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Pinch Analysis of Process Plants Increase in Efficiency: A Review

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ABSTRACT

In ethyl benzene plant the heat exchanger network (HEN) is retrofitted by pinch analysis. In ethyl benzene plant ethyl benzene is produce by alkylation process of ethyl and benzene and it is used to produce styrene monomer. Current HEN is working efficiently but there is a possibility to improve the heat exchange in light removal columns. After analysis we get new HEN which better in performance than previous. Alternate HEN get by replacing Heat Exchangers and changing the operating condition. We can save energy. In replacement of new Heat exchangers the capital investment is necessary but the annual saving is enough to recover the cost within the year.

1. INTRODUCTION

In the petrochemical industry energy saving is the most important issue associated with cost, regulations, and social relationships. The petrochemical industry is a consuming much energy and it is more expensive to produce and its major portion lost in environment due to not proper integration of heat. Energy cost is affect on the total production cost of the product. So the Oil prices increases recently. And it is also harmful for environment to discharging of CO_2 in to the environment during the production of Energy, so the regulation requires reduction of energy use. This study uses pinch retrofit analysis to save energy in the ethyl benzene process.

2. PINCH ANALYSIS

Pinch analysis is a methodology for minimizing energy consumption of chemical processes by calculating thermodynamically feasible energy targets and achieving them by optimizing heat recovery systems, energy supply methods and process operating conditions. It is also known as process integration, heat integration, energy integration or pinch technology. [1]

3. METHODOLOGY

There is a various method for saving energy in chemical plant. Methods are optimization of operating condition and retrofit of a HEN.

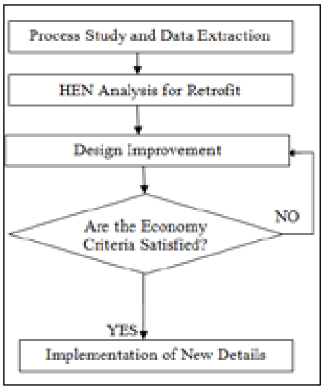

Fig. 1 Methodology of Pinch Retrofit Analysis

In retrofit pinch analysis the data extraction step is most important and also understand the process well. If this step is not carried out correctly than result is meaningless because necessary data are inlet and outlet temperatures and heat duties of process streams requiring energy transfer. By the data, it is possible to understand the current energy situation for each stream in the whole process. Heat energy has to be removed from hot streams and heat energy has to be supplied to cold streams. Energy recovery using the pinch method is achieved by matching the appropriate hot and cold streams. Heat capacity is used to calculate inlet and outlet temperatures of a heat exchanger. And then the heat exchange area is estimated using the temperature data and quantity of heat exchange. And other necessary data are information ON which utilities are available and where utilities are use. [2]

However a typical industrial process has some gap between the ideal and the current energy consumption. A composite curve is used to analyse the gap between the ideal and current HEN. If the current HEN does not achieve ideal energy consumption, the HEN is redesigned by the pinch design method at the design improvement step in Fig. 1. Details of the pinch design method are found in the work of Linnhoff et al. [3]

Then the economic analysis is followed. Retrofit of a HEN is a trade-off problem between the energy saving and the capital investment. If a new HEN suggested by the design improvement step satisfies given economic criteria, then the detail engineering step is followed. If the HEN does not satisfy the criteria, another new HEN design must be carried out in the design improvement step until HEN satisfying the criteria is found. ([2], [4], [5], [6], [7])

4. LITERATURE REVIEW

B.linhoff and E.Hindmarsh, 1983, presented the pinch design method for heat exchanger networks. The method is the first to combine sufficient simplicity to be used by hand with near certainty to identify "best" designs, even for large problems. "Best" designs feature the highest degree of energy recovery possible with a given number of capital items. Moreover, they feature network patterns required for good controllability, Plant layout, intrinsic safety, etc. The heuristic approach was developed for performing the pinch analysis for the process plants design. [8]

S. Ahmad, B. Linnhoff and R. Smith, 1990 presented a procedure for the design of near-optimum cost heat exchanger networks. The procedure is based on setting targets for capital and energy costs and optimizing these targets prior to design. The authors extends the model of capital cost to allow for: exploiting differences in heat transfer coefficients for reduced network area, a non-linear exchanger cost law, noncountercurrent heat exchangers, non-uniform materials of construction, pressure ratings and exchanger types in the network. Using these extensions both targeting and design for minimum capital cost are considered. This technique is particularly useful for identifying and screening the effects of different exchanger specification when locating neat optimal networks.([9], [10])

B. Linnhoff and A. R. Eastwood, 1997, at the University of Manchester highlighted the distillation between the application of process integration techniques-in particular pinch technology-within an individual process and their wider application in the overall site context. The "counterproductive" aspect of heat savings in the context of installed heat and power networks is given attention. In addition to energy, the article discusses yields, flexibility and capital cost savings. [11]

L. Matijasevae and H. Otmaeiae, in 2002, studied the heat exchanger network of a nitric acid plant. It was found that it is possible to reduce requirements for cooling water and medium pressure steam. In order to enable these savings, three heat exchangers should be replaced with new ones. Energy consumption in steam power system increases slightly. However, the final result is a reduction of energy costs and a payback time of 14.5 months. With the problem table algorithm, data were quickly extracted from the flow sheet and were analysed for energy saving. From the thermodynamic point of view the process requires only cooling utilities and does not need any heating utilities. This case study corresponds to that of a threshold case where only cold utility is needed. The nitrous gas stream is used for heat transfer with ammonia without any additional heating stream. The total number of exchangers is one less than in the original case and three of them had to be redesigned. [12]

Sung-Geun Yoon, Jeongseok Lee and Sunwon Park,2007, performed the heat integration analysis of an industrial ethyl benzene plant using pinch analysis. In this study, a heat exchanger network (HEN) for an industrial ethyl benzene plant is retrofitted by pinch analysis. In the ethyl benzene process, ethyl benzene is produced by alkylation of ethylene and benzene, and the whole product is used to produce styrene monomer. From the real operating data, a HEN of the ethyl benzene process is extracted. Analysis of the HEN reveals that the current process is operated efficiently, but there is a possibility to improve the heat exchange in light removal columns. After analysis, an alternative HEN is proposed to save the energy. The alternative HEN is achieved by adding a new heat exchanger and changing operating conditions. It reduces the annual energy cost by 5.6%. In order to achieve it, the capital investment is necessary but the annual cost saving will be enough to recover the cost in less than one year. [13]

Angel Martin and Fidel A. Mato, 2008, at the university of Valladolid Spain, presented educational software named HINT which can be used for the Pinch Analysis and Heat exchanger network design of the process plant. This suite is very user friendly and the same is used for the analysis in the present thesis. However the insights of the technology should be very well studied before one uses this software for the analysis purpose. [14]

PekkaRuohonen and PekkaAhtila2010 analysed the mechanical pulp and paper mill using the advanced composite curves. a mechanical pulp and paper mill is analysed using advanced composite curves. It is a graphical pinch-based approach that takes into account the existing heat exchanger network and the utilities actually used at the mill. The possibilities of making a cost-effective heat exchanger retrofit in an operating mechanical pulp and paper mill are discussed. This study also shows that the advanced composite curves can be used to describe the amount of no isothermal mixing taking place in the process. [15]

5. CONCLUSION

From the above related literature on pinch analysis of process plant analyse a current HEN and after analysis we get a new HEN which perform better than previous. We can save energy. In replacement of new Heat exchangers the capital investment is necessary but the annual saving is enough to recover the

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