Mass Conserving Models of Vapor Compression Cycles

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Dynamic models of vapor compression cycles are becoming increasingly common due to their capabilities for system design, specification, and control. Because of the complexity of these models, their calibration to measured experimental data is an essential step in developing models that have predictive capabilities. One variable that can easily be compared between simulation and experiment is the the cycle's refrigerant mass inventory, or charge, which is usually known to a fairly high degree of precision and is constant over extended time intervals.

Unfortunately, many common model formulations for vapor compression cycles demonstrate significant variation in the total system charge that do not correspond to observed experimental behavior. Such variation can be seen in the output of a representative cycle simulation in Figure 1; in this simulation, the total cycle charge drops to 20% of its initial value due to numerical artifacts and errors. These variations in the total refrigerant inventory can be problematic because the dynamics associated with the variations in the cycle charge will be coupled to other system dynamics, causing erroneous system behavior.

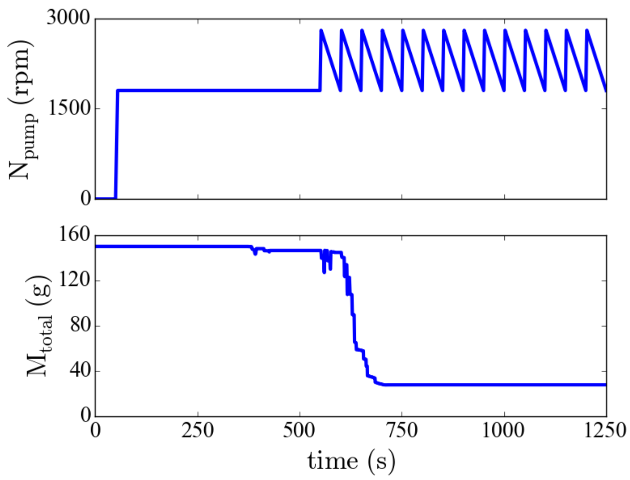

Figure 1. Observed variations in total cycle mass caused by numerical artifacts.

This paper presents an analysis of these models of vapor compression cycles to explain the causes of these variations in the system charge, as well as the development of alternative modeling approaches that eliminate this behavior and successfully conserve refrigerant mass in the cycle. An implementation of these alternative models in Modelica is also presented which demonstrates that these new modeling strategies are both effective at conserving refrigerant mass and are computationally efficient.