Modeling of transformer-rectifier sets for the energization of electrostatic precipitators using Modelica

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Abstract

Many industrial plants need to satisfy low and strict emission levels of pollutants in the emitted flue gases. One method to reduce the emission of solid pollutants suspended in gas streams is the use of electrostatic precipitators (ESPs). In ESPs, the particles of pollutants are electrically charged and pass through a strong electric field. The charged particles moving within the gas stream are thus deflected towards collecting plates, to which they stick. To create the ions that are required to charge the particles and to sustain the required strong electric field, high-voltage power supplies are required. ESPs are normally internally subdivided in electrically isolated sections which are independently energized and controlled. Different topologies of power supplies which can be used to energize ESPs exist. One of them, also the most traditional, is called transformer/rectifier (T/R) set. T/R sets can be single phase or three phase: because of the different output voltage they generate, their usage depends on the particular process of which the ESP is part. The basic diagram of a three-phase T/R set is shown as an example in Fig. 1. The aim of this paper is to model open-loop controlled, single- and three-phase T/R sets coupled to ESPs. After introducing the main components of single- and three-phase T/R sets, the Modelica models which have been built are described. The Modelica Standard Library and the OpenModelica Connection Editor (OMEdit) have been used to model both single- and three phase T/R sets. The availability of interfaces between different physical domains makes Modelica ideal for modeling multiphysical systems like ESPs. For this work, the following physical domains have been used: *electrical*, for the power electronics stage; *blocks*, for the open-loop control of the power electronics stage; *thermal*, for the calculation of the losses. The simulation results and field measurements are presented and compared. The models have been validated with measurements from existing plants and an example for three-phase T/R sets is given in Fig. 2. Further work will be required, like the derivation of the models of the ESP, of closed-loop controllers and of other topologies of power supplies. The derivation of a complete thermal model for these power supplies is planned.

Keywords: Modelica, power supply, electrostatic precipitator, ESP

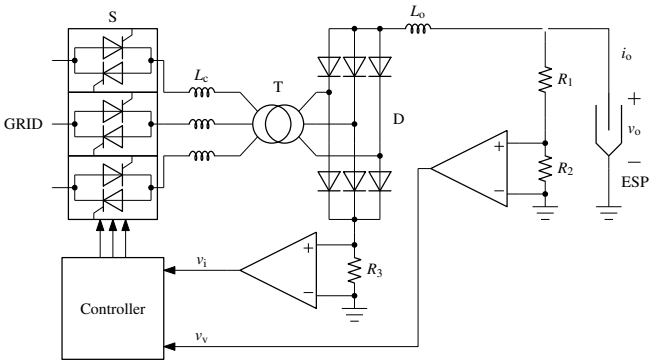

Figure 1. Schematic and block diagram of a three-phase T/R set connected to an electrostatic precipitator (ESP)

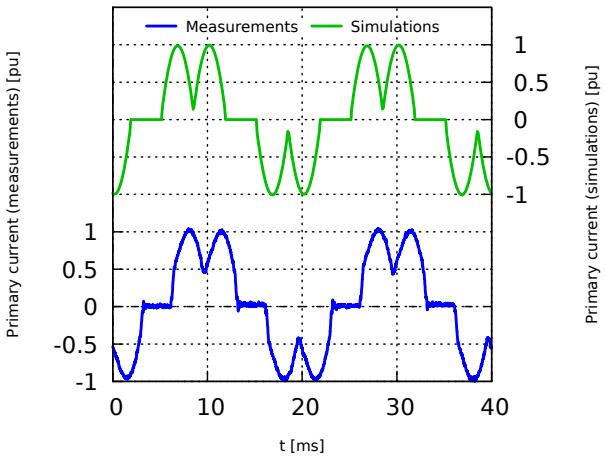

Figure 2. Measured and simulated normalized primary current for two different three-phase T/R sets