Computational Fluid Dynamics

Lecture 8

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Post-Processing

- Aims
  - The aim of this chapter is to introduce students the main stages of CFD analysis
- Expected Outcomes: At the end of this lecture, students should be able to understand
  - how to visualize results and analysis
- References

1) J. Tu, G.H. Yeoh, C. Liu, Computational Fluid Dynamics : A Practical Approach, Elsevier, 1st Edition, 2013.
2) C.T. Shaw, Using Computational Fluid Dynamics, Prentice Hall, 1992

Analyzing the results

- The type of solution produced by the CFD solver often consists of:
  - ✓ Results of residual errors (usually saved as ASCII data)
  - ✓ Complete list of flow and thermal values
  - ✓ Results that indicate the progress of the solution

- CFD has the reputation of providing visual images of flow and temperature that are not possible to see in experimental measurements.

List of some popular computer graphics software packages [1]

Developer	Code	Distributor Web Address
Advanced Visual Systems	AVS, Gsharp, Toolmaster	http://www.avs.com/
Amtec Engineering	Tecplot	http://www.amtec.com/
CEI	EnSight	http://www.ceintl.com/
IBM (free, apparently)	OpenDx	http://www.opendx.org/
Intelligent Light	Fieldview	http://www.ilight.com
Numerical Algorithms Group (NAG)	Iris Explorer	http://www.nag.co.uk/
Visual Numerics	PV-Wave	http://www.roguewave.com/
Kitware	Paraview	http://www.paraview.org/
Department of Energy (DOE) Advanced Simulation and Computing Initiative (ASCI)	VisIt	https:/wcl.llnl.gov/

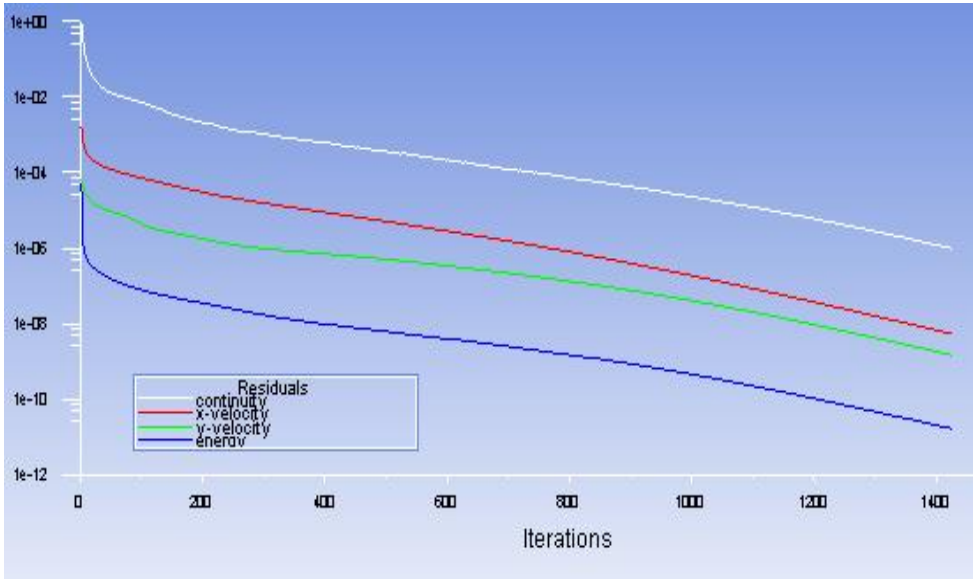
- The results can be visualized or reported in a form of
  - ✓ X-Y plots,
  - ✓ Direct visualization and
  - ✓ Indirect visualization
- Indirect visualization include
  - ✓ Scalar values derived from vector fields such as
    - velocity magnitude,
    - Temperature,
    - vorticity number,
    - Mach number,
  - ✓ Render using volume rendering techniques

