FLUENT - Over-expanded Nozzle

Author: Julio Sampaio Gabriel de Pieri, Cornell University

Over-expanded Nozzle

Created using ANSYS 16.2

This problem was inspired by the work of Balasubramanyam Sasanapuri, Manish Kumar & Sutikno Wirogo (ANSYS Inc.) on the "Simulation of flow through Supersonic Cruise Nozzle: A validation study".

Everything was created from scratches, but the geometry was based on the pictures presented on that workshop. That work does not provide details on how the mesh was created, and there are very few words about the solver configuration. Therefore this tutorial is only **inspired** by that workshop, and all the results and methods presented here were obtained from the author's learning, experience and testing.

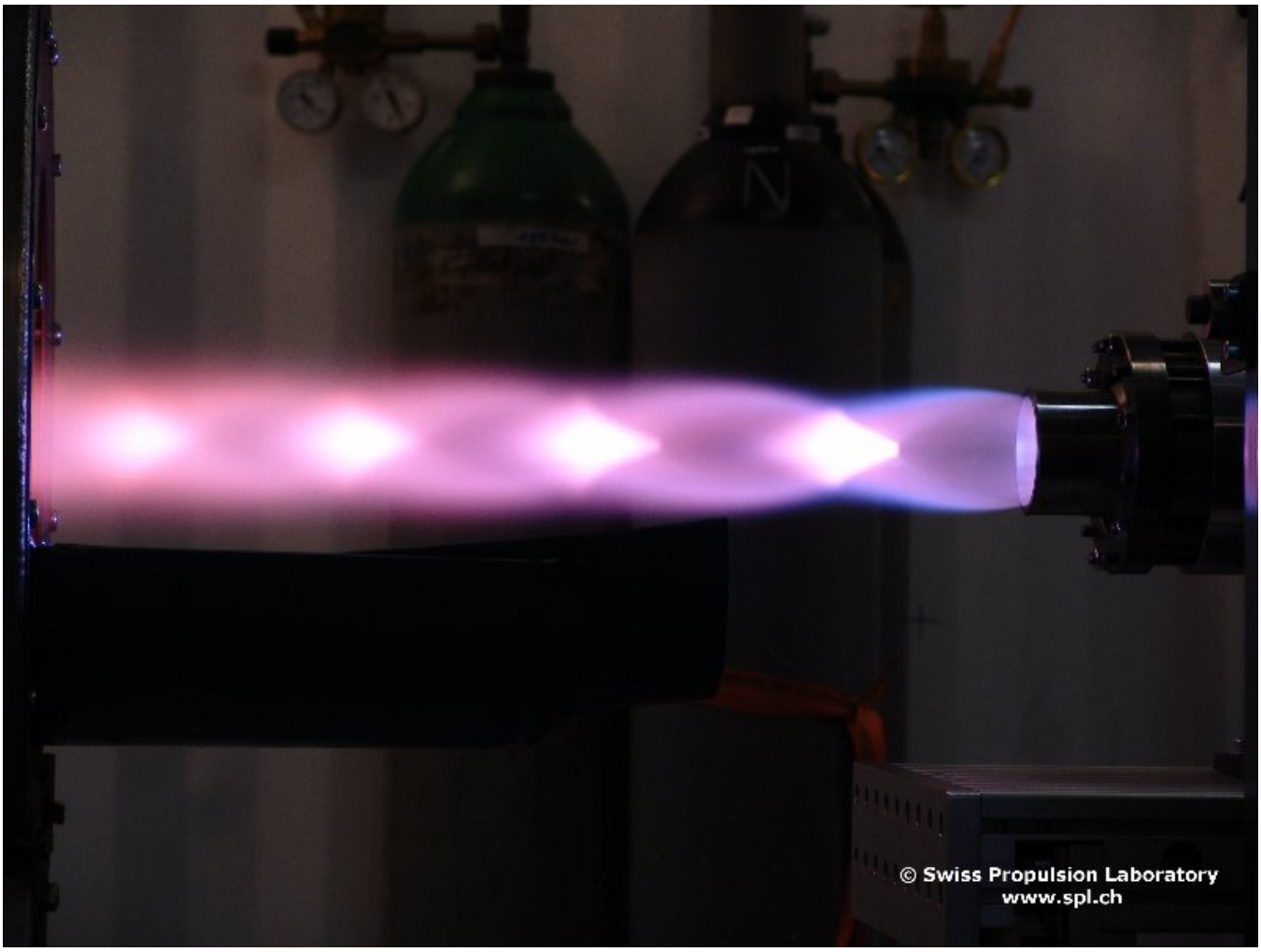
Learning Goals

In this tutorial, you will learn to:

- Obtain the diamond shocks on a nozzle using an axisymmetric geometry.
- Apply more advanced concepts of Compressible Flows and generate a more sophisticated simulation
- Qualitatively verify the CFD results from FLUENT by comparing the contour plots to the expected shape. The Verification & Validation section will give insights on how one could get a more precise comparison with real data and other more accurate simulations.

Problem Specification

We want to simulate an over-expanded nozzle in FLUENT, and try to obtain this cool "Diamond Shock" pattern shown in the figure below:



For that, we need to design a Nozzle that has a measured exit pressure **smaller** than the ambient pressure. This means that the nozzle is "too big" and will end up expanding the flow too much.

The flow exits the nozzle with a lower pressure, and will try to accommodate to the higher ambient pressure, forming an oblique shock outside the nozzle. The shock will then reflect "on the axis" (on another shock instance, actually), and the reflected shock will now make the pressure become too high (compared to the ambient). This will lead to expansion waves, making the flow with the correct pressure again. These expansion waves, however, will reflect "on the axis" as well, dropping too much the pressure of the flow, what will lead to another oblique shock, like the first one. This is then repeated, resulting on a series of diamond shaped shocks/expansion waves.

Another characteristic of over-expanded nozzle is that the "plume" of the jet gets contracted, opposed to an under-expanded nozzle where the plume "diverges" in the radial direction.

Go to Step 1: Pre-Analysis & Start-Up

Go to all FLUENT Learning Modules