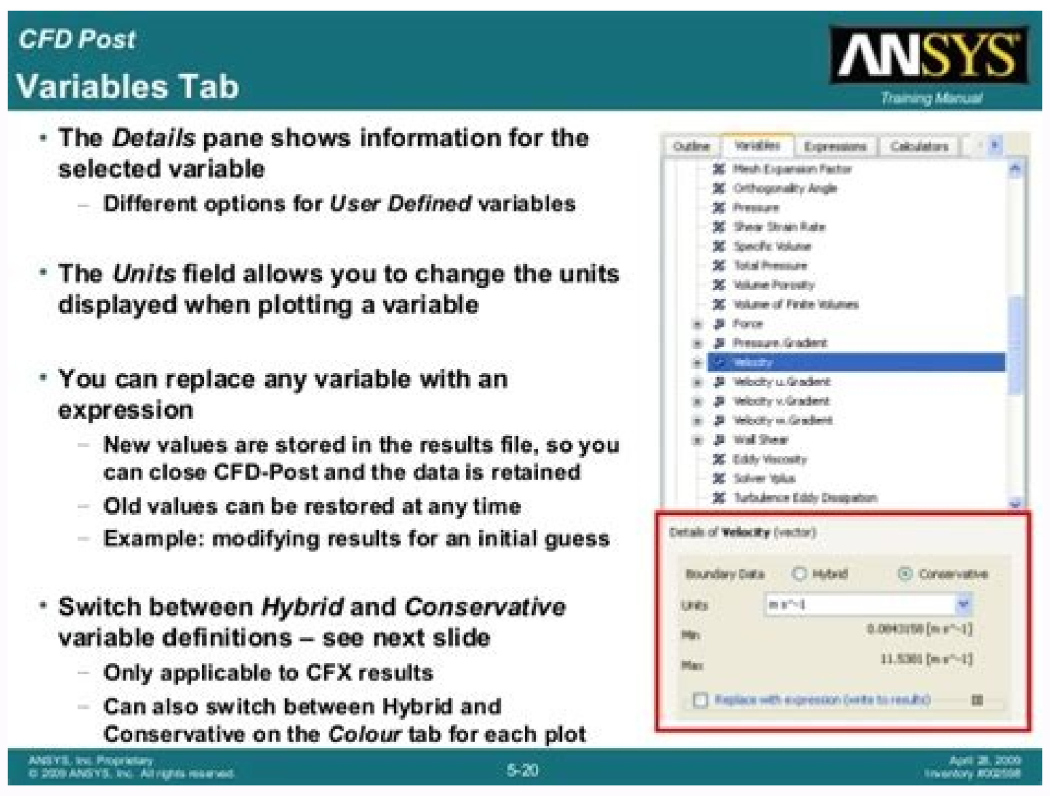
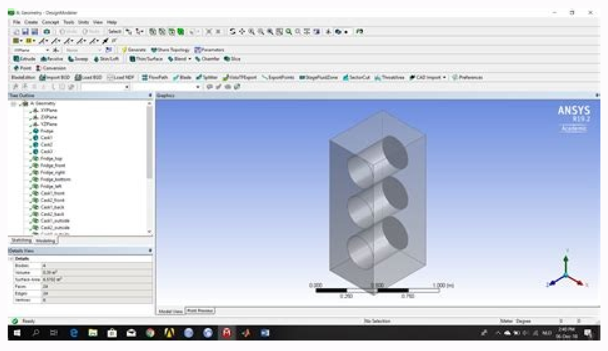
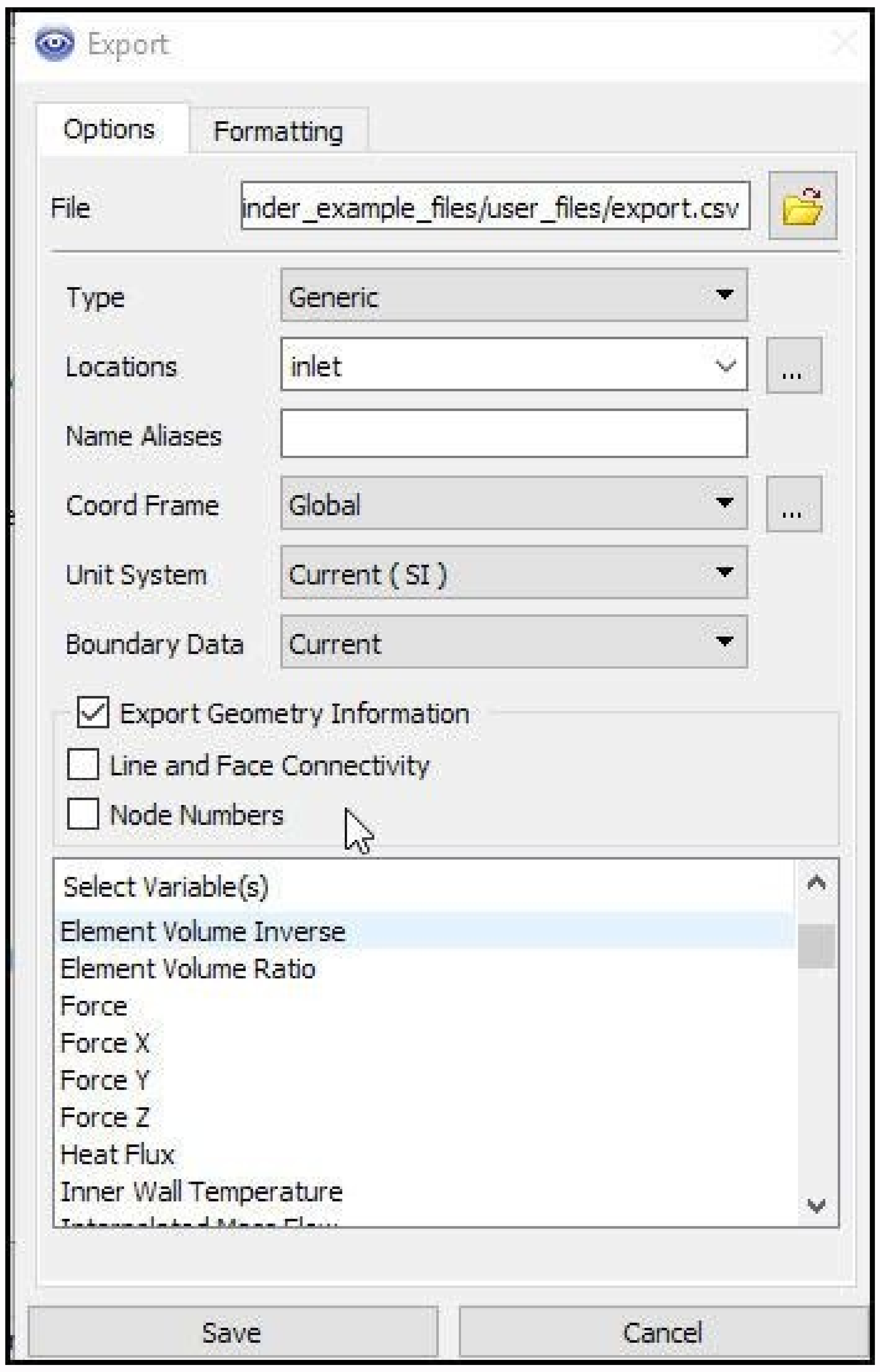
Ansys cfx post user guide pdf

I'm not robot!


CFD Post
Variables Tab
ANSYS
Training Manual
The Details pane shows information for the selected variable
Different options for User Defined variables
The Units field allows you to change the units displayed when plotting a variable
You can replace any variable with an expression
New values are stored in the results file, so you can close CFD-Post and the data is retained
Old values can be restored at any time
Example: modifying results for an initial guess
Switch between Hybrid and Conservative variable definitions – see next slide
Only applicable to CFX results
Can also switch between Hybrid and Conservative on the Colour tab for each plot
5-20

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Line and Face Connectivity
Node Numbers
Select Variable(s)
Element Volume Inverse
Element Volume Ratio
Force
Force X
Force Y
Force Z
Heat Flux
Inner Wall Temperature
Save
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ANSYS CFX Reference Guide

ANSYS, Inc.
