World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:11, No:01, 2017

An Assessment of Different Blade Tip Timing (BTT) Algorithms Using an Experimentally Validated Finite Element Model Simulator

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Abstract : Blade Tip Timing (BTT) is a technology concerned with the estimation of both frequency and amplitude of rotating blades. A BTT system comprises two main parts: (a) the arrival time measurement system, and (b) the analysis algorithms. Simulators play an important role in the development of the analysis algorithms since they generate blade tip displacement data from the simulated blade vibration under controlled conditions. This enables an assessment of the performance of the different algorithms with respect to their ability to accurately reproduce the original simulated vibration. Such an assessment is usually not possible with real engine data since there is no practical alternative to BTT for blade vibration measurement. Most simulators used in the literature are based on a simple spring-mass-damper model to determine the vibration. In this work, a more realistic experimentally validated simulator based on the Finite Element (FE) model of a bladed disc (blisk) is first presented. It is then used to generate the necessary data for the assessment of different BTT algorithms. The FE modelling is validated using both a hammer test and two firewire cameras for the mode shapes. A number of autoregressive methods, fitting methods and state-of-the-art inverse methods (i.e. Russhard) are compared. All methods are compared with respect to both synchronous and asynchronous excitations with both single and simultaneous frequencies. The study assesses the applicability of each method for different conditions of vibration, amount of sampling data, and testing facilities, according to its performance and efficiency under these conditions.

Keywords : blade tip timing, blisk, finite element, vibration measurement
Conference Title : ICAMAME 2017 : International Conference on Aerospace, Mechanical, Automotive and Materials Engineering
Conference Location : Sydney, Australia
Conference Dates : January 26-27, 2017