# Economical Aspect of Heat Exchanger Cleaning Affected by Fouling

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***Abstract - Fouling is the accumulation of foulant in a heat exchanger. Fouling increases the pressure drop and energy loss. Losses due to fouling in the distillation unit for crude oil reached US $ 4.2-10 billion per year in the United State. Fouling couldn't be avoided, but it could be mitigation. One of the mitigation method is periodic cleaning of the heat exchanger. The time interval of a heat exchanger cleaning schedule is 1-36 months. Energy recovery, additional costs due to the performance of the pump and the cleaning cost are used as variables to determine saving. Results from this research showed that the heat exchanger is cleaned at 9 month is optimal cleaning schedule. Heat exchanger has savings about IDR 7.9 billion at 9 month. The amount is derived from the energy recovery about IDR 8.8 billion, reduced by a cleaning cost about IDR 0.2 billion and the advantage due to additional pumping cost about IDR 1.1 billion.***

***Index Terms - Cleaning schedule, fouling, heat exchanger, optimization.***

## INTRODUCTION

Heat exchanger is an equipment to minimize energy used. Heat exchanger usually use in a chemical process [1]. The main function of heat exchanger is recover heat from the product stream. Heat exchanger transfer of heat from hot fluid to cold fluid.

Fouling is the accumulation of deposit /foulant in a heat exchanger [2]. Fouling increases the pressure drop and decrease energy loss. The pressure drop occurs in the heat exchanger because fouling decrease flow area thereby increasing the additional cost of pumping [3]. Loss of energy derived from the heat transfer in the heat exchanger. The increase in fouling resistance will decrease the overall heat transfer coefficient thereby the heat transfer decreases. Losses due to fouling in the distillation unit for crude oil reached US $ 4.2-10 billion per year in the United State [4].

Fouling couldn't be avoided, but it could be mitigation. Therefore, effective mitigation techniques fouling is very important [3]. Fouling mitigation techniques include (i) the efficient design of heat exchanger, (ii) the addition of antifoulant chemicals and (iii) periodic cleaning of the heat exchanger.

Each fouling mitigation technique has its own drawbacks. Better design of heat exchangers such as improvements in the mechanical design by designing appropriate tube and baffle arrangement could reduce the effect of fouling [5]. Lawler estimates that the addition of heat transfer surface area of 30-40% will increase 25% the price of the equipment [5]. Installation costs for larger heat exchanger increase due to stronger foundation and more space area are needed. Additional heat transfers surface area increase installation costs. Installation cost for heat exchangers is estimated 2-3 times of purchasing cost [3].

Additional chemicals antifoulant increase operating costs. Application of this method has been successfully reported in the literature, the annual costs decrease because fouling has been reduced up to 50%, with consider of antifoulant cost [6]. Using antifoulant reduce performance of heat exchangers. Antifoulant chemicals corresponding very difficult to study [7].

Another alternative is clean heat exchanger periodically. Heat exchanger is cleaned when heat exchanger in fouled condition. Cleaning heat exchanger periodically is used to recover the thermal efficiency of the heat exchanger. Cleaning heat exchanger increase additional cost and may require to shut down the refinery which resulted in lost production. Cleaning heat exchanger rarely increase annual cost because it increase heat loss and increase pressure drop. Fouling in the refinery increase cost up to 5-10% from production capacity. On the other hand, higher cost will occur when the heat exchanger is cleaned frequently. Thereby, the appropriate cleaning heat exchanger is important to determine optimal cleaning interval for a heat exchanger [8].

## METHOD

In this paper, a heat exchanger cleaning schedule will be discussed. The time interval of a heat exchanger cleaning schedule is not more than 29 months [9]. Thereby, time interval that is used in this research is 1-3 years or 1-36 months. Energy recovery, additional costs due to the performance of the pump and the cleaning cost are used as variables to determine saving.

