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GEOMETRIC MODEL UPDATE OF BLISKS AND ITS EXPERIMENTAL VALIDATION FOR A WIDE FREQUENCY RANGE

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ABSTRACT

The contribution discusses a model update procedure and its experimental validation in the context of blisk mistuning. Object of investigation is an industrial test blisk of an axial compressor which is milled from solid using a state of the art 5-axis milling machine. First, the blisk geometry is digitized by a blue light fringe projector. Digitization is largely automated using an industrial robot cell in order to guarantee high repeatability of the measurement results. Additionally, frequency mistuning patterns are identified based on vibration measurements. Here, the system excitation is realized by a modal impact hammer. The blade response is detected using a laser scanning vibrometer. Furthermore, all blades except the currently excited one are detuned with additional masses. Applying these masses allows to identify a blade dominated natural frequency for each blade and every mode of interest. Finally, these blade dominated frequencies are summarized to mode specific mistuning patterns. The key part of the contribution presents a model update approach which is focused on small geometric deviations between real engine parts and idealized simulation models. Within this update procedure the nodal coordinates of an initially tuned finite element blisk model were modified in order to match the geometry of the real part measured by blue light fringe projection. All essential pre- and post-processing steps of the mesh morphing procedure are described and illustrated. It could be proven that locally remaining geometric deviations between updated finite element model and the optical measurement results are below 5 µm. For the purpose of validation blade dominated natural frequencies of the updated finite element blisk model are calculated for each sector up to a frequency of 17 kHz. Finally, the numerically predicted mistuning patterns are compared against the experimentally identified counterparts. At this point a very good agreement between experimentally identified and numerically predicted mistuning patterns can be proven across several mode families. Even mistuning patterns of higher modes at about 17 kHz are well predicted by the geometrically mistuned finite element model. Within the last section of the paper, possible uncertainties of the presented model update procedure are analyzed. As a part of the study the digitization of the investigated blisk has been repeated for ten times. These measurement results serve as input for the model update procedure described before. In the context of this investigation ten independent geometrical mistuned simulation models are created and the corresponding mistuning patterns are calculated.