Turbulent Pipe Flow (LES) - Verification & Validation

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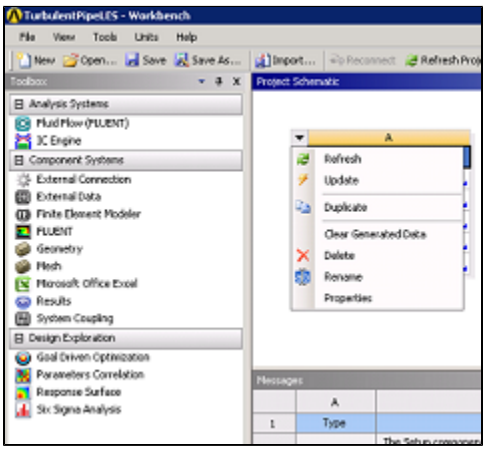
Verification & Validation

In order to verify the LES solution to the turbulent pipe flow problem, we will compare it against the solution obtained using standard k-e model.

Turbulent Pipe with k-e model

In the ***Workbench Project Page,*** left-click on the downward pointing arrow on the top-left corner of the ***TurbulentPipeLES*** project and select ***Duplicate*** fro m the drop down menu as shown in the figure below.



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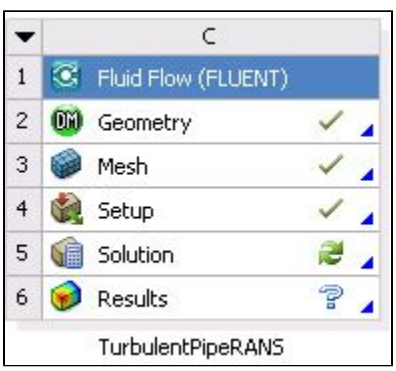
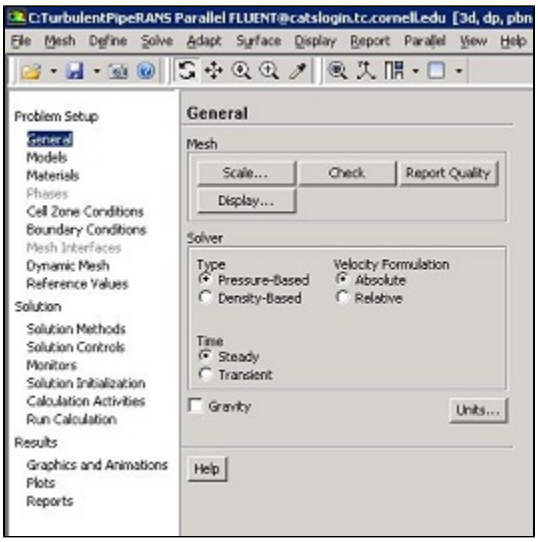
A new project will be created. Rename this new project as ***TurbulentPipeRANS*** as shown in figure below.



Next, double click on the ***Solution*** cell of the ***TurbulentPipeRANS*** project. This will launch the FLUENT solver. Here we will change the viscosity model to k-e model. In the FLUENT window, click on ***General*** tab on the left hand side pane. Choose ***Steady*** for ***Time***. Click ***OK*** for the pop-up warning.



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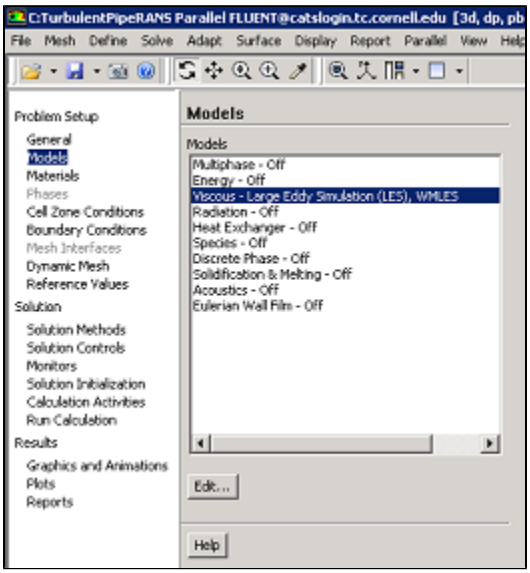
Next click on ***Models>Viscous*** on the left hand side pane as shown below. Choose ***Edit...***.



