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AEROTHERMODYNAMIC OPTIMIZATION OF HYPERSONIC RE-ENTRY SPACE CAPSULE CONFIGURATIONS

Abstract

This research delves into comprehending diverse aerodynamic trends in hypersonic re-entry capsule geometries, aiming to deepen our understanding of their performance characteristics. Utilizing advanced computational tools like computational fluid dynamics (CFD), we systematically analyze various capsule configurations to elucidate how subtle geometric changes impact aerodynamic behaviour.Understanding these trends is crucial for optimizing capsule design by studying how different geometries affect aerodynamic forces such as lift, drag, and stability. This optimization enhances re-entry safety by predicting potential instabilities or aerodynamic loads that could compromise the vehicle's integrity. It also improves mission success by informing decisions on trajectory planning, landing site selection, and overall mission architecture based on predicted aerodynamic behavior. The insights gained drive future innovations in space vehicle design, pushing the boundaries of human space exploration.This research emphasizes the analysis and optimization of hypersonic re-entry capsule configurations, streamlining the design process and expediting improvements in capsule geometry. By investigating the latest technologies in the space industry for re-entry vehicles, the study addresses key challenges, enhancing the trustworthiness of space capsules/vehicles.The focus on improving the lift-to-drag (L/D) ratio via numerical analysis using ANSYS Fluent underscores aerodynamic efficiency's critical role in facilitating safe and controlled descents during re-entry. Meticulously studying and optimizing the aerodynamic characteristics aims to enhance performance under various re-entry conditions, ensuring smoother descents and minimizing risks associated with re-entry. Advanced computational analysis and optimization techniques push the boundaries of aerodynamic design for more reliable and efficient re-entry vehicles in manned space missions.Incorporating aerothermodynamics principles aids in understanding thermal effects during atmospheric re-entry. This allows more accurate prediction of heat flux, thermal loads, and other aerothermodynamic parameters, improving design optimization and enhancing re-entry vehicle safety.Additionally, the use of aerothermodynamics principles enables the development of sophisticated models for simulating hypersonic flow phenomena, such as shock waves and boundary layer transition. This leads to better understanding and prediction of aerodynamic behavior under extreme conditions, resulting in more robust and reliable design solutions.Our focus on aerothermodynamics-based approaches represents a significant advancement in computational aerodynamics, offering improved accuracy, efficiency, and scalability. Particularly in designing and optimizing re-entry vehicles for manned space missions, these approaches contribute to the ongoing progress in aerospace engineering