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INTEGRATED PROCESS DESIGN AND CONTROL METHODOLOGY FOR HEAT EXCHANGER NETWORK

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EXTENDED ABSTRACT

This paper explains about methodology framework development for integrated process design and control (IPDC) of heat exchanger network (*HEN*). In most of the *IPDC HEN* problems, the feasible solutions to the problems may lie in a relatively small portion of the search space due to the large number of variables and constraints involved. The ability to solve such problems depends on the effectiveness of the method of solution in identifying and locating the feasible solutions. Hence, one approach to solve this *IPDC HEN* problem is to apply a decomposition method. The method starts with defining the IPDC HEN problems and formulated as a mathematical programming. The IPDC HEN problem is decomposed into four hierarchical sequential stages: (i) target selection, (ii) HEN design analysis, (iii) controllability analysis, and (iv) optimal selection and verification. This method simultaneously combines the solution for both process design and process control problem by selecting a manipulated variable that represent both process design and process control which is minimum allowable temperature difference, ΔT_{min}. The decision on selection ΔT_{min} are guided by a new propose Trade-off plot that combine process design criteria and steady state process control criteria. A simple case study are used to demonstrate the methodology framework. The result shows that HEN with large ΔT_{min} is more flexible and easy to operate.

Introduction: Most of *HENs* super targeting activities only considering a design cost as a major issue. In HEN control research, the analysis has been done after the HEN has created. As a result, the designed *HEN* may face controllability challenges because of the tight-fixed design and may lead to dynamic constraint violations and may not guarantee robust performance. If disturbances propagate severely through the process, the process may be extremely difficult to operate or even uncontrollable regardless of advanced of control techniques.

However, finding the optimal solution that satisfies design and control optimization problem is a challenge. While other optimization methods may or may not be able to find the optimal solution, depending on the performance of their search algorithms and computational demands. Therefore, this proposed methodology will use the reverse approach by decomposing the complex optimization problem into several sequential hierarchical sub-problems.

In decomposition-based approach, the constraint equations are solved in a pre-determined sequence such that after every sequential sub-problem. The search space for feasible solutions is reduced and a sub-set of design-manipulated and/or decision variables are fixed. When all the constraints are satisfied, it remains to calculate the objective function for all the identified feasible solutions to locate the optimal. The solution approach could be termed as identify-define target and then match the target.

Methodology: This paper presents a method use to solve IPDC HEN problem which is called flexible and operable heat exchanger network (*FNO HEN*) methodology. This method combines the solution of process design and process control simultaneously by selecting only one manipulated variable. The manipulated variable is the minimum allowable temperature difference ΔT_{min}. In the process design point of view, ΔT_{min} can determine the maximum energy recovery and cost, whereas in the process control point of view, the same ΔT_{min} can determine the steady state controllability. Specific *FNO HEN* problems are defined based on generic optimization problem. Then the problems are solved by decomposed into four several sequential hierarchical sub-problems: (i) target selection, (ii) *HEN* design analysis, (iii) controllability analysis, and (iv) optimal selection. The proposed methodology framework is presented in Figure 1. The advantage of using this method is it gives insight to design engineer to synthesis *FNO HEN* that applicable in real industries at early stage of HEN development. Solving the *FNO HEN* problem using decomposition-based methodology in which the optimal solution will help engineers to solve the *FNO HEN* problem.

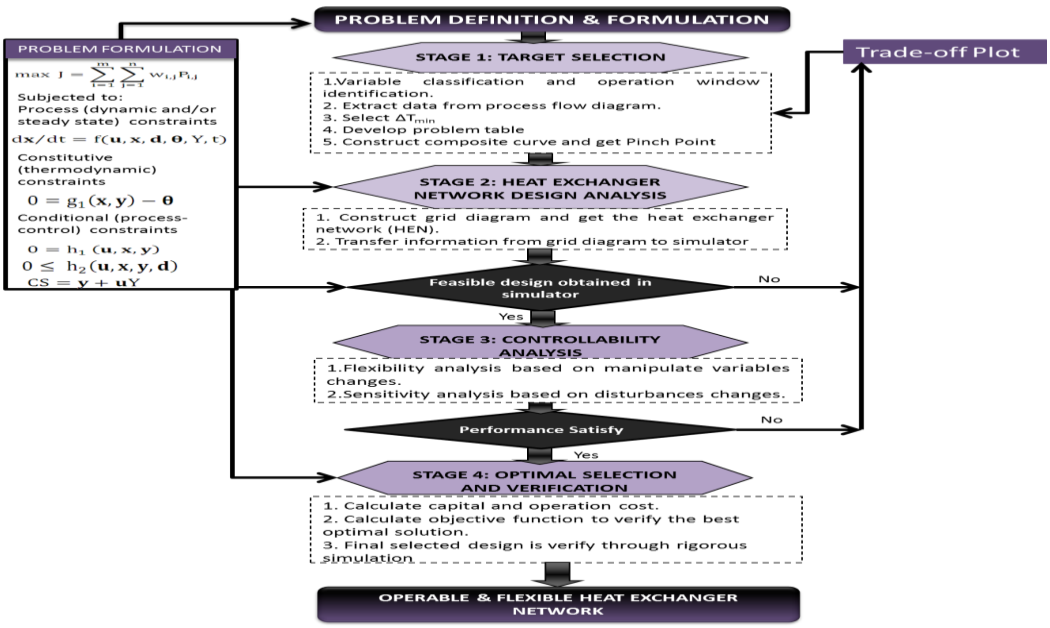

Figure 1: Methodology framework of flexible and operable heat exchanger network

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