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Improving the sensory capabilities of an electromagnetic guided rotary table for the use in machine tools

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Abstract

Difficult-to-machine materials are still challenging the production industry. Examples are highly complex components of aircraft engines. Alongside innovative processes, also improved machine tool components are helping to comply with the demands of this task.
This paper presents a swivel rotary table with an active magnetic bearing (AMB). Opportunities in machining through employing a workpiece-sided AMB are presented. The inherent capabilities to work as a sensor and actor as well as its stiffness and damping depend on the precise knowledge of the magnets characteristics. Therefore, a methodology to automatically identify the characteristic curve is presented.

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Keywords: active magnetic bearing; AMB; swivel rotary table; machine tool

1. Introduction

Active magnetic bearings (AMB) are a growing technology for coping with high demands in industrial challenges. Due to the fact that magnetic bearings neither have any mechanical friction nor need lubrication, they can be used in high speed and hazardous environments. There are no risks of inflammation. Furthermore, damping and stiffness can be adjusted to the needs. An impressive example for the use of this technology are modern gas turbines made by the company Siemens [1]. Rotors of multiple tones are magnetically guided in 5 degrees of freedom (DOF) during their use. The safe properties reduce the risk of inflaming the gas and raise the turbines efficiency.

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Moreover, AMBs can be used in a variety of applications such as the well-known magnetically levitating train "Transrapid" or in production environments e.g. machine tools. Examples for linear magnetic guides in machine tools are the machine prototypes "Schnelle Maschine" and "Neximo" ([2], [3]). Both guides are implemented in the z-axis. A stand-alone rotary table is presented in [4] and a swivel rotary table for machine tools is presented in [5]. The last mentioned prototype of a swivel rotary table is further presented in this paper.

Nomenclature

δ_A	levitating rotor displacement at the magnets (vector)
δs	measured rotor displacement at the sensors (vector)
F_A	magnet force vector
J_A	Jacobian matrix to transform the generalized pose to δ_A
Js	Jacobian matrix to transform the generalized pose to δs
M	mass matrix of levitating rotor
q	generalized pose
Q	generalized forces

2. The magnetic guided swivel rotary table

To machine complex parts with high demands on form and accuracy 5-axis machine tools are used. Beside the three standard linear axis (x, y and z) a rotary motion for turning and a swivel motion for tilting are used. These two motions are implemented into swivel rotary tables. Common swivel rotary tables rely on YRT roller bearings. By interchanging them with an AMB the performance and usability can be extended. Especially, higher rotating speeds and adjustable damping and stiffness are beneficial. Complex vibration prone machining parts, for example aircraft components, can achieve a higher precision due to the controlled damping. In [6] the shifting stability lobes due to the changing eigenfrequency are shown for a milling process while re-contouring a blisk.

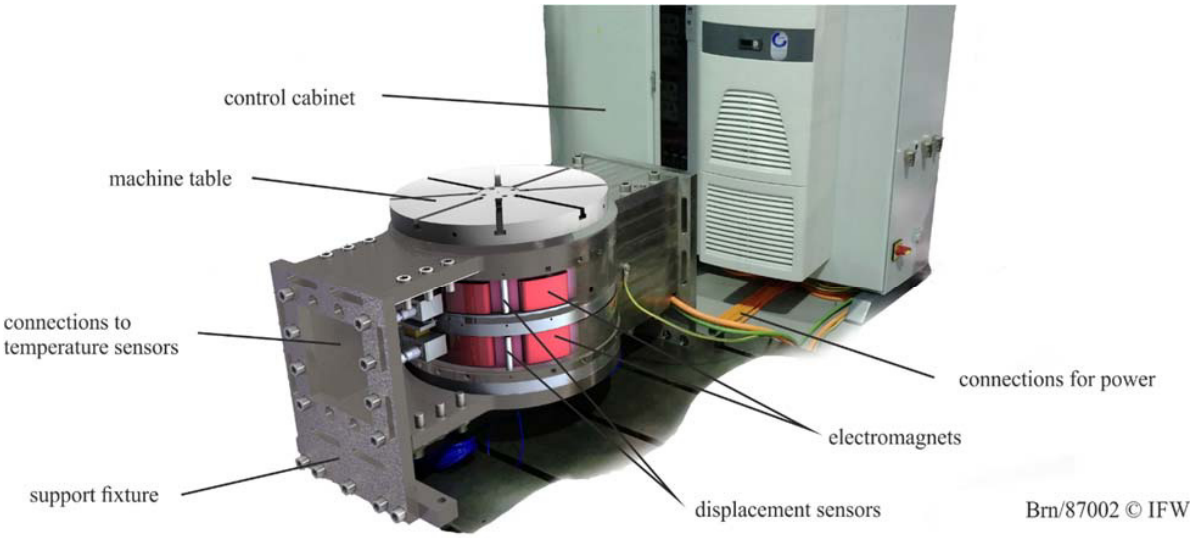

Fig. 1. Picture of the magnetic guided swivel rotary table with CAD overlay.