

PINTLE INJECTOR PROGRAM (PIP)

In 1991 TRW Space and Technology Group (TRW) and NASA Lewis Research Center (NASA/LERC) entered into an agreement to establish a cooperative test program. Its objective was to demonstrate the feasibility of operating a TRW Coaxial Pintle Injector Rocket Engine using liquid oxygen (LOx) and liquid hydrogen (LH₂) as propellants. The purpose of this effort was to demonstrate technology that would significantly reduce the cost of launching payloads into space. It was based on studies conducted by the participating parties that also included the McDonnell Space Systems Company (MDSSC).

NASA/LERC had been approached by TRW because of NASA's expertise in LOx/LH₂ rocket engine development and testing, and expertise in bombing of rocket engine chambers to test for combustion stability (no pressure oscillations). The TRW Coaxial Pintle Pressure – Fed Engine Concept had been tested on storable hypergolic propellants, but not with the cryogenic propellants – LOx and LH₂. Therefore it was necessary to test and demonstrate that the Pintle Injector Concept would display good combustion stability characteristics running on LOx and LH₂ for long burn durations typical of a booster. Other test objectives were to obtain ignition and combustion performance, combustion stability, heat transfer and combustion efficiency data.

The Pintle Injection Program was completed in 3 phases over a 4-year period. The first 2 phases were done with a 16K(thousand) thrust configuration using both LOx/LH₂ and LOx/hydrocarbons as propellants. The third and final phase configuration was at a thrust level of 40K with LOx/LH₂ propellants. All test and development work were very successful and accomplished on schedule.

PINTLE INJECTOR PROGRAM. (PIP) ①

IN 1991 TRW SPACE AND TECHNOLOGY GROUP (TRW) AND NASA LEWIS RESEARCH CENTER (NASA) ENTERED INTO AN AGREEMENT TO ESTABLISH A COOPERATIVE TEST PROGRAM, ~~HAVING AS ITS~~ OBJECTIVE ~~WAS~~ ^{WAS TO} THE DEMONSTRATION ~~OF~~ THE FEASIBILITY OF OPERATING A TRW COAXIAL PINTLE INJECTOR ROCKET ENGINE ~~ON~~ ^{USING} LIQUID OXYGEN (LOX) AND LIQUID HYDROGEN (LH₂) PROPELLANTS, THE PURPOSE OF THIS EFFORT ~~WOULD BE~~ ^{WAS} TO DEMONSTRATE TECHNOLOGY THAT ~~WOULD~~ SIGNIFICANTLY REDUCE THE COST OF LAUNCHING PAYLOADS INTO SPACE. ~~THIS EFFORT~~ ^{THIS} WAS BASED ON STUDIES CONDUCTED BY THE PARTICIPATING PARTIES, WHICH ALSO INCLUDED THE MCDONNELL SPACE SYSTEMS COMPANY. (MDSSC)

THE TRW COAXIAL PINTLE PRESSURE-FED ENGINE CONCEPT HAD BEEN TESTED ON STORABLE HYPERGOLIC PROPELLANTS, BUT NOT WITH ~~THE~~ ^{CRYOGENIC} PROPELLANTS - LOX AND LH₂. THE ~~NEED~~ ^{REQUIREMENT} WAS ~~TO~~ ^{TO} TEST AND DEMONSTRATE THAT THE PINTLE INJECTOR CONCEPT WOULD DISPLAY GOOD COMBUSTION STABILITY (~~ZERO PRESSURE OSCILLATIONS~~) CHARACTERISTICS RUNNING ON LOX & LH₂, ~~AND~~ FOR LONG BURN DURATIONS, TYPICAL OF A BOOSTER. OTHER TEST OBJECTIVES WERE TO OBTAIN IGNITION AND COMBUSTION PERFORMANCE ~~DATA~~, COMBUSTION STABILITY, HEAT TRANSFER, AND COMBUSTION EFFICIENCY DATA.

NASA/LERC ~~had been~~ approached by

~~That~~ ~~IS~~ WAY TRW/MCDSSC ~~APPROACHED~~
NASA/LERC, BECAUSE OF THEIR EXPERTISE IN
LOX/LH₂ ROCKET ENGINE DEVELOPMENT AND TESTING,
AND ALSO ~~THEIR~~ ^{THEIR} EXPERTISE IN BOMBING OF ROCKET
ENGINE ~~CHAMBERS~~ CHAMBERS TO TEST FOR COMBUSTION
STABILITY (NO PRESSURE OSCILLATIONS).

The Pintle Injection
→ ~~that~~ PROGRAM WAS ACCOMPLISHED IN 3 PHASES,
OVER A 4 YEAR PERIOD. THE FIRST 2 PHASES
WERE DONE WITH A 16 K (THOUSAND) THRUST
CONFIGURATION, USING BOTH LOX/LH₂ AND LOX/
HYDROCARBONS AS PROPELLANTS. THE THIRD AND
FINAL PHASE CONFIGURATION WAS AT A THRUST
LEVEL OF 40K, WITH LOX/LH₂ PROPELLANTS.
ALL TEST AND DEVELOPMENT WORK WERE VERY
SUCCESSFUL AND ~~ON~~ ACCOMPLISHED ON SCHEDULE.

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In 1991 TRW Space & Technology Group (TRW) and NASA Lewis Research Center (NASA) entered into an agreement to establish a cooperative test program, having as its objective the demonstration of the feasibility of operating a TRW coaxial pintle injector rocket engine on liquid ~~(LOX)~~ oxygen (LOX) and liquid hydrogen (LH₂) propellants. The purpose of this ~~demonstration~~ ^{agreement} would be to ~~develop~~ demonstrate

technology that would significantly reduce the cost of launching payloads into space according to studies of the participating parties, ~~which~~ which also included McDonnell Space Systems Company.

EFFICIENCY / This TRW coaxial pintle pressure-fed engine concept had been tested on storable hypergolic propellants, but not cryogenic propellants. The need was to test and demonstrate that this pintle injector concept would ^{display} good combustion stability characteristics running on LOX/LH₂, and for long burn durations, typical of ~~a~~ a booster. Other test objectives were to obtain ignition and combustion performance, ~~test~~ stability, and heat transfer data.

That is why TRW + ^{MCDONNELL} ~~McDonnell~~ approached
NASA-LERC ~~because~~ because of their ~~expertise~~
expertise in testing LH_2/LOX rocket engines,
and also our expertise in bombing ~~the~~ of rocket
engines to test the combustion stability.

The ~~project~~ program was accomplished in 3 phases,
over a 4 year period. The first 2 phases were
done with a 16K thrust configuration, using both
 LOX/LH_2 and $\text{LOX}/\text{HYDROCARBONS}$ as propellants.
That third and final ~~for~~ phase configuration ~~was~~ was
at a thrust level of 40K, with LOX/LH_2 .
All test were successful and stable and.