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Introduction

Surge is an unstable operational mode of a compressor that can occur at low mass flows. The instability is characterized by a limit-cycle oscillation in mass flow and pressure rise that reduces compressor performance and efficiency. Surge can also endanger the safe operation of a compressor due to the large mechanical and thermal loads involved.

The final goal of this research is to develop a model-based surge control strategy to stabilize the compression system at low mass flows. For this purpose we developed a second order nonlinear dynamic model of the compression system, similar to the well-known *Greitzer* model. From previous work we concluded that the important stability parameter in this model cannot be defined uniquely from surge measurements. In this work we will apply a stability parameter identification method, developed to overcome the mentioned ambiguity, to a single stage industrial compressor test rig.

The experimental results show that the estimate for the model parameter of interest is highly inaccurate. In a subsequent sensitivity analysis it will be proven that there exists a limited set of model parameters that have a significant influence on the dynamic behavior of the investigated compression system.

Identification results

According to [1] the stability parameter can be determined from a linear time-invariant system that approximates the relevant dynamics of the actual system. The required LTI system is extracted from measured step response data, using a modified approximate realization algorithm.

Results from the realization algorithm for the measured step response of the experimental system are shown in Figure 1. This plot shows that the step response data can be described reasonable well by a first order LTI approximation, despite the relatively high influence of noise. However, because the parameterized model is of order two, and the identified is of order one, the stability parameter still cannot be determined uniquely.

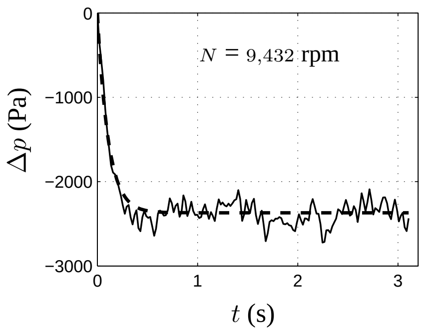

Figure 1: Measured step responses (-) and the step response of the corresponding approximated LTI model (- -).

Sensitivity analysis

Analyzing the pole locations of the linearized second order compressor model showed that one of the poles is highly dominant over the other, namely

$$\lambda_1 \approx -8$$
$$\lambda_2 \approx -870$$

This explains the fact that the step response measurements could be approximated by a first order LTI system. Through a sensitivity analysis we were able to show that the dominant dynamics of the system are only influenced by a limited set of model parameters. Therefore, the identification of the other model parameters from step response data virtually impossible, because we do not have the means to excite the high frequent dynamics.

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References

[1] Van Helvoirt, J., De Jager, B., Steinbuch, M., Smeulers, J. (2004), "Stability parameter identification for a centrifugal compression system", In Proc. 43rd IEEE Conf. on Decision and Control.