Abstract of the PhD thesis

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Title:
Influence of the low-speed balancing process parameters on the accuracy of determining the residual unbalance of selected rotating elements of an aircraft engine

The balancing of rotating components is a special process in the aviation industry, affecting the level of engine vibration. Ensuring that vibration does not exceed a certain level is one of the main determinants for ensuring the safety of an engine powering an aircraft, as defined by aviation regulations. The level of engine vibration is influenced by many factors, the main one being unbalance, which is checked at the product production level, on a properly configured balancer.

The configuration of a balancing machine, in addition to programmable parameters such as the distances of individual planes and balancing parameters, also consists of the selection of appropriate instrumentation and conditions for implementing the unbalance control process. Hence, the purpose of this dissertation was to conduct research related to the determination of the influence of individual low-speed balancing parameters on the accuracy and repeatability of determining the residual unbalance of selected rotating components of an aircraft engine.

The research was also conducted to reduce the aforementioned influences on the accuracy and repeatability of determining the residual unbalance of the aircraft engine rotating components under analysis. A simplified model of balancing dynamics was developed and used for preliminary numerical simulations of the residual unbalance control process. Several parameters were analyzed in the basic research characterizing the dynamics of the unbalance control process, related to both the operation of the balancer and the entire "balancer-instrumentation-balanced rotor" system. A model for accurate assessment of the unbalance reduction ratio (URR) was developed. Software was written to support the analysis of unbalance results, considering information about the value of unbalance and its location with respect to the assumed base point. A model was prepared to simulate the influence of position errors of the tested part on the balancer on the obtained results regarding the mass and location of the unbalance.

As a result of the study, it was found that the introduction of non-rotating balancing, as a special case of slow balancing, of ring elements with a diameter of about 600 mm and a mass of 15 kg, instead of balancing on a single-plane centrifugal balancer for determining static unbalance, has many advantages. It has been shown to reduce unbalance control time by

half without compromising the quality of the obtained repeatability and accuracy results. This is due to the elimination of preparation and set-up times for the rotor to be balanced, which belong to the main setting parameters of the balancer. Additional advantages of a non-rotating balancer are the increase in operator comfort and safety, as well as comparable purchase costs and lower operating costs for this balancer and instrumentation compared to a low-speed balancer.

Dynamic balancing, characterized by the need for a two-plane centrifugal balancer, was also analyzed in the basic research. Various parameters were taken into account, such as those related to the foundation of the supercritical machine, the influence of the preload of the drive belt, the location of the drive belt, the zone of contact between the roller bearing supports and the journal surface of the rotor to be balanced, and the errors of fixing the rotor on the balancer relative to the parameters specified by the manufacturer at the balancer calibration stage. The effects of acceleration and balancing speeds on the obtained accuracy and repeatability of residual unbalance readings were analyzed and studied. Both acceleration speed and balancing speed tests were performed on a centrifugal single-plane balancing machine.

Almost all of the factors analyzed were found to affect the accuracy or repeatability of the residual unbalance results achieved. The least influence was shown by drive belt tension, while the greatest influence was shown by balancing speed. The parameter studied that did not noticeably affect the accuracy of the obtained results was the location of the drive belt.

Keywords: *aircraft engines, rotating machines, low-speed balancing, residual unbalance, measurements, accuracy and repeatability of measurements, balancing machine*