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A Tool Chain for Model-Based Development of Heat Pump Dryers

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Abstract

This work describes a tool chain structured and synchronised in the actual development process of environment friendly heat pump tumble dryers for a sustainable model-based systems engineering. The challenge, the benefit and the success of a hardware-in-the-loop (HiL) test bench is presented as an example to demonstrate the sustainability of the tool chain.

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Keywords: model-based development; heat pump; laundry dryers; object-oriented modelling of thermodynamic systems; hardware-in-the-loop

1. Introduction

The Miele company focuses on manufacturing domestic appliances for kitchen, laundry-care and for floor-care, as well as machines for use in commercial operations and medical facilities. This work shows the company's experience using advanced product development methods for the laundry-care products.

In the first steps during the development of innovative laundry dryers there is a variety of possible designs that might fulfill the product targets. The use of advanced product development methods as model-based systems engineering and the V-model [8] is strongly recommended in order to arrive at a sustainable decision regarding the best product concept in cooperation with partners.

In the last years the household laundry drying technology has changed dramatically. The product complexity has increased rapidly from vented dryer through to condenser dryer. The last using electrical heater or more recently a heat pump. The design of heat pump laundry dryers requires the knowledge of different disciplines such as refrigeration, process and control engineering. A reasonable way to bring these disciplines together and optimize the development process is by means of the multi-physics modelling of the product at an early stage of development. The approach described in this work uses an object-oriented multi-physics model library of the heat pump dryer to describe the laundry, the refrigeration and air cycle, see [5,6]. The transient model has also a simplified model of the controller.

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In this tool chain proposal, the mechanical design of the newly developed heat pump dryer is finished when the multi-physics modelling is ended. The synergy and knowledge gained in this development stage should be transported within the development process for design of the electronic components. There are nowadays several methods that use models for the design of electronics. These methods might be structured in a V-Model for development of mechatronic systems. However, the success of using these methods depends strongly on their integration into the product development process of each company. In this work, we propose a unique tool chain to use the methods of mechatronic product development coupled to the well established actual development process of heat pump laundry dryers.

2. Tool chain overview

Fig. 1 gives an overview of the tool chain proposed for the development of new tumble dryers. The product development flow from the marketing requirements until the series production is represented by the arrows on the top of Fig. 1. The mechanical domain (laundry dryer development) is represented on the left side while the electronic domain (electronics development) is shown on the right side of the picture. The techniques of model-based development (HiL, model-in-the-loop/MiL, rapid control prototyping/RCP) are included in the appropriate stage of the product development.

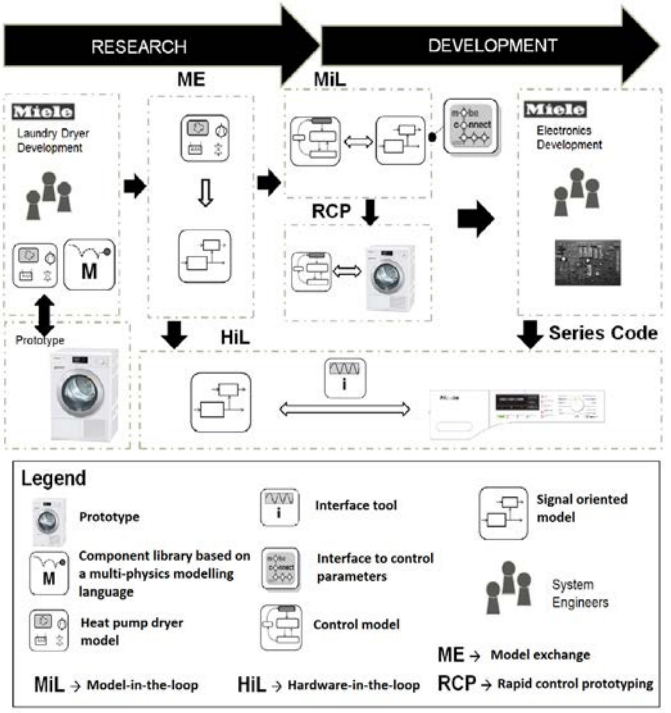

Fig. 1. A tool chain for the model-based development of heat pump dryers.

In the mechanical domain it has been observed that the use of a multi-physics modelling language (e.g. Modelica® /Dymola® [1]) and an object-oriented component library provides more flexibility regarding parametric and system structure change as well as faster results at an early stage of product development. These tools seem to be near to the reality and academic background of the engineers in this domain. This might be used to deliver feasibility and risk information of the heat pump dryer in an early stage of the product development.

[1] Modelica® is a registered trademark of the Modelica Association. Dymola ® is a registered trademark of Dassault Systèmes