An Experimental Study of Wall-Injected Flows in a Rectangular Chamber

A. Perrotta1,* G.P. Romano1, B. Favini1
1: Dept. of Mechanical and Aerospace Engineering, Sapienza University of Rome, Italy
* Correspondent author: andrea.perrotta@uniroma1.it

Keywords: Wall-Injected Flows, PIV, Confined Flows

HIGHLIGHTS

- PIV flow measurements in a closed chamber.
- The flow is injected inside the chamber through a porous media (white porous polyethylene).
- Comparison with analytical solutions of the steady, incompressible and inviscid model are presented.
- This kind of flows is used to simulate what happens inside a solid rocket motor while the propeller is burning.
- The most sensitive part of the chamber is the head. While going down, the flow becomes nearly parallel to the walls.

ABSTRACT

We performed an experimental investigation of the flow inside a rectangular chamber with two of the six sides injecting air as shown in Fig. 1. The flow, which enters perpendicularly to the injecting wall, turns suddenly its direction being pushed out to the exit of the chamber. This kind of flows is a bi-dimensional approximation of what happens inside a solid rocket motor, where the lateral grain burns expelling exhaust gas, which goes out through the nozzle and pushes the launcher. Under the incompressible and inviscid hypothesis, two analytical solutions were proposed. The first one, known as Hart-McClure solution, is irrotational and with non-perpendicular injection velocity. The other one, due to Taylor and Culick, has non zero vorticity and constant, imposed injection velocity. We propose a brief derivation of those solutions and a comparison between the analytical solutions and experimental data. Mean velocity data are obtained by averaging 500 instantaneous PIV flow field reconstructions, which are captured at a frequency of 5 Hz. The characteristic Reynolds number inside the chamber is based on the half height of the chamber (H/2) itself and the orthogonal injection velocity (y-component), which is though really hard to measure because of the high, with respect to the orthogonal one, parallel component (z-component). Anyhow, we estimate a value around 20 ÷ 40, whereas the Reynolds number based on the exit velocity is around (1 ÷ 2)×10^3.

Fig. 1 A sketch of the rectangular chamber, fluid flow directions and plane of measurement, i.e. the laser sheet (left). A representation of the reference frame (center and right).