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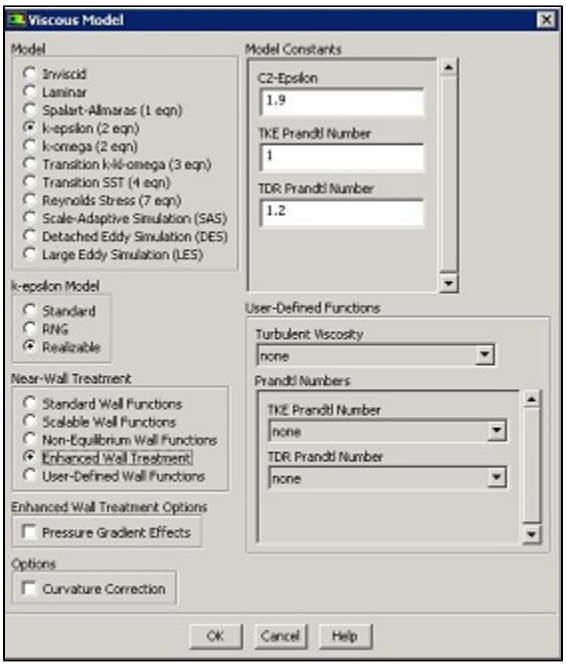
In the ***Viscous Model*** window, choose ***k-epsilon (2 eqn)*** for ***Model***. Choose ***Realizable*** for ***k-epsilon Model***. Choose ***Enhanced Wall Treatment*** for ***Near-Wall Treatment***. Click ***OK*** as shown in the figure below.



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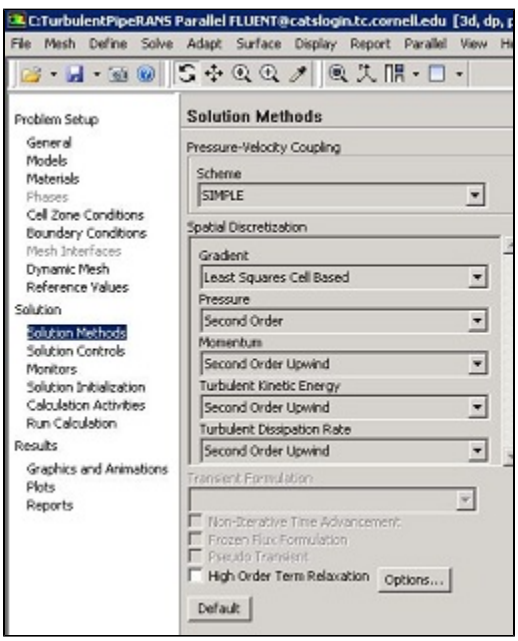
Click on ***Boundary Conditions*** tab on the left hand side pane. Choose ***Outlet*** and click ***Edit...***.Change the ***Turbulence Specification Method*** to ***Intensity and Hydraulic Diameter***. Set ***Backflow Turbulent Intensity*** to ***10%*** and ***Backflow Hydraulic Diameter*** to ***0.0127m***. Click ***OK***.

Next, click on ***Solution Methods*** tab on the left hand side pane. Choose ***Second Order Upwind*** for ***Turbulent Kinetic Energy*** and ***Turbulent Dissipation Rate***.



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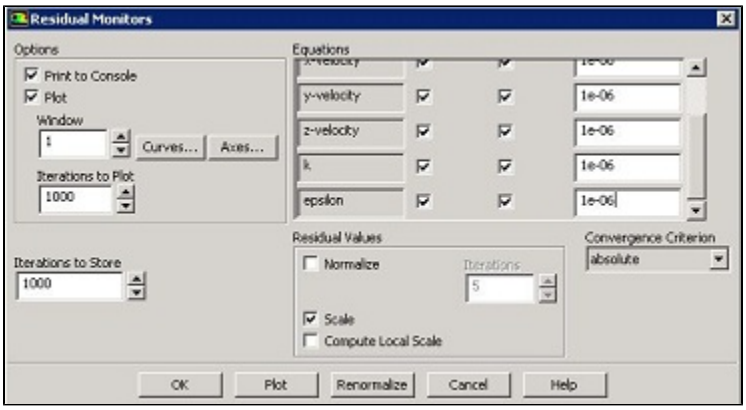
Click on ***Monitors > Residual*** and click ***Edit...***. Set ***1e-06*** for ***k*** and ***epsilon***. In order to get faster convergence, choose ***1e-05*** for ***continuity*** and click ***OK***.