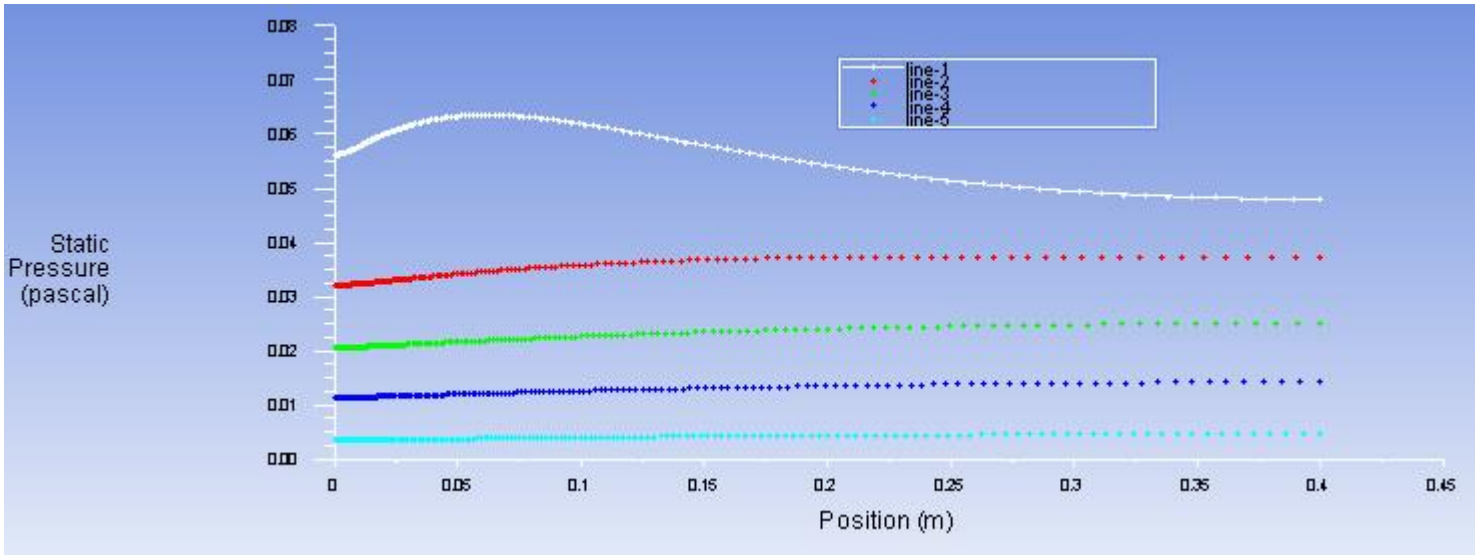
- Direct visualization include
  - ✓ Vector plots,
  - ✓ Traditional: path, streak, and time lines,
  - ✓ Streamlines: tangent to the velocity vector,
  - ✓ Stream ribbons: tiling of two adjacent streamlines,
  - ✓ Stream surfaces: connecting stream ribbons,
  - ✓ Stream polygons: polygon normal to vector flow,
  - ✓ Stream tube: connect stream polys,
  - ✓ Surface particles: model particle as small polygon,
  - ✓ Flow topology: find critical points

X-Y plots

- ✓ They are the simplest and most straightforward category of graphical representation of CFD results.
- ✓ They are the most precise quantitative way to present numerical data on a graph.
- ✓ Another person can readily read quantitative data from curves on an xy plot without making any mental or arithmetic interpolation.
- ✓ However, they do not illustrate the global nature of a set CFD results all in one view.

