Solid propellant rocket nozzle design and validation using Finite Difference Method and CFD technique

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ABSTRACT

A convergent-divergent nozzle, known as Laval Nozzle, is used in solid propellant rocket engines with the aim to increase the outcome combustion gases speed as thermal energy is turned into kinetic energy.

The objective of the present work is to compare a set of results of flow behavior inside the nozzle and in the following atmospheric discharge zone, obtained using different computational techniques. The first step was to calculate the isotropic 1-D flow along the nozzle using the Finite Difference Method, reaching estimative values of pressure and velocity. Then, a new study was carried out using Computational Fluid Dynamics (CFD), particularly the finite volume method, in a 2-D mesh that includes the nozzle and a gases discharge zone that allows to evaluate the development of the plume. To carry out the numeric method analysis, free open source computational tools were selected such as Octave for the 1-D case and the finite volume tool OpenFOAM for the CFD.

To validate the numeric outcome, each set of results was contrasted with experimental data from several trials over the rocket engines test bench.

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