Turbulence Modelling in OpenFOAM

Spoken Tutorial Project
https://spoken-tutorial.org
National Mission on Education through ICT
http://sakshat.ac.in/

Padmini Priyadarshini & Swetha Sridhar
IIT Bombay

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Learning Objectives

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- `Run` **the** `simulation`

System Specifications

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- OpenFOAM version 7
- ParaView version 5.6.0
- gedit Text Editor

Prerequisites

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- **You should be familiar with** `simulating a turbulent flow through a channel`

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- **You should also be familiar with** `Multi-block Meshing of 2D Geometry`

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- **If not, please go through the prerequisite** `OpenFOAM` **tutorial on** **https://spoken-tutorial.org**

Code Files

- **The files used in this tutorial are available in the `Code Files` link on this tutorial page**

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- **Make a copy and then use them while practising**

Solver detail

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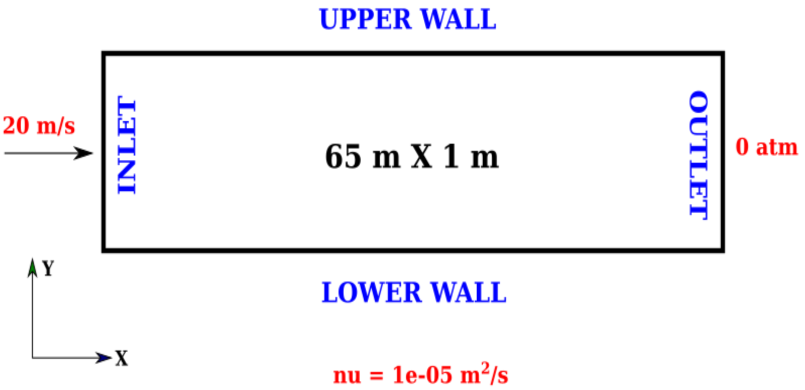
- `simpleFoam` **is a** `steady-state solver` **for** `incompressible, turbulent flow`

Problem statement



Flow properties

- Reynolds Number:

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The flow is turbulent

Wall distance, y_p

- **Distance between the** `wall` **and the nearest** `cell centre`

$$y_p = \frac{Y^+ \nu}{\sqrt{0.5 C_f {U_{inf}}^2}}$$

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$$\color{red}{y_p = 0.0031m}\ \textbf{(for } y^+ = 200\textbf{)}$$

For channel flow, $C_f = 0.078 Re^{-1/4}$

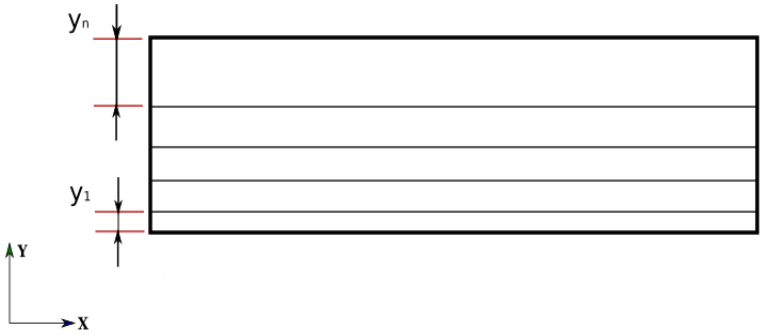
Cell width

`Width` **of the** `cell` **near** `wall`**,**

$$2 \times y_p = 0.0062$$

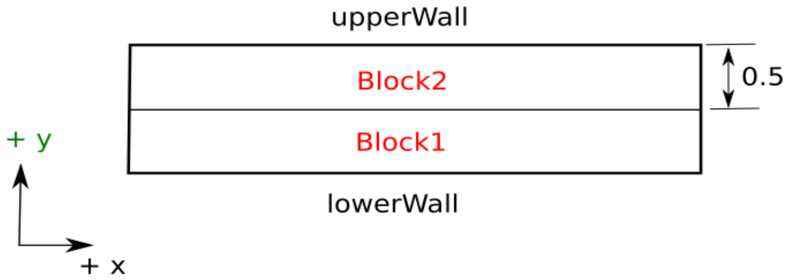
Expansion ratio

last `cell width` / **first** `cell width`



Expansion ratio calculation

Calculated using `geometric progression formula`



Expansion ratio value

The `expansion ratio` **in** `+y direction`**:**

- **For** `block 1` $= 5.57$

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- **For** `block 2` **= 0.18**