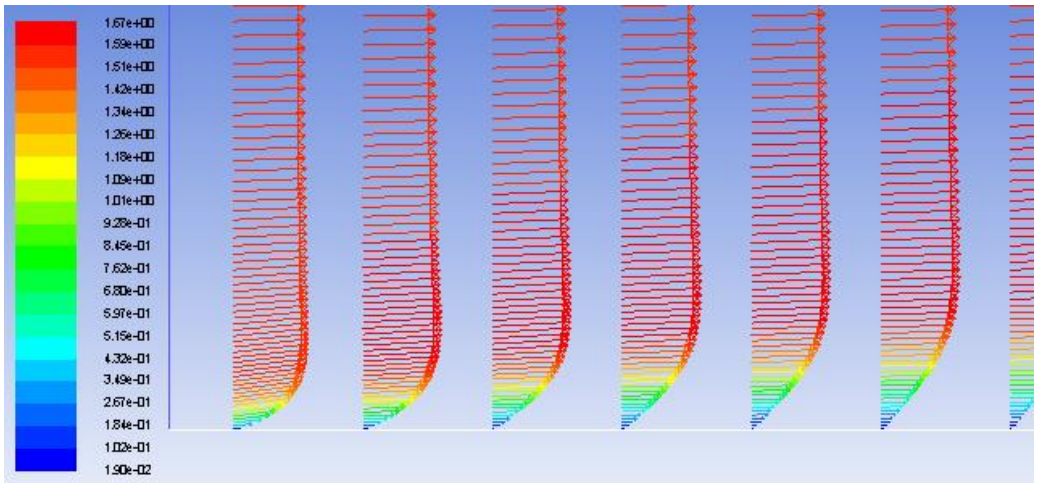
Examples of xy plots





Vector plots

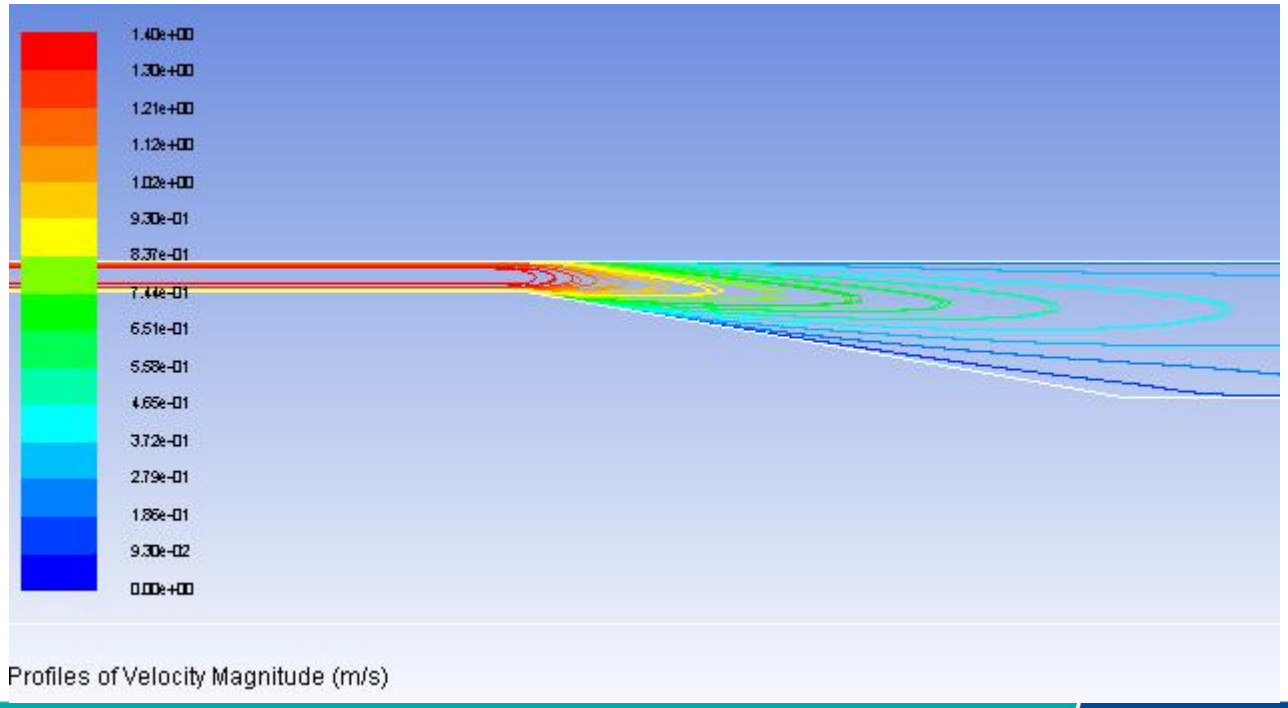
- ✓ They provide the means whereby a vector quantity (usually velocity) is displayed by an arrow.
- ✓ The direction the variable is indicated by the orientation of the vector.
- ✓ The size of the vector indicates the magnitude of the variable.



