THE PARAMETRIC PREDICTIVE CONTROL ALGORITHM IN THE MAGNETIC SUPPORT SYSTEM OF A HIGH-SPEED MACHINE

P. Kurnyta-Mazurek[1], T. Szolc[2], M. Henzel[1] and K. Falkowski[1]

[1]*Faculty of Mechatronics, Armament and Aerospace, Military University of Technology, 00-908, Warsaw, Poland*
[2]*Institute of Fundamental Technological Research, Polish Academy of Science, Warsaw, 02-106, Poland*

e-mail: paulina.mazurek@wat.edu.pl, tszolc@ippt.pan.pl, maciej.henzel@wat.edu.pl, krzysztof.falkowski@wat.edu.pl

Abstract

In recent years, magnetic bearing technology has been implemented in many practical applications. In comparison with mechanical bearings, the magnetic ones have decreased stiffness coefficients and increased damping coefficients of radial bearings reducing the critical rotor speeds, [1]. These features are given the magnetic bearings a considerable potential to become a key element in rotating machines, like jet engines, turbo-compressors, generators and many others, [2]. Active magnetic bearings allow precise control of a rotor position and enable "online" monitoring, diagnosing, and identifying high-speed machines, [3].

The magnetic bearings are structurally unstable. Namely, an effective control system with a proper controller ought to be designed to ensure defined control quality indicators. In general, control systems of magnetic bearings are mostly restricted for using proportional-integral-derivative (PID) controllers. However, robust and slide control methods are also used in similar systems, [4]. Some predictive control algorithms were implemented in the analyzed AMB control loop [1].

The paper presents the research results of a parametric predictive control algorithm implemented in a high-speed rotor machine's magnetic bearing support system. The theoretical and experimental analyses of the control system with the Extended Horizon Adaptive Control (EHAC) algorithm are presented using an AutoRegressive with eXogenous input (ARX) model. A laboratory model of the magnetic suspension system consists of two active radial magnetic bearings and one axial (thrust) active magnetic bearing. The levitated rotor displacement in air-gaps and control current signals in control loops were measured for various rotor speeds and several parameters of the control algorithm, and they were presented in the form of time histories. Moreover, the power consumption of the magnetic bearing system with the predictive control algorithms was analysed, and the influence of a tuning factor and control horizon on rotor dynamic properties were determined. The theoretical studies were carried out using Matlab and Simulink software, whereas the experimental studies were performed using an appropriately dedicated test rig.

References

[1] Kurnyta-Mazurek P., Szolc T., Henzel M., Falkowski K.: „Control system with nonparametric predictive algorithm for the high-speed rotating machine with magnetic bearings", *Bulletin of the Polish Academy of Sciences: Technical Science*, 2021

[2] Brusa: "Semi-active and active magnetic stabilisation of supercritical rotor dynamics by contra-rotating damping", *Mechatronics* 24, 2014, pp. 500–510, //doi.org/10.1016/j.mechatronics.2014.06.001.

[3] R. Siva Srinivas, R. Tiwari, Ch. Kannababu: "Application of active magnetic bearings in flexible rotordynamic systems – A state-of-the-art review", *Mechanical Systems and Signal Processing*, 106, 2018, pp. 537-572

[4] A. Tonoli, A. Bonfitto, M. Silvagni, and L. D. Suarez, "Rotors on Active Magnetic Bearings: Modeling and Control Techniques", in Advances in Vibration Engineering and Structural Dynamics. London, United Kingdom: IntechOpen, 2012 [Online]. Available: https://www.intechopen.com/chapters/41670 doi: 10.5772/51298

INSTITUTE OF FUNDAMENTAL TECHNOLOGICAL RESEARCH
AND COMMITTEE ON MECHANICS
POLISH ACADEMY OF SCIENCES

7th European Conference on Structural Control

Book of Abstracts and Selected Papers

Editors:
Jan Holnicki-Szulc, David Wagg and Łukasz Jankowski

Co-editors:
Bartłomiej Błachowski and Piotr Tauzowski

since 1993 EACS

WARSAW 2022