Dynamic Stiffness and Damping Characteristics of a High-Temperature Air Foil Journal Bearing

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Abstract

Using a high-temperature optically based displacement measurement system, a foil air bearing's stiffness and damping characteristics were experimentally determined. Results were obtained over a range of modified Sommerfeld Number from 1.5E6 to 1.5E7, and at temperatures from 25 to 538 °C.

An Experimental procedure was developed comparing the error in two curve fitting functions to reveal different modes of physical behavior throughout the operating domain. The maximum change in dimensionless stiffness was 3.0E-2 to 6.5E-2 over the Sommerfeld Number range tested. Stiffness decreased with temperature by as much as a factor of two from 25 to 538°C. Dimensionless damping was a stronger function of Sommerfeld Number ranging from 20 to 300. The temperature effect on damping being more qualitative, showed the damping mechanism shifted from viscous type damping to frictional type as temperature increased.

Keywords

Fluid Film Compliant Bearings; Foil Bearings; Gas Bearings; Turbomachinery

Nomenclature

C	radial clearance
D	general damping coefficient
D'	Dimensionless damping coefficient: $D'\Omega R/(W\mu_f(T))$
E(T)	modulus of elasticity, a function of temperature
g	gravity
L	bearing length
K	stiffness
K'	dimensionless stiffness: $K' = KC/P_aR^2$
κ	dimensionless stiffness: $\kappa = K/E(T)t$
m	mass of the foil
M	mass of the bearing and holder
n	number of data points
N	speed in radians per second
P	load per unit area: $P = W/2RL$
P_a	ambient pressure
R	journal radius
S	Sommerfeld Number; $S = \mu N/P(R/C)^2$
S'	modified Sommerfeld Number or bearing number: $S' = W/(\mu(T)RNL)$
t	foil thickness
T	temperature
W	load
W'	dimensionless load: $W' = W/P_aR^2$
X	displacement of the bearing and housing, M
Y	displacement of the foil, m
Λ	dimensionless speed: $\Lambda = 6\mu N/P_a(R/C)^2$
$\mu(T)$	absolute viscosity, a function of temperature