Designing an LNG Pump for the Titan Rocket Engine in AxSTREAM

Summary

Client:

STAR Dresden

Need:

Develop a reusable closed expander-cycle rocket engine fueled by liquid oxygen (LOX) and liquefied natural gas (LNG). As STAR Dresden's first pump-fed rocket engine, the project required a baseline 3D hydraulic flow path using rapid 1D/2D methods rather than complex full-scale CFD.

Solution:

AxSTREAM System Simulation balanced the closed expander cycle energy budget. Empirical data was used to establish initial boundary conditions for the pump design in AxSTREAM. The software then automatically generated and verified the LNG pump's final geometry using real-gas models and loss correlations.

Product Requirements:

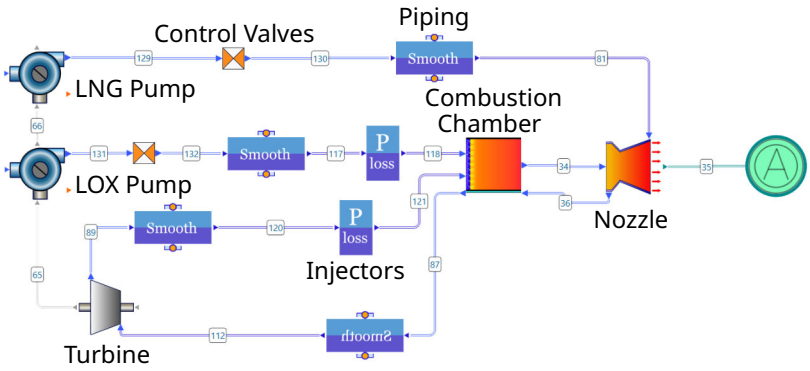
Pressurize subcooled LNG from a tank pressure of 2 bar to a minimum of 55.4 bar at a nominal mass flow rate of 1 kg/s and a shaft speed of 40,000 rpm. The architecture had to suppress cavitation at the inlet, accommodate secondary cooling tap-offs, and integrate onto a single common shaft with a LOX pump and a turbine.

Results:

A compact two-stage pump design featuring an inducer for improved suction performance. Validation achieved 55.6 bar outlet pressure at 67.3% hydraulic efficiency.

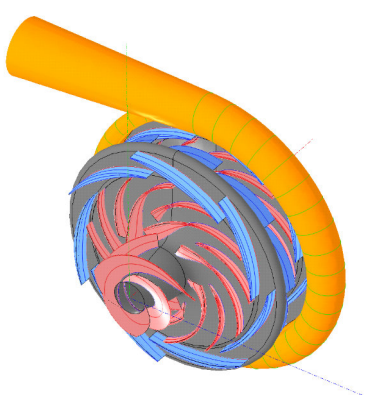
Rocket Engine Cycle Simulation

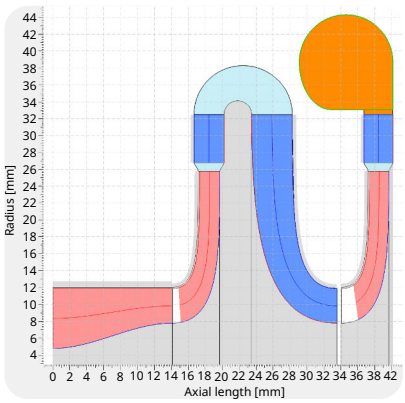
AxSTREAM System Simulation served as the primary thermodynamic modeling environment for the closed expander cycle rocket engine. By coupling all major engine components and using the integrated CoolProp library, the software resolved the energy transfers governing the cycle. This balance established the baseline fluid and power states functioning as boundary conditions for the turbopump's hydraulic design.



LNG Pump Design

AxSTREAM translated the boundary conditions into 3D flow paths by coupling an automated inverse solver directly with NIST REFPROP data. It screened candidate flow paths against loss models for slip, blockage, and profile friction. Through the integrated blade profiler and meanline solver, the team fine-tuned the geometry, iteratively verifying performance to satisfy the requirements.





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