National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Power Generation and Storage

Stirling Thermoacoustic Power Converter and Magnetostrictive Alternator

New system eliminates all moving parts for maximum efficiency and reliability

Innovators at NASA's Glenn Research Center have developed two novel technologies that make Stirling engines more efficient and less costly. First, Glenn's thermoacoustic power converter uses sound to turn heat into electric power. Utilizing heat-driven pressures and volume oscillations from thermoacoustic sources to power piezoelectric alternators or other power-converter technologies, this device can generate electricity with unprecedented efficiencies. Unlike conventional Stirling-based devices, this thermoacoustic engine achieves high thermal-to-electrical efficiencies with no moving parts. Glenn's second advancement for Stirling engines replaces the conventional linear alternator with a magnetostrictive alternator that converts the oscillating pressure wave into electric power (see cut-away diagram above). These innovations offer a reliable and efficient way to generate power from any heat source, benefiting applications such as combined heat and power (CHP) systems, distributed generation, solar power generation, and heating and cooling systems.

BENEFITS

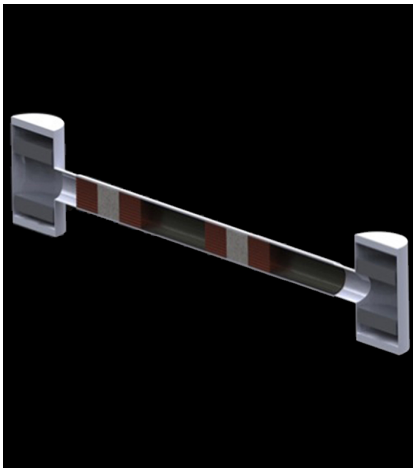
- Efficient: Offers very high thermal-to-electrical efficiency compared to other heat engines
- Reliable: Features no moving parts or bearing systems, limiting opportunities for failure
- Lower-cost: Reduces fabrication expense by using fewer parts and allowing wide tolerances in manufacturing
- Compact: Enables significantly reduced engine mass and volume
- Versatile: Provides flexibility in design so that any heat source can be used to provide power

THE TECHNOLOGY

Glenn's thermoacoustic power converter reshapes the conventional Stirling engine from a toroidal shape into a straight colinear arrangement. Instead of relying on failure-prone mechanical inertance and compliance tubes, this design achieves acoustical resonance by using electronic components. In a typical Stirling engine, the acoustical wave travels around a toroid and reflects back, forming a standing wave. In Glenn's device, by contrast, the wave instead travels in a straight plane where a transducer receives the acoustical wave and electrical components modulate the signal. A second transducer on the diametrically opposed side reintroduces the acoustic wave with the correct phasing to achieve amplification and resonance. Glenn's design allows the transducers to operate at high frequency while presenting a mass rather than stiffness impedance.

Glenn's magnetostrictive alternator uses stacked magnetostrictive materials under a biased magnetic and stress-induced compression. The acoustic energy from the engine travels through an impedance-matching layer (which can be formed from aerogel materials) that is physically connected to the magnetostrictive mass. Compression bolts keep the structure under compressive strain, allowing for the micron-scale compression of the magnetostrictive material and eliminating the need for bearings. The alternating compression and expansion of the magnetostrictive material creates an alternating magnetic field that then induces an electric current in a coil wound around the stack. This alternator produces electrical power from the acoustic pressure wave and, when the resonant frequency is tuned to match the engine, can replace the linear alternator to great effect.

Glenn's technological advances can generate electricity from natural gas to power and heat homes



Glenn's thermoacoustic power convertor uses sound to turn heat into electric power

APPLICATIONS

The technology has several potential applications:

- Distributed generation and residential power systems
- Combined heat and power systems
- Concentrated solar power generation
- Hybrid electric vehicles
- Refrigeration systems
- Heat pumps
- Underwater and marine power systems
- Auxiliary power units

PUBLICATIONS

Patent No: 9,163,581; 10,119,525; 10,309,376; 9,871,186; 11,183,626

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