Stability Control of Driveline System with Internal Damping and Non-Constant Velocity Couplings

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Abstract

Many researchers and engineers have employed Active Magnetic Bearings (AMB) to eliminate frictional wear and to actively suppress vibration in various sub- and supercritical rotordynamic applications. Specifically, in addition to providing stable levitation, active control laws have been developed to suppress shaft imbalance vibration as well as provide isolation from foundation disturbances. However, one issue that has not yet been addressed in previous AMB-driveline control studies is the effect of non-constant velocity (NCV) flexible couplings, e.g. U-Joint or disk-type couplings, present in many drivelines. Previous research on supercritical drivelines has shown that both the ratio of internal to external shaft damping and the NCV effects greatly impact stability. The NCV effects, which are represented by periodic parametric and forcing terms, are functions of the driveline misalignment and load-torque. Specifically, it was found that misalignment and load-torque have both stabilizing and destabilizing effects at certain shaft speeds. Therefore, in order to ensure closed-loop stability of any AMB-driveline system involving NCV couplings, the NCV terms must be accounted for in the control law design. In this paper, the closed-loop stability of a flexible segmented driveline connected by NCV coupling and supported on AMBs with PD control is investigated. For a range of shaft speeds and for various sets of controller P and D gains, the stability effects of internal damping, driveline misalignment, and load-torque are investigated. Finally, using results from the stability analysis, a methodology for designing a PD controller that is robustly stable to internal damping and NCV effects is demonstrated.