Abstract

In this dissertation a model identification adaptive state space controller for a rigid rotor suspended in active magnetic bearings is developed and tested by means of simulation.

An experimental setup used for testing of adaptive control algorithms in conjunction with non-conservative cross-coupling effects is the starting point for the modelling process. A comprehensive nonlinear model of the entire plant including a rigid rotor, position and current sensors, analogue to digital converters, digital signal processor, digital to analogue converters, switching power amplifiers with pulse width modulators and magnetic actuators is established for simulation purposes. An internal current control loop is designed for the point of operation in order to reduce the order of the state space model. Using this simplification a linear continuous time model is derived from the nonlinear model and transformed into the discrete time domain.

The core objective is the design of a model identification adaptive controller performing under on-line conditions. A discrete time state space innovations model in controller canonical form is used by an adaptation algorithm incorporating the recursive prediction error method to estimate all entries of the system matrices, the Kalman filter matrix and all states. To provide numerical stability, a special implementation of this algorithm is introduced. In addition, an effective algorithm is proposed to detect system parameter changes. Based upon the identified linear model a state controller with or without additional integrative feedback is calculated.

Simulation results of the closed loop system consisting of the nonlinear plant model and the proposed algorithm show the successful operation of the entire control concept. The current control loop provides the necessary bandwidth to cover the frequency band of the position control loop using the state space controller. The operation of the latter loop is investigated by both step responses and reactions to additional disturbances.

Simulation runs prove that the model identification adaptive controller can cope with changes in system parameters. In the present case the sudden appearance of non-conservative cross-coupling forces, as generated by seals, for example, is assumed to change the parameters of the system.