CONTROLABILITY ANALYSIS ON DELTA TEMPERATURE MINIMUM TO OBTAIN OPERABLE AND FLEXIBLE HEAT EXCHANGER NETWORK

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INTRODUCTION

The requirement to synthesis heat exchanger network (HEN) is to select design target, which is temperature minimum difference (ΔT_{min}). The purpose of ΔT_{min} is to optimize between capital cost and energy recovery. Currently, research on ΔT_{min} effects on HEN is commonly associated with the design outcomes such as energy recovery and cost. There are several research studies on the effect of ΔT_{min} towards HEN design. An optimal ΔT_{min} for heat exchanger network is set between 5°C to 50°C, (Kemp, 2011). Jensen and Skogestad (2008) explained about specified ΔT_{min} effect on the wrong decision in the design of HEN. Abdullahi (2012) has studied the effect on ΔT_{min} contribution for individual process stream in the heat exchanger system. Basically, HEN synthesis method using ΔT_{min} focus more on design prospective. Not so many studies on the ΔT_{min} effect to the controllability part.
Based on a new trade-off plot proposed by Abu Bakar et al (2014), lower ΔT_{min} has better design criteria (higher energy recovery), however, higher in total cost and lower controllability criteria (higher flexibility and lower sensitivity). On the other hand, higher ΔT_{min} has lower design criteria, however, lower in total cost and higher in controllability criteria.
The objective of this paper is to describe the controllability effects on the delta temperature minimum (ΔT_{min}) in order to obtain an operable and flexible heat exchanger network (HEN) and provide proof based on the new trade-off plot. The controllability analyses used in this research are done in three sequential steps: 1) feasibility analysis, 2) flexibility analysis, and 3) sensitivity analysis. There are several designed of HENs with different ΔT_{min} from a single case that has been developed from HEAT MATRIX software, which include ΔT_{min} = 20°C, 25°C, 30°C, 35°C, 40°C, and 50°C. From the HEAT MATRIX results, cooling, heating and utility duties can be obtained. In the feasibility analysis, all the designs are tested using Aspen HYSYS in terms of design feasibility, whether the heat exchanger has a problem or not. If there is one of the heat exchanger has problem such as 'temperature cross' or 'ft correction factor is low' the design is not feasible and cannot be proceeded to the next step. In the flexibility analysis, the feed flowrate is increased until there is a heat exchanger has temperature crossed. The information of the highest

flowrate with a no temperature cross is taken as the flexible designs. Then the percentage increment was calculated. For the sensitivity analysis, the temperatures in the feed streams were increased by 1% and the changes in the value of temperature stream in the HEN is taken and calculated.

MAIN RESULTS

Table 1. Data needed for synthesis heat exchanger network.

Stream	Supply temp.	Target temp.	Heat capacity flowrate, FCp (kW/°C)	Enthalpy, ΔH (kW)
H1	300	160	3	-420
H2	230	120	7	-770
H3	160	60	2	-200
C1	40	230	2	380
C2	100	230	4	520
C3	230	300	3	210

Table 2. Feasibility, flexibility and controllability analyses results.

ΔT_{min}	20°C	25°C	30°C	35°C	40°C	50°C
Feasibility	-	-	-	ok	ok	ok
Flexibility (%)	-	-	-	51.552	53.355	60.15
Sensitivity	-	-	-	1.114	1.060	0.991

Conclusion

HEN design at ΔT_{min} = 35°C, 40°C and 50°C are feasible. It prove the proposed new trade-off plot HEN design with higher ΔT_{min} is more flexible however HEN design with lower ΔT_{min} is more sensitive.

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