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Zero Clearance Auxiliary Bearings for Magnetic Bearing Systems

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Abstract

Active magnetic bearings (AMBs) while offering many unique design and operational opportunities for advanced rotor systems, require some form of backup or auxiliary bearing in the event of a component failure or the onset of high transient loads. A zero clearance auxiliary bearing (ZCAB) has recently been conceived and a prototype system tested. The ZCAB presented in this paper uses a series of interconnected rollers to surround a shaft. In the open position, a clearance exists between the ZCAB rollers and the shaft. When the shaft drops on the ZCAB due to either an AMB failure or transient shock, the rollers move circumferentially and radially inward to eliminate the clearance and re-center the shaft. Besides centering the shaft, the low shaft-to-ZCAB traction coefficient and composite support dynamic characteristics eliminate the possibility of backward whirl. This paper presents the design methodology used, results of an analytical design study, including time transient analysis, as well as preliminary feasibility prototype testing under simulated AMB failure and transient shock conditions. The test rotor was supported by a rolling element bearing at one end and an integrated magnetic bearing/ ZCAB support system at the other end. Both rotor drop and shock tests were performed with this configuration. Experimental results under simulated AMB failure and transient shock conditions

demonstrated successful operation of the ZCAB.

NOMENCLATURE

X	Rotor displacement	d_r	Roller outside diameter
a	Shock acceleration	K_{assy}	Stiffness of roller assembly
ω_n	ZCAB natural frequency	K_{hzt}	Contact stiffness between shaft and roller
ξ	Damping ratio	K_b	Ball bearing stiffness
t	Time	K_s	Bending stiffness of roller stud shaft
ω_d	ZCAB damped frequency	K_{hzz}	Contact stiffness between stud shaft and support plates
ϕ	$\cos^{-1} \delta$	K_{zcab}	ZCAB dynamic stiffness
t_o	Free fall time	F_b	ZCAB reaction force
h	Radial clearance	X_b	ZCAB displacement
K	ZCAB stiffness	K_r	Total stiffness of loaded rollers
M	Rotor mass	K_z	Resilient mount stiffness coefficient
C	ZCAB damping	C_z	Resilient mount damping coefficient
F_{roller}	Shock force on a ZCAB roller	j	$\sqrt{-1}$
F_{max}	Maximum shock force	M_z	ZCAB mass
d_b	Ball bearing bore		