Southpointe
275 Technology Drive
Canonsburg, PA 15317
ansysinfo@ansys.com
http://www.ansys.com
(T) 724-746-3304
(F) 724-514-9494

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Turbo Post-processing (p. 45) demonstrates the turbomachinery post-processing capabilities of CFD-Post to visualize flow in a centrifugal compressor. Quantitative Post-processing (p. 65) demonstrates the quantitative post-processing capabilities of CFD- Post using a 3D model of a circuit board with a heat-generating electronic chip mounted on it. For information on the CFD-Post interface (menu bar, tool bar, workspaces, and viewers), see CFD-Post Graphical Interface. Using Help To open the help viewer, from the menu bar select Help > Contents. You may also use context-sensitive help, which is provided for many of the details views and other parts of the interface. To invoke the context-sensitive help for a particular details view or other feature, ensure that the feature is active, place the mouse pointer over it, then press F1. Not every area of the interface supports context-sensitive help. Tip For more information on the help system, see Accessing Help. 1 6 2 7 Chapter 2: Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow This tutorial illustrates how to use CFD-Post to visualize a three-dimensional turbulent fluid flow and heat transfer problem in a mixing elbow. The mixing elbow configuration is encountered in piping systems in power plants and process industries. It is often important to predict the flow field and temperature field in the area of the mixing region in order to properly design the junction. This tutorial demonstrates how to do the following: 2.1. Create a Working Directory 2.2. Launch CFD-Post 2.3. Display the Solution in CFD-Post 2.4. Save Your Work 2.5. Generated Files Problem Description The problem to be considered is shown schematically in Figure 2.1: Problem Specification (p. 4). A cold fluid at 20 C flows into the pipe through a large inlet and mixes with a warmer fluid at 40 C that enters through a smaller inlet located at the elbow. The pipe dimensions are in inches, but the fluid properties and boundary conditions are given in SI units. The Reynolds number for the flow at the larger inlet is 50,800, so the flow has been modeled as being turbulent. Note This tutorial is based on an existing Fluent case. The combination of SI and Imperial units is not typical, but follows a Fluent example. Because the geometry of the mixing elbow is symmetric, only half of the elbow is modeled. 3 8 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Figure 2.1: Problem Specification 2.1. Create a Working Directory CFD-Post uses a working directory as the default location for loading and saving files for a particular session or project. Before you run a tutorial, use your operating system's commands to create a working directory where you can store your sample files and results files. By working in that new directory, you prevent accidental changes to any of the sample files. Copying the CAS and DAT/CDAT Files Sample files are provided so that you can begin using CFD-Post immediately. You may find sample files in a variety of places, depending on which products you have: If you have ANSYS CFX or ANSYS CFX, sample files are in \examples, where is the installation directory for ANSYS CFX or CFD-Post. Copy the.cas and.cdat files (elbow1.cas.gz, elbow1.cdat.gz, elbow3.cas.gz, and elbow3.cdat.gz) and the particle track file (elbow_tracks.xml) to your working directory. If you have Fluent 12 or later: 1. Download cfd-post-elbow.zip (or a zip file that contains it) from the ANSYS Customer Portal. To access tutorials and their input files on the ANSYS Customer Portal, go to 4 9 Launch CFD-Post 2. Extract the CAS files and DAT files (elbow1.cas.gz, elbow1.dat.gz, elbow3.cas.gz and elbow3.dat.gz) and the particle track file (elbow_tracks.xml) from cfd-post-elbow.zip to your working directory Launch CFD-Post Before you start CFD-Post, set the working directory. The procedure for setting the working directory and starting CFD-Post depends on whether you will launch CFD-Post stand-alone, from the ANSYS CFX Launcher, from ANSYS Workbench, or from Fluent: To run CFD-Post stand-alone On Windows: 1. From the Start menu, right-click All Programs > ANSYS 15.0 > Fluid Dynamics > CFD-Post 15.0 and select Properties. 2. Type the path to your working directory in the Start in field and click OK. 3. Click All Programs > ANSYS 15.0 > Fluid Dynamics > CFD-Post 15.0 to launch CFD-Post. On Linux, enter cfdpost.exe in a terminal window that has its path set up to run CFD-Post (the path will be something similar to /usr/ansys_inc/v150/cfd-post/cfdpost.exe). To run ANSYS CFX Launcher 1. Start the launcher. You can run the launcher in any of the following ways: On Windows: From the Start menu, go to All Programs > ANSYS 15.0 > Fluid Dynamics > CFX In a DOS window that has its path set up correctly to run ANSYS CFX, enter cfx5launch (otherwise, you will need to type the full pathname of the cfx5launch command, which will be something similar to C:\Program Files\ANSYS Inc\v150\CFX\bin). On Linux, enter cfx5launch in a terminal window that has its path set up to run ANSYS CFX (the path will be something similar to /usr/ansys_inc/v150/cfx/bin). 2. Select the Working Directory (where you copied the sample files). 3. Click the CFD-Post 15.0 button. ANSYS Workbench 1. Start ANSYS Workbench. 2. From the menu bar, select File > Save As and save the project file to the directory that you want to be the working directory. 