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MODELING OF FRICTION INDUCED VIBRATION DUE TO THIRD-BODY EFFECTS

David S. Xu and Hooshang Heshmat
Mohawk Innovative Technology, Inc.
1037 Watervliet-Shaker Road
Albany, NY 12205
dsxu@miti.cc, hheshmat@miti.cc

ABSTRACT

Friction induced vibration at contact interfaces is still a big challenging problem and not well understood how to affect the high cycle fatigue (HCF) failures in gas turbine engine and other machinery. Most researchers conducted on the subject of only two bodies in contact with the Coulomb's friction law only. In this paper, the interface friction phenomena and induced vibration are investigated by means of the improved third-body composite interface micro-slip model which includes a variable friction coefficient and a flexible contact, represented as effective stiffness and equivalent viscous damping elements. The third-body considered herein is almost always present at contacting interfaces and is comprised of generated wear debris or a soft intermediate anti-fretting coating applied to the mating surfaces. This kind of third-body can be viewed as a thin frictional damping material layer to provide shear energy dissipation in order to mitigate the destructive effects of high frequency vibrations in components with highly stressed contacts. A properly engineered third-body can also play the role of both a damping material and a lubricant to decrease wear rate.

For the study presented, a semi-empirical formula for the third-body powder properties was employed, depending on the experimental data and the non-linear regression approach. The experimental powder T_iO_2 data included density, shear strength, frictional coefficients, loss factor as a function of normal load, shear strain, speed and frequency. The results in this paper indicate that the third body semi-empirical equivalent stiffness / viscous damping representation of a flexible contact with variable friction coefficient does indeed have merit and does have influence on overall system response. It has been shown that the third body effects should be considered in the friction and damping induced vibration on the contact interfaces. Such a model may be used to assess designs and material coating approaches to counter fretting in highly stressed contacts as well as assessing the interaction of contact kinematics on HCF failures. Further experimental investigation of specified friction contact configuration of the components needs to be conducted in order to evaluate their friction characteristics and move this technology toward a practical engineering applications.

NOMENCLATURE

a = amplitude
C_{eq} = equivalent damping
F = friction force
K = stiffness
k_d = friction stiffness
K_{eff} = effective stiffness
m = mass
N = normal load
P = exciting force
P_0 = amplitude exciting force
T = temperature
t = time
u = velocity
W_n = normal load
x,y = coordinates
x = displacement in x-direction
X = amplitude displacement
: = friction coefficient
0 = loss factor
ϑ = shear stress
T = frequency
M = phase angle