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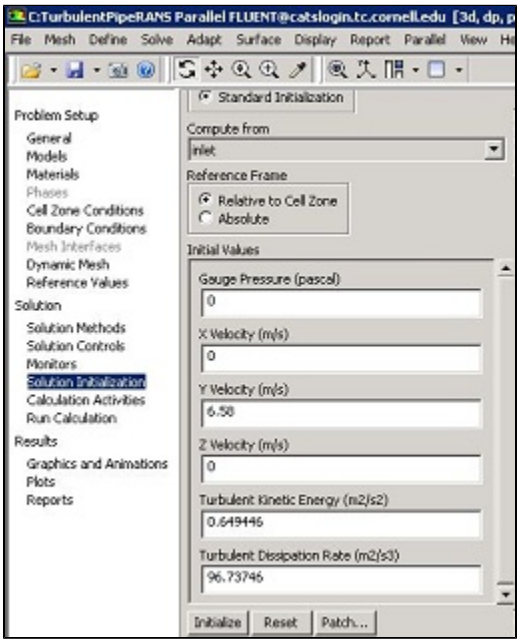
Click on ***Solution Initialization*** and click ***Compute from*** and choose ***inlet***.Click ***initialize*** as shown below.



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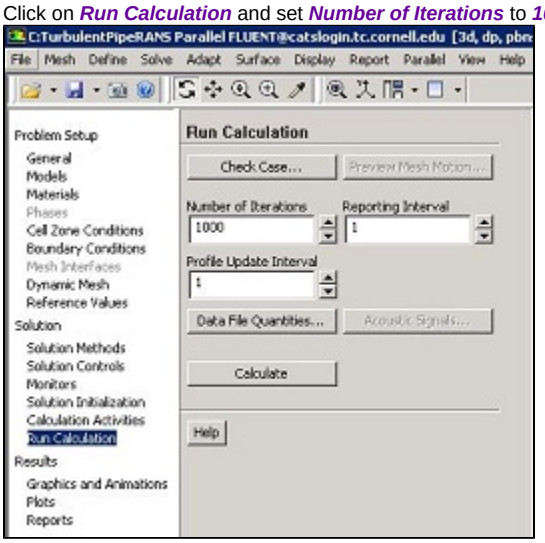
Click on ***Run Calculation*** and set ***Number of Iterations*** to ***1000***.Click ***Calculate*** as shown below.



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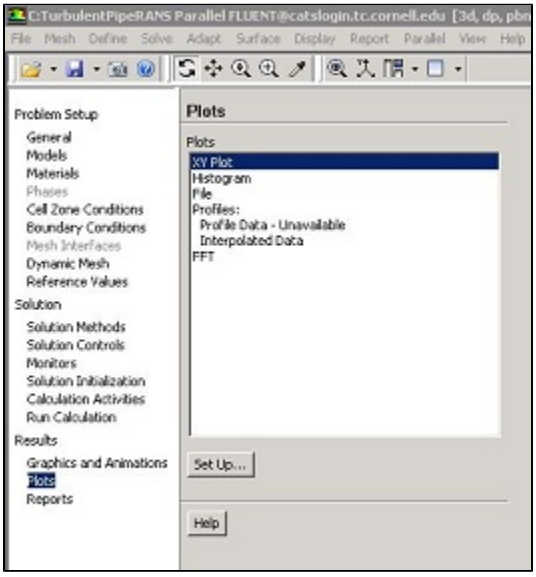
The solution converges in about 600 iterations.

Create Line

Click on ***Plots > XY Plot > Set Up...*** as shown below.



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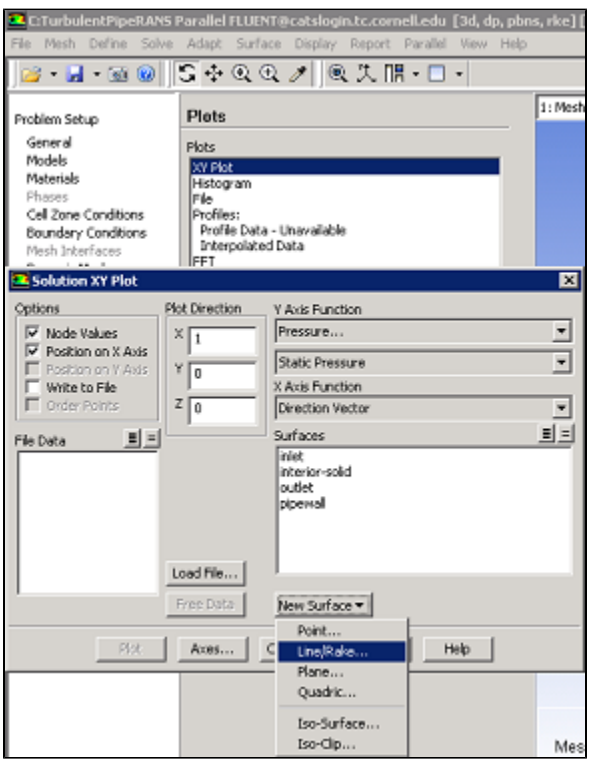
In the ***Solution XY Plot***, choose ***New Surface > Line/Rake...*** as shown below.



