Improved Rare-Earth Emitter Hollow Cathode

These cathodes have applications in electric thrusters and in industry for plasma processing of optical coatings.

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An improvement has been made to the design of the hollow cathode geometry that was created for the rare-earth electron emitter described in "Compact Rare Earth Emitter Hollow Cathode" (NPO-44923), *NASA Tech Briefs*, Vol. 34, No. 3 (March 2010), p. 52. The original interior assembly was made entirely of graphite in order to be compatible with the LaB_6 material, which cannot be touched by metals during operation due to boron diffusion causing embrittlement issues in high-temperature refractory materials. Also, the graphite tube was difficult to machine and was subject to vibration-induced fracturing.

This innovation replaces the graphite tube with one made out of refractory metal that is relatively easy to manufacture. The cathode support tube is made of molybdenum or molybdenum-rhenium. This material is easily gun-bored to near the tolerances required, and finish machined with steps at each end that capture the orifice plate and the mounting flange. This provides the manufacturability and robustness needed for flight applications, and eliminates the need for expensive e-beam welding used in prior cathodes. The LaB_6 insert is protected from direct contact with the refractory metal tube by thin, graphite sleeves in a cup-arrangement around the ends of the insert. The sleeves, insert, and orifice plate are held in place by a ceramic spacer and tungsten spring inserted inside the tube.

To heat the cathode, an insulating tube is slipped around the refractory metal hollow tube, which can be made of high-temperature materials like boron nitride or aluminum nitride. A screw-shaped slot, or series of slots, is machined in the outside of the ceramic tube to constrain a refractory metal wire wound inside the slot that is used as the heater. The screw slot can hold a single heater wire that is then connected to the front of the cathode tube by tack-welding to complete the electrical circuit, or it can be a double slot that takes a bifilar wound heater with both leads coming out the back. This configuration replaces the previous sheathed heater design that limited the cycling-life of the cathode.

This work was done by Dan M. Goebel of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46782

High-Temperature Smart Structures for Engine Noise Reduction and Performance Enhancement

The most direct beneficiary of this hardware would be next-generation subsonic transports.

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One of key NASA goals is to develop and integrate noise reduction technology to enable unrestricted air transportation service to all communities. One of the technical priorities of this activity has been to account for and reduce noise via propulsion/airframe interactions, identifying advanced concepts to be integrated with the airframe to mitigate these noise-producing mechanisms.

An adaptive geometry chevron using embedded smart structures technology offers the possibility of maximizing engine performance while retaining and possibly enhancing the favorable noise characteristics of current designs. New high-temperature shape memory alloy (HTSMA) materials technology enables the devices to operate in both low-temperature (fan) and high-temperature (core) exhaust flows. Chevron-equipped engines have demonstrated reduced noise in testing and operational use. It is desirable to have the noise benefits of chevrons in takeoff/landing conditions, but have them deployed into a minimum drag position for cruise flight.

The central feature of the innovation was building on rapidly maturing HTSMA technology to implement a next-generation aircraft noise mitigation system centered on adaptive chevron flow control surfaces. In general, SMA-actuated devices have the potential to enhance the demonstrated noise reduction effectiveness of chevron systems while eliminating the associated performance penalty. The use of structurally integrated smart devices will minimize the mechanical and subsystem complexity of this implementation.

The central innovations of the effort entail the modification of prior chevron designs to include a small cut that relaxes structural stiffness without compromising the desired flow characteristics over the surface; the reorientation of SMA actuation devices to apply forces to deflect the chevron tip, exploiting this relaxed stiffness; and the use of high-temperature SMA (HTSMA) materials to enable operation in the demanding core chevron environment.

The overall conclusion of these design studies was that the cut chevron concept is a critical enabling step in bringing the variable geometry core chevron within reach. The presence of the cut may be aerodynamically undesirable in some respects, but it is present only when the chevron is not immersed in the core jet exhaust. When deployed, the gap closes as the chevron tip enters the high-speed, high-temperature core stream. Aeroacoustic testing and flow visualization support the contention that this cut is inconsequential to chevron performance.

This work was done by Todd R. Quackenbush and Robert M. McKillip, Jr., of Continuum Dynamics, Inc. for Glenn Research Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18416-1