GSOC SU 2 Assignment - 2

Vikram Bharadwaj

Axis Symmetric Turbulent Jet Analysis

In this assignment, we aim to generate and analyze a 2D axisymmetric, steady-state, turbulent jet case using computational fluid dynamics (CFD) tools. The focus is on setting up a custom test case from scratch, including mesh generation, configuration setup, simulation execution, and result extraction.

Turbulent jets are common in many engineering applications, including aerospace propulsion, combustion systems, and industrial mixing processes. Accurately simulating such flows helps in understanding their behavior and validating numerical solvers against experimental data.

0.1 Meshing

As the experiment in the reference [1], is a rectangular test section has dimensions $110 \times 110 \times 300\,\mathrm{mm}^3$ and is fitted in a closed-loop water pipe facility.

As it is a axisymmetric mesh we will be considering half of the height, The mesh generated is as shown below in the figure.

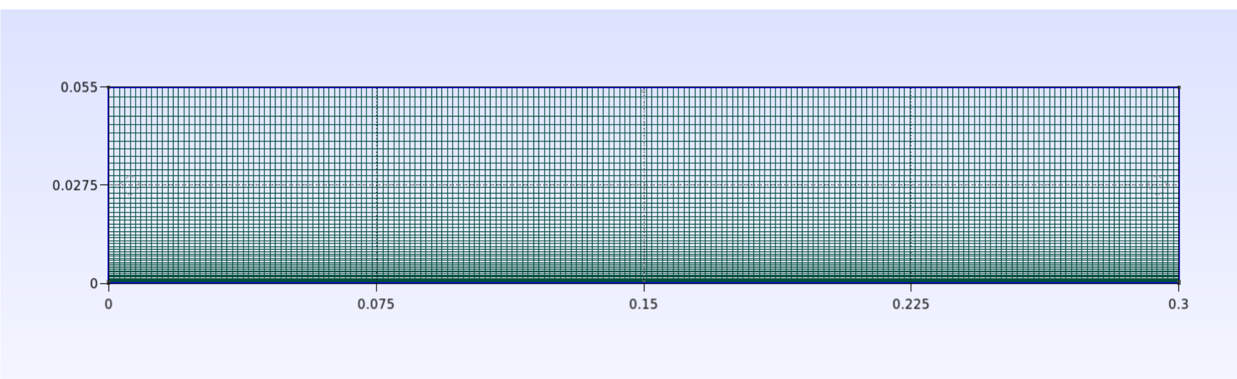

Figure 1: Generated Mesh for the Analysis

0.2 Physics Setup

The experiment in the reference [1] is conducted with water at a Reynolds number of 2×10^3.

For analysis we will be using Air,

For air, the properties at 25°C are:

$$\rho \approx 1.225\,\mathrm{kg/m}^3, \quad \mu \approx 1.81 \times 10^{-5}\,\mathrm{Pa{\cdot}s}$$

Using the Reynolds number formula:

$$Re = \frac{\rho \cdot U \cdot L}{\mu}$$

where:

$Re = 2000 \quad \text{(given)}, \quad L = 1.0{\times}10^{-3}\,\text{m} \quad \text{(Reynolds length)}, \quad \rho = 1.225\,\text{kg/m}^3, \quad \mu = 1.81{\times}10^{-5}\,\text{Pa·s}$

To find the velocity U, rearrange the formula:

$$U = \frac{Re \cdot \mu}{\rho \cdot L}$$

Substitute the values:

$$U = \frac{2000 \cdot 1.81 \times 10^{-5}}{1.225 \cdot 1.0 \times 10^{-3}} = \frac{3.62 \times 10^{-2}}{1.225 \times 10^{-3}} \approx 29.6\,\text{m/s}$$

So, the velocity for air should be approximately $U \approx 29.6\,\text{m/s}$.
All the above conditions will be specified in the SU2 configuration file for the simulation.

