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Research Paper

Development and calibration of a model for the dynamic simulation of fans with induction motors

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HIGHLIGHTS

- A model for dynamic simulation of fans with induction motors was developed.
- The performances of control logics applied to air supply systems can be simulated.
- The model was validated against empirical data.
- The model was compared with both dynamic time domain and non-transient models.

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ABSTRACT

In this paper a model for the dynamic simulation of fans used in mechanical air supply systems is described. Thanks to this model, the behavior of fans subject to control by variable frequency drives (VFD) can be predicted, which includes power absorbed by the fan and expected ventilation rates. Hence, it can help design energy control systems for buildings. The proposed model was based on the Modelica language and was developed from the dynamic phasor domain representation, because this representation is a trade-off between the basic non transient representation, that is computationally efficient but cannot describe fan dynamics, and the dynamic time domain model, that is the most representative one but computationally very demanding. A comparison among these models showed that, within fan frequency variations typical of ventilation systems in buildings, the phasor domain model is as representative as the more complex dynamic time domain model in terms of prediction of the dynamic behavior, that is neglected by the basic non transient model. Moreover, the new phasor domain model was validated against measured data relative to a fan installed in a subway station in Barcelona. Thanks to this model, energy consumption of dynamically driven fans can be estimated at the simulation stage, at the expense of a reasonable computational effort.

1. Introduction

Due to the huge amount of energy consumption determined by buildings, HVAC renovation of the existing building stock can provide a rather high contribution to the overall energy saving. Renovation often consists in the partial replacement of aged components and in the definition of new control strategies. However, the design and development of advanced control strategies, whose performances are usually affected by several parameters, requires testing of alternative strategies, either in the field or through simulation, prior to implementation [7]. Indeed, the availability of reliable models would allow designers to compare and evaluate control strategies at the design phase. The models should be used first to establish the baseline and then to predict expected performances by candidate control strategies, as a result of enhanced regulation and control of HVAC, in order to select the best one. Moreover, simulation models should be used not only to select the best control strategy, but also to accurately estimate expected savings and include such figures in cost-benefit analyses.

Several reasons are produced in literature to stress the importance of user friendly simulators. First, designers should be allowed to easily change parameters and immediately evaluate results, as explained in Tomažič et al. [21]. Even Nagano et al. [15] showed at what extent user-friendly design and performance prediction tools can help in the execution of quick feasibility studies. Several authors highlighted that simulators should be able to carry out reliable simulations in short times, e.g. in Park and Krarti [16].

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