Student Research Project / Master Thesis

Design of an Additively Manufactured Heat Exchanger for Innovative Engine Cycles

With few exceptions, rocket engines are still operated with gas generators and hot gas turbines to this day. However, hot gas turbines have the disadvantage that they are subject to high wear due to the high exhaust gas temperatures of the gas generator and require additional cooling mechanisms. In comparison, cold gas turbines are used in engines with an expander cycle, which are operated solely by vaporized fuel from the regenerative cooling of the engine. This reduces the maintenance of the turbine components and is therefore particularly suitable for reusable launch systems. However, depending on the design, expander cycles either have a relatively low combustion chamber pressure or an open cycle, which in turn leads to a loss of performance and efficiency.

The GAIA Network e.V. is currently investigating a new expander cycle for reusable rocket engines, which is intended to combine the advantages of previous systems. An additively manufactured heat exchanger, which is fed with cryogenic propellants, is to be used to increase performance. The particular challenge of this heat exchanger is to bring the medium to be cooled below a certain critical temperature in order to realize the cycle.

For the development of this heat exchanger, the work is divided into the following steps:

1. Literature research on the design of rocket engines, heat exchangers, metal 3D printing, cryogenic propellants, thermodynamics, corrosion and CFD analyses
2. Identification and definition of requirements for the heat exchanger based on the predefined engine cycle
3. Definition of various 3D printing geometries for a preliminary heat exchanger design including the creation of CAD models
4. Performing CFD analyses for fluidic and thermodynamic analysis of the heat exchanger approaches
5. Selection and optimization of the most promising solution approach based on the analysis results and the previously recorded and defined requirements
6. Critical analysis of the final concept and presentation of further optimization potential

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Execution only after consultation of supervising university institute