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Design and experimental research of a centrifugal fan with backward-curved blades

An experimental study of the characteristics of a centrifugal fan with backward-curved blades of two types: with open and closed impellers is presented. Practical recommendations for developers and designers of centrifugal fans have been developed

The centrifugal fan is one of the most demanded devices for delivering compressed air in large volumes at the required pressure. The design is optimized for continuous air movement in any necessary quantity, making centrifugal compressors widely used across various economic and industrial sectors. Their versatility and reliability, combined with a carefully designed construction, enable their use in enterprises around the world [1, 2].

The design of the centrifugal fan is shown in Fig. 1.

Key advantages of the equipment include: high efficiency, absence of lubrication in the compressed air, operational safety, low maintenance costs, long service life, minimal operational noise, compact size, and the ability to operate continuously for extended periods, among others [2-4].

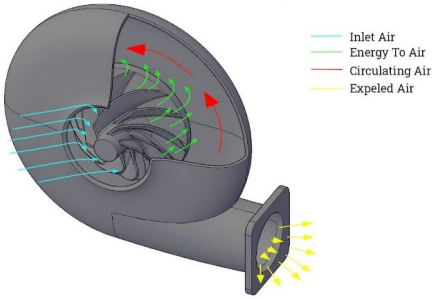

Fig. 1. Design of the centrifugal fan. Source: IQS Directory

This study aims to create a solid model of the impeller of a centrifugal fan with backward-curved blades of two types: with open and closed impellers, and to compare their pressure characteristics.

Flow modeling was carried out using numerical experimentation. The Navier-Stokes equations were closed using the SST Menter turbulence model (based on the selection and justification of numerical experiment parameters mentioned above).

The computational mesh is unstructured, with boundary layer adaptation. The

created models are shown in Fig. 2 and Fig. 3.

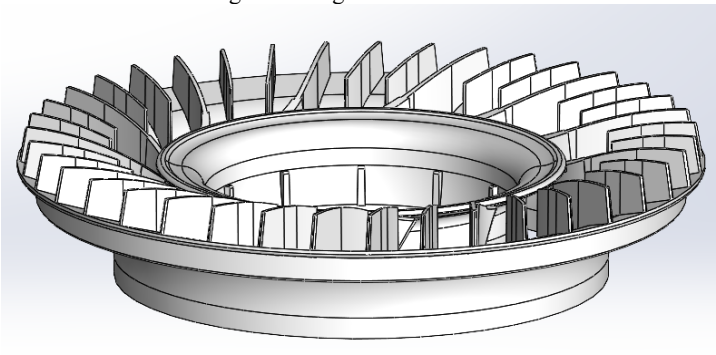

Fig. 2. Model of the centrifugal fan impeller with backward-curved blades and an open impeller

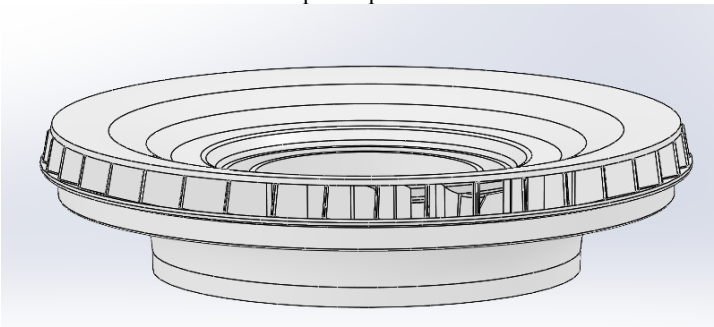

Fig. 3. Model of the centrifugal fan impeller with backward-curved blades and a closed impeller

The experimental part of the study was conducted on a test stand, shown in Fig. 4.

It complies with the requirements of the ANSI/AMCA 210-07 ANSI/ASHRAE 51-07 standard, «Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating», with some differences in the measurement equipment.

The standard uses measuring nozzles with a measurement range of 0…1800 m^3/h to determine the air flow rate [5-7].

Figs. 5-7 show the dependencies of static pressure, power consumption, and efficiency of the centrifugal fan with backward-curved blades on air flow rate. The research results highlight differences in the efficiency and performance of these models.

