The Effects of Variable Rotor Pitch on Axial Compressor Efficiency

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Axial compressors, the first stage of gas turbine engines, compress air by accelerating it through many stages of rotors and stators. Variable pitch stator vanes are a technology that prevent compressor stall and surge by controlling flow angles. This study tested the effect of using variable pitch rotors to improve compressor flow and efficiency while also retaining the ability to control flow angles. Three sets of rotors with different pitch angles approximately ten degrees apart and three stators were 3D printed to create a three and a half stage axial compressor. Powered by an electric motor and two 12V batteries, the compressor was run from 0-15,000 RPM and data points for flow velocity were taken at 3,000, 6,000, 9,000, 12,000, and 15,000 RPM/s with a digital anemometer. High pitch rotors yielded the greatest flow rate with a mean of 0.099m^3/s Moderate pitch rotors reached a maximum flow rate of 0.082m^3/s, while the low pitch rotors saw 0.075 m^3/s. All tested rotor pitches reached their maximum flow rates at 15,000 RPM. Data were analyzed with a mixed repeated two way ANOVA test which returned a p-value of 7.098E-8, suggesting that the experiment’s findings are statistically significant. The high pitch rotors' flow coefficient of 0.2045 was the greatest of the pitches tested, which supports the conclusion that they are the most efficient. Their isentropic efficiency, however, was low, at 3.568%. Though further experimentation is needed to determine the efficacy of rotor pitch in preventing compressor stall, this study supports that varying rotor pitch is a viable method of controlling compressor flow rate. This ability is useful if a gas turbine engine is required to operate within a narrow engine speed range but adjustable power levels are desired.

Awards Won:
Third Award of $1,000