

ABSTRACT

The development of various types of turbomachines depends on the possibility of improving their efficiency and optimizing the geometry of the flow system. This optimization enables these machines to operate efficiently within specified parameter ranges. Therefore, numerous research and industrial centres worldwide are currently engaged in developing new technologies to enable the rapid and precise manufacturing of turbomachine components with complex geometries. This is especially the case for high-speed rotating machines, which have the capability to generate substantial power despite their small dimensions. New methods of testing prototypes of such machines are also being developed in various regions across the globe. This doctoral dissertation is part of this trend and was aimed at determining the dynamic and flow characteristics of rotating systems with components manufactured using Additive Manufacturing methods. The object of the research was a turbocompressor with a compressor rotor disk that was manufactured using a 3D printing method.

The introduction of the doctoral dissertation is dedicated to a literature review, which discusses the technological capabilities and application areas of additive manufacturing. Based on this review, a decision was made to undertake research work toward the application of the selected new manufacturing technology at the design stage and experimental verification of the newly optimized flow systems of high-speed rotating machines, including microturbines and turbocompressors. The application of the selected additive manufacturing method required a series of different types of tests, starting with material tests. These works included the study of the properties of materials selected by the author, which made it possible to choose the most suitable material for a specified 3D printing technology. Subsequently, a series of works were carried out to determine the area of application of 3D printing technology in high-speed machines. The next part of the dissertation presents the results of numerical analyses performed for a compressor rotor disk with the selected geometry. Strength and flow analyses were carried out to predetermine the conditions for the experimental tests. The final part presents experimental tests that were carried out for different operating states of the turbocompressor, first with the original compressor rotor disk, and then with a disk of the same geometry made of an unconventional material. All experimental tests of the turbocompressor were performed on a test rig that was specifically designed to determine the flow characteristics of this machine. The results are presented in the form of various types of graphs and the results obtained for the original and new rotor disk are compared.

After determining the acceptable range of tests for rotors made with the selected additive manufacturing technology, additional tests were conducted for a compressor with a compressor rotor disk whose geometry was modified. Through the proposed test method, it was possible to experimentally verify the new blade system, and the results obtained confirmed the suitability of the approach used. At the same time, it was a positive verification of the research hypothesis set forth. Based on the results obtained, it was unequivocally concluded that this technology can be used to manufacture parts with complex geometries in order to experimentally verify the newly designed flow systems of rotating machines.