Coupled Mechanical and Electromagnetic Modeling of Eddy Current Sensors

N. Jamia[1*], M.I. Friswell[1], S. El-Borgi[2] and P. Rajendran[2]

[1] College of Engineering, Swansea University,
Bay Campus, Swansea, SA1 8EN, United Kingdom
e-mail: 842543@swansea.ac.uk, web page: http://www.swansea.ac.uk/

[2] Texas A&M University at Qatar, Mechanical Engineering Program,
Engineering Building, P.O. Box 23874, Education City, Doha, Qatar
e-mail: sami.el_borgi@qatar.tamu.edu, web page: http://www.qatar.tamu.edu/

ABSTRACT

To effectively monitor the vibration of blades in a rotating machine, a non-contacting method called blade tip-timing (BTT) has been used [1]. The method is based on the analysis of the differential arrival times of the blades at sensors mounted on the stator to characterize the vibration amplitude and frequency of the blades. These sensors can also provide blade tip clearance measurement. A combination of these data can provide a robust condition monitoring approach for the early detection of blade cracks.

Eddy current sensors have shown great potential to assess the health of an engine without any need for direct access to the blade and therefore they are insensitive to the presence of any type of contaminant [2]. Also, both, tip timing and tip clearance of each blade could be measured by these sensors in real time and at high resolution.

Eddy current sensors measure the magnetic field caused by eddy currents during the blade motion, and hence are a coupled mechanical and electromagnetic problem. An eddy current sensor on the casing of a machine has been modeled to fully understand how the dynamic response of the blade is measured by the sensors. Detailed 2-D and 3-D modeling and simulation of a rotating simplified bladed disk passing an eddy current sensor is presented.

The effect of the variation of the rotation speed and the gap between the sensor and the blade tip on the accuracy of the measurement is investigated. Finally, the modeling results are verified using experimental results provided by a manufactured test rig and the results are presented. Such an analysis will enable the reliable monitoring of blade damage during engine operation.

REFERENCES

[1] V. Georgiev, M. Holík, V. Kraus, A. Krutina, Z. Kubín, J. Liška, M. Poupa, *The Blade Flutter Measurement Based on the Blade Tip Timing Method*, *Proceedings of the 15th WSEAS International Conference on Systems, Corfu Island, Greece, 2011 July 14–16*, pp. 270–275.

[2] M. Lackner, *Vibration and Crack Detection in Gas Turbine Engine Compressor Blades using Eddy Current Sensors*, Master of Science thesis, Massachusetts Institute of technology, Department of Aeronautics and Astronautics, Cambridge (2004).