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STME NOZZLE THERMLA ANALYSIS

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The National Launch System (NLS), previously known as the Advanced Launch System (ALS), is a joint program of the DoD and NASA. After being initiated in July 1987, the phase I of the program was completed in 1988 in collaboration with seven contractors. Work is now in progress on phase II, based on the concepts developed in phase I. The NLS program is anticipated to acquire launch and operational capabilities by the beginning of the next century. A common cryogenic (liquid oxygen and hydrogen) core engine called Space Transportation Main Engine (STME) provides the common core for a variety of reference vehicle concepts developed in phase I.

A review of the current technology, relevant to the design and development of the STME, was undertaken by the author in the Summer of 1991 as a NASA/ASEE Summer Faculty Fellow at MSFC. The review involved an extensive literature search relevant to the development of the following major components of the STME:

1) Gas Generator
2) Hydrostatic/Fluid Bearings
3) Seals/Clearances
4) Heat Exchangers
5) Nozzle
6) Nozzle/Main Combustion Chamber Joint
7) Main Injector Face Plate
8) Rocket Engines-General

The details of this investigation are given in Ref. 1.

The current summer project which is a continuation of last year's summer project, has the objective of carrying out a detailed thermal analysis of the STME nozzle.

The design and development of the STME nozzle has been undertaken by Pratt & Whitney in collaboration with NASA/MSFC and DoD. The nozzle design has adopted film/convective cooling techniques. The turbine exhaust has been utilized as the coolant in the nozzle cooling system. The coolant is injected into the nozzle wall at a section about 21 inches downstream of the throat. At the inlet, the coolant is divided into three different streams: (1) convective, (2) primary film, and (3) secondary film coolant as shown in figure 1.
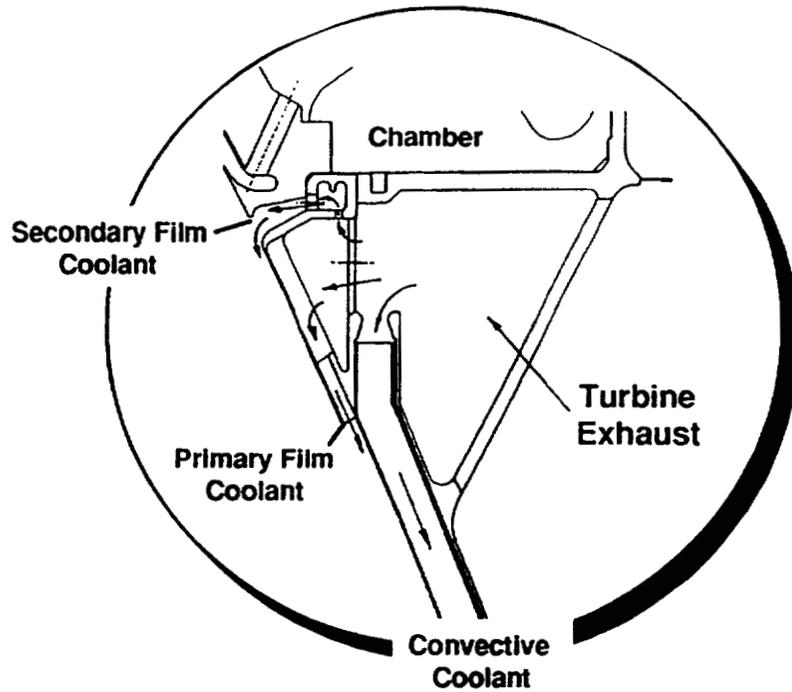
Figure 1

Some of the important parameters are shown in table 1.

TABLE 1

Coolant Parameters	Value
Inlet pressure	268.90 psia
Exit pressure	71.00 psia
Inlet temperature	1168.06°R
Exit temperature	1504.00°R
Flow:	66.72 lbm/sec
- Convective	55%
- Primary Film	38%
- Secondary Film	7%

An attempt is being made to develop a coupled (conjugate) fluid/thermal analysis model for the nozzle cooling system using the software Systems Improved Numerical Differencing Analyzer (SINDA) 1987/ANSI (Gaski Version). Owing to the limited time available for the summer project (ten weeks), it was decided that initially, the model should be developed for the convective coolant flow only. Further development of the model to include the primary and secondary coolant flows will be undertaken as a continuation project.

The Convective Flow/Thermal Analysis Model

The one-dimensional conjugate model has been developed according to the standard SINDA 1987/ANSI (Ref. 2) procedure. The geometric input data were obtained form the engineering drawings made available by Pratt & Whitney and the gas properties were derived from the archives of Rocketdyne. The model consists of 44 flow nodes and 43 thermal nodes and utilizes the standard SINDA subroutine SNHOSS. The solution procedure follows the four steps outlined below:

(1) The solution is initiated by solving a set of linear incompressible, but physically unrealistic network equations.

(2) This solution is used as a starting point for the linearized incompressible flow equations.

(3) The model then calculates the steady state solution of the linearized compressible flow equations.

(4) The final solutions are then obtained with the density corrected for the static pressure.

Further details on the solution procedure can be obtained from (Ref. 3). The flow chart of the model presented in Fig. 2.

As indicated earlier, the model in its present form deals only with one-dimensional convective coolant flow. Extension of the model to include the primary and secondary coolant flows will be undertaken as a continuation project.

REFERENCES

1. Das, D.K., "An Overview of the Current Technology Relevant to the Design and Development of the Space Transportation Main Engine (STME)," NASA/MSFC Report, Thermal Analysis Branch, ED64. August 1991

2. Gaski, J.D., "SINDA 1987/ANSI," User's Manual, Network Analysis Associates, Inc., Fountain Valley, CA

3. Owen, J.W., "Thermal Analysis Workbook," NASA Technical Memorandum, NASA TM-103568, Jaunary 1992

Figure 2
The Input Deck: Flow chart of logic blocks