THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
345 E. 47th St., New York, N.Y. 10017

97-GT-112

Zero Clearance Auxiliary Bearings for Magnetic Bearing Systems

H. Ming Chen, James Walton, Hooshang Heshmat

Mohawk Innovative Technology, Inc
1059 Belridge Road
Niskayuna, New York

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
a	Shock acceleration
ω_n	ZCAB natural frequency
ξ	Damping ratio
t	Time
$_d$	ZCAB damped frequency
ϕ	$\text{Cos}^{-1}\,\delta$
t_o	Free fall time
h	Radial clearance
K	ZCAB stiffness
M	Rotor mass
C	ZCAB damping
F_{roller}	Shock force on a ZCAB roller
F_{max}	Maximum shock force
d_b	Ball bearing bore
d_r	Roller outside diameter
K_{assy}	Stiffness of roller assembly
K_{hz1}	Contact stiffness between shaft and roller
K_b	Ball bearing stiffness
K_s	Bending stiffness of roller stud shaft
K_{hz2}	Contact stiffness between stud shaft and support plates
K_{zcab}	ZCAB dynamic stiffness
F_b	ZCAB reaction force
X_b	ZCAB displacement
K_r	Total stiffness of loaded rollers
K_z	Resilient mount stiffness coefficient
C_z	Resilient mount damping coefficient
j	$\sqrt{-1}$
M_z	ZCAB mass

Presented at the International Gas Turbine & Aeroengine Congress & Exhibition
Orlando, Florida — June 2–June 5, 1997