Student Research Project / Master Thesis

Aerodynamic Impact of Re-Entry Burns On Reusable Launchers

As part of the reuse of launch vehicles, the principle of re-entry burns is often used for controlled deceleration during the re-entry of first stages. In this process, the first stage is aligned against the direction of flight and a certain number of engines are ignited a second time. Various effects occur during this maneuver. Firstly, the exhaust jets are deflected by the air flowing in the opposite direction. This can result in heat spots at various points on the launch vehicle, which must be specially protected from the additional heat.

Secondly, the air in front of the launcher body is deflected, which leads to a change in the aerodynamic properties of the vehicle depending on the atmospheric boundary conditions and the associated expansion of the exhaust gas jets. The exhaust front can be actively influenced by means of thrust vector control, which has a corresponding effect on thrust and drag. Ideally, the fuel consumption of first stages can be reduced during re-entry burn by adjusting the engines to suit the environment, which means that more fuel and payload capacity is available for the ascent. This benefit of thrust vector control is to be investigated in more detail in this thesis.

The work is divided into the following steps:

1. Literature research on reusable rockets, thrust vector control, nozzle expansion, engine clusters, flight simulations and CFD.
2. Definition of a re-entry scenario with the corresponding flow conditions and a reference launcher with corresponding engine deflections
3. CAD modeling of the reference launcher system and the engine deflections
4. Comparative recording of the aerodynamics and thrust characteristics via CFD
5. Implementation and testing of the properties in a predefined flight simulation environment in Matlab/Simulink
6. Critical analysis of the properties and presentation of further optimization potential

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