0.3 Results

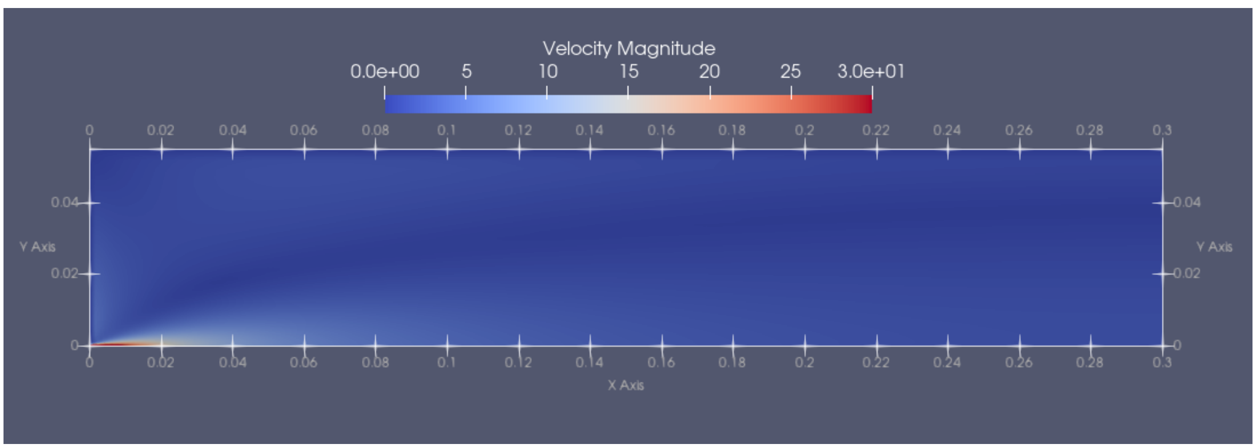

Figure 2: Velocity Contour

From the velocity Contour we can observe the decrease in velocity along the x direction of the domain.

