Air-Standard Thermodynamic Analysis of Gas Turbine Engines Using Wave Rotor Combustion
AIAA Paper 2007-5050, 43rd Joint Propulsion Conference, Cincinnati, OH
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Introduction
Constant-volume combustion (CVC) can substantially boost gas turbine performance, by creating pressure gain. The wave rotor combustor can implement CVC while retaining nearly steady flow in turbomachinery.

Why CVC with wave rotor?
• Pressure gain from confined combustion and wave processes, with lower entropy production
• Multiple channels in one moving part, allow nearly steady flow in compressor and turbine
• Efficient and rapid internal wave compression and expansion raises peak cycle pressure and density, for higher efficiency, reduced combustor volume, and lower NOx emissions

Method
A consistent air-standard aero-thermodynamic model with real-gas caloric behavior, and a simple gas-dynamic model of wave processes

Gas caloric effects are important
Thermal efficiency prediction using various constant specific heats differs significantly from prediction with actual gas behavior. The errors are even greater for the wave-rotor engine than the conventional engine, and with a different trend.

Net Pressure Gain and Internal Pressures
The net combustor pressure ratio $P_{\text{c}}/P_{\text{a}}$ and internal pressure ratio increase with exit Mach number, $M_{\text{e}}$, due to stronger compression expansion waves. Optimal $M_{\text{e}}$ may be subsonic due to frictional losses.

Cycles Temperature Prediction and Gas Caloric Effects
Use of an assumed constant specific heat may lead to large errors in predicting turbine inlet temperature and compressor exit temperature in the wave rotor gas turbine. A constant that works for efficiency may give errors for other variables.

Pressure Gain Drives Performance Gains
• 25% combustor pressure gain causes ...
• 24% more specific work output
• 19% lower specific fuel consumption

Conclusion
• The wave rotor combustor in a gas turbine engine offers significant performance improvement over the conventional constant-pressure combustor.
• Strong wave compression and expansion boosts performance and has other benefits.
• Significant performance prediction errors if a constant specific heat is used.
• A single constant specific heat ratio does not predict all important variables well. Simplified analysis or computational codes may select a constant using the above error trends, for a particular purpose.