Adaptive rotor systems with piezoelectric actuation

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Introduction

High speed rotating machines can be supplied with unbalance compensation, stabilization & excitation functions by adding piezoelectric fiber actuators or ultrasonic motors with accompanying control & identification algorithms. The resulting adaptive rotor systems are complex but can be modelled by taking advantage of e.g. energy conservation principles, spatiotemporal periodicity and weak coupling between subsystems & physical subdomains. Experimental work is required to investigate the full system dynamics without tedious simulation.

Objective

The aim is to gain insight in model-based monitoring & control of weakly actuated rotor dynamic systems.

Methods

'Functional complexity' of engineering systems is related to the uncertainties which complicate the achievement of functional requirements. Sources of uncertainty in rotating machinery are damping, unbalance, misalignment, bearing properties and component degradation. 'Artificial intelligence' methods are able to succeed in spite of uncertainty. Such methods can be passive, e.g., methods which combine algorithms for discernment, classification & memorization of measurement data features, or active, e.g. methods which use planned diagnostic tests to improve the convergence speed of model & fault identification (see Fig.1a). For example, an active balancing device may be used to apply a large oriented excitation for identification purposes.

Results

A rotor dynamics code for general asymmetric rotor systems with sensors, actuators and controllers was developed in Matlab (Fig.1b). An experimental setup with piezoelectric actuators was built (Fig.1c). Submodels for high voltage generation and power harvesting were simulated and tested. Currently, submodels and components are being integrated and cosimulation of nonlinear electromechanical models is being considered. Further research will focus mainly on extending the current models by nonlinear models of hysteresis, supports, bearings and failure.

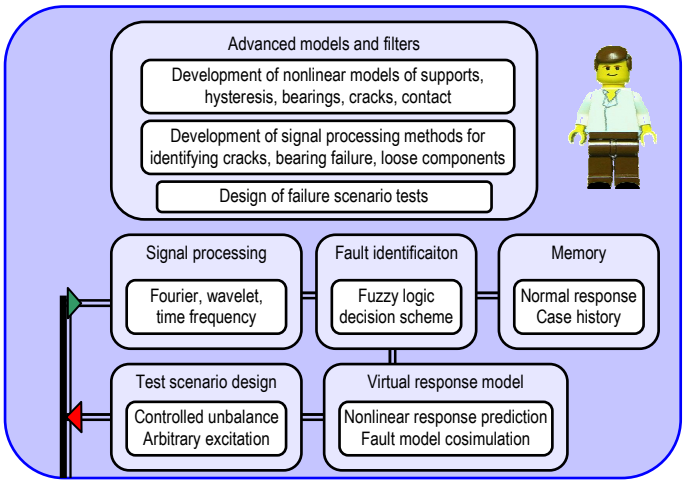

Fig.1a) Advanced models and fault identification

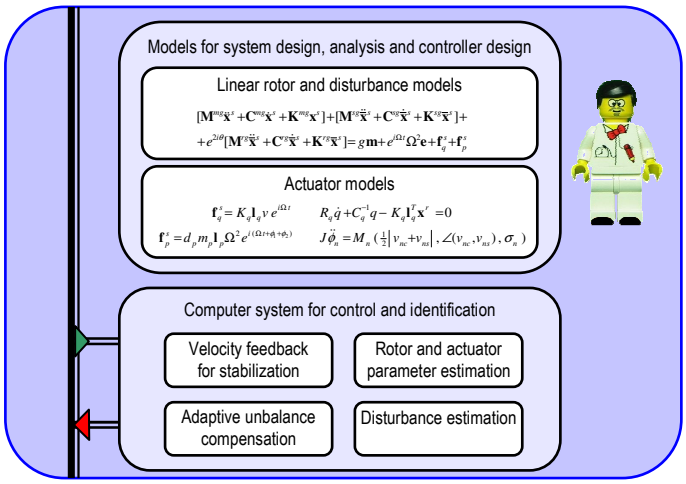

Fig.1b) Basic models and control algorithms

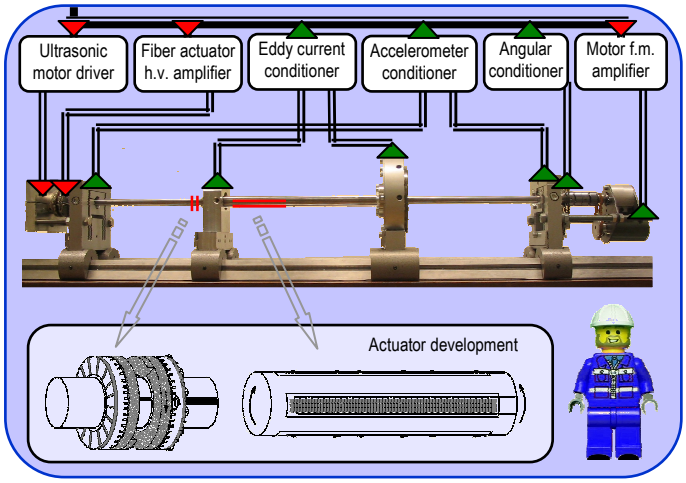

Fig.1c) Rotor dynamics setup with actuators