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## RESULTS AND DISCUSSION

The growth of fouling would be decrease energy recovery. Cleaning every 6 month is maximum energy recovery. Maximum energy recovery is about IDR 53.85 billion. Cleaning frequently not guarantee have big amount from energy recovery. It's only have energy recovery about IDR 47.57 billion if cleaning every month. Aside from cleaning every month, if heat exchanger clean rarely it could be minimum energy recovery. It's only have energy recovery about IDR 44.60 billion. Thereby cleaning every 6 month is the optimal amount from energy recovery point.

Fouling decrease diameter of inner tube. Cleaning every month is minimum pump cost. Minimum pump cost is about IDR 0.43 billion.

Cleaning frequently have big amount from pump cost. Aside from cleaning every month, if heat exchanger clean rarely it would be maximum pump cost because diameter inner tube would be decrease when heat exchanger clean rarely. Thereby cleaning every month is the optimal amount from pump cost point. Cleaning frequently increase cleaning cost. Cleaning every month is maximum cleaning cost. Maximum cleaning cost is about IDR 12.65 billion. Aside from cleaning every month, if heat exchanger clean rarely it would be minimum cleaning cost. Thereby cleaning every 36 month is the optimal amount from cleaning cost point.

Saving obtained from energy recovery, pump cost and cleaning cost. Maximum saving obtained from maximum energy recovery, minimum pump cost and minimum cleaning cost. Maximum saving is cleaning every 9 month.

Maximum saving is about IDR 7.95 billion. The amount obtained from the total energy recovery of heat exchanger in under clean schedule (*Energy Recovery* $_{cs}$ *- Cleanup Costs* $_{cs}$ *– Pump Cost* $_{cs}$) subtract the total energy recovery under fouled condition (*Energy Recovery* $_{fouled}$ *– Pump Cost* $_{fouled}$). Where the net energy recovery in under clean schedule is IDR 51.89 billion subtract total energy recovery under fouled condition is IDR 43.94 billion obtained saving IDR 7.95 billion.

## CONCLUSION

Results from this research showed that the heat exchanger is cleaned at 9 month is optimal cleaning schedule. Heat exchanger has savings about IDR 7.9 billion at 9 month. The amount is derived from energy recovery about IDR 8.8 billion, reduced by a cleaning cost about IDR 0.2 billion and the advantage due to additional pumping energy about IDR 1.1 billion.

## REFERENCES

[1] Á. Martín and F. a. Mato, "Hint: An educational software for heat exchanger network design with the pinch method," *Educ. Chem. Eng.*, vol. 3, no. 1, pp. 6–14, 2008.

[2] T. R. Bott, *Fouling of Heat Exchanger*, 26th ed. Amsterdam: Elsevier Ltd, 1995.

[3] F. Smaïli, V. S. Vassiliadis, and D. I. Wilson, "Mitigation of fouling in refinery heat exchanger networks by optimal management of cleaning," *Energy and Fuels*, vol. 15, no. 5, pp. 1038–1056, 2001.

[4] L. Wang, B. Sundén, and R. M. Manglik, *Plate Heat Exchangers: Design, applications and performance*, vol. 25, no. 3. Southampton, UK: WIT Press, 2007.

[5] D. Lawler, *Fouling of Crude Oil in Refinery Heat Exchangers*. UK, 1979.

[6] W. L. Van Nostrand, S. H. Leach, and J. L. Haluska, "Economic penalties associated with the fouling of refinery heat transfer equipment," *Fouling heat Transf. Equip.*, pp. 619–643, 1981.

[7] T. R. Biyanto, *Optimal cleaning schedule for crude pre heat train affected by fouling using genetic algorithm*. Bandar Seri Iskandar, Perak: Universiti Teknologi Petronas, 2013.

[8] S. Sanaye and B. Niroomand, "Simulation of heat exchanger network (HEN) and planning the optimum cleaning schedule," *Energy Convers. Manag.*, vol. 48, no. 5, pp. 1450–1461, 2007.

[9] T. R. Biyanto, S. W. Suganda, Y. Susatio, and H. Justiono, "Cleaning Schedule Optimization of Heat Exchanger Networks Using Particle Swarm Optimization," in *Applied Science for Technology Innovation*, 2014, no. August, pp. 13–14.