Sudden Expansion - Numerical Results

Authors: Yong Wang & Said Elghobashi, UC Irvine

Problem Specification 1. Pre-Analysis & Start-Up 2. Geometry 3. Mesh 4. Physics Setup 5. Numerical Solution 6. Numerical Results 7. Verification & Validation Exercises Comments

Numerical Results

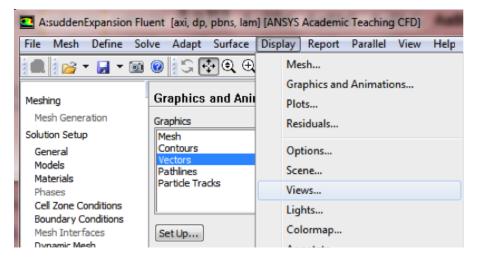
The results steps shown below are for the CFD-Post postprocessor that is included in ANSYS Workbench.

Velocity Vectors

One can plot vectors in the entire domain, or on selected surfaces. Let us plot the velocity vectors for the entire domain to see how the flow develops downstream from the inlet and redevelops from the expansion entrance. First, click on *Graphics & Animations*. Next, double click on *Vectors* which is located under *Graphics*. Then, click on *Display*. Zoom into the region near the inlet. The length and color of the arrows represent the velocity magnitude. The vector display is more intelligible if one makes the arrows shorter as follows:

Change Scale to 0.4 in the Vectors menu and click Display.

The laminar pipe flow was modeled asymmetrically; however, the plot can be reflected about the axial axis to get an expanded sectional view. In order to carry this out (*Click*) *Display* > *Views...* as shown below.



Under *Mirror Planes*, only the *axis (or centerline)* surface is listed since that is the only symmetry boundary in the present case. Select *axis (or centerline)* and click *Apply*, as shown below.

Views	-	X
Views back front	Actions Default Auto Scale Previous Save Delete	Mirror Planes 🗐 🚍
Save Name view-0	Read Write	Define

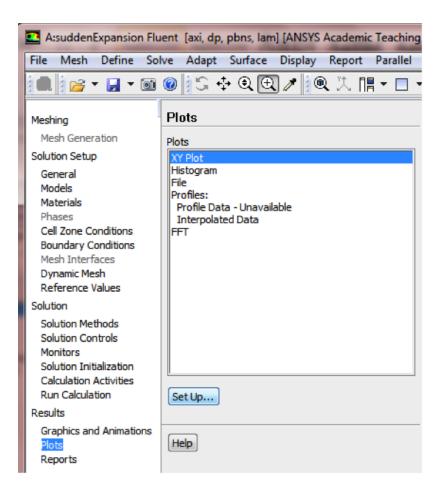
Then click Close to exit the Views menu. Your vector field should have been reflected across the axially axis as, shown below.

5.32e-01 5.05e-01 4.79e-01 4.52e-01 3.99e-01 3.72e-01 3.46e-01 3.19e-01 2.39e-01 2.13e-01 1.86e-01 1.86e-01 1.86e-01 1.86e-01 1.33e-01 1.96e-01 1.33e-01 1.96e-01 5.33e-02 2.07e-02	1: Velocity Vectors Colored B 👻	
5.05e-01 4.79e-01 4.52e-01 3.99e-01 3.72e-01 3.19e-01 7.53e-01 2.13e-01 1.86e-01 1.86e-01 1.86e-01 1.86e-01 1.92e-02 5.33e-02	£ 00+ 01	
4.79e-01 4.52e-01 4.26e-01 3.99e-01 3.72e-01 3.46e-01 3.19e-01 2.53e-01 2.39e-01 2.13e-01 1.86e-01 1.86e-01 1.86e-01 1.33e-01 1.00e-01 7.99e-02 6.33e-02		
4.52e-01 4.26e-01 3.99e-01 3.72e-01 3.46e-01 3.19e-01 2.03e-01 2.13e-01 1.86e-01 1.86e-01 1.86e-01 1.33e-01 1.06e-01 7.99e-02 6.33e-02		
4.26e-01 3.99e-01 3.72e-01 3.46e-01 3.19e-01 2.33e-01 2.39e-01 2.13e-01 1.86e-01 1.86e-01 1.33e-01 1.06e-01 7.99e-02 6.33e-02		
3.99e-01 3.72e-01 3.46e-01 3.19e-01 2.39e-01 2.39e-01 2.13e-01 1.86e-01 1.86e-01 1.33e-01 1.33e-01 1.06e-01 7.99e-02 6.33e-02		
3.72e-01 3.46e-01 3.19e-01 2.39e-01 2.39e-01 2.13e-01 1.86e-01 1.60e-01 1.33e-01 1.06e-01 7.99e-02 6.33e-02		
3.46e-01 3.19e-01 2.39e-01 2.39e-01 2.13e-01 1.86e-01 1.60e-01 1.33e-01 1.06e-01 7.99e-02 5.33e-02		
3.19e-01 2.99e-01 2.39e-01 2.13e-01 1.86e-01 1.33e-01 1.06e-01 1.06e-01 7.99e-02 5.33e-02	3.72e-01	
2,396-01 2,396-01 2,13e-01 1,86e-01 1,33e-01 1,06e-01 1,06e-01 7,99e-02 5,33e-02	3.46e-01	
2.39e-01 2.13e-01 1.86e-01 1.60e-01 1.33e-01 1.06e-01 7.99e-02 6.33e-02	3.19e-D1	
2.39e-01 2.13e-01 1.86e-01 1.60e-01 1.33e-01 1.06e-01 7.99e-02 6.33e-02	12.93e-01	
2.39e-01 2.13e-01 1.86e-01 1.60e-01 1.33e-01 1.06e-01 7.99e-02 5.33e-02	n atticker tindenen indenen idenen idenen iden	PFC IN A REPFECTATION FOR THE STATE OF THE
1.86e-01 1.60e-01 1.33e-01 1.06e-01 7.99e-02 5.33e-02		Hipering and a second
1.60e-01 1.33e-01 1.06e-01 7.99e-02 5.33e-02	2.13e-D1	
1.33e-01 1.06e-01 7.99e-02 5.33e-02	1.86e-D1	
1.06e-01 7.99e-02 5.33e-02	1.60e-01	
1.06e-01 7.99e-02 5.33e-02	1.33e-01	
7.99e-02 5.33e-02		
5.33e-02		
7.35e-05		

