

# Robust Active Vibration Control of Flexible Rotors Using Piezo Actuators as Active Bearing

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## ABSTRACT

Bending vibrations of a rotor can generally lead to large mechanical loads of the structure. Sometimes passive damping does not have a large effect, so the improvement of the dynamic behavior of the rotating machines by means of active elements was investigated. This paper focuses on the active vibration control of flexible rotors by piezo actuators located at the bearings. The aim of our work is to provide a methodology of active vibration control of rotor-dynamic systems for industrial usage.

Because the practical questions arising with the application of active vibration control are if the efficiency of actuators is sufficient and if adequate amplitudes can be generated, at first general relations are derived, that allow to specify the required power and dimensions of the piezo actuators from the balance quality factor of the rotor and the stiffness of the system. The piezo actuator is compared with other actuators and its advantages are enumerated.

Secondly, two control concepts, integral force feedback and robust control, are presented. For the integral force feedback controller the active bearing consists of a linear piezoelectric actuator collocated with a force sensor in each plane. The support works like a decentralized active bearing with local controllers connecting each actuator to its collocated force sensor. The controller synthesis requires a model in state space representation, which describes the relationship between the controlled and the manipulated variable. The robust controller synthesis requires also the uncertainty modelling and shaping of weighting functions to obtain an implementable and well-performing controller. The design procedure of the robust  $\mu$ -synthesis controller including uncertainty modelling and selection of weighting functions is roughly described. Unlike other control concepts, the robust controller only requires a single displacement sensor per plane. Following, both control concepts, integral force feedback and robust control, are compared.

Finally, the implementation and technical feasibility of the described methods is presented. The experimental results obtained from a simple test rig show that the  $\mu$ -synthesis enables a practical application of the theoretically developed controller to the real plant without loss of performance.