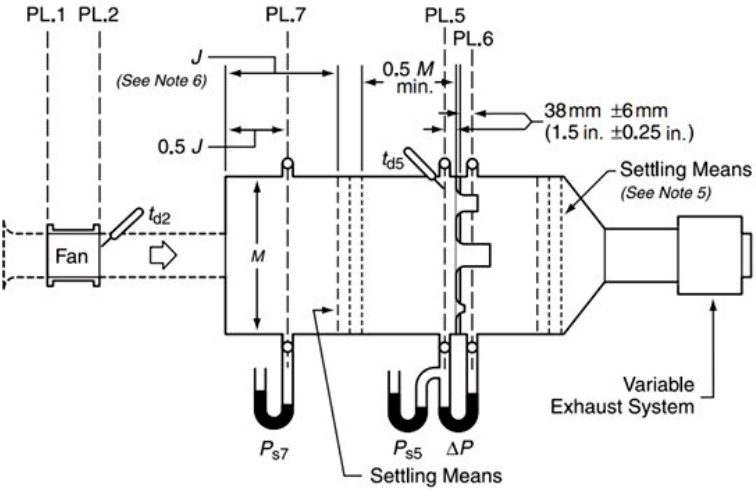

Fig. 4. Schematic diagram of the test stand according to ANSI/AMCA 210-07

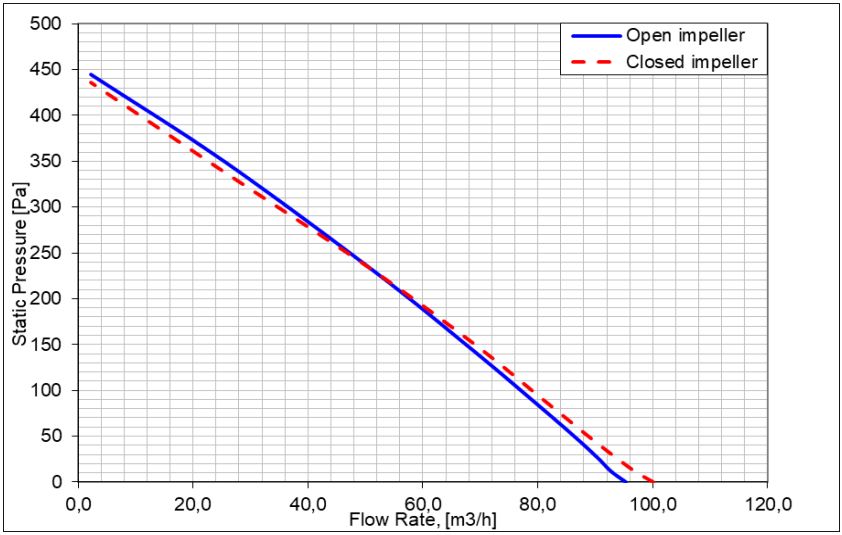

Fig. 5. Dependency of static pressure of the centrifugal fan with backward-curved blades on air flow rate

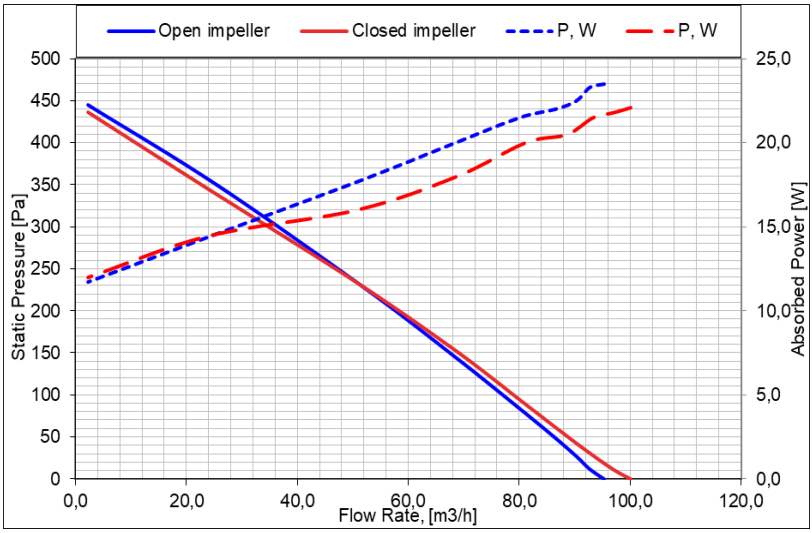

Fig. 6. Dependency of static pressure and power consumption on air flow rate

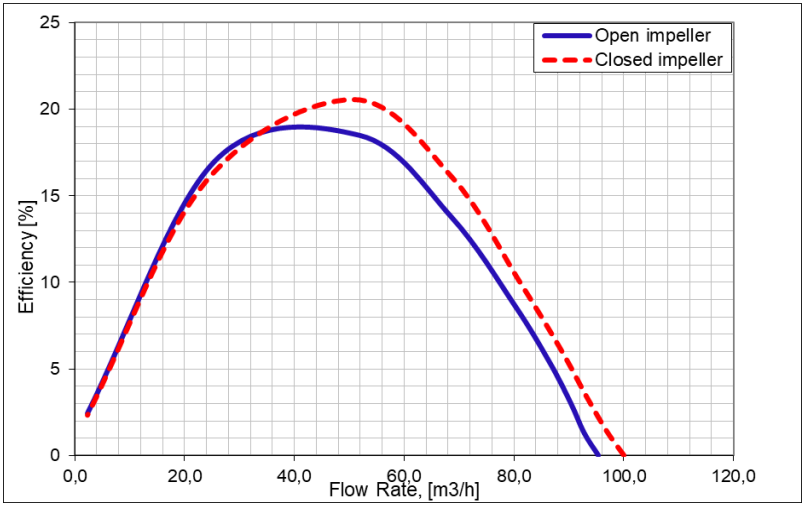

Fig. 7. Dependency of the efficiency of the centrifugal fan with backward-curved blades on air flow rate

The model of the fan with an open impeller showed that as power consumption increases, the air volume rises and reaches a maximum value of 95,3 m^3/h at a power consumption of 23,5 W.

With further increases in power consumption, the performance decreases due to rising pressure. The efficiency of the fan with an open impeller increases with power consumption, reaching a maximum of 18,50 % at a power consumption of 17,8 W. High efficiency is observed at moderate levels of power and pressure. As pressure increases, efficiency significantly decreases. The highest efficiency is achieved at moderate pressure, indicating that open impellers perform better under average pressure conditions.

The model with a closed impeller shows that the air volume is significantly greater at the same power levels, reaching a maximum of 100,1 m^3/h at a power consumption of 22,1 W. This indicates more effective air circulation in this design.

The efficiency of the closed impeller model increases with power consumption, reaching a maximum of 20,57 % at a power consumption of 16,0 W.

This model exhibits higher efficiency at all power levels compared to the open impeller model. The closed impeller model shows less decrease in efficiency at high pressures compared to the open impeller model, suggesting that closed impellers better retain airflow while maintaining high performance.

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