High Temperature Electro Magnetic Actuation (HTEMA) Technology

Background

Many modern fighter aircraft use jet fuel as the hydraulic fluid for actuation and thermal management for key engine actuators. The high temperature actuator environment (235->410^{o}F) places a heavy demand on the thermal heat sink capacity of the fuel/coolant, which can affect the aircraft flight envelope, hence the motivation for advanced electromagnetic actuators as potential replacement for current actuators (Figure 1). HTEMAs will also be applicable to future "more electric aircraft (MEA)" systems for control surfaces, and engine controls.

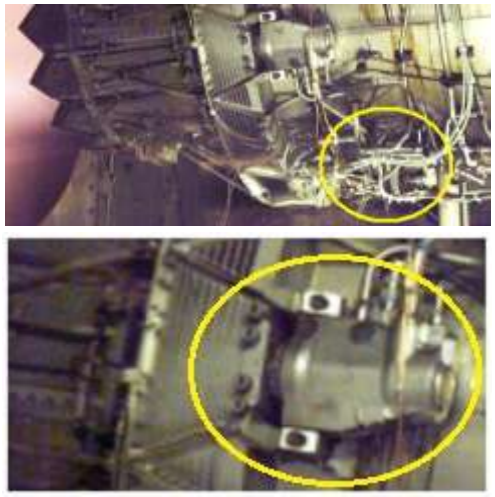


Figure 1: CNAS Fuel-draulic System Manifold[1] & Actuator (5X)[2]

[1] http://www.sentinelscience.com
[2] http://en.wikipedia.org/wiki/File:F-35_engine.jpg

Air Force Critical Ph II SBIR Program:

RCT Systems developed proof of concept, HTEMA hardware for the Convergent Nozzle Actuation System (CNAS) presently used in fifth generation fighter engines, with minimal heat load on aircraft cooling system (Figure 2). Size and weight are consistent with next generation engine actuator requirements for programs such as the Adaptive Engine Technology Development (AETD), as well as the Adaptive Versatile Engine Technology (ADVENT), and the Navy's Variable Cycle Advanced Technology (VCAT).

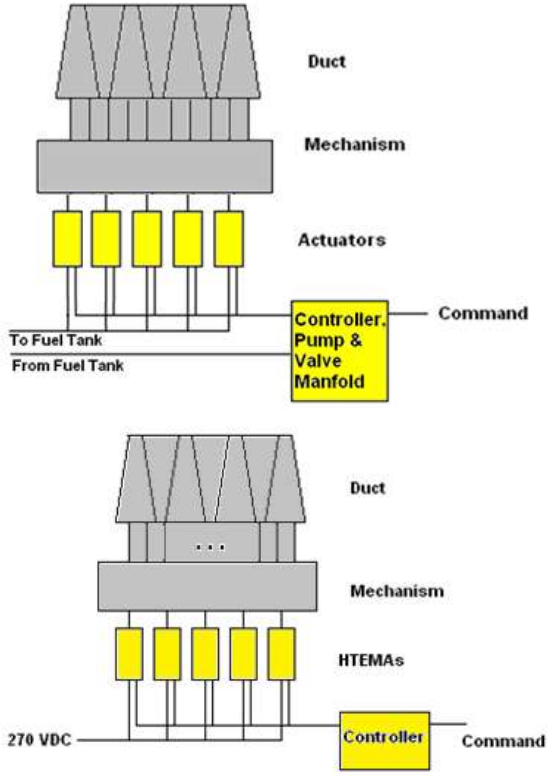


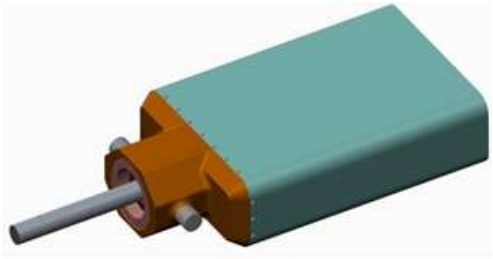
Figure 2: Fuel-draulic and HTEMA CNAS Comparison

HTEMA Performance

Table 1: HTEMA Actuator Performance

CONVERGENT NOZZLE ASSEMBLY SYSTEM (CNAS) ACTUATOR ARRAY		
Parameter	**Value**	**Units**
Peak Force	6,500	Lbf
Stroke	4	in
Slew Rate	4	in/sec
Efficiency	80	%
Weight	52	Lbm
Volume	2.5x6.5x11	in
Voltage	270	V DC
Bandwidth	4	Hz
# of Actuators	5	
Temperature	235-410	°F

