

Alan Pierce

pierceaj@techtoday.us; follow on Twitter @TechToday_us

The Hybrid Jet-Rocket Engine

Hybrid cars give you the fuel efficiency of an electric vehicle with the range of an old-fashioned gas guzzler.

that a jet engine mixes ordinary air, which it draws in from its surroundings, with the fuel it carries in its

straight up toward low Earth orbit. In jet engine mode, the engines are pulling in outside air and combining this air with its fuel for combustion. As in any jet plane, the hot gases coming out the back of the engine push the plane forward.

As the plane accelerates and climbs, it encounters thinner and thinner air. Its speed also causes the air around the plane to superheat. The combination of thinner air that is also being superheated to almost 2,000° F would prevent a normal jet engine from continuing to provide proper thrust. Past research into a hybrid jet-rocket engine had been stymied by the problem of cooling and compressing the hot, thin air. This was a significant obstacle that the aerospace engineers at Reaction Engines Ltd had to overcome. They have now developed and tested a solution that might make their engine a big player in the future of space flight.

The engineers developed a liquid helium cooling system for the SABRE engine. This cooling system can quickly cool 2,000° F air down to -238°. Still flying in jet engine mode, the air is now compressible as it is fed into the SABRE engine turbo-compressor. (See Photo 2.) While

Photos: Reaction Engines Ltd



Photo 1—The Skylon spaceship will have two SABRE engines and will be able to fly both as a jet airplane and as a rocket-powered spaceship.

Engineers at Reaction Engines Ltd, a company located in Oxfordshire, England, have been creating the same synergistic hybrid relationship in a new type of engine that operates both as a jet engine and a rocket engine.

They think that a hybrid jet-rocket engine would provide the aerospace industry with the perfect power plant to propel a single-stage spaceship from the ground directly into low Earth orbit. Photo 1 shows a Skylon spaceship designed to fly with SABRE hybrid jet-rocket engines mounted on the end of each wing.

With funding from the European Space Agency and the British government, the Reaction Engines Ltd engineers have now successfully tested their hybrid SABRE rocket engine. (The SABRE name is an acronym for Synergistic Air Breathing Rocket Engine.) The main difference between a jet engine and a rocket engine is

fuel tanks. It combines this air with the fuel for combustion. A liquid-fuel rocket has a tank full of fuel and also a tank full of an oxidizer such as liquid oxygen.

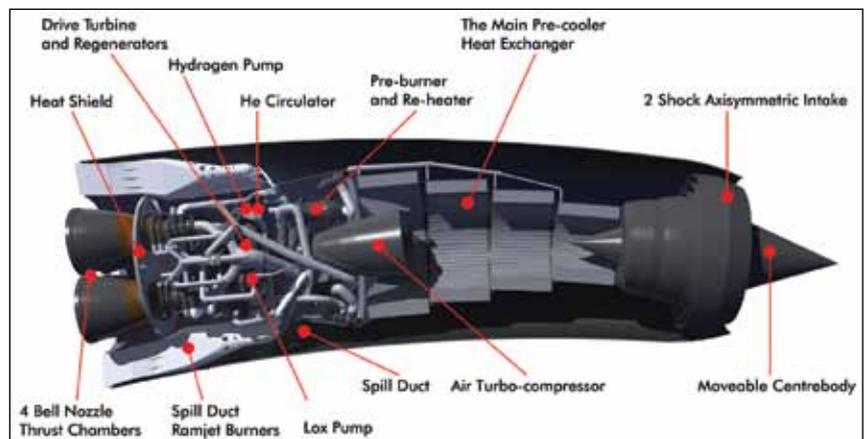


Photo 2—Parts of the SABRE engine. When the outside air becomes too thin for combustion, the engine switches from jet mode to rocket mode.

A hypothetical flight plan for a spaceship powered by SABRE engines calls for the plane to take off from a regular runway and then quickly accelerate to over five times the speed of sound, flying almost

climbing into thinner atmosphere, the compressed air continues to support combustion as it is mixed with the plane's liquid hydrogen fuel. As long as the air is thick enough to compress for proper combustion, the

Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.

hybrid jet-rocket spaceship continues to fly in jet mode.

When the outside air becomes too thin for efficient combustion, the SABRE hybrid engine is switched to rocket mode. In this mode, it uses liquid oxygen that is stored on the plane for propulsion outside of Earth's usable atmosphere. The spaceship now gets all it needs for combustion from its hydrogen fuel tank and its separate liquid oxygen oxidizer tank. In both the jet and rocket modes, the SABRE engine combustion chamber and nozzle create the thrust that pushes the spaceship on to its destination. (Again, refer to Photo 2.)

When it returns from space, the engines switch from rocket mode to jet mode as soon as the atmosphere is thick enough for the SABRE engines to once again use ordinary air for combustion. The hybrid system reduces the amount of oxidizer that the spaceship needs for combustion to get into orbit. The hybrid system also allows the spaceship to return to earth flying like an ordinary airplane.

A spaceship powered by hybrid rocket engines could take off from an airport runway and then directly fly cargo and people into low Earth orbit. Initially, SABRE-powered spaceship flights would deliver cargo and people to the International Space Station. The advantage of SABRE engines is that they will allow a spaceship to carry much less weight in fuel and also fly back to Earth and land like an ordinary airplane. Eventually, if the technology proves to be as safe as current jet engines, these planes

could carry passengers to any place in the world in just a few hours.

