ENHANCEMENT OF REFINERY PROFITABILITY VIA INCREASING THE LIFE-CYCLE OF WELDED PLATE HEAT EXCHANGER IN THE SOUR WATER STRIPPING PROCESS

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ABSTRACT

K°Bloc welded PHE with double dimple free-flow plates operating in the sour water stripping process could lower realized fouling rate, minimize maintenance costs, extend service interval cycles, and increase the heat exchanger's availability in comparison with the same model with chevron plates. The measurements over about 8 years (3 years history on a competitor bloc with chevron plates and 5 years history on new designed K°Bloc operation with double dimple plates) showed that the cleaning cycle of the K°Bloc with double dimple plates improved to four times longer between required cleanings than that for the same unit with chevron plates. Moreover, the K°Bloc thermal performance was almost twice that of the old unit.

INTRODUCTION

Heat exchangers play a significant role in oil and gas production and processing. Since decades, welded plate heat exchangers (WPHE) have improved various operations in oil and gas applications [1]. K°Bloc a fully-welded plate heat exchanger is increasingly used in the oil and gas industry, the chemical industry as well as in the petrochemical sector. Two different plate corrugations are available. Chevron corrugation enables effective heat transfer. In contrast, double dimple corrugation is the first choice for highly viscous or solid containing media as well as for vacuum applications like vacuum condensers [2].

Using K°Bloc welded plate heat exchanger in the sour water stripping process can help refineries to improve profitability. K°Bloc solution with the advantage of being more compact and providing significant space savings can enable the refinery to recover more heat from the stripper bottoms to divert to the stripper feed. This will improve the overall efficiency of the sour water stripping process, resulting in a greater return on the investment.

PROCESS DESCRIPTION

Sour water stripping is a main stage in the wastewater treatment process in many industrial operations, and especially in refineries [3]. Most refinery sour water systems contain low concentrations of CO_2. H_2S content makes sour water "sour", and H_2S concentrations can become very high. This high H_2S content can make sour water extremely fouling, and if the H2S is not recovered, pollution levels would be completely out of hand [4].

Sour water generated in the refinery is fed into a stripping tower where it is heated with steam to remove hydrogen sulfide and ammonia. The distilled water from the bottom of the stripper (commonly called stripper bottoms) is used to preheat the incoming stripper feed. This reduces the steam consumption required by the stripper reboiler and hence the energy required for steam generators providing the steam supplied to the reboiler.

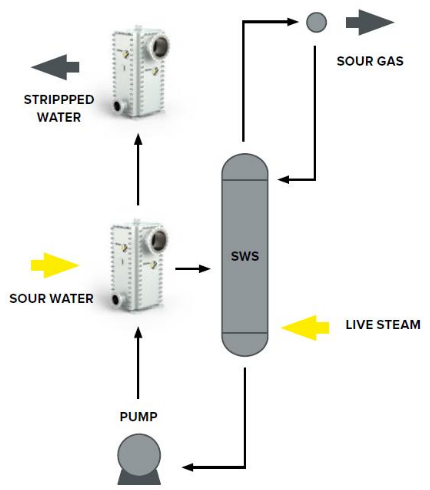

Fig. 1. Sour water stripping process.

The heat exchanger is a welded plate heat exchanger (K°Bloc) with double-dimple plates. The basic design of K°Bloc can be found elsewhere

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[2]. The unit has 250 plates of 50 cm plate size with 20 passes on both sides. The plates have the double dimple corrugation that create a unique tubular profile which is easy to clean. They are needed for high volume flows with low pressure drop, viscous fluid or for fluids with high fouling tendency as they can be easily cleaned. Figure 2 shows the view through the double-dimple plate pack. These corrugations offer sufficiently free spaces; high-pressure straight through cleaning is possible from any direction.

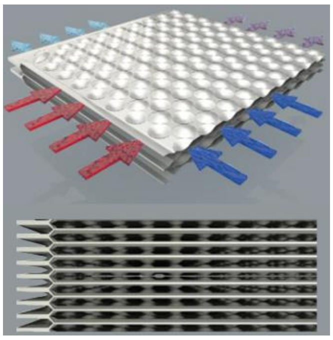

Fig. 2. K°Bloc plates with double dimple corrugation

Results and Discussion

The thermal performance of the welded plate heat exchanger in the sour water stripping process was measured for about 8 years (3 years (2013 - 2015) on a competitor's bloc manufactured with chevron plates and 5 years (2016 - 2020) in on a new designed K°Bloc manufactured with double dimple plates).

The gradual increase in fouling decreased the overall heat transfer coefficient gradually as could be seen in Fig. 3. At the initial level of fouling, there was a major drop in fouled heat transfer coefficient and as the fouling increased, the fouling rate decreased resulting in reduced fouled heat transfer coefficient drop

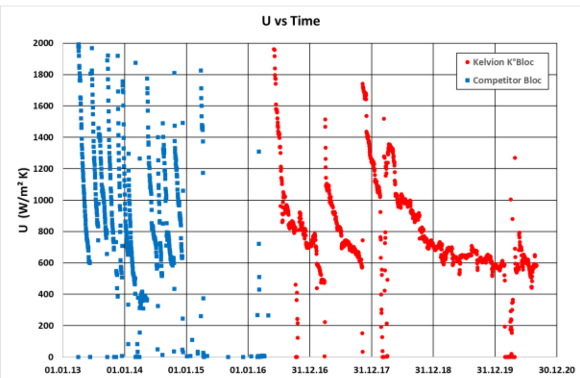

Fig. 3. Overall heat transfer coefficients as a function of time for both K°Bloc and competitor unit.