Table 1 summarizes the original HTEMA Performance goals. Each of RCT Systems' High Temperature Electro-Magnetic Actuators (HTEMAs) (Figure 3) is capable of producing 6,500 Lbf over a 4" linear stroke with a 4 in/sec slew rate operating on a 270V DC bus; an array of five electro-mechanical actuator working in parallel satisfy the CNAS application goals. Each actuator can produce 1.25 times the rated output force, in the event one unit is inoperable. The demonstration actuator hardware is based on a COTS roller screw driven by a pair of parallel gear motors driven electrically in series.



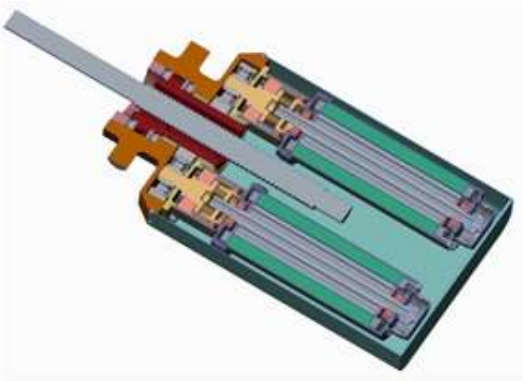


Figure 3: High Temperature Electro-Magnetic Actuator (HTEMA) Developed for AFRL

RCT is building HTEMA hardware and preparing for a test effort demonstrating a TRL of 4-5 in Q3 2015.

Scalability:

The actuator technology is readily scalable for other applications. For example, changing the actuator stroke is readily achievable by modifying the screw length within the existing package. The roller screw is capable of increased force, but impacts to life must be traded. The gear heads with different ratios can be selected to trade the rated torque or force and speed. The motors can be scaled to length to meet different forces or torques and rates. The existing motor windings are scaled for a 4in/sec slew rate and a 270V bus; the windings can be scaled to meet other slew rates and/or bus voltages.

Air flow with a convection coefficient of >5 W/m^2 °C at the actuator must be provided to keep the internal motor temperature at 30C delta above ambient, while slewing at full load. Similarly, a 25C delta at stall & full load will exist at the same conditions. For 20% load at stall a delta of 2C is estimated. If the air flow cannot be provided, the design can be modified for ~ 0.5 GPM of 200F JP8 coolant. The required power electronics coolant flow is estimated at 0.6 GPM of 200F JP8.

Rotary Actuators

The HTEMA motors (Figure 4 can be used separately or in pairs for rotary direct drive or geared applications.

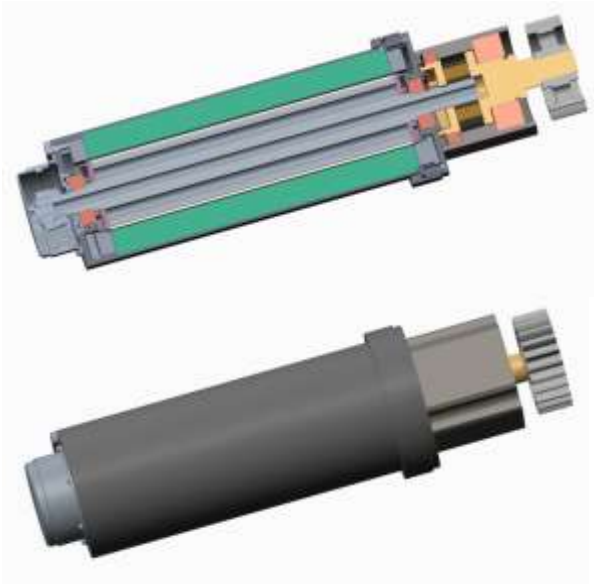


Figure 4: HTEMA Rotary Drive Sub System

Future Applications:

While this actuator could be backfit to an existing engine system, it requires 270VDC (at present) for the power electronics. As mentioned before, all future engine development programs including AETD, AFRL's ADVENT, and the Navy's VCAT could use this actuation technology. RCT Systems has briefed major military engine manufacturers on this development work. Continued advancement in the TRL level of this HTEMA technology through additional development and testing steps would ensure the availability of the technology for the advanced engines resulting from these programs.

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