Trinity University, Nigeria
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LASUSTECH Multidisciplinary Innovations Conference (LASUSTECH-MIC)

16th – 18th April, 2022

Analytical, Numerical, and Experimental Assessment of a Bladeless Turbine's Performance

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ABSTRACT

A bladeless turbine is an energy transfer mechanism that uses flow-generated forces to transmit energy between a continuous flow of fluid and a continuously spinning blade assembly. It is a cost-effective and ecologically beneficial method of energy generation. However, low efficiency due to air moisture, large turbine radii ratios, and parasitic loss prompted this research. The goal of this research is to design, build, and test the performance of fluid flow in a bladeless turbine in order to address the issue of poor efficiency. The study methods used both theoretical and experimental approaches to enhance the efficiency of bladeless turbines. The Navier-Stokes equation and the energy equation with boundary conditions were reduced to nonlinear partial differential equations as governing equations and boundary conditions, and then transformed to nonlinear ordinary differential equations with appropriate similarity variables for theoretical evaluation. The shooting methodology was used to create numerical values of the skin friction coefficient, Nusselt number, and a graphical representation of flow behavior using the fourth order Runge-Kutta method. Furthermore, analytical flow computations of radial, tangential, and pressure of the fluid within rotating discs were generated, predicting torque, power production, and efficiency over a wide range of rotor rotational speeds. The experiment was conducted with compressed air as the working fluid and an airflow moisture regulator device built into the design and construction for analysis. The airflow moisture regulator, which was connected to the turbine's inlet nozzle, lowered the moisture content influx into the bladeless turbine. The analytical solutions yielded 34% efficiency. The results of the experimental study showed that the incorporated device has a strong influence and yielded better performance with a 23.9% efficiency, parasitic loss ranging from 3.3 percent to 15.6 percent, proficient to achieve 28.5 percent, low Reynold's number of Re 528.53, and rotational speed of 944.31 rad/s. A significant value of $P < 0.0054$ was obtained in the statistical analysis of the comparison of analytical and experimental efficiency, showing a high correlation. Because the efficiency of 23.9% acquired from the study fits within the stipulated 18–25% bladeless turbine efficiency, this study has increased the energy efficiency of bladeless turbines.

Keywords: Air-moisture-regulator (AMR), Bladeless turbine, Compressed-air, Efficiency.

Proceedings Citation Format

O.K.Onanuga, N.E. Erusiafe & M.A. Olopade (2022): Analytical, Numerical, and Experimental Assessment of a Bladeless Turbine's Performance. Proceedings of the LASUSTECH 30th iSTEAMS Multidisciplinary Innovations Conference. Lagos State University of Science & Technology, Ikorodu, Lagos State, Nigeria May 2022. Pp 326 www.isteams.net/lasustech2022
DOI: https://doi.org/10.22624/AIMS/iSTEAMS/LASUSTECH2022V30P27