

On the Formulation of Steady-State Initialization Problems in Object-Oriented Models of Closed Thermo-Hydraulic Systems

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The object-oriented formulation of steady-state initialization for models of closed thermo-hydraulic systems yields singular problems, due to system-wide structural issues. The first contribution of the paper, based on a formal analysis of the problem, is a modular, object-oriented solution, taking the form of an additional component that allows to uniquely determine the initial conditions of the system. The solution has been successfully tested in two application cases: a closed, supercritical CO₂ Brayton cycle plant, Fig. 1(a), and a refrigeration system, Fig. 1(b).

Such singular initialization systems can arise without the end user being aware of the problem (and of its solution). When the solver is started, the singular Jacobian of the initialization problem leads to numerical errors, whose diagnostic messages hardly convey any useful information to the user. The second contribution of the paper is a method based on the analysis of the null space of the Jacobian of the initialization problem and on suitable annotations, providing the end user with meaningful, high-level, context-relevant diagnostic messages in this case.

This diagnostic method can also be applied to other well-known cases of models with system-level singularities, such as closed systems with constant density fluid or electrical circuits lacking a ground connection.

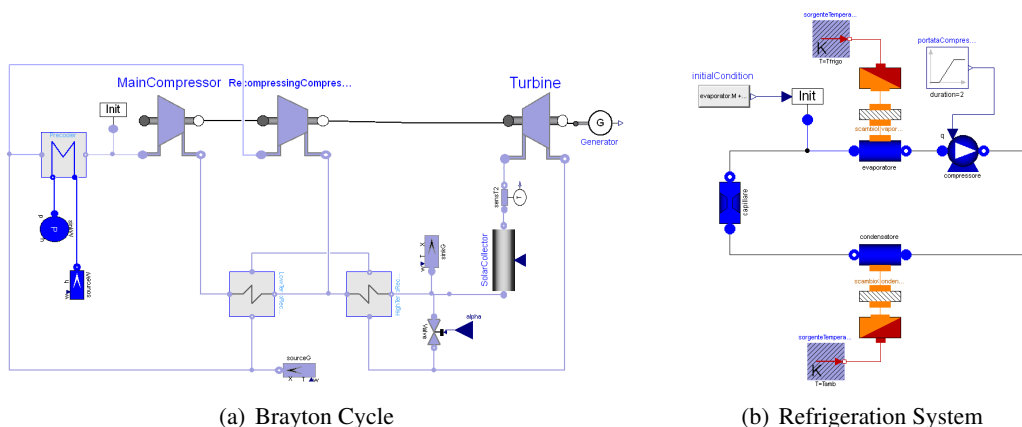


Figure 1: Example models