Velocity Vectors Colored By Velocity Magnitude (m/s)

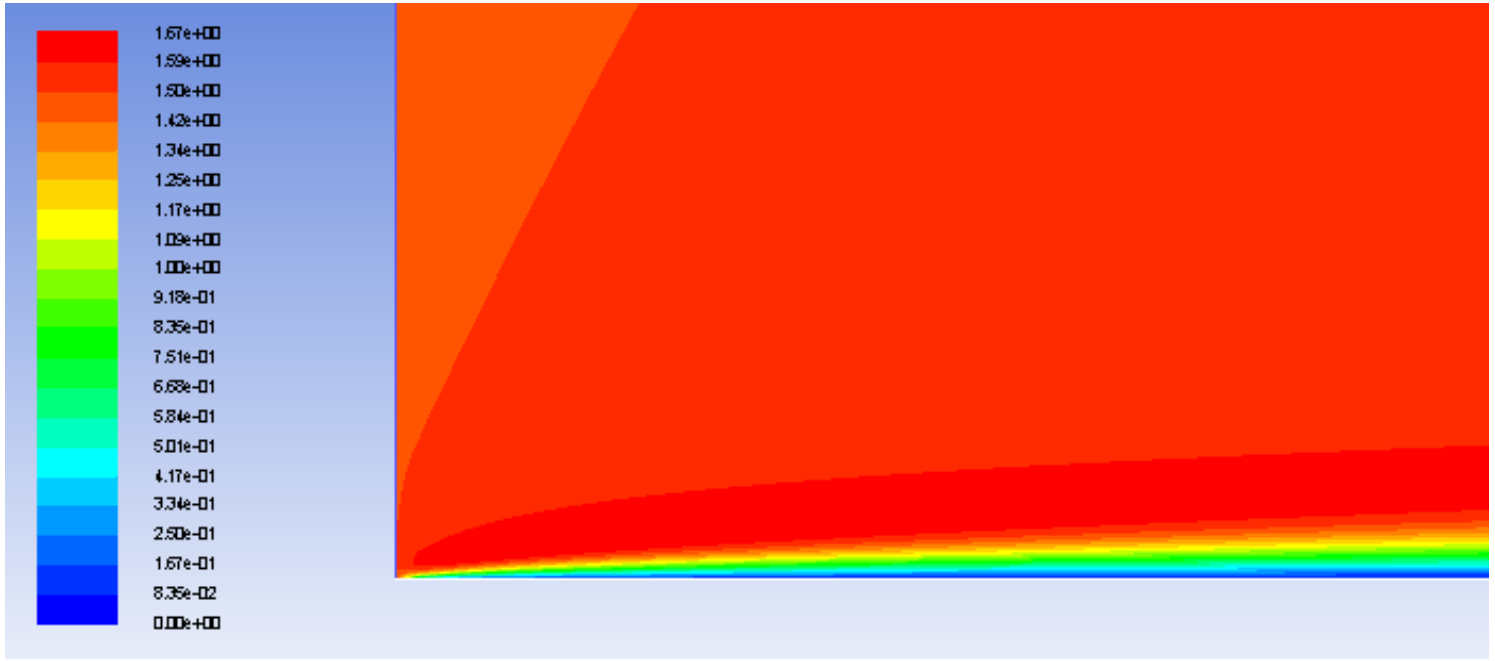
Contour plots

- ✓ They are one of the most common used graphical representation of CFD data
- ✓ They can be in a form of line or flooded contour
- ✓ Line contours are lines connecting constant values of a property (variable) .



- ✓ If the gap between adjacent line contours is wide, then the thermal-flow variables being examined are slowly varying in space.
- ✓ On the other hand, if the gap between adjacent line contours is small, then the thermal-flow variables are rapidly varying.

- ✓The other type of contour is flooded contour where colour intensity that denotes the value of the flow-field property



Contours of Velocity Magnitude (m/s)

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Research interest:

- Computational Fluid Dynamics,
- Thermo-fluids,
- Multidisciplinary Numerical Modelling and Simulation

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