Prof. Janos Abonyi

Department of Process Engineering

Faculty of Engineering

University of Pannonia

janos@abonyilab.com

PhD Thesis Review

Applicant: **Andreja NEMET**

Supervisor: Prof. Dr. Jiří Klemeš DSc

Co-supervisor: Dr. Zdravko Kravanja

Title:

OPTIMISATION AND INTEGRATION OF RENEWABLE ENERGY

GENERATION AND MANAGEMENT OPTIONS

Veszprém, 09. 09. 2014.

Summary

Integration of solar thermal energy to process systems requires a specific approach to handle variations in energy supply and demand.

Andreja Nemet developed a *multi-period model* based integration strategy for this purpose. The proposed approach is similar to the idea applied to batch process integration (Kemp and Deakin, 1989). The utilized multi-period model involves a series of steady-state models. Within these time intervals (Time Slices) the heat integration can be performed in the same manner as for the continuous processes. A mixed integer linear programming (MILP) has been used for the piecewise constant approximation of the energy supply. The proposed methodology was validated in a case study taken from the literature.

Structure of the thesis

The PhD thesis is written in English and has 94 pages.

The thesis is well structured.

- Section 1 gives an excellent problem statement, defines the objective of the research, and presents the key idea of the methodology.
- In Section 2 the most common renewable energy sources and their properties are overviewed. This is an excellent overview, but it is not closely connected to the topic of the thesis.
- Section 3 presents an interesting approach for piecewise constant approximation of the nonlinear energy supply and demand. This session is based on the paper published in Energy 44 (2012) 29-37.
- Heat exchange related to the integration of solar thermal energy is not always feasible. A methodology how special conditions of energy transfer should be checked is presented in Section 4. This session is based on the paper published in Clean Techn Environ Policy (2012) 14:453–463.
- Session 5 presents detailed calculations of the temperatures and the cumulative heat gained from solar irradiation.
- Session 6 shows a details case study
- The applicability of the presented model in process monitoring is discussed on Session 7.
- The results are summarized in Section 9.

About the contribution – Questions and remarks

Although Section 2 gives an excellent overview of renewable energy sources, it is not related to the topic of the thesis. I think instead of this textbook-like material, a detailed analysis of the related literature of (online) modelling, optimization, scheduling and process integration should be presented.

The proposed MILP based linear approximation assumes that the whole profile of solar irradiation is known. I think this information is available only at the end of the day. I assume the variations of the supply in a cloudy day could be much higher than the differences between the actual and the approximated steady state values of a time slices.

Since the variance of the irradiation is higher than the approximation error, I think the application of MILP for the approximation of a univariate function is a kind of overengineering

It is stated that "the aim is to minimise the number of Time Slices, in order to simplify the computations in the following steps of the integration procedure."

One of the main contributions of the thesis is that it presents an extremely simple steady state model, so simple algebraic equations (implemented in an excel spreadsheet) are suitable for the calculation of the feasibility of energy integration. From this viewpoint, I do not see why the computational complexity is critical, why the number of time slices should be minimized. Please compare the computational complexity of the model and the MILP based optimization of the time slices.

The inlet and outlet temperatures from collectors and from storage are varying from one TSs to another. However, these temperatures have great importance during integration, therefore some assumptions were made in order to be able to determine those temperatures

(The outlet temperature of collector and the storage temperature after heat exchanges are determined based on a simple as described in following Chapters 5.1 and 5.2.)

Please discuss why not measured values are used.

Conclusion, about the theses

The theses can be regarded as original and important scientific contribution.

As a summary of my opinion, the PhD thesis of Andreja Nemet satisfies the conditions of the Doctoral School in Information Science and Technology, and can be the basis to achieve a PhD degree.