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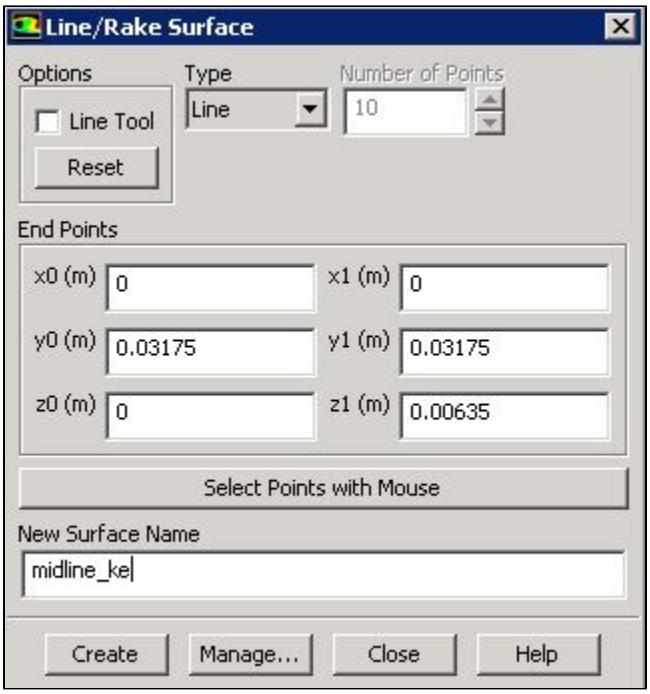
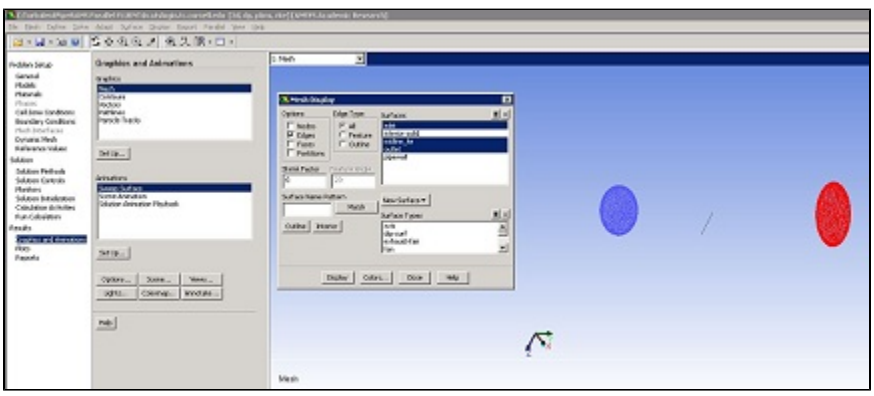
Choose the coordinates of the two points that define the line as below and name the line as ***midline_ke*** and click ***Create*** and ***Close*** the window.



The line can be viewed by clicking ***Graphics and Animations > Mesh > Set Up...***.



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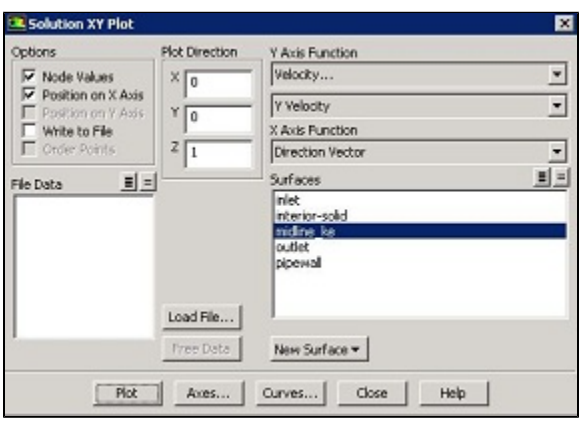
Go back to the ***Solution XY Plot*** window by clicking ***Plots > XY Plot > Set Up...***. In this window, choose ***Velocity...*** and ***Y Velocity*** for ***Y-Axis Function***. Also, choose ***0, 0, 1*** as the ***Plot Direction***. Finally, choose ***midline_ke*** under ***Surfaces***. and click ***Plot***.