Also, the gradual decrease in the overall heat transfer coefficient decreased the heat transfer rate of the heat exchanger. This is due to the increase in the thermal resistance with time, see Fig. 4.

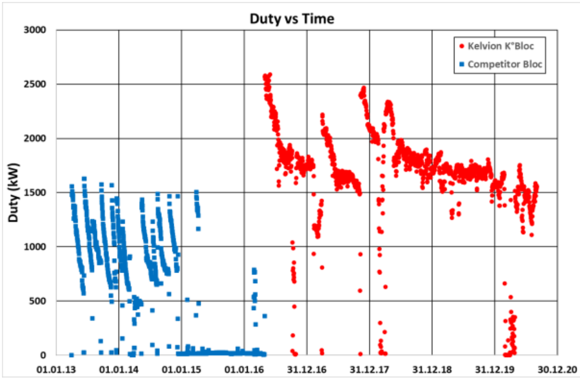

Fig. 4. Heat duty as a function of time for both K°Bloc and competitor unit.

It could be clearly seen that the resulting heat transfer rate of the new designed K°Bloc with double dimple plates was almost twice that of the old unit with chevron plates. The unique tubular profile of the dimple plates could decrease fouling rate and hence increase the thermal performance. It should be noted that the cycles in the data in figures 3 and 4 are the cleaning cycles and the dates of those cleaning cycles are summarized in Table 1.

Moreover, the K°Bloc with double dimple plates should be less frequently cleaned in comparison with the same unit with chevron plates, as could be seen in Table 1. This decreased the required shutdowns for cleaning and hence increased the heat exchanger's availability in the process.

<table>
<tr><th colspan="2">Competitor Bloc</th><th colspan="2">K°Bloc</th></tr>
<tr><td rowspan="6">2013</td><td>1-Apr-13</td><td rowspan="2">Installation & Startup</td><td rowspan="2">30-Apr-16</td></tr>
<tr><td>10-Jun-13</td></tr>
<tr><td>30-Jul-13</td><td rowspan="2">2017</td><td>29-Mar-17</td></tr>
<tr><td>19-Sep-13</td><td>7-Nov-17</td></tr>
<tr><td>18-Nov-13</td><td>2019</td><td>24-Apr-19</td></tr>
<tr><td>17-Dec-13</td><td colspan="2" rowspan="10"></td></tr>
<tr><td rowspan="7">2014</td><td>21-Jan-14</td></tr>
<tr><td>4-Mar-14</td></tr>
<tr><td>12-May-14</td></tr>
<tr><td>12-May-14</td></tr>
<tr><td>13-Aug-14</td></tr>
<tr><td>20-Oct-14</td></tr>
<tr><td>9-Dec-14</td></tr>
<tr><td rowspan="2">2015</td><td>31-Jan-15</td></tr>
<tr><td>26-Mar-15</td></tr>
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Table 1. Dates of cleaning for both K°Bloc and competitor unit.

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The heat transfer coefficients on both sides of K°Bloc unit were measured over about one year and the results are shown in Fig. 5.

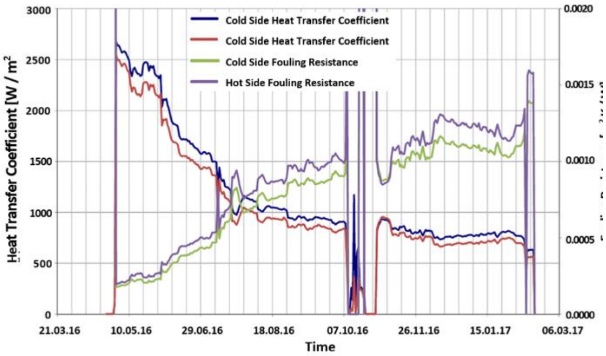

Fig. 5. Measured heat transfer coefficients as well as thermal resistance over K°Bloc unit with double dimple plates.

Only a gradual increase in fouling was witnessed which had a minimal effect on the heat transfer coefficients for both sides of the heat exchanger leading to longer operating time between cleanings/shut down of the equipment.

CONCLUSION

Using a K°Bloc welded plate heat exchanger with double dimple plates in the sour water stripping process could help refineries improve its system availability and hence its profitability.

The measurements over about 8 years (3 years over a competitor bloc with chevron plates and 5 years over K°Bloc with double dimple plates) showed that the cleaning cycle of the K°Bloc with double dimple plates improved minimum to four times longer between required cleanings than that for the same unit with chevron plates.

The realized heat transfer rate of the K°Bloc with double dimple plates for the same time of operation was almost twice that experienced of the competitor unit with chevron plates leading to longer periods of operation between cleanings.. The unique tubular profile of the dimple plates could decrease the resulting fouling rate and hence increase the thermal performance.

NOMENCLATURE

U Overall heat transfer coefficient, W/m²K

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