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CONTROLABLE PLANAR NOZZLES FOR MICRO THRUSTERS

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Abstract. Planar nozzles can be used as component of a small propulsion system required for the orbital maneuvering of micro and nanosatellites. These nozzles could be machined using efficient design methods with optimum control of geometry and surface roughness, in contrast with axis-symmetrical nozzles where complex contours are difficult to machine.
It is known that throat active control is hard to achieve in axis-symmetrical geometry and in particular in the micro scale, however it can be done in planar nozzles.
Hence to get a controllable nozzle at low cost, a planar nozzle was designed using the method of characteristics to get a hypersonic contour. Profile was then machined in AISI 1010 steel sheets using laser cutting techniques with a manufacturing cost less than 5% of a similar conical nozzle.
Tests were carried out in a vacuum chamber under several working conditions including throat area, measuring pressure, thrust, mass flow and temperature and correlating them to an ANSYS CFD model.
Both the CFD model and tests show that planar nozzles have no performance disadvantage over axis-symmetrical nozzles. Controllability analyses were performed assuming a feasible mechanism for orbital thrust control using an improved code based on the method of characteristics and testing. The designed system actuates on nozzle throat area and expansion ratio moving nozzle contours providing real-time thrust control. Tests showed that the thrust-inlet pressure ratio is a linear function of such displacement, and that no additional losses are introduced in the system. Hence it can be concluded that planar nozzles technology is suitable for small scale propulsion systems, with high impulse efficiency and controllable behavior.