# Comparative analysis and implementation of selected new alternating current electric arc models

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## ABSTRACT

Electric arc furnaces (EAFs) are one of the largest and most disturbing loads found in electrical power systems. Their random and nonlinear nature can result in many power quality problems. Mitigating these problems involves the use of power quality improvement systems and the appropriate design of the power system itself. This, in turn, requires detailed knowledge of the furnace behavior and its influence on the electrical circuit. An accurate model can provide that kind of data.

The doctoral dissertation is focused on the development of new, more accurate models of the electric arc phenomena occurring in electric arc furnaces. The modeling process has especially been oriented to the melting stage of the EAF work cycle because of its worst impact on power quality, compared to other stages. The proposed models have been based on measurement data originating from three differently sized real furnaces: a large industrial furnace, a small industrial furnace, and a laboratory-sized self-designed furnace. The analysis carried out based on those datasets has confirmed that the proposed approaches can be successfully applied to installations with various rated powers.

The main part of the thesis is devoted to the actual development of the EAF models using different theoretical approaches. One of the primary goals was to create models capable of reflecting not only the deterministic component of the furnace behavior, but also its stochastic part. To do so, four concepts have been proposed: a model based on a random differential equation, a chaotic model, models using shallow and deep learning artificial neural networks, and a novel fractional order model. Both qualitative and quantitative evaluations presented in the text have shown that all proposed approaches can be effectively applied for EAF model development, significantly reducing errors between modeled and measured waveforms.

Another goal of the dissertation has been related to comparative analysis leading to the selection of a model suitable for implementation in the widely known EMTP-ATP simulation software. The comparison has highlighted the differences between the proposed approaches and evaluated their performance. In conclusion, the models varied in the precision of the stochastic component reflection, the computational power required, and the calculation time. Based on those criteria, a random differential equation model has been chosen and implemented in the EMTP-ATP software using built-in components and the programming language. The results of simulations conducted with the EMTP-ATP software indicate that the proposed model can be applied not only to reflect the single-phase arc but also to model a three-phase device.

An analysis contained in the doctoral dissertation yielded an overview of modern methods for simulation of the stochastic electric arc phenomena. Furthermore, it revealed potential paths for further studies related to the indicated limitations and the simplified assumptions used.