Expansion ratio value

The `expansion ratio` **in** `+y direction`**:**

- **For** `block 1` = 5.57
- **For** `block 2` = 0.18

for a `block` **of** `width` = 0.5 `m`**, and** `cell number` = 30

K-Omega turbulence model

Two-equation model

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It solves

- turbulent kinetic energy transport equation

K-Omega turbulence model

Two-equation model

It solves

- turbulent kinetic energy transport equation
- specific turbulent dissipation rate transport equation

Inlet Boundary Condition - omega

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turbulentMixingLengthFrequencyInlet

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- Turbulent length scale, l:
  $l = 0.07 d_h = 0.07m$

Inlet Boundary Condition - omega

- Specific turbulent dissipation rate:

$$\omega = C_{\mu}^{-1/4}\frac{\sqrt{\kappa}}{l} = 16.67\ 1/s$$

where,

empirical constant, $C_{\mu} = 0.09$

Wall and outlet Boundary Condition - omega

Wall:

`omegaWallFunction`

Wall and outlet Boundary Condition - omega

Wall:

`omegaWallFunction`

Outlet:

`zeroGradient`

K-Omega SST turbulence model

Hybrid model:

K-Omega SST turbulence model

Hybrid model:

- Near-wall **region**

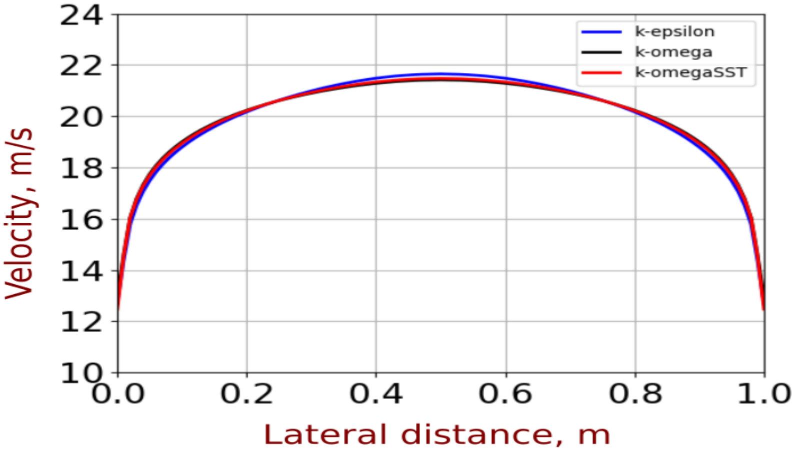
  k-omega

K-Omega SST turbulence model

Hybrid model:

- Near-wall **region**
  k-omega
- **Region away from** wall
  k-epsilon

Exit velocity profile



Summary

We have learnt to:

- **Set up the** `blockMeshDict` **file for a given** `YPlus` **value**
- **Implement** `k-omega` **and** `k-omega SST turbulence models`
- `Run` **the** `simulation`

Assignment

- **Repeat the** `simulation` **for a** `YPlus` **value of** `250` **using** `k-epsilon model`
- **Repeat the** `simulation` **for a** `velocity` **of** `40 m/s` **using** `k-omega` **and** `k-omega SST model`

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- **Watch the video available at https://spoken-tutorial.org /What_is_a_Spoken_Tutorial**
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- The Spoken Tutorial project will ensure an answer

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- **For more details, please visit:**
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  https://fossee.in/

Acknowledgements

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