3. Open the Component Systems toolbox and double-click Results. A Results system opens in the Project Schematic. 4. Right-click the A2 Results cell and select Edit. CFD-Post opens. Fluent 1. Click the Fluent icon ( ) in the ANSYS program group to open Fluent Launcher. Fluent Launcher allows you to decide which version of Fluent you will use, based on your geometry and on your processing capabilities. 2. Ensure that the proper options are selected. Fluent Launcher retains settings from the previous session. a. Select 3D from the Dimension list. b. Select a Processing Option (for example Serial). c. Make sure that the Display Mesh After Reading and Embed Graphics Windows options are selected. d. Make sure that the Double-Precision option is disabled. Tip You can also restore the default settings by clicking the Default button. 6 11 Launch CFD-Post 3. Set the working path to the directory created when you created the working directory. 4. Click OK to launch Fluent. 7 12 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 5. Select File > Read > Case & Data and choose the elbow1.cas.gz file. 6. Select File > Export to CFD-Post. 7. In the Select Quantities list that appears, highlight the following variables: Static Pressure Density X Velocity Y Velocity Z Velocity Static Temperature Turbulent Kinetic Energy (k) 8. Click Write. CFD-Post starts with the tutorial file loaded. 9. In the Fluent application, select File > Read > Case & Data and choose the elbow3.cas.gz file. 10. In the Export to CFD-Post dialog box, clear the Open CFD-Post option and click Write. Accept the default name and click OK to save the files. 8 13 Display the Solution in CFD-Post 11. Close Fluent Display the Solution in CFD-Post In the steps that follow, you will visualize various aspects of the flow for the solution using CFD-Post. You will: Prepare the case and set the viewer options Become familiar with the 3D Viewer controls Create an instance reflection Show fluid velocity on the symmetry plane Create a vector plot to show the flow distribution in the elbow Create streamlines to show the flow distribution in the elbow Show the vortex structure Use multiple viewports to compare a contour plot to the display of a variable on a boundary Review and modify a report Create a custom variable and cause the plane to move through the domain to show how the values of a custom variable change at different locations in the geometry Compare the results to those in a refined mesh Load a particle track file, then animate the particles, create a chart of a particle's velocity, and create an animation of a plane moving through the domain Prepare the Case and Set the Viewer Options 1. If you have launched CFD-Post from Fluent, proceed to the next step. For all other situations, load the simulation from the data file (elbow1.cdat.gz) from the menu bar by selecting File > Load Results. In the Load Results File dialog box, select elbow1.cdat.gz and click Open. 2. If you see a message that discusses Global Variables Ranges, it can be ignored. Click OK. The mixing elbow appears in the 3D Viewer in an isometric orientation. The wireframe appears in the view and there is a check mark beside User Location and Plots > Wireframe in the Outline tree view; the check mark indicates that the wireframe is visible in the 3D Viewer. 3. Optionally, set the viewer background to white: a. Right-click the viewer and select Viewer Options. b. In the Options dialog box, select CFD-Post > Viewer. 9 14 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow c. Set: Background > Color Type to Solid. Background > Color to white. To do this, click the bar beside the Color label to cycle through 10 basic colors. (Click the right-mouse button to cycle backwards.) Alternatively, you can choose any color by clicking to the right of the Color option. Text Color to black (as above). Edge Color to black (as above). d. Click OK to have the settings take effect. e. Experiment with rotating the object by clicking on the arrows of the triad in the 3D Viewer. This is the triad: In the picture of the triad above, the cursor is hovering in the area opposite the positive Y axis, which reveals the negative Y axis. Note The viewer must be in viewing mode for you to be able to click the triad. You set viewing mode or select mode by clicking the icons in the viewer toolbar: When you have finished experimenting, click the cyan (ISO) sphere in the triad to return to the isometric view of the object. 4. Set CFD-Post to display objects in the units you want to see. These display units are not necessarily the same types as the units in the results files you load; however, for this tutorial you will set the display units to be the same as the solution units for consistency. As mentioned in the Problem Description (p. 3), the solution units are SI, except for the length, which is measured in inches. 10 15 Display the Solution in CFD-Post a. Right-click the viewer and select Viewer Options. Tip The Options dialog box is where you set your preferences; see Setting Preferences with the Options Dialog for details. b. In the Options dialog box, select Common > Units. c. Notice that System is set to SI. In order to be able to change an individual setting (length, in this case) from SI to imperial, set System to Custom. Now set Length to in (inches) and click OK. Note The display units are saved between sessions and projects. This means that you can load results files from diverse sources and always see familiar units displayed. You have set only length to inches; volume will still be reported in meters. To change volume as well, in the Options dialog box, select Common > Units, then click More Units to find the full list of settings. 