Modal Analysis of Elastic Ring Squeeze Film Damper for Small Gas Turbine Engines

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Abstract

The high speed gas turbine is a power plant developed for modern aircrafts. It is widely used and developed because it can meet the high power to weight ratio. The rotor system of modern small gas turbine works above the critical speeds. Hence, there is a stricter requirement for the control and isolation of vibration magnitude under heavy unbalance load and passing through critical speeds. An advanced oil film damper known as Elastic Ring Squeeze Film Damper (ERSFD) built with orifice pattern has better dynamic characteristics, vibration-isolating effect, simple structure, high reliability, enhanced damping effect when compared with conventional SFD. This ERSFD and rotor components are analyzed using COMSOL Multiphysics® software to find its mode shapes and ERSFD's profile pressure distribution at orifice under the ring subjected to vibration. These analyses made using the Structural Mechanics Module and CFD Module. The above study results on ERSFD which enhances the controlled flow at identified locations. It also helps in designing small gas turbine engine high speed rotor system operating at super critical speeds.

1.Introduction
Elastic Ring Squeeze film damper (ERSFD) which is the current interest of study. Reynolds et al. published the squeeze film effect in his study [8] on lubrication. This effect was an important mechanism for the generation of pressure in a lubricating film together with the wedge effect. The primary goal of a fluid film damping system is to limit the vibration of a given structure by dissipating the energy to the fluid within the film [1-4].
The modelling and numerical simulation of ERSFD have been used in designing and investigating ERSFD systems dynamics to control rotor vibrations and transmitted forces to the base structure [6-8]. The detailed assembly view in aero engine is shown in Fig 1.

2.Modelling of ERSFD
This 3D model of test rig small engine rotor system with dual ERSFD is illustrated in Fig. 2 with an exploded view of ERSFD components for better understanding.

3. Modal and FSI Analysis using COMSOL Multiphysics® software
The modal based frequency response analysis carried out using structural mechanics for

undamped and damped eigenfrequency response of shaft and undamped response of rings. The obtained results are shown in Fig. 3. This FSI model is used to compute the damping force acting on ERSFD ring. Also to compute pressure distribution over the entire ring during high frequency response. These analyses were carried out by interaction between fluid flow and structure via CFD under thin film flow (tffs) between vibrating narrow surfaces [5].

4.Conclusions

In this work using COMSOL Multiphysics® software, the modal and FSI on rotor and ERSFD effects was investigated. To determining the mode shapes on the test shaft and ERSFD's. The values of the alternate pressure intensity profile are shown in Fig. 4. This FEM analysis using COMSOL® software provides eigenfrequencies and locations to give flow through openings. These are the essential basic inputs to design multi configured ERSFD's to enhance damping effects.

Reference

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Figures used in the abstract

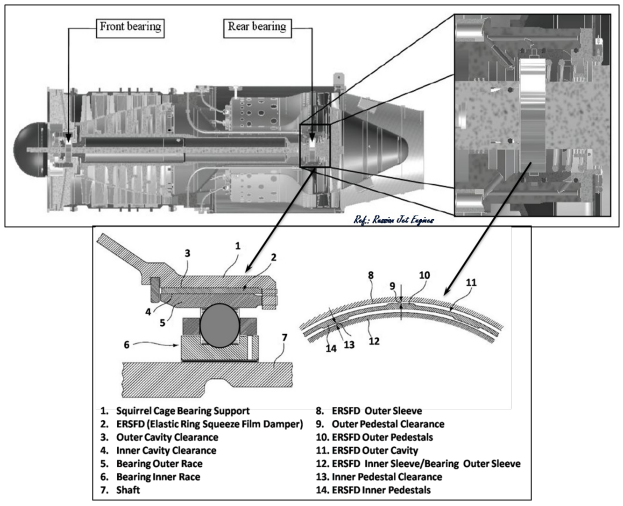


Figure 1: Current Technology ERSFD Detailed Assembly View.

