Student Research Project / Master Thesis

Design of a Cluster Nozzle for a Reusable Propellant Settling Thruster

Propellant settling thrusters (PST) are small rocket engines that are able to ignite under microgravity conditions and cause the propellant in the tanks of the main engines to settle. Such microgravity conditions can occur either during the launch of systems in orbit, the ignition of second stages or, in the case of air launch rockets, during the free-flight phase after the drop from the carrier aircraft. Until now, solid-fuel rockets have often been used as PSTs for air launch rockets. However, these are neither controllable nor reusable.

A concept for a reusable PST cluster that is to be operated with liquid propellant is currently being investigated for a reusable air launch rocket. In the case of this PST cluster, the question is whether it makes sense to use a common cluster nozzle instead of several separate nozzles for each individual engine. The advantage of a common cluster nozzle lies in the more compact and lighter design of the PST cluster, as the engines can be positioned closer together. The resulting smaller cross-section of the cluster can further lead to lower aerodynamic drag of the overall launch system. In terms of nozzle flow, however, this design could lead to higher losses resulting in a lower thrust and efficiency of the PST system. For this reason, the advantages and disadvantages of a PST cluster nozzle are to be investigated in more detail in this thesis.

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

1. Literature research on the design of rocket engines, nozzles and CFD analyses
2. Identification and definition of requirements for the PST system and the common nozzle of the PST cluster
3. Creation of a CAD model for a PST system with cluster nozzle and a PST system with separate individual bell nozzles
4. Carrying out CFD analyses for the fluidic optimization of the cluster nozzle based on the previously identified and defined requirements
5. Comparison of the two PST nozzle concepts in terms of efficiency, impact on the overall launch system and effects of individual engine failures
6. Critical analysis of the results and presentation of further optimization potential

Contact: **Kai Höfner, M.Sc.**
Tel. +49 (0) 162 / 656-8462, E-Mail: kai.hoefner@gaia-network.de
Execution only after consultation of supervising university institute