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Title

Outflow measurements on porous injector elements

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Abstract

Shear-Coaxial injectors represent the state of the art for injectors used in gas-/liquid-fueled rocket engines. When carefully designed, very high mixing efficiencies are possible. On the downside, these high mixing efficiencies are only possible within a narrow operating regime and require precise manufacturing. This limits throttling capability and results in high manufacturing cost [1].
In contrast, porous injection concepts maintain high mixing efficiency over a wide throttling range [2]. Additionally, the efficiency is not as sensitive to manufacturing tolerances, resulting in easier manufacturing. Finally, the pressure loss over the injector can be minimized by the design of the porous media. Although atomization mechanisms for porous injectors have been developed [3], the detailed outflow distribution of the propellant from the porous surface is up to now not known in detail.
Therefore, in this work a small injector element consisting of 5 injection tubes and a porous face plate made of Rigimesh is characterized regarding the permeability as well as the outflow distribution.
For this, the AORTA test bench developed at the DLR Institute of Structures and Design is used. With this test bench, porous samples are being perfused by gaseous nitrogen and the resulting mass flow rates, pressures and temperatures are recorded. With these measurements, the permeability is determined, describing the pressure loss of the fluid flow through the porous medium. This permeability is expressed by the well-known Darcy-Forchheimer equation.
Additionally, the outflow distribution of the porous element could be characterized by measuring dynamical pressure via displaceable pitot tubes mounted on linear axes. This allows for an automated, detailed measurement of the outflow characteristics of porous media [4].
In this work the detailed outflow distribution of the injector elements is measured with pitot tubes of varying inner diameters. Using these measurements, distinct outflow jets, evenly distributed at the intersections of the wires of the Rigimesh could be identified. Additionally, by measuring at different distances to the injector element the mixing of the distinct jets can be seen, giving further insight into the mixing process. Where at 0,3mm downstream the individual jets are clearly visible, at 3mm the jets started to combine but are still visible. At 8mm, no single jets can be identified. Nonetheless, small inhomogeneities in the outflow distribution measured at 0,3mm distance are still visible at a distance of 8mm. Finally, by changing the measurement angle of the pitot tubes the outflow direction of the single jets can be determined.

References

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