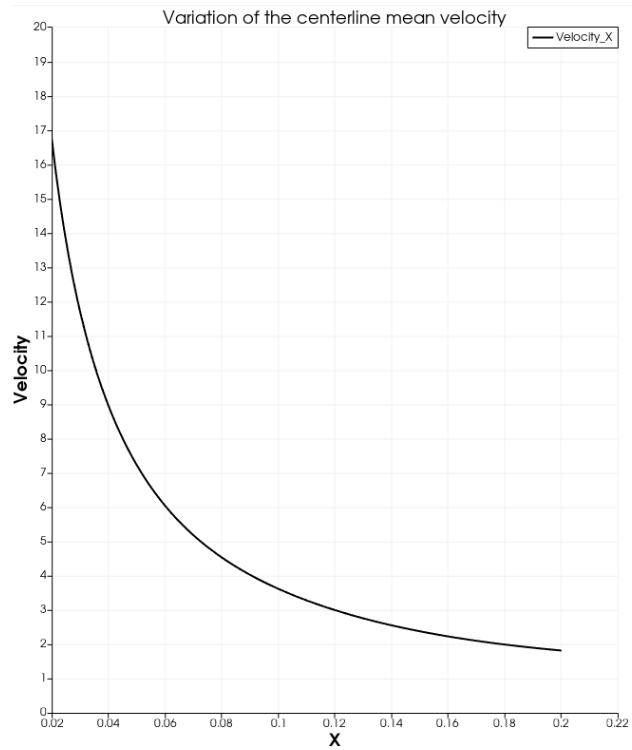

Figure 3: Variation of the centerline mean velocity

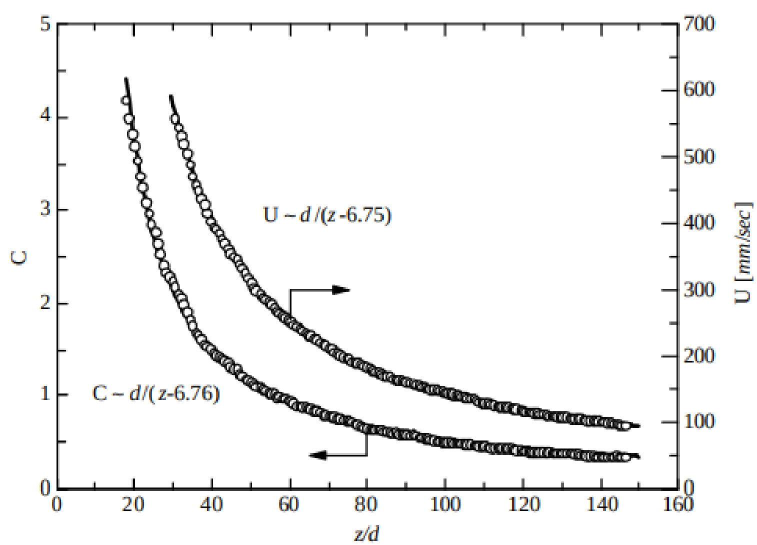

Figure 4: Exp Variation of the centerline mean velocity [1]

From the graphs above, it is evident that the velocity along the centerline decreases. This trend is consistent with the experimental data, as both graphs display parabolic curves, further validating the similarity between the simulation results and experimental observations.

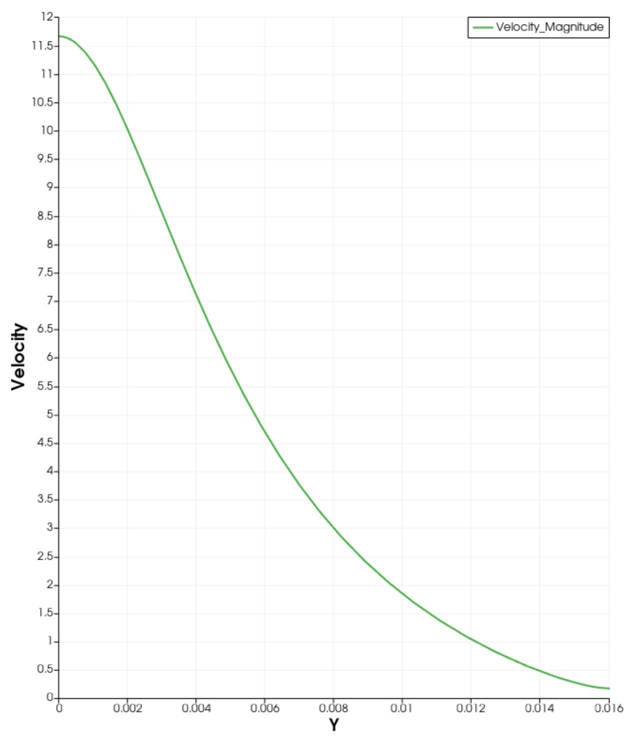

Figure 5: Axial mean velocity profile across the jet.

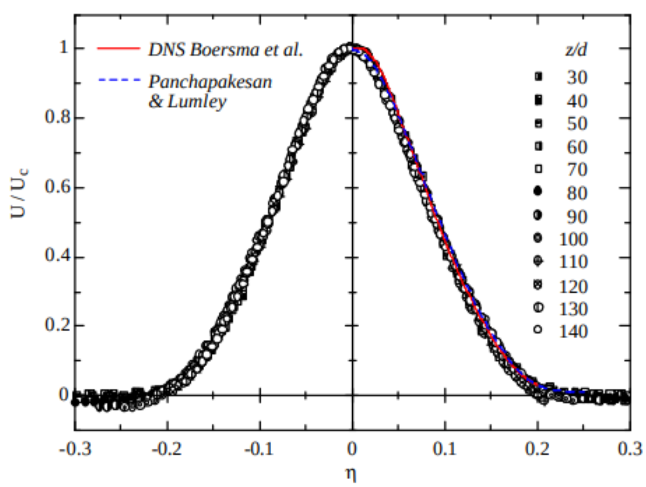

Figure 6: Experimental Axial Velocity profile[1]

From the graphs above, it is clear that the simulated axial mean velocity profile closely matches the experimental axial mean velocity profile, indicating a strong correlation between the two.

References

[1] Author Name. "Investigation of the Mixing Process in an Axisymmetric Turbulent Jet Using PIV and LIF". In: *ResearchGate* (Year of Publication). URL: https://www.researchgate.net/publication/254224677_Investigation_of_the_Mixing_Process_in_an_Axisymmetric_Turbulent_Jet_Using_PIV_and_LIF.