Optimization of a Compressed Air Turbine design for CAES Systems and Grid Stability

Carrero, Adrian (School: Dr. Carlos González High School)

This project explores the design, construction, and optimization of a 3D-printed impulse turbine using compressed air for electricity generation, to reduce intermittency in renewable energy sources. Three turbine rotors were designed and tested with 4, 8, and 14 blades respectively (T4, T8, and T14) to evaluate their impact on the rpm of the turbine. Additionally, two turbine housings with 180-degree and 240-degree exhaust positions were designed and tested for performance differences. The 14-bladed rotor validated 3D-printing feasibility, so it was used for performance testing. Later, 8- and 4-bladed versions were tested to check if they performed better. The 180-degree exhaust followed other common designs, while the 240-degree exhaust checked if more flow rate time improved energy transfer between the air and the rotors. Later refinements focused on design accessibility, manufacturability, and compatibility with pneumatic components. Performance tests began at 20 psi, increasing by 5 psi to 55 psi (one minute of testing for each psi value, to determine which rotor and housing combination achieved 1800 rpm with the least psi. After performance tests of all the rotor and housing combinations, the T14 rotor with the 180-degree exhaust proved most effective, achieving 1874 rpm at 30 psi and a maximum of 3088 rpm at 55 psi. Other models also reached the project's target of 1800 rpm, but T14 achieved this at a lower psi, demonstrating higher efficiency. Test results were graphed in Excel for performance comparison. Future work will couple the turbine to a generator to evaluate power output.

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