Three Phases of Low-Cost Rocket Engine Demonstration Program Completed

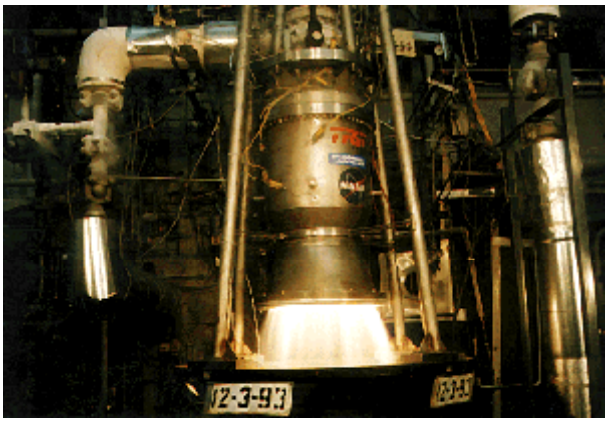
The NASA Lewis Research Center and the TRW Space & Technology Group have successfully completed three phases of testing on the Low-Cost Rocket Engine Demonstration Program. TRW and the McDonnell Douglas Corporation are working, in a joint effort, to quickly develop and produce a highly stable, inexpensive, simple, yet reliable, expendable launch vehicle. Studies have shown that this launch system is required to maintain U.S. viability to space access in the face of growing foreign competition. For the U.S. commercial launch industry to remain competitive, a low-cost launch vehicle must be developed to place payloads into low-Earth orbit. Trade studies performed by McDonnell Douglas and TRW have shown that a low-cost, commercial, expendable launch vehicle could be designed that uses low-pressure turbopumps and rocket combustors. These studies show that expensive high-performance technology can be sacrificed for inexpensive lower performance technology and still meet mission requirements. Because the propulsion system is more than half of a launch vehicle's cost, TRW proposed the pintle injector engine design used in the Apollo Program--the lunar module descent engine.

TRW's pintle injector engine, which runs on liquid hydrogen or RP-1 fuels and liquid oxygen oxidizer, uses modified low-pressure turbopumps to supply the propellants. The engine consists of a centrally located, coaxial injector; an ablative liner for insulating the metal surfaces of the combustion chamber and nozzle; and annular sleeves to throttle the propellant feeds.

Lewis and TRW entered into a Space Act Agreement to demonstrate that the pintle injector can operate at acceptable stable performance levels and to demonstrate the life of a low-cost, combustion chamber with an ablative lining. The test program consisted of three phases: (1) testing a 16,500-lb-thrust liquid oxygen/liquid hydrogen (LOX/LH2) engine, (2) testing a 40,000-lb-thrust LOX/LH2 engine, and (3) testing a 13, 000-lb-thrust LOX/RP-1 engine. All testing was done at Lewis' Rocket Engine Test Facility (REF).

The 16,500-lb-thrust engine was tested from December 1991 through March 1992. Results show that the engine delivered 95 to 97 percent characteristic velocity (C^*) efficiency, about 2 to 4 percent higher than expected. No combustion instabilities were exhibited, and the ablative liner showed acceptable levels of ablation.

The 40,000-lb-thrust engine was tested from September 1993 through February 1994 to determine scaling issues and to demonstrate life of the flight-weight ablative liner. The Lewis test results show that the engine delivered 95-percent C^* efficiency. The data indicate no combustion instabilities, and the ablative liner showed acceptable levels of ablation (<0.006 in./sec).



Combustion chamber with ablative liner tested with 40,000-lb-thrust liquid oxygen/liquid hydrogen.

The 13,000-lb-thrust liquid oxygen/RP-1 engine was tested from January 1995 through March 1995. The *C** efficiency demonstrated on this configuration was 95 percent. The engine was stable in general but had low-frequency, rough combustion at startup because of slow manifold filling, a minor design issue. Because of a leaky pintle seal design, TRW's pintle was damaged on several tests. This problem was soon corrected by the Lewis team. During the ablative liner test, half of the throat region ablative liner fell out because it had delaminated from the shell during fabrication. The approximate radius ablation rate was 0.013 in./sec. Using these test results, TRW and McDonnell Douglas are now working on expendable launch vehicle upgrades.

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