Student Research Project / Master Thesis

Impact of Axially Offset Core Engines in Engine Clusters during Ascent

In reusable launchers, axially offset core engines are often used in engine clusters. This concept has various advantages. Firstly, the aerodynamics of the launcher are improved during re-entry, as the shock waves occurring at the nozzle ends are better deflected around the launcher. This reduces the drag and therefore also the aerodynamic heat development at the engines. On the other hand, an axially offset core engine enables a better introduction of the thrust into the launcher structure and facilitates the installation of the feed systems inside the launcher. A further advantage lies in the improvement of pogo stability as well as the pressure ranges and interaction between the engines, which can also lead to an increase in thrust performance. For landing rocket stages that perform a so-called landing burn, this approach also extends the lever arm to the rocket's center of gravity, enabling smaller and more precise movements of the thrust vector control and thus making landings safer and more precise.

Currently, only recommended values for the axial offset of the core engine for large launch vehicles are available in the literature. The aim of this work is therefore to develop a recommended value for the ascent of reusable launchers of the size of a nanolauncher.

The work is divided into the following steps:

1. Literature research on reusable launchers, thrust vector control, nozzle expansion, engine clusters, flight simulations and CFD.
2. Definition of an ascent scenario with the corresponding inflow conditions and a reference launcher with corresponding core engine positions
3. CAD modeling of the reference launcher system with the different core engine positions
4. Comparative evaluation of the thrust characteristics of different engine positions via CFD
5. Implementation and testing of the thrust characteristics in a predefined flight simulation environment in Matlab/Simulink
6. Critical analysis of the thrust characteristics and presentation of further optimization potential

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Execution only after consultation of supervising university institute