

Control of Compressor Surge in Systems with Uncertain Equilibrium States

Problem

Nonlinear systems with uncertain equilibrium states are difficult to stabilize.

Introduction

- Equilibrium states represent natural resting points of dynamic systems.
- Knowledge is essential for system analysis and control techniques.
- Case Study: Dynamic compression systems.
- Flow instability (surge) induced when operated near peak capacity.
- Causes violent vibration and high gas temperature, and can lead to extensive structural damage.
- Active surge control using Active Magnetic Bearings (AMBs).

System Definition

Plant:

Controller:

 $\delta \dot{x} = f_0(\delta x, u),$ $y = g_0(\delta x).$ $u = \phi(z),$ $\dot{z} = \eta(z, u, \tilde{y}).$ $\dot{p} = -Eu$.

Adaptation:

Stability Analysis (Singular Perturbation)

$$\begin{bmatrix} \delta \dot{x} \\ \dot{\tilde{z}} \\ \dot{\tilde{p}} \end{bmatrix} = \begin{bmatrix} f_0(\delta x, \phi(\dot{\tilde{z}})) \\ \zeta(\tilde{z}, p) \\ -\varepsilon E \phi(\delta x + \tilde{z}) \end{bmatrix},$$

 $\dot{p} = -\varepsilon EK(A + BK)^{-1}A(A$

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Goal

Design controller to stabilize system at true equilibrium.



$$(+LC)^{-1}Lp.$$



Conclusion

An observer-based output feedback controller with adaptation mechanism is proposed and analyzed using singular perturbation analysis. This is implemented on the model of the centrifugal compressor and an improvement in control is observed when the adaptation mechanism is included as opposed to having the output feedback controller alone.