Review on the PhD dissertation titled as

„Tools and Methods in Aiding Heat Exchanger Network Retrofit for Better Economic Performance"

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The dissertation presents techniques and tools applied for design of Heat-Exchanger Networks (HENSs). The topic has practical industrial importance, and high potential economical impact, that is why the research in the field is very active worldwide. Because of its complexity, HEN design requires computational aid.

The structure of the dissertation is easy to follow. At the beginning the research target is defined clearly in Chapter 2 after the review of the field and state of the art in Chapter 1. Chapters 3, 4, and 5 present the novel developments of the author. At the end, results are summarized and concluded in Chapters 6 and 7. The dissertation is written in English, the language meets the quality standards of the international scientific publications.

In Chapter 3 an optimization algorithm is proposed for the identification of an existing HEN in terms of temperatures and energy contents of the streams in the system. The identification is the first step of a retrofit design.

An optimization model is defined for the identification of temperature and heat capacity flow rates. Unfortunately, the heat transferred is the product of the temperature change and the heat capacity flow rate, yielding in a mathematical model involving numerous nonlinear terms. The aim of the identification problem is to minimize the difference between the measured and calculated values while resulting in a feasible mathematical representation. In agreement with the literature, the error of the estimation is measured by the sums of the squares of differences.

The candidate provides an algorithm for the error minimization, where the differences in temperatures and heat capacity flowrates are minimized through several iterations one after the other. While minimizing one, the other value is considered to be constant calculated as the result of the previous iteration. As the result of the novel formulation the constraints in the optimization become linear, nonlinearity appears in the objective function, thus model is easier and faster to solve. The iterations are stopped when sufficient accuracy is achieved, i.e., the differences between the measured and estimated values are practically small enough.

Question #1:

- Can the convergence of the algorithm be guaranteed, i.e., can it be guaranteed, that the differences between the measured and estimated values of t-s and cp-c decreases in each iteration, and the iterative algorithm will stop?

Chapter 4 proposes a graphical representation for HEN design, where heat capacities of hot and cold stream are also visible besides the potential heat exchanges according to temperatures. In addition to graphical representation a matrix form is given for easier computation.

According to my experience the proposed graphical SRTGD representation not only more informative, but much easier understandable than conventional grid diagram notations of heat paths. By the help of the proposed visualization, it is much easier to estimate how sufficient a hot stream – cold stream pairing is for potential heat exchange while minimizing utility need.

In latter part of the chapter a series of heuristic considerations are detailed for determining heat paths supported and visualized by the proposed representation. It is illustrated by multiple case studies that the additional visible information may lead to better engineering decisions and better overall HEN design.

Question #2:

- Can the presented steps of heat path design applying SRTGD be formulated as an algorithm in the form of a flowchart for example?

In Chapter 5 the above introduced tools are applied to a specific design problem, where not only the utility minimization is taken into account, but potential external utilization of waste heat is considered as well. As a result a more beneficial network design is presented for a case study known from the literature.

In my opinion Chapter 5 extends the problem to be solved itself by proposing a solution method for the extended problem as well. At least utilities with negative costs are introduces to HEN design. However, the method partly opens gates to integrated synthesis of process and heat-exchanger networks by providing options for producing hot water as a potential process product not required before.

As a summary I can say that the candidate demonstrated his research results and capabilities sufficient to get the PhD degree. I fully support the acceptance of achievements of the candidate as new scientific results, and propose to award the PhD degree.

Veszprem, January 18, 2019

Sincerely yours,

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