Cost Optimization In The Scheduling On Heat Exchanger Cleaning Process

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***Abstract* – Cost utility is very important in an industry, particularly in the chemical industry. For an industry that operates the heat exchanger in the production process, utility usage is determined by the maintenance of this devices, one of which is cleaning. Therefore, it is necessary to schedule the optimal cleaning in order to obtain optimum expenses as well. in this paper, a cost optimization model has been developed to obtain ideal scheduling that takes into account the time of cleaning with minimum targets utility costs. Simple case study problem will be given to show the application and the results**

***Index Terms* – Cost utility, heat exchanger, optimization, scheduling.**

INTRODUCTION

The rationale for the optimization of utility costs depend on the characteristics of heat exchanger fouling [1]. These characteristics follow an exponential function
$U = a.e^{-b.t}$

Additional utility is used when the efficiency of heat exchangers decreased as a result of fouling so that the process can keep running. So that the benefits of cleaning is to restore the working efficiency of the heat exchanger to the optimum condition [2]. Various fouling characteristics models have been developed, for example two layer model [3], fouling effect on the output temperature and extended to networks of heat exchanger [4].

MODEL FORMULATION

The objective Function of this problem is defined as follows, to find Minimum Utility Cost (UC):

$$UC = Q.k_q + n_j.k_c + \left(\sum_{j=1}^{j} n_j.Q_{HE,cl}.\tau\right).k_q$$

With equality constraints:

$$Q = \left(\sum_{j=1}^{j}\int_0^{t_e} Q_{HE,cl}\,.dt\right) - \left(\sum_{j=1}^{j} Q_{rec,j}\right)$$

$$Q_{rec} = n_j.(\int_0^{t_{clean}} U_f.A.\Delta T_{LM}.dt + Q_{HE,cl}.\tau)$$

$$t_{clean} = \frac{t_e}{n_j}$$

$$Q \geq 0;\ Q_{rec} \geq 0$$

where $Q_{HE,cl}$ is the heat load for each exchanger (j = 1,2,...) and τ is the duration of the cleaning. t_e (days) is the production time in one period of production. Variables A and ΔT_{LM} considered constant during the production process. k_p and k_c respectively is a factor in utility costs ($/BTU.hr^{-1}) which is constant and cleaning fee ($/each cleaning action) in each heat exchanger.

DISCUSSION

For the implementation of this model, a case study is used as a model as shown in Table 1.

TABLE 1. PROCESS DATA.

Type	Material	T_{in} (°F)	T_{out} (°F)	$m.c_p$ (Btu/hr.°F)
H_1	Iso-Butane	260	160	30,000
H_2	Toluene	250	130	15,000
C_1	Benzene	120	235	20,000
C_2	Butane	180	240	40,000

After the calculation the characteristic equation obtained as given in Table 2 [1].

TABLE 2. CHARACTERISTIC FUNCTION DATA.

Device No.	Characteristic function (U_f)
1	$U_f = 50.17593.e^{-0.001355t}$
2	$U_f = 34.985682.e^{-0.001t}$
3	$U_f = 56.42526.e^{-0.00149t}$
4	$U_f = 48.334566.e^{-0.001314t}$

Heat integration was applied for the case study above, in order to determine the number of heat exchanger for energy recovery and minimum utility requirements.

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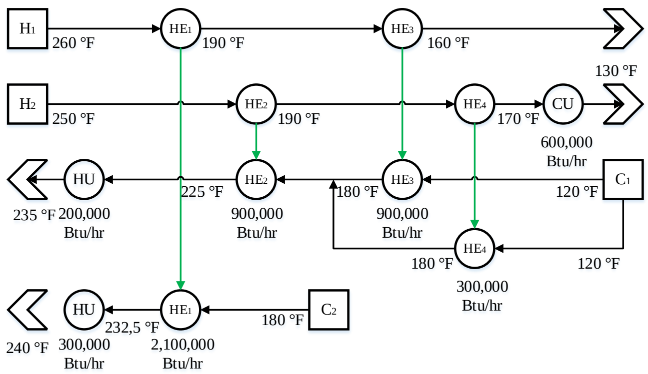

Figure 1. Heat integration depicted in the diagram grid.

The results of the heat integration was known to be 4 units (see Figure 1). Then by setting the variable k_q = \$ 0.005/(BTU.hr^{-1}), variable k_c = \$ 10,000/cleaning action and τ (cleaning time) for 3 days, we get the following results as given in Table 2.

TABLE 2. OPTIMUM SCHEDULING RESULTS.

Device No.	Cleaning action (n_j)	Total cost (US\$)
1	3	392,998.8
2	3	
3	4	
4	2	

So if one plots between Q_{rec} versus time (days) the results are shown in Figure 2.

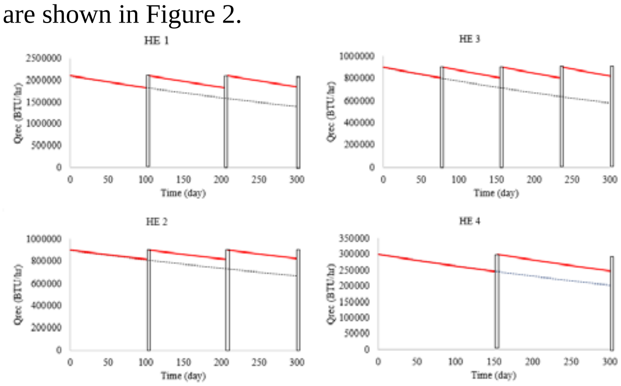

Figure 2. Graph representation for cleaning action.

Line empty box indicates an interval during cleaning, which at that period of the heat exchanger in the off condition and all the energy needs for the period was replaced with utilities from the outside. If viewed from the cleaning time based on the performance limit of the heat exchanger, one gets the following results, see Table 3.

TABLE 3. LIMIT OF THE PERFORMANCE HEAT EXCHANGER BEFORE BEING CLEANED.

Device No.	Q_{rec} (%)
1	87.32392
2	90.48379
3	89.41766
4	82.10674

CONCLUSION

From the results above, it can be concluded that the scheduling of the cleaning cycle of the heat exchangers is strongly influenced by the duration and frequency of cleaning. During the cleaning time, the utility needs to rise, proportionally with the needs of the energy to be recovered due to the operation of the exchanger.

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