Numerical Simulation of Propellant Management for Rockets and Spacecrafts

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Abstract

In order to improve the payload capacity of spacecraft, it is necessary to optimally design the propellant amount on board under the uncertainty of cryogenic propellant evaporation and low gravity environment. This project has been conducting numerical simulation development for the cryogenic propellant thermal flow analysis. By understanding the internal heat flow of the propellant tank and the feed line, it is linked to the change of propellant system design and operation.

Reasons for using of JSS2

In the thermal flow analysis inside upper stage propellant tanks, the calculation lattice is as small as several millimeters in order to consider a evaporation on the liquid surface, and it is necessary to solve operation time of 500 seconds or more. The calculation load of this tank thermal flow analysis is so large that it requires the supercomputer's performance.

Achievements of the Year

The flow in the upper propellant tank during flight operation is changing every moment due to the difference in fluid density and rocket's acceleration.

From improving the evaluation of the heat transferred to the liquid surface by implementing a physical model that takes into consideration the effects of evaporation and component mixing such as helium, the upper stage of the H-IIA rocket Simulation from engine start to inertial flight after engine stop was realized.

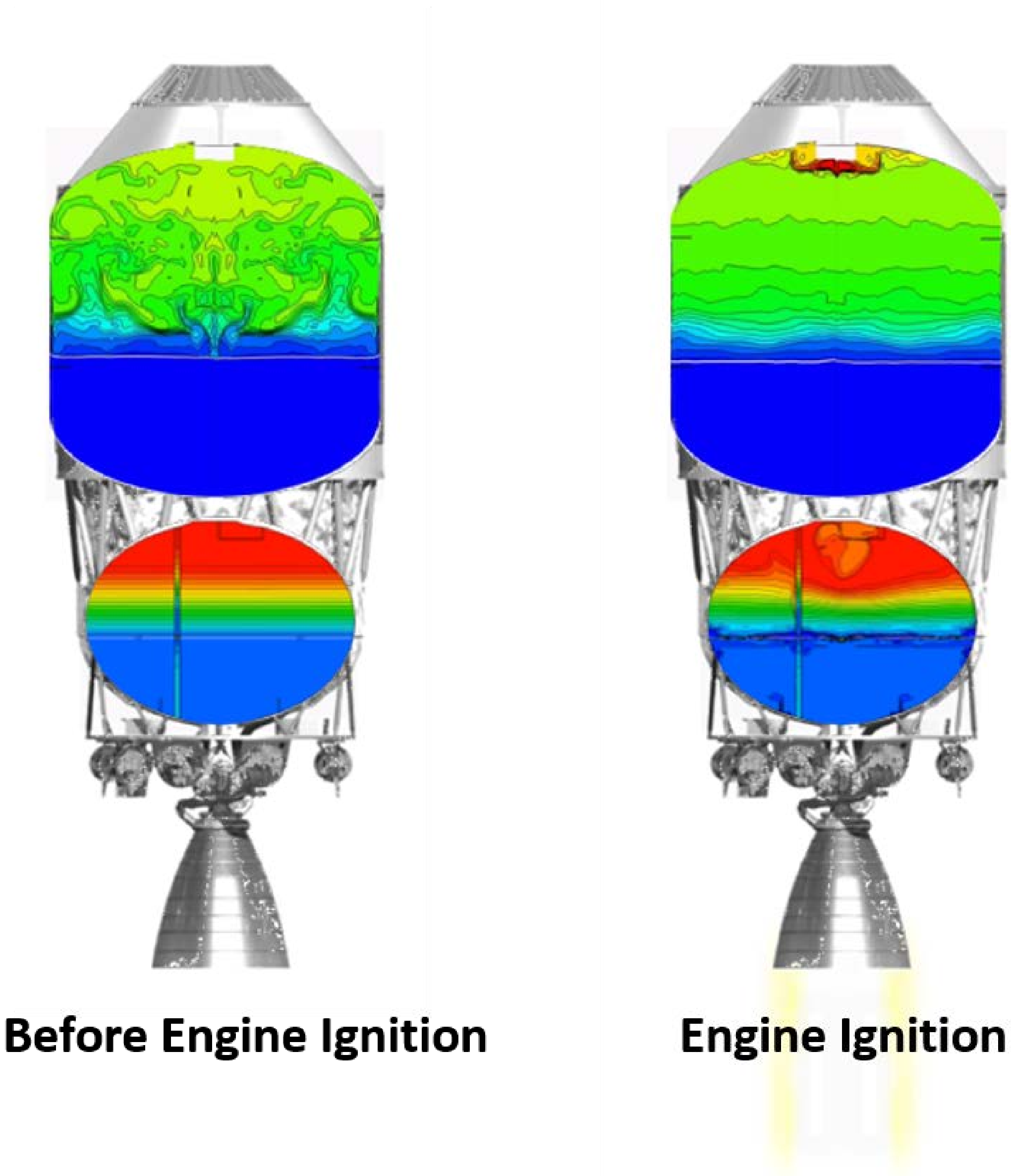

Fig.1 The thermal flow behavior inside the upper stage propellant tank

Publications

- Non peer-reviewed papers

1) Liquid Nitrogen Chill-down Process Prediction by Direct Interface Tracking Approach, Yutaka UMEMURA, Takehiro HIMENO, Osamu KAWANAMI, Wataru SARAE, Kiyoshi KINEFUCHI, Hiroaki KOBAYASHI, Osamu FUKASAWA, Propulsion & Energy 2017
2) Visualization for Liquid Behavior under Low Acceleration Attitude Control, Yutaka UMEMURA, Takehiro HIMENO, Daichi HABA, Osamu FUKASAWA, Mayu MATSUMOTO, Yasuhiro SAITO
3) Study on Simulation Technology for Improving the Cryogenic Propellant Management in the Space Transfer Vehicle, Yutaka UMEMURA, Takehiro HIMENO, Daichi HABA, Osamu KAWANAMI, Osamu FUKASAWA

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	3 - 4
Elapsed Time per Case	104.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.92

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	4,481,020.35	0.59
SORA-PP	537,755.45	6.73
SORA-LM	81.10	0.04
SORA-TPP	8,021.22	0.89

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	646.24	0.45
/data	22,964.06	0.42
/ltmp	15,688.24	1.18

Archiver Resources		
Archiver System Name	Storage used(TiB)	Fraction of Usage*2 (%)
J-SPACE	0.24	0.01

*1 Fraction of Usage in Total Resources: Weighted average of three resource types (computing, file system, and archiver)

*2 Fraction of Usage: Percentage of usage relative to each resource used in one year