Recalling the Facts

1. Why can't a jet plane fly people or cargo directly into low Earth orbit?
2. Describe the different modes of the SABRE engine and how these modes will provide the thrust to send a future spaceship into low Earth orbit.
3. What factors might make the SABRE engine more efficient than a conventional liquid-fuel rocket? ☺



Statement of Ownership, Management, and Circulation: 1. Title of publication—TECH DIRECTIONS; 2. Publication No. 484-160; 3. Date of filing—October 1, 2013; 4. Issue frequency—monthly, August through May (No December, June, or July); 5. Number of issues per year—6; 6. Annual subscription price—\$30.00; 7. Complete mailing address of known office of publication—PO Box 8623, Ann Arbor, Washtenaw Co., MI 48107-8623; 8. Complete mailing address of headquarters or general business office of publisher—2851 Boardwalk St., Ann Arbor, MI 48104-6715; 9. Full names and complete mailing addresses of publisher, editor, and managing editor—Publisher, Turalee A. Barlow, 2851 Boardwalk St., Ann Arbor, MI 48104-6715; Editor, none; Managing Editor, Susanne Peckham, 2851 Boardwalk St., Ann Arbor, MI 48104-6715; 10. Owner—Praxair Publications, Inc., Ann Arbor, Michigan; Turalee A. Barlow, Dudley R. Barlow, 1316 S. Seventh St., Ann Arbor, MI 48103; Janice E. Knoppe, 2323 Baker Rd., Dexter, MI 48130; Susanne Peckham, 1006 Bath St., Ann Arbor, MI 48103; 11. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities—none; 13. Publication title—TECH DIRECTIONS; 14. Issue date for circulation data below—October 2013; 15. Extent and nature of circulation—Average no. copies each issue during preceding 12 months: a. Total no. copies (net press run) 6,594; b. Legitimate Paid and/or Requested Distribution (By Mail and Outside the Mail) (1) Outside County Paid/Requested Mail Subscriptions Stated on PS Form 3541 (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, advertiser's proof copies, and exchange copies)—6,231; (2) In-County Paid/Requested Mail Subscriptions Stated on PS Form 3541 (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, advertiser's proof copies, and exchange copies)—209; (3) Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid or Requested Distribution Outside USPS—none; (4) Requested Copies Distributed by Other Mail Classes Through the USPS (e.g., First-Class Mail)—none; c. Total Paid and/or Requested Circulation (Sum of 15b (1), (2), (3), and (4))—6,440; d. Nonrequested Distribution (By Mail and Outside the Mail) (1) Outside County Nonrequested Copies Stated on PS Form 3541 (Include Sample copies, Requests Over 3 years old, Requests induced by a Premium Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists and other sources)—none; (2) In-County Nonrequested Copies Stated on PS Form 3541 (Include Sample copies, Requests Over 3 years old, Requests induced by a Premium Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists and other sources)—none; (3) Nonrequested Copies Distributed Outside the Mail (Include Pickup Stands, Trade Shows, Showrooms and Other Sources)—none; e. Total Nonrequested Distribution (Sum of 15d (1), (2), and (3))—none; f. Total Distribution (Sum of 15c and 15e)—6,440; g. Copies not Distributed (See Instructions to Publishers #4, (page #3))—154; h. Total (Sum of 15f and g)—6,594; i. Percent Paid and/or Requested Circulation (15c divided by f times 100)—100%; No. Copies of Single Issue Published Nearest to Filing Date: a. Total no. copies (net press run) 6,800; b. Legitimate Paid and/or Requested Distribution (By Mail and Outside the Mail) (1) Outside County Paid/Requested Mail Subscriptions Stated on PS Form 3541 (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, advertiser's proof copies, and exchange copies)—6,463; (2) In-County Paid/Requested Mail Subscriptions Stated on PS Form 3541 (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, advertiser's proof copies, and exchange copies)—211; (3) Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid or Requested Distribution Outside USPS—none; (4) Requested Copies Distributed by Other Mail Classes Through the USPS (e.g., First-Class Mail)—none; c. Total Paid and/or Requested Circulation (Sum of 15b (1), (2), (3), and (4))—6,674; d. Nonrequested Distribution (By Mail and Outside the Mail) (1) Outside County Nonrequested Copies Stated on PS Form 3541 (Include Sample copies, Requests Over 3 years old, Requests induced by a Premium Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists and other sources)—none; (2) In-County Nonrequested Copies Stated on PS Form 3541 (Include Sample copies, Requests Over 3 years old, Requests induced by a Premium Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists and other sources)—none; (3) Nonrequested Copies Distributed Outside the Mail (Include Pickup Stands, Trade Shows, Showrooms and Other Sources)—none; (4) Nonrequested Copies Distributed Outside the Mail (Include Pickup Stands, Trade Shows, Showrooms and Other Sources)—none; e. Total Nonrequested Distribution (Sum of 15d (1), (2), and (3))—none; f. Total Distribution (Sum of 15c and 15e)—6,674; g. Copies not Distributed (See Instructions to Publishers #4, (page #3))—126; h. Total (Sum of 15f and g)—6,800; i. Percent Paid and/or Requested Circulation (15c divided by h times 100)—100%; 16. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the November 2013 issue of this publication; 17. I certify that all information furnished on this form is true and complete. Vanessa K. Revelle, Circulation Manager.

The last graduation cap they'll ever need.



JOHN DEERE

Give your students the advantage by introducing the same learning series our John Deere technicians use in their first year on the job. John Deere Publishing offers five comprehensive series of educational curricula covering agribusiness management practices, agricultural machinery operation, and equipment maintenance. Written in simple language instruction with detailed and easy-to-follow illustrations, these books give students clear demonstrations for greater understanding and retention. Our textbooks will help students to think and analyze, enabling them to become better technicians or machine operators of large and small equipment. For more information visit us at www.JohnDeere.com/publications.

