

A 700,000 rpm Feasibility Demonstration for Mesoscopic Scale Gas Turbine Engines

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ABSTRACT

A new class of miniature weapons and war fighting systems is being developed that requires a mesoscopic sized turbojet engine for power and propulsion applications. These systems require a high power density, low cost, and fuel efficient turbojet engine that must operate reliably, even after being stored for an indefinite period of time. Due to the extremely high operating speeds expected (up to one million rpm), bearings have been shown to be a key limiting factor. A revolutionary design approach that integrates and uses oil-free, self-acting hydrodynamic compliant foil air bearings is therefore offered. This paper presents the preliminary design and testing of a simulator rotor bearing system that demonstrates the feasibility of developing such a system.

A nine-gram, single piece metallic rotor was fabricated and spun to 705,000 rpm. The rotor was sized to be representative of a turbojet engine with integral compressor and turbine stages capable of approximately 2 pounds of thrust or up to 144 watts of electrical power. The single piece rotor design, used to simulate the expected ceramic rotor construction, dictated that a unique split housing and split foil bearings be designed and fabricated. Testing was completed with the rotor subjected to a wide range of orientations, including rotor inverted (i.e., 180 degree roll) and rotor spin axis vertical. Changes in rotor orientation were accomplished while the rotor was spinning at speeds in excess of half a million rpm to demonstrate suitability for air vehicle application. Correlation between design predictions and measured response was good, indicating scalability of existing analysis tools and physical hardware to the mesoscopic scale. The success of these tests has demonstrated the feasibility of developing ultra high-speed mesoscopic rotating machinery systems for power and propulsion applications.

Key words: mesoscopic turbojet, mesoscopic generator, oil-free gas turbine engine, micro air vehicle, uninhabited air vehicle, compliant foil bearing, air bearing, gas bearing.