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Port-Based Thermo-Fluid Models

Philippus J. Feenstra and Peter C. Breedveld
Drebbel Institute for Mechatronics & CE-lab, Faculty of Electrical Engineering
University of Twente,
P.O. Box 217, 7500 AE Enschede
The Netherlands
{p.j.feenstra, p.c.breedveld}@el.utwente.nl

1 Abstract

The port-based approach that can be represented by bond graphs or iconic diagrams optimally supports a multidomain-modeling context. This approach is for mechanical, hydraulic and electrical systems clearly described in the literature. However, thermal systems or in particular thermo-fluid systems can be described by various port-based approaches. Some of these approaches are discussed.

Two bond graph approaches are useful for modeling thermo-fluid systems in a simulation package (e.g. 20-sim). The pseudo bond approach (effort and flow are dynamically conjugated instead of power conjugated as in true powerbonds), by Karnopp et al [1] is easy to implement and therefore often used as its use of variables coincides with the common approach. However, it may lead to wrong results, e.g. in combination with transformers it becomes invalid. Breedveld's approach [2] provides insight and a more systematic way to model the convection process, unlike Karnopp's approach. (The term convection is used for energy transport by a moving fluid.) A drawback is that the engineer is not always acquainted with the conjugate power variables in this domain. Apart from the above-mentioned approaches, Brown's convection bond approach [3] is investigated; he proposes to use a convection bond in order to cancel the redundant information. The result of this new representation is a notation that differs significantly from conventional bond graphs and is not easily incorporated into most bond graph modeling environments. Finally, Shoureshi's approach [4] is examined for incompressible fluids, which does not correspond to thermodynamics and is simply incorrect. A major conclusion concerning the different approaches is that the three correct approaches can be transformed into each other, and give exactly the same results in the test case of an ideal gas with irreversible convection [5].

A second, but related topic is the causality assignment procedure of thermal elements. Causality assignment is necessary in order to get assignment statements in a form that is optimal for numerical simulation. The conventional causality assignment algorithms do not handle all assignments of thermal elements. A heat conduction- or RS-element has a particular causal constraint. A comparable situation occurs for a multiport C-element representing a single component system. An algorithm is discussed for the causality assignment of a heat-conduction RS-element and for the three-port C.

A model of a dual-sided air cylinder, see figure 1, will used as an example to illustrate the various approaches and representations.

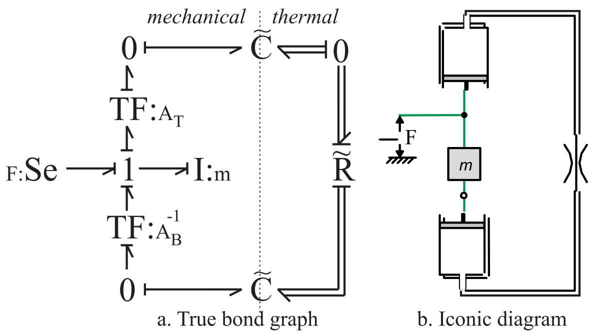

Figure 1: Dual sided air cylinder in two representations

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