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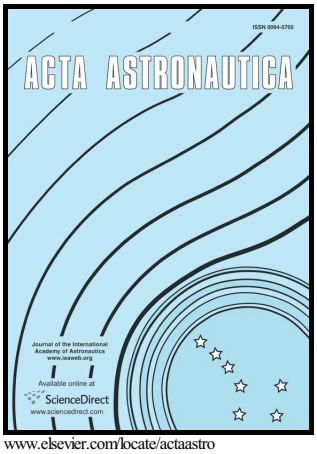

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INCIDENT SHOCK STRENGTH EVOLUTION IN OVEREXPANDED JET FLOW OUT OF ROCKET NOZZLE

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Abstract

The evolution of the incident shock in the plane overexpanded jet flow or in the axisymmetric one is analyzed theoretically and compared at the whole range of governing flow parameters. Analytical results can be applied to avoid jet flow instability and self-oscillation effects at rocket launch, to improve launch safety and to suppress shock-wave induced noise harmful to environment and personnel.

The mathematical model of "differential conditions of dynamic compatibility" was applied to the curved shock in non-uniform plane or axisymmetrical flow. It allowed us to study such features of the curved incident shock and flow downstream it as shock geometrical curvature, jet boundary curvature, local increase or decrease of the shock strength, flow vorticity rate (local pressure gradient) in the vicinity of the nozzle lip, static pressure gradient in the compressed layer downstream the shock, and many others. All these quantities sufficiently depend on the flow parameters (flow Mach number, jet overexpansion rate, nozzle throat angle, and ration of gas specific heats). These dependencies are sometimes unusual, especially at small Mach numbers. It was also surprising that there is no great difference among all these flowfield features in the plane jet and in the axisymmetrical jet flow out of a nozzle with large throat angle, but all these parameters behave in a quite different way in an axisymmetrical jet at small and moderate nozzle throat angles.

Keywords: supersonic jet flow, longitudinal instability, self-oscillations, shock-wave noise, rocket launch safety, theoretical analysis.