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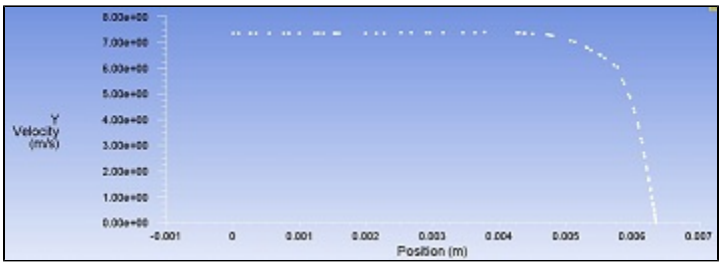

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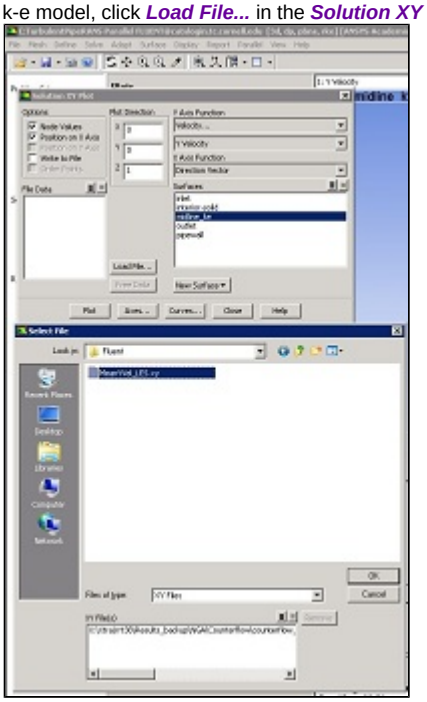
To compare the solution from LES simulation with that from the k-e model, click ***Load File...*** in the ***Solution XY Plot*** and choose the saved file ***MeanYVel_LES.xy*** from the previous section as shown in the figure below.



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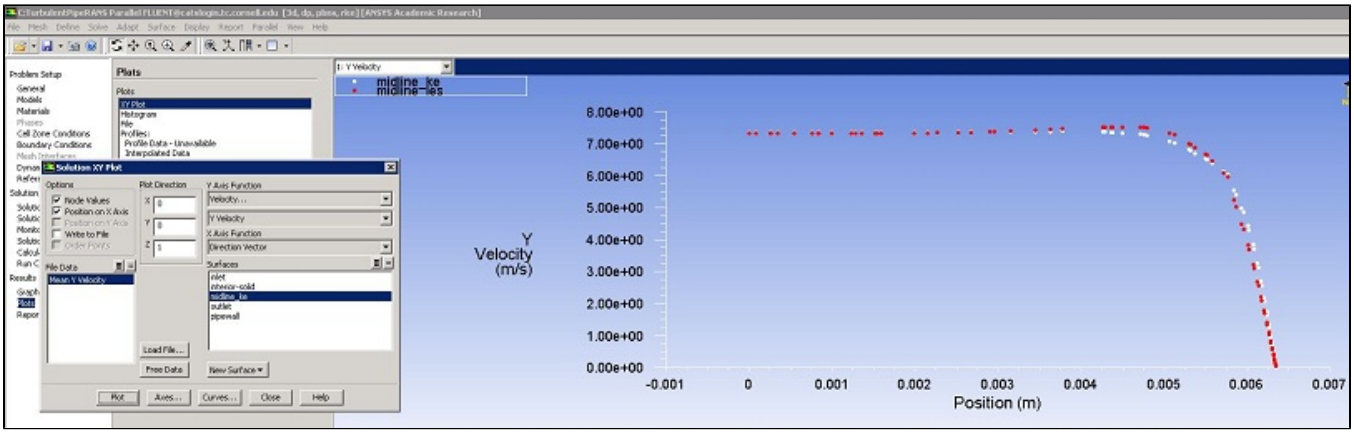
In the ***Solution XY Plot*** select ***Mean Y Velocity*** under ***File Data*** and click ***Plot***. The figure below shows the comparison of the mean Y velocity from k-e and LES simulations, both the results are very close which validates the solution procedure for the LES simulation.



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