Abstract of doctoral thesis.:

Assessment of the possibility of applying the concept of a cycloidal rotor for energy devices

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Abstract

Scientifical analysis of various concepts of the cycloidal rotor have been carried out for almost a century. The development of computational computer techniques and better access to various measurement techniques in the last two decades, resulted in an increased interest in the idea of a cycloidal rotor. Due to the historical aspect and the popularity of commercial application, most of the scientific work focuses on the application of this idea in the form of propulsion for unmanned aerial vehicles or propulsion for watercrafts. In recent years, scientific studies are trying to apply this concept to wind turbines and water energy converters have also started to appear. However, there are no studies describing usage of a cycloidal rotor in HVAC (heat, ventilation & air conditioning) as machine used to transport gas.

In this study, an attempt was made to assess the possibility of using a cycloidal rotor in HVAC installations. For this purpose, numerical and experimental studies were carried out. Based on similar solutions available in the literature, an experimental stand of a fan with a cycloidal rotor was designed and then built, which was placed in the aerodynamic duct. Assessing the popularity of the structure in various research centers, it was decided to construct a compact machine with a diameter of 140mm and a span of 250mm, equipped with a four-blade rotor. Based on the current research, three different fan operation states were developed, due to the cycloidal function performed, which was optimized in terms of rotor operating conditions. Two variants of the fan were tested, each equipped with different blade profiles. Due to the large number of publications, it was decided to choose the symmetrical NACA 0012 blade profile and the asymmetrical CLARK Y. To determine the optimal measurement method that could be used in the future to measure a fan installed in an aerodynamic tunnel, experimental tests were carried out on a test stand using constant temperature anemometry (CTA) and laser doppler anemometry (LDA). Due to the non-invasive nature and accuracy, the LDA technique was chosen as the main measurement method. For each variant of the fan and each amplitude of blade changes, measurements of the flow velocity distributions were carried out for various rotational speeds of the rotor. In order to compare the experimental data with the data obtained from the numerical analysis, a model of a fan with a cycloidal rotor was made in the Ansys CFX software. A satisfactory consistency of the CFD model with the experimental data was obtained. The tests carried out showed a slightly higher efficiency of the fan equipped with asymmetrical blades. The symmetrical shape of the blade profiles resulted in greater flow curvature than the CLARK Y profile, for the same working conditions. An attempt was also made to determine the efficiency of a fan with a cycloidal rotor. The highest efficiency was obtained for the variant working with the highest amplitude and rotational speed, equipped with CLARK Y profile blades, for which the force reached 25%. For the analogous case equipped with a symmetrical profile, the efficiency was 24%. The paper also presents a proposal to improve the efficiency of a cycloidal fan by

optimizing the cycloidal function in terms of efficiency or design changes. An exemplary solution for typically commercial industrial use has also been proposed.