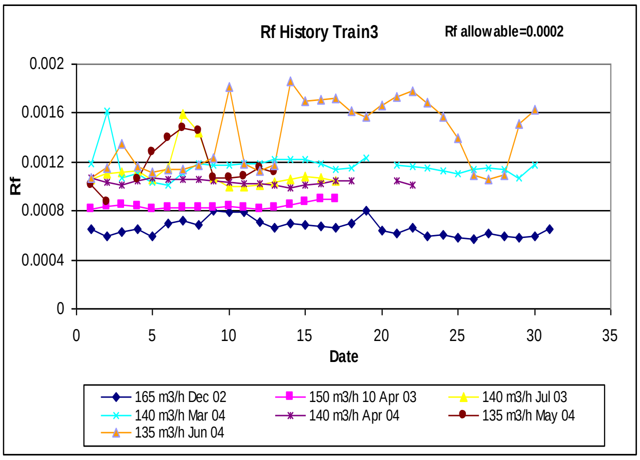

Figure 4. Fouling factor trends in different amine flow rate (train 3)

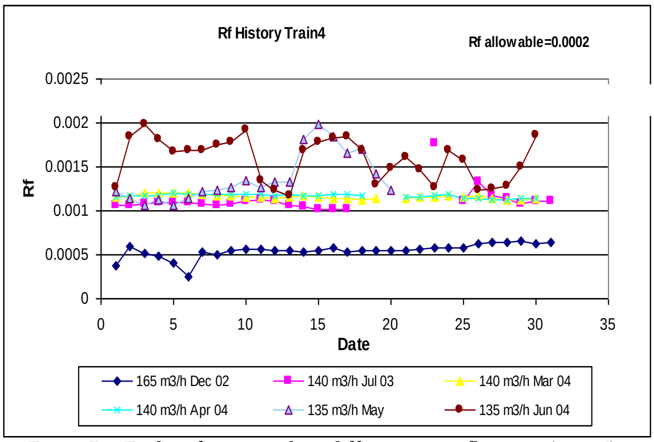

Figure 5. Fouling factor trends in different amine flow rate (train 4)

IV. CONCLUSION

Because of variety of plate design and arrangement of plate's groove and measurement the possibility of maintain plates and seals get easily. The optimizing heat transfer is possible because of turbulent fluid and small hydraulic diameter. The other benefits of heat plate exchanger are reduction of sediments because of turbulent flow at plates. Saving volume and weight of fabrication and maintenance costs will help us to use PHE. This type of exchanger is the best option for corrosive liquid. One of its defects is the limitation of working pressure (25 bars) because of gasket type when the operation fluids have high viscosity and corrosion characteristics. According to fouling factor trends, it has been increased since plant start-up time up to now. Allowable amount of fouling factors for these plate heat exchangers are 0.0002 regarding to the vendor data sheet but the latest amount of fouling factor is about more than 0.001 (about more than 5 times greater than allowable amount). The main sources of fouling on plate heat exchangers in gas sweetening units are as follows:

A. *Precipitation fouling*

This relates to the precipitation of dissolved substances on the heat transfer surfaces. Certain dissolved substances such as calcium sulphate have inverse solubility versus temperature characteristics as scaling. Lean MEG injection in upstream of gas sweetening units (Reception facility) is used for preventing of corrosion and hydrate formation. High concentration of calcium contents in lean MEG and high lean MEG injection flow rates are the main sources of scaling because of carrying over lean MEG.

B. *Particulate fouling*

This occurs when finely divided solids (rust, dust, sand, etc.) surface. If the solids settle by gravity, it is as sedimentation fouling. Low velocities of fluid flow help to precipitate suspended solids on the surface of heat exchangers. During start-up time, amine filtration package didn't work well and it was not in service for long periods. Therefore, it was caused some contaminants such as solids particles coming from initial start-up operation and iron are in precipitated (insoluble) iron sulfide form (filterable particles) on rich side. The reduction of amine flow from design case (250m3/hr) to optimum flow (135m3/hr) help to precipitate suspended solids on the surface of heat exchangers especially when amine filtration packages are out of service.

C. *Corrosion fouling*

This occurs when the heat transfer surfaces itself react to product adherent corrosion product. Comp bloc welded plate heat exchanger; each composed of one pack welded square exchange plates in stainless steel 316L,enclosed in a bolted rectangular shell with encased steel casted A352 LCB square head. The amine reactions with acids stronger than H_2S and CO_2 form heat stable salts, which do not disassociate in the regenerator. Formed inorganic salts can potentially precipitate and cause further corrosion problems on the surface of heat exchangers. The factors of heat stable salts formation are as follows:

-Inlet gas contaminants (organic acids)

-Oxygen degradation

-Thermal degradation by-products

Amine flow velocities exceeding 3 ft/s in carbon steel and 8 ft/s in stainless steel should consider for corrosion problems. The distance between plates is 5 mm and it is very difficult to clean the totally fouled plate exchangers regardless of the used cleaning methods. Now, maintenance team and inspection should organize a plan to clean these heat exchangers individually.

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