11 16 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Become Familiar with the Viewer Controls Optionally, take a few moments to become familiar with the viewer controls. These icons switch the mouse from selecting items in the viewer to controlling the orientation and display of the view. First, the sizing controls: 1. Click Zoom Box 2. Click and drag a rectangular box over the geometry. 3. Release the mouse button to zoom in on the selection. The geometry zoom changes to display the selection at a greater resolution. 4. Click Fit View to re-center and re-scale the geometry. Now, the rotation functions: 1. Click Rotate on the viewer toolbar. 12 17 2. Click and drag repeatedly within the viewer to test the rotation of the geometry. Notice how the mouse cursor changes depending on where you are in the viewer, particularly near the edges: Figure 2.2: Orientation Control Cursor Types Display the Solution in CFD-Post The geometry rotates based on the direction of movement. If the mouse cursor has an axis (which happens around the edges), the object rotates around the axis shown in the cursor. The axis of rotation is through the pivot point, which defaults to be in the center of the object. Tip See Mouse Button Mapping for details about other features that you can access with the mouse. Now explore orientation options: 1. Right-click a blank area in the viewer and select Predefined Camera > View From -X. 2. Right-click a blank area in the viewer and select Predefined Camera > Isometric View (Z Up). 3. Click the Z axis of triad in the viewer to get a side view of the object. 13 18 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 4. Click the three axes in the triad in turn to see the vector objects in all three planes; when you are done, click the cyan (ISO) sphere. Now explore the differences between the orienting controls you just used and select mode. 1. Click to enter select mode. 2. Hover over one of the wireframe lines and notice that the cursor turns into a box. 3. Click a wireframe line and notice that the details view for the wireframe appears. 4. Right-click away from a wireframe line and then again on a wireframe line. Notice how the menu changes: Figure 2.3: Right-click Menus Vary by Cursor Position 5. In the Outline tree view, select the elbow1 > fluid > wall check box; the outer wall of the elbow becomes solid. Notice that as you hover over the colored area, the cursor again becomes a box, indicating that you can perform operations on that region. When you right-click the wall, a new menu appears. 6. Click the triad and notice that you cannot change the orientation of the viewer object. (The triad is available only in viewing mode, not select mode.) 7. In the Outline tree view, clear the elbow1 > fluid > wall check box; the outer wall of the elbow disappears. 14 19 Display the Solution in CFD-Post Create an Instance Reflection Create an instance reflection on the symmetry plane so that you can see the complete case: 1. With the 3D Viewer toolbar in viewing mode, click the cyan (ISO) sphere in the triad. This will make it easy to see the instance reflection you are about to create. 2. Right-click one of the wireframe lines on the symmetry plane. (If you were in select mode, the mouse cursor would have a box image added when you are on a valid line. As you are in viewing mode there is no change to the cursor to show that you are on a wireframe line, so you may see the general shortcut menu, as opposed to the shortcut menu for the symmetry plane.) See Figure 2.3: Right-click Menus Vary by Cursor Position (p. 14). 3. From the shortcut menu, select Reflect/Mirror. If you see a dialog box prompting you for the direction of the normal, choose the Z axis. The mirrored copy of the wireframe appears. Tip If the reflection you create is on an incorrect axis, click the Undo toolbar icon twice Show Velocity on the Symmetry Plane Create a contour plot of velocity on the symmetry plane: 1. From the menu bar, select Insert > Contour. In the Insert Contour dialog box, accept the default name, and click OK. 2. In the details view for Contour 1, set the following: Tab Geometry Setting Locations Variable Value symmetry a Velocity b a Notice how the available locations are highlighted in the viewer as you move the mouse over the objects in the Locations drop-down list. You could also create a slice plane at a location of your choice and define the contour to be at that location. b Velocity is just an example of a variable you can use. For a list of Fluent variables and their CFX equivalents, see Fluent Field Variables Listed by Category in the CFD-Post User's Guide. 3. Click Apply. The contour plot for velocity appears and a legend is automatically generated. 4. The coloring of the contour plot may not correspond to the colors on the legend because the viewer has a light source enabled by default. There are several ways to correct this: You can change the orientation of the objects in the viewer. You can experiment with changing the position of the light source by holding down the Ctrl key and dragging the cursor with the right mouse button. You can disable lighting for the contour plot. To disable lighting, click the Render tab and clear the check box beside Lighting, then click Apply. 