EVALUATION REPORT – DIPLOMA THESIS

Thesis title: Parameter Identification and Filter Design for a Repetitive Controller of Hot Rolling Mills

Author: Can Kutlu Yuksel

The objectives of the thesis originate from research activities performed within the project Centre of Applied Cybernetics 3 (CAK3), where the dynamics analysis and control design of rolling mills are being solved. In particular, the thesis solves two aspects of application of repetitive control concept in compensation of the roll eccentricity which has negative impact on surface quality of the steel plate. The first task of the thesis is to design an easy to apply algorithm for model parameter identification, which is then used in the applied internal model control scheme. The second task, which is the main task of the thesis, is to propose a filter to robustify the control scheme.

The thesis starts with a comprehensive state of the art section. Next to highlighting the problem at hand with thorough literature survey, general topics such as system identification, stability analysis and internal model control are discussed in relation to the thesis aims. The special attention is paid to relation of the repetitive and internal model schemes. Concerning the stability robustness, the Nyquist stability criterion and its application to systems with time delays is addressed in detail. Based on the state of the art analysis, the general tasks mentioned above are turned to three specific objectives.

The first objective is to develop an algorithm for model parameter identification, which is considered in the form of a first order system plus input time delay. It is solved by sweeping the delay length, shifting the data and applying the standard identification procedure to delay free ARMAX model part. The second objective is to propose a filter, which increases robustness of the internal model control (repetitive) scheme. After the robustness analysis of existing second order filter, a third order filter is proposed, which has minimal H-infinity norm. The robustness is thoroughly analysed for both the cases and provided in the form of gain and phase margins. Based on the robustness analysis and simulation results, a procedure for tuning the third order filter parameters is proposed, which is the third stated objective of the thesis.

The thesis is very carefully written on 97 pages. It includes 32 references correctly cited in the text. The thesis is well structured and written in excellent English. The thesis contains a large number of explanatory examples with a number of results presented in many figures (50 altogether). A very positive aspect of the thesis is relation to an engineering problem which is solved by applying theory of time delay systems. The thesis revealed for example the inefficiency of Nyquist stability criterion implementation in Matlab within the command *margin*, if applied to a time delay system. This opens potential for further research and subsequent publications. Once the proposed repetitive controller is finalized, it is likely to provide a wide potential for commercialization.

To conclude, the thesis is very well written and provides contributions to both time delay system theory and to applied control engineering. The author proved that he is able to work independently and has skills for both engineering and scientific work. All the objectives of the thesis were fulfilled. **I fully recommend the thesis for defence with a grade A - excellent**.

In Prague, June 18th , 2019

prof. Ing. Tomáš Vyhlídal, Ph.D.
Thesis supervisor
Department of Instrumentation and Control Engineering,
Faculty of Mechanical Engineering,
Czech Technical University in Prague