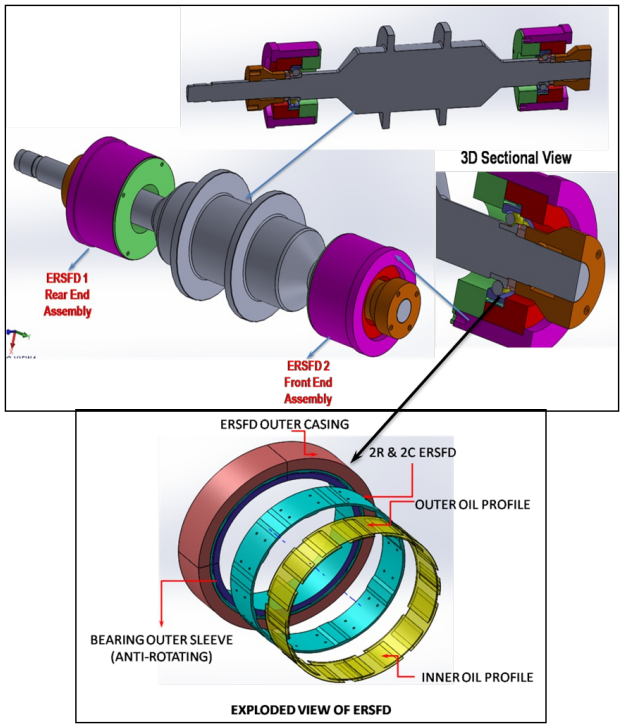
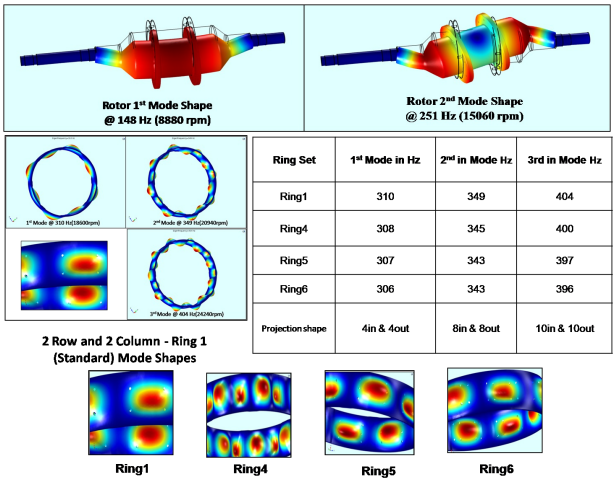


Figure 2: 3D Model of Test Rig Engine Rotor System with an Exploded Dual ERSFD.



Ring Set	1st Mode in Hz	2nd in Mode Hz	3rd in Mode Hz
Ring1	310	349	404
Ring4	308	345	400
Ring5	307	343	397
Ring6	306	343	396
Projection shape	4in & 4out	8in & 8out	10in & 10out

Figure 3: Modal Analysis Results of Shaft and Different ERSFD Ring.

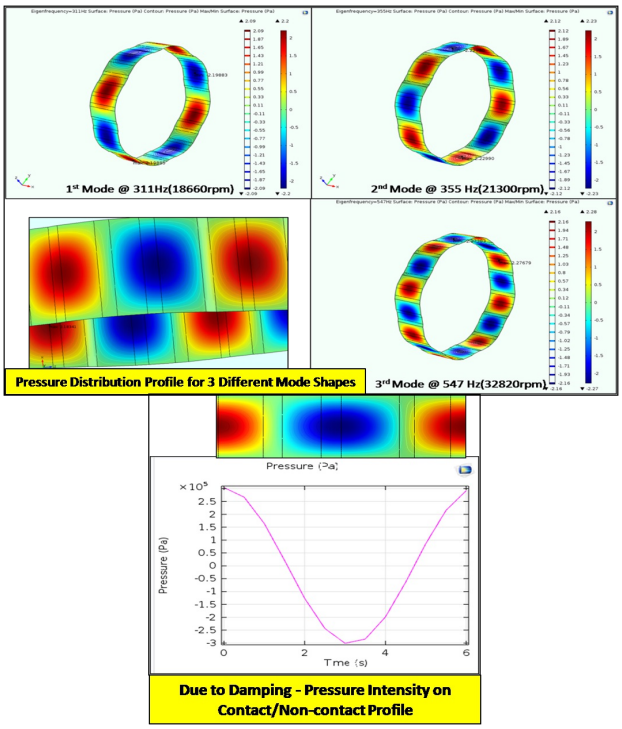


Figure 4: FSI Analysis Result of ERSFD Ring.