15 20 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Disabling the lighting is the method that provides you with the most flexibility, so change that setting now. 5. Click the Z on the triad to better orient the geometry (the 3D Viewer must be in viewing mode, not select mode, to do this). Figure 2.4: Velocity on the Symmetry Plane 6. Improve the contrast between the contour regions: a. On the Render tab, select Show Contour Lines and click the plus sign to view more options. b. Select Constant Coloring. c. Set Color Mode to User Specified and set Line Color to black (if necessary, click the bar beside Line Color until black appears). d. Click Apply. 16 21 Display the Solution in CFD-Post Figure 2.5: Velocity on the Symmetry Plane (Enhanced Contrast) 7. Hide the contour plot by clearing the check box beside User Locations and Plots > Contour 1 in the Outline tree view. Tip You can also hide an object by right-clicking on its name in the Outline tree view and selecting Hide Show Flow Distribution in the Elbow Create a vector plot to show the flow distribution in the elbow: 1. From the menu bar, select Insert > Vector. 2. Click OK to accept the default name. The details view for the vector appears. 3. On the Geometry tab, set Domains to fluid and Locations to symmetry. 1722 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 4. Click Apply. 5. On the Symbol tab, set Symbol Size to Click Apply and notice the changes to the vector plot. Figure 2.6: Vector Plot of Velocity 7. Change the vector plot so that the vectors are colored by temperature: a. In the details view for Vector 1, click the Color tab. b. Set the Mode to Variable. The Variable field becomes enabled. c. Click the down arrow beside the Variable field to set it to Temperature. d. Click Apply and notice the changes to the vector plot. 8. Optionally, change the vector symbol. In the details view for the vector, go to the Symbol tab and set Symbol to Arrow3D. Click Apply. 1823 9. Hide the vector plot by right-clicking on a vector symbol in the plot and selecting Hide. In this example you will create streamlines to show the flow distribution by velocity and color those streamlines to show turbulent kinetic energy. CFD-Post uses the Variable setting on the Geometry tab to determine how to calculate the streamlines (that is, location). In contrast, the Variable setting on the Color tab determines the color used when plotting those streamlines. 1. From the menu bar select Insert > Streamline. Accept the default name and click OK. 2. In the details view for Streamline 1, choose the points from which to start the streamlines. Click the down arrow beside the Start From drop-down widget to see the potential starting points. Hover over each point and notice that the area is highlighted in the 3D Viewer. It would be best to show how streamlines from both inlets interact, so, to make a multi-selection, click the Location editor icon. The Location Selector dialog box appears. 3. In the Location Selector dialog box, hold down the Ctrl key and click velocity inlet 5 and velocity inlet 6 to highlight both locations, then click OK. 4. Click Preview Seed Points to see the starting points for the streamlines. 5. On the Geometry tab, ensure that Variable is set to Velocity. 6. Click the Color tab and make the following changes: a. Set the Mode to Variable. The Variable field becomes enabled. b. Set the Variable to Turbulence Kinetic Energy. c. Set Range to Local. Display the Solution in CFD-Post 7. Click Apply. The streamlines show the flow of massless particles through the entire domain. 1924 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Figure 2.7: Streamlines of Turbulence Kinetic Energy 8. Select the check box beside Vector 1. The vectors appear, but are largely hidden by the streamlines. To correct this, highlight Streamline 1 in the Outline tree view and press Delete. The vectors are now clearly visible, but the work you did to create the streamlines is gone. Click the Undo icon Streamline 1. to restore 9. Hide the vector plot and the streamlines by clearing the check boxes beside Vector 1 and Streamline 1 in the Outline tree view Show the Vortex Structure CFD-Post displays vortex core regions to enable you to better understand the processes in your simulation. In this example you will look at helicity method for vortex cores, but in your own work you would use the vortex core method that you find most instructive. 1. In the Outline tree view: a. Under User Locations and Plots, clear the check box for Wireframe. b. Under Cases > elbow1 > fluid, select the check box for wall. c. Double-click wall to edit its properties. 2025 Display the Solution in CFD-Post d. On the Render tab, set Transparency to e. Click Apply. This makes the pipe easy to see while also making it possible to see objects inside the pipe. 2. From the menu bar, select Insert > Location > Vortex Core Region and click OK to accept the default name. 3. In the details view for Vortex Core Region 1 on the Geometry tab, set Method to Absolute Helicity and Level to On the Render tab, set Transparency to 0.2. Click Apply. The absolute helicity vortex that is displayed is created by a mixture of effects from the walls, the curve in the main pipe, and the interaction of the fluids. If you had chosen the vorticity method instead, wall effects would dominate. 5. On the Color tab, click the colored bar in the Color field until the bar is green. Click Apply. This improves the contrast between the vortex region and the blue walls. 6. Right-click in the 3D Viewer and select Predefined Camera > Isometric View (Y up). 