The velocity vectors provide a picture of how the flow develops downstream from the inlet and redevelops from the expansion entrance.

Centerline Velocity

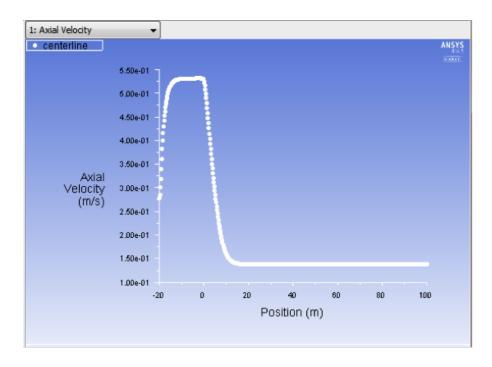
Here, we'll plot the variation of the axial velocity along the centerline. In order to start the process (Click) Results > Plots > XY Plot... > Set Up.. as shown below



In the Solution XY Plot menu make sure that Position on X Axis is selected, and X is set to 1 and Y is set to 0. This tells FLUENT to plot the xcoordinate value on the abscissa of the graph. Next, select Velocity... for the first box underneath Y Axis Function and select Axial Velocity for the second box. Please note that X Axis Function and Y Axis Function describe the x and y axes of the graph, which should not be confused with the x and y directions of the pipe. Finally, select centerline under Surfaces since we are plotting the axial velocity along the centerline. This finishes setting up the plotting parameters. Your Solution XY Plot should look exactly the same as the following image.

Solution XY Plot
Options Plot Direction Y Axis Function V Node Values X 1 V Position on X Axis Y 0 Position on Y Axis Y 0 Order Points Z 0 File Data Image: Centerline inlet interior-surface_body line-0 outlet wall Image: Centerline inlet interior - surface body line-0 outlet Image: Determine inlet New Surface Image: Centerline inlet interior - surface body line-0 outlet New Surface Image: Centerline inlet interior - surface body line-0 outlet Image: Determine inlet Image: Centerline inlet interior - surface body line-0 outlet Image: Centerline inlet interior - surface body line-0 outlet Image: Determine inlet Image: Centerline inlet interior - surface body line-0 outlet Image: Centerline inlet interior - surface body line-0 outlet Image: Determine inlet Image: Centerline inlet interior - surface body line-0 outlet Image: Centerline inlet interior - surface independent Image: Determine inlet Image: Centerline interior - surface independent Image: Centerline interior - surface independent Image: Determine independent Image: Centerline interior - surface independent Image: Centerline interior - surface independent Image: Determine independent Image: Centerline interior - surface independent Image: Centerline interior

Now, click Plot. The plot of the axial velocity as a function of distance along the centerline now appears.



In the graph that comes up, we can see that the velocity reaches a constant value (about 5.25e-1 m/s) beyond a certain distance from the inlet. This is the fully-developed flow region in the small pipe. When the flow pass the expansion entrance at x=0 m, the velocity will decrease due to the sudden expansion of the pipe. After another development, the velocity will reach a constant value (about 1.5e-1m/s) again.

Saving the Plot

In this section, we will save the data from the plot and a picture of the plot. The data from the plot will be saved first. In order to save the plot data open the *Solution XY Plot* menu and then select *Write to File*, which is located under *Options*. The *Plot* button should have changed to *Write...*, Click on *Write...*, and then enter vel.xy as the XY File Name. Next, click *OK*. Check that this file has been created in your FLUENT working directory. Lastly, close the *Soluti on XY Plot* menu.

At this point, we'll save a picture of the plot. First click on File then click Save Picture, as shown below.

File	Mesh	Define	Solve	Adapt	
	Refresh Input Data				
	Save Project				
	Read			•	
	Write			•	
	Import				
	Export			•	
	Solution	n Files		ĺ	
	Interpo	late			
	FSI Map	oping		- +	
	Save Pie	cture	1		
	Data Fil	e Quantit	ies		
	Close F	LUENT			

Under *Format*, choose one of the following three options: *EPS*, *TIFF*, or *JPG*. After selecting your desired image format and associated options, click on *Sa ve...* Enter vel.eps, vel.tif, or vel.jpg depending on your format choice and click *OK*. Verify that the image file has been created in your working directory. You can now copy this file onto a disk or print it out for your records.

Go to Step 7: Verification & Validation

Go to all FLUENT Learning Modules