Space Propulsion 2024

Team work project

Your company is developing a new product branch. It is based on liquid semi-cryogenic propulsion (LOX-RP1) to be operated in vacuum.

Liquid propulsion

The liquid propulsion system has not yet been designed. It is only known that:

- you have an initial thrust of 1 kN
- you have an initial chamber pressure of 50 bar in the combustion chamber and a minimum of 20 bar
- the total space allocated to your propulsion system is a cylinder of 2 meter length and 1 meter diamter. The empty spaces in your propulsion system will be about 20% of the total available space (so 80% is tanks + combustion chamber up to the convergent … the nozzle will protrude from the cylinder so it is not considered)
- The system will be blow-down. Pay attention at the pressure change which will modify the mass flow rate in an uneven way for the oxidizer and the fuel branch.
- The system will be based on produced in additive manufacturing. Both minimum size and accuracy are of primary concern for the injection plate.

The team has to prepare a design of the propulsion system and a performance evaluation:

- two blow-down tanks (assuming adiabatic expansion of the pressurizing gas in the tank)
- for the nominal configuration, nozzle, combustion chamber, and injection plate
- for the nominal configuration, evaluate the time profile of thrust, specific impulse and compute the total impulse including losses
- Verify if the engine can be cooled with RP1 during its all operative life (only check with comment)
- Quantiy the expected effect produced by the uncertainties in the additive manufacturing of the injection plate, if no post-machining refinement is performed.

The report

The report will be 25 pages max and will have to include:

- A brief literature analysis on nozzle losses, metallic additive manufacturing uncertainty, and on blow-down architectures.
- The modeling approach (essential collection of equations with references, no theory)
- The results

- A comment to the results

Outside the 25 pages, the students can attach an appendix that can complement the text but they are not essential for the comprehension of the work.

In addition, an authorship declaration is mandatory. The declaration is considered accepted by the whole team. Each member has to be enlisted for at least one technical task. Literature, programming, modeling, etc. are technical tasks. Writing/revising the report is NOT a technical task. One task may be allocated to more than one member.

Example of authorship declaration

MEMBER A: contribution to model of tanks, internal ballistics, thermal protection sizing

MEMBER B: literature survey of solid propellants

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