7. In the Outline tree view, select the check box beside Streamline 1. This shows how the streamlines are affected by the vortex regions. 2126 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Figure 2.8: Absolute Helicity Vortex 8. Clear the check boxes beside wall, Streamline 1 and Vortex Core Region 1. Select the check box beside Wireframe Show Volume Rendering CFD-Post displays volume rendering to enable you to better understand the processes in your simulation. 1. From the menu bar, select Insert > Volume Rendering and click OK to accept the default name. 2. In the details view for Volume Rendering 1 on the Geometry tab, set Variable to Temperature. 3. On the Color tab, set Mode to Variable and Variable to Temperature. Click Apply. 4. If necessary to orient the simulation as shown below, right-click in the 3D Viewer and select Predefined Camera > Isometric View (Y up). 2227 Display the Solution in CFD-Post Figure 2.9: Volume Rendering of Temperature 5. Hide the Volume Rendering object by clearing the check box beside Volume Rendering 1 in the Outline tree view Compare a Contour Plot to the Display of a Variable on a Boundary A contour plot with color bands has discrete colored regions while the display of a variable on a locator (such as a boundary) shows a finer range of color detail by default. The instructions that follow will illustrate a variable at the outlet and create a contour plot that displays the same variable at that same location. 1. To do the comparison, split the 3D Viewer into two viewports by using the Viewport Layout toolbar in the 3D Viewer toolbar: 2328 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 2. Right-click in both viewports and select Predefined Camera > View From -Y. 3. In the Outline tree view, double-click pressure outlet 7 (which is under elbow1 > fluid). The details view of pressure outlet 7 appears. 4. Click in the View 1 viewport. 5. In the details view for pressure outlet 7 on the Color tab: a. Change Mode to Variable. b. Ensure Variable is set to Pressure. c. Ensure Range is set to Local. d. Click Apply. The plot of pressure appears and the legend shows a smooth spectrum that goes from blue to red. Notice that this happens in both viewports; this is because Synchronize visibility in displayed views is enabled. e. Click Synchronize visibility in displayed views to disable this feature. Now, add a contour plot at the same location: 1. Click in View 2 to make it active; the title bar for that viewport becomes highlighted. 2. In the Outline tree view, clear the check box beside fluid > pressure outlet From the menu bar, select Insert > Contour. 4. Accept the default contour name and click OK. 5. In the details view for the contour, ensure that the Locations setting is pressure outlet 7 and the Variable setting is Pressure. 6. Set Range to Local. 7. Click Apply. The contour plot for pressure appears and the legend shows a spectrum that steps through 10 levels from blue to red. 2429 Display the Solution in CFD-Post 8. Compare the two representations of pressure at the outlet. Pressure at the Outlet is on the left and a Contour Plot of pressure at the Outlet is on the right: Figure 2.10: Boundary Pressure vs. a Contour Plot of Pressure 9. Enhance the contrast on the contour bands: a. In the Outline tree view, right-click User Locations and Plots > Contour 2 and select Edit. b. In the details view for the contour, click the Render tab, expand the Show Contour Lines area, and select the Constant Coloring check box. Then set the Color Mode to User Specified. Click Apply. c. Click the Labels tab and select Show Numbers. Click Apply. 10. Explore the viewer synchronization options: a. In View 1, click the cyan (ISO) sphere in the triad so that the two viewports show the elbow in different orientations. b. In the 3D Viewer toolbar, click the Synchronize camera in displayed views icon. Both viewports take the camera orientation of the active viewport. c. Clear the Synchronize camera in displayed views icon and click the Z arrow head of the triad in View 1. The object again moves independently in the two viewports. d. In the 3D Viewer toolbar, click the Synchronize visibility in displayed views icon. 2530 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow e. In the Outline tree view, right-click fluid > wall and select Show. The wall becomes visible in both viewports. (Synchronization applies only to events that take place after you enable the synchronize visibility function.) 11. When you are done, use the viewport controller to return to a single viewport. The synchronization icons disappear Review and Modify a Report As you work, CFD-Post automatically updates a report, which you can see in the Report Viewer. Later in this tutorial you can publish the report to an HTML file. In this section you will add a picture of the elbow and produce an HTML report: 1. Click the Report Viewer tab at the bottom of the viewer to view the current report. 2. In the Outline tree view, double-click Report > Title Page. In the Title field on the Content tab of the Details of Report Title Page, type: Analysis of Heat Transfer in a Mixing Elbow 3. Click Apply, then Refresh Preview to update the contents of the Report Viewer. 4. In the Outline tree view, ensure that only User Location and Plots > Contour 1, Default Legend View 1, and Wireframe are visible, then double-click Contour 1. On the Geometry tab, set Variable to Temperature and click Apply. 