Start-up Optimization of a Combined Cycle Power Plant

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In the electricity market of today, with increasing demand for electricity production on short notice, the combined cycle power plant stands high regarding fast start-ups and efficiency. In this paper, it has been shown how the dynamic start-up procedure of a combined cycle power plant can be optimized using direct collocation methods, proposing a way to minimize the start-up time while maximizing the power production during start-up.

Physical models derived from first principles have been developed in Modelica specifically for optimization purposes, in that the models contain no discontinuities. Also, the models used for optimization are simpler than typical high-fidelity simulation models. Two different models used for optimization in four different start-up scenarios are presented in the paper.

A critically limiting factor during start-up is the stress of important components, e.g., the evaporator. In order to take this aspect into account, constraints on the stress levels of such components have been introduced in the optimization formulation. In particular, it is shown how a pressure dependent stress constraint, similar to what is used in actual operation, can be applied in optimization. Also, different assumptions about which control variables to optimize are explored.

Results are encouraging and show that energy production during start-up can be significantly increased by increasing the number of control inputs available to the optimizer, while maintaining desirable lifetime of critical components by introducing constrains on acceptable stress levels.
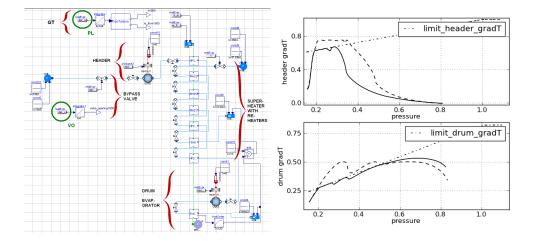
Figure 1: Left: a Modelica model for a combined cycle power plant optimized in the paper. Right: stress levels in a steam header and in the drum, respectively, constrained by constant bounds (dashed) and a pressure dependent constraint (solid).