Thermodynamic Cycle Analysis for Wave Rotor Combustor Based Combined Cycle

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The conventional combustor that exists in today's market is a constant pressure device; whereas, the wave rotor combustor investigated in the present research is a constant volume pressure gain device. This pressure gain wave rotor combustor improves the engine efficiency and reduces fuel consumption, engine weight and emissions. The objective of the present study is to observe and analyze the potential benefits of pressure gain combustion. Therefore, thermodynamic analysis has been conducted to evaluate the performance by comparing the simple Brayton constant pressure combustor with the wave rotor constant volume combustor, recuperated engines with unrecuperated engines, the pressure gain combustor with the work producing combustor, and the single stage Brayton cycle to the combined cycle for power generation applications. Thermodynamic analysis has been carried out by developing in-house code using engineering equation solver (EES) software to determine the overall specific fuel consumption, specific work, and efficiency of the constant volume combustion based cycles. A series of experiments have been conducted in the wave rotor combustor rig available at Combustion and Propulsion Research Laboratory, IUPUI. A high speed camera and pressure transducers have been employed to capture the jet ignition characteristics and to measure the pressure fluctuations during the combustion process respectively. Edge detection analysis is being conducted in MATLAB to determine the ignitability and ignition delay time in the combustion chamber. The measured pressure data are analyzed by EES software, using thermo- and gas dynamics theory, which performs exact analysis as opposed to limited previous studies using approximate analysis. This is expected to more accurately quantify the established results that replacing constant pressure with constant volume combustion increases the turbine cycle fuel efficiency. This work should encourage quicker application of constant volume combustion technology in gas turbines and power generation applications.

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