5. On the menu bar, select Insert > Figure. The Insert Figure dialog box appears. Accept the default name and click OK. 6. In the Outline tree view, double-click Report > Figure 1. In the Caption field, type Temperature on the Symmetry Plane and click Apply. 7. Click the 3D Viewer, then click the cyan (ISO) sphere in the triad. 8. Click the Report Viewer. 9. On the top frame of the Report Viewer, click the Refresh icon. The report is updated with a picture of the mixing elbow at the end of the report. 10. Optionally, click Publish to create an HTML version of the report. In the Publish Report dialog box, click OK. The report is written to Report.htm in your working directory. 11. Right-click in the Outline and select Hide All, then select Wireframe. Tip For more information about reports, see Report Create a Custom Variable and Animate the Display In this section you will generate an expression using the CFX Expression Language (CEL), which you can then use in CFD-Post in place of a numeric value. You will then associate the expression with a variable, which you will also create. Finally, you will create a plane that moves through the elbow, then move the plane to see how the values for the variable change. 2631 1. Create a custom expression for the dynamic head formula (rho V ^2)/2 as follows: a. On the tab bar at the top of the workspace area, select Expressions. Right-click in the Expressions area and select New. b. In the New Expression dialog box, type: DynamicHeadExp c. Click OK. d. In the Definition area, type in this definition: Density * abs(velocity)^2 / 2 where: Density is a variable also is a CEL function (abs is unnecessary in this example, but it simply illustrates the use of a CEL function) Velocity is a variable Display the Solution in CFD-Post Tip You can learn which predefined functions, variables, expression, locations, and constants are available by right-clicking in the Definition area. e. Click Apply. 2. Associate the expression with a variable (as the plane you define in the next step can display only variables): a. On the tab bar at the top of the workspace area, select Variables. Right-click in the Variables area and select New. b. In the New Variable dialog box, type: DynamicHeadVar c. Click OK. d. In the details view for DynamicHeadVar, click the drop-down arrow beside Expression and choose DynamicHeadExp. Click Apply. 3. Create a plane and animate it: a. Click the 3D Viewer tab. b. Right-click the wireframe and select Insert > YZ Plane. c. If you see a dialog box that asks in which direction you want the normal to point, choose the direction appropriate for your purposes. A plane that maps the distribution of the default variable (Pressure) appears. 2732 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow d. On the Color tab, set Variable to "DynamicHeadVar". On the Render tab, clear Lighting. Click Apply. The plane now maps the dynamic head distribution. e. In the 3D Viewer with the mouse cursor in select mode, click the plane and drag it to various places in the object to see how the location changes the DynamicHeadVar values displayed. f. Right-click the plane and select Animate. The Animation dialog box appears and the plane moves through the entire domain, displaying changes to the DynamicHeadVar values as it moves. g. On the Animation dialog box, click the Stop icon, then click Close. Tip You can define multiple planes and animate them concurrently. First, stop any animations currently running, then create a new plane. To animate both planes, hold down Ctrl to select multiple planes in the Animation dialog box and click the Play icon. 4. In the upper-left corner of the 3D Viewer, click the down arrow beside Figure 1 and change it to View In the Outline view, right-click User Locations and Plots > Contour 1 and select Hide All Appears 2. On the Load Results File dialog box, select Keep current cases loaded and keep the other settings unchanged. 3. Select elbow3.cdat.gz (or elbow3.cdat) and click Open. 3. In the 3D Viewer, there are now two viewports: in the title bar for View 1 you have elbow1, and in View 2 you have elbow3. 4. In the Outline tree view under Cases you have elbow1 and elbow3; all boundaries associated with each case are listed separately and can be controlled separately. You also have a new entry: Cases > Case Comparison. 4. In the Toolbar, select Synchronize camera in displayed views icon and then select it again. Examine the operation of CFD-Post when the two views are not synchronized and when they are synchronized: 1. In the viewer toolbar, clear Synchronize visibility in displayed views. 2833 2. With the focus in View 1, select Insert > Contour and create a contour of pressure on pressure outlet 7 that displays values in the local range. Note that the contour appears only in View 1. When visibility is not synchronized, changes you make to User Location and Plots apply only to the currently active view. 3. In either view (while in viewing mode), click the Z axis on the triad. Both views show their cases from the perspective of the Z axis. 4. In the viewer toolbar, select Synchronize visibility in displayed views. Display the Solution in CFD-Post 5. With the focus on the view that contains elbow3, select Insert > Contour. Click OK. Define a contour that displays temperature on the symmetry plane: Tab Render Range Temperature Variable Lighting Value Setting symmetry Locations Geometry Local (clear) Click Apply. Note that the contour appears in both views. You can see the differences between the coarse and refined meshes: 2934 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Figure 2