ISROMAC 2017
International Symposium on Transport Phenomena and Dynamics of Rotating Machinery
Maui, Hawaii
December 16-21, 2017

[Extended Abstract]

An advanced underplatform damper modelling approach based on a microslip contact model

L.Pesaresi[1], J.Armand[1], C.W.Schwingshackl[1], L.Salles[1], C.Wong[2]

[1] Department of Mechanical Engineering, Imperial College London, Exhibition road SW72AZ, London

[2] Rolls-Royce plc, Derby DE2 48J, UK

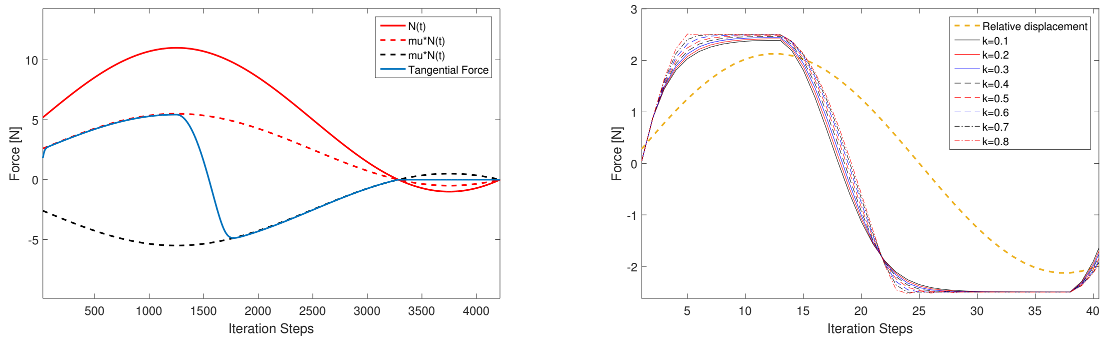
Introduction

High-cycle fatigue caused by large resonance stresses remains one of the most common causes of turbine blades failures. Friction dampers are one of the most effective and practical solutions to limit the vibration amplitude, and shift the resonance frequencies of the turbine assemblies far from operating speeds [1]. However, predicting with good accuracy the effects of underplatform dampers on the blades dynamics, still represents a major challenge today, due to the complex nature of the nonlinear forces at the interface, characterised by transitions between stick, slip, and separation conditions. The most common modelling approaches developed recently are based on the explicit FE model for the damper, and on a dense grid of 3D contact elements comprised of Jenkins elements [2,3], or on few 2D microslip elements [4,5]. In this paper, a combination of the two approaches is proposed. A 3D microslip element, based on a modified Valanis model is proposed and a series of these elements are used to describe the contact interface. The proposed model and its predicting capabilities are then applied to a simplified blade-damper model, based on an underplatform damper test rig recently developed by the authors [2].

1. Methods

The modelling approach proposed starts from an FE model of the simplified blade-damper test case made of two pseudo-blades and one wedge damper in between [2]. The blades and damper are then coupled by the newly developed 3D Valanis elements at the friction interface. The Valanis element formulation was modified to allow normal load variation during a vibration cycle, which can be very strong due to the angle of the platform. An example of the evolution of the friction force, with a relative normal motion super imposed to the tangential motion is shown in Fig.1a. Fig.1b highlights the effect of the variation of the microslip parameter of the 3D Valanis element when the normal load is constant.

A BEM-based contact solver , capable to simulate rough contacts at a reasonable computational expense, is then used to tune the microslip parameter of the derived contact model, based on measured roughness values of a real damper. Each 3D contact element is associated to a patch of the discretized contact interface, and represents the microslip and macroslip behaviour as well as the stiffness relative to that particular portion of the contact as shown in Fig.2. The correct initial pre-load caused by the centrifugal force acting on the damper, is specified for each element based on a previously performed contact analysis. A multi-harmonic balance method is then used to solve the nonlinear problem in the frequency domain for the reduced nodes at the contact interface.



(a) **(b)**

Figure 1. a) Variation of the tangential friction force with the normal load, b) variation of the tangential friction force with the microslip parameter 'k'.

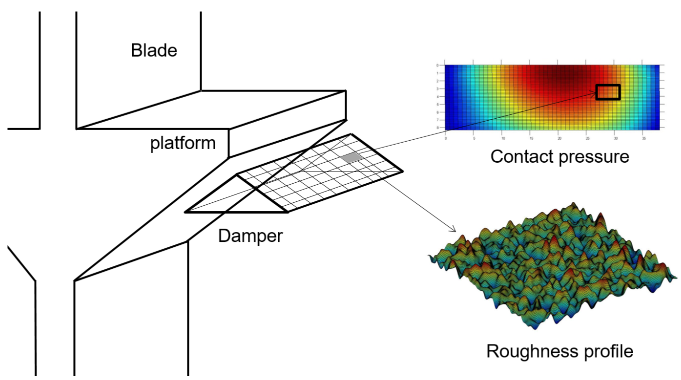


Figure 2. Discretization of the damper-platform contact interface.

References

[1] J. H. Griffin. A review of friction damping of turbine blade vibration. *International Journal of Turbo and Jet Engines*, 7:297–307, 1990.

[2] L. Pesaresi, L. Salles, A. Jones, J.S. Green, and C.W. Schwingshackl. Modelling the nonlinear behaviour of an underplatform damper test rig for turbine applications. *Mechanical Systems and Signal Processing*, 85:662 – 679, 2017.

[3] Christian M. Firrone, Stefano Zucca, and Muzio M. Gola. The effect of underplatform dampers on the forced response of bladed disks by a coupled static/dynamic harmonic balance method. *International Journal of Non-Linear Mechanics*, 46(2):363–375, 2011.

[4] G. Csaba. Forced Response Analysis in Time and Frequency Domains of a Tuned Bladed Disk With Friction Dampers. *Journal of Sound and Vibration*, 214(3):395–412, July 1998.

[5] M. H. Jareland. A parametric study of a cottage-roof damper and comparison with experimental results. In *Proceedings of ASME TURBOEXPO*, pages 1–9, 2001.