CFD methods for the characterization of the mixing process inside a supersonic air – air ejector

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Abstract

Supersonic ejectors are flow devices of rugged and simple construction, used to convert pressure energy into kinetic energy. They are usually made of two coaxial nozzles. The primary nozzle is designed to deliver a supersonic jet which sucks and entrains a secondary flow along the mixing chamber of the secondary nozzle. Supersonic ejectors are employed in a large variety of applications [1] including vacuum pump, thermocompressor, static mixer, jet propulsion thrust augmentation systems, hydrogen recirculation in fuel cell. In all these applications, the role of an ejector is to suck, to entrain, to recompress and to mix two fluids. The fluid mixing process remains not well known and researches for improving the mixing process are very active [2, 3].

One of the main objectives of this study concerns the development of numerical tools making it possible to analyze the mixing process between the primary and induced flows and to quantify the mixing quality. The scientific approach is based on CFD simulation of the flow in a 2D axisymmetric ejector. Flow turbulence is taken into account using RANS models. First, a validation of the CFD simulations is carried out against experimental data (i.e. flow visualizations by laser tomography and static pressure along the ejector axis) obtained on a test bench.

In the second time, two approaches to analyze numerically the quality of the mixing process in the ejector are considered. The first approach consists in following the evolution of the radial distributions of the flow velocity along the mixing chamber of the ejector.
The second approach lies on the observation of the development of the turbulence kinetic energy in order to provide information regarding the zones of interaction between the primary and secondary flows. A comparison of these two approaches is proposed. The results obtained by these two methods are show in good agreement. They both show that the fluid mixing is completely achieved at the entrance of the diffuser, thus confirming that the mixing chamber served its purpose correctly. Further, the evolution of the turbulence kinetic energy seems to provide correct information on the non mixing zone. The results obtained by comparing the fields of the turbulence kinetic energy to experimental flow visualizations are indeed in good agreement.

Finally, the methods proposed for the evaluation of the mixing quality seem to be able, in the future, to be used to study the improvement of the mixing process inside ejectors.

References

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