PIEZO ACTUATORS FOR VIBRATION REDUCTION OF AERO ENGINE ROTORS – CASE STUDY

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ABSTRACT

Rotor vibrations of aero engines are mainly driven by imbalances or failure cases. Often additional damping devices like squeeze film dampers (SFD) were used to reduce the vibration level. SFD are working quite well in aero engines but they need a cost intensive oil supply and show a strong non-linear behavior. The current SFD theory and the related simulations correlate well with test results. But those models are too complex to be usable in whole engine analyses, which are needed for an overall vibration prediction of the engine. In the light of future "More Electric Engine" (MEE) concepts active vibration control devices came into consideration to be a long-term alternative to the SFD. An improvement in vibration reduction and the possible use for machine diagnosis during flight are the expected benefits of active control devices like piezo actuators.

Therefore a case study has been performed to see whether piezo-actuators are appropriate to replace the SFD. The piezo actuators are part of a closed loop control in order to achieve active vibration reduction. The control concept is integral force feedback; i. e. force sensors are connected in series to the actuator. This well-known and comparably simple concept guarantees robust performance and robust stability being essential for a varying structure like an aero engine.

The scope of the paper is to point out that state of the art piezo actuators principally meet the requirements of the aero engine. The dominant excitation force is the unbalance of the rotor. Since the main restrictions are size and weight, it can be proven that the diameter and length of the actuators are in the range of 50 mm and 60 mm respectively. Such actuators can be integrated in the aero engine. The required maximum power is in the range of one kilowatt, which today's high-voltage power amplifiers are able to supply.

The conclusion is that piezo-actuators meet the requirements very well from the control, size and power requirement point of view. Open problems like the thermal behaviour, fail-safe, necessary cooling, rotor damage leading to high unbalances, and the integration of small size power amplifiers are discussed and shall be further investigated in future work.

Keywords: aero engine, vibration reduction, piezo actuator, active vibration control, squeeze film dampers, rotor dynamics