Rotating Detonation Rocket Engine Cooling System

Graduate

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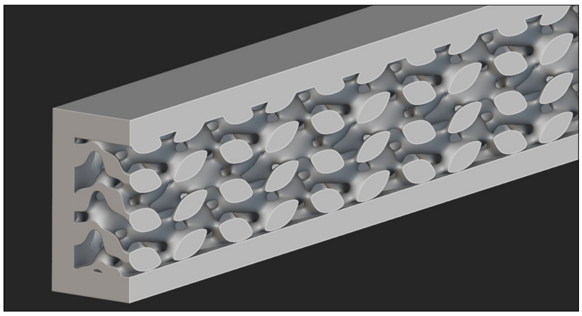
Initial Situation: Rotating Detonation Rocket Engines (RDREs) offer significantly increased thermal efficiency compared to conventional combustion rocket engines, translating directly into higher specific impulse and more compact nozzle designs. To support ARIS' upcoming projects, which aim to launch an RDRE-powered rocket to a height of 3'000 m, this thesis investigates and guides the design of an RDRE cooling system.

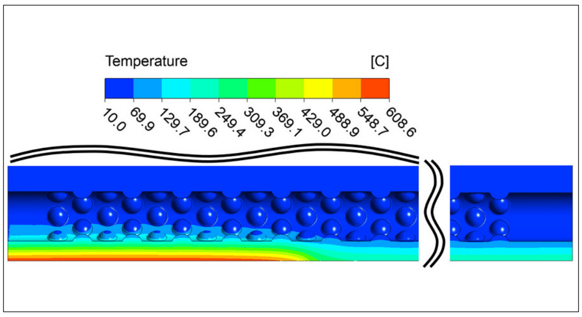
Objective: The objective of this thesis is to develop and evaluate an effective RDRE cooling concept by reviewing regenerative and alternative cooling methods, performing preliminary calculations regarding estimated heat load inside the engine and heat transfer as well as conducting initial CFD simulations. This approach aims to identify key design parameters, optimize geometric and material choices, and establish a decision logic for cooling system selection under expected operating conditions. The resulting cooling concept and design guidelines will be applied to an upscaled RDRE prototype for ground testing, which is not yet intended for integration into a flight ready rocket.

Result: Basic regenerative cooling with water as coolant is selected for its robust heat removal capability and reliability. A subsequent CFD study quantifies key geometric and material parameters. For an inconel alloy with water coolant, a distance to the combustion chamber of 2 to 3 mm and diameters of 3 to 4 mm achieve an optimal balance between conduction path length and pressure drop. Switching to a copper alloy (CuCrZr) significantly lowers peak temperatures through its roughly 25 times higher thermal conductivity and results in better overall temperature distribution. Channel surface dimpling further reduces wall temperatures by the order of 50 K but increases pressure loss by 6 to 10 times, suggesting textured walls to only be used in the highest heat flux zones. Overall, regenerative cooling with water emerges as the most feasible approach given the estimated 3 000 K combustion chamber temperatures and engine dimensions. The guidelines developed as well as the CFD findings offer a path for ARIS' future engine cooling designs.

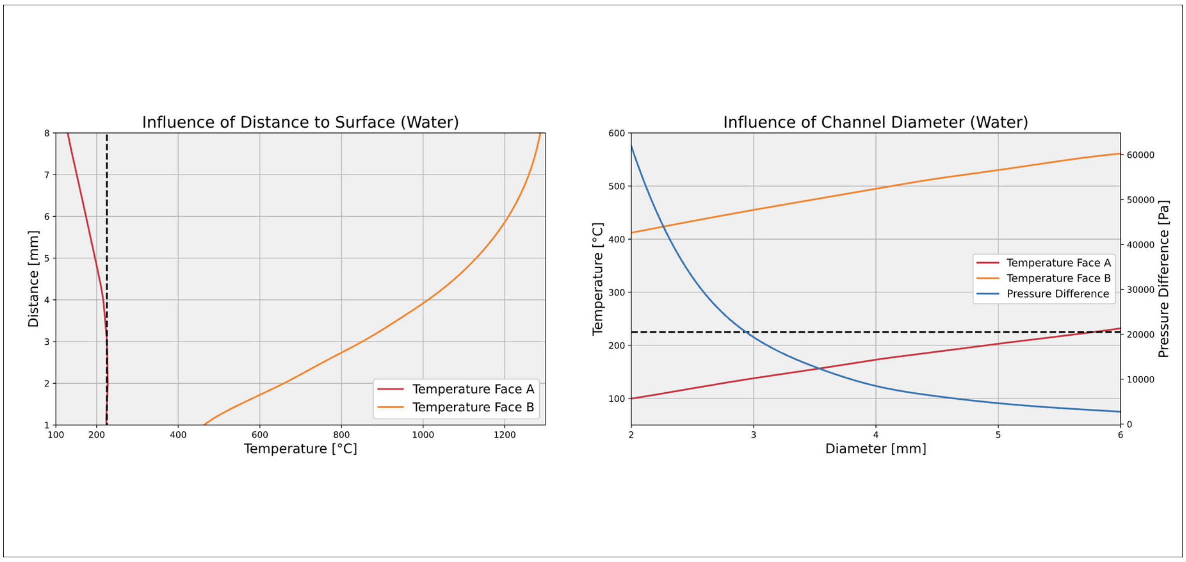
Section view of a lattice infill used to increase surface area and cause turbulences
Own presentment



Temperature distribution of an inconel alloy with a dimpled surface texture and water used as coolant
Own presentment



Temperature profile of an inconel alloy, depending on the channel diameter and the distance to the combustion chamber
Own presentment



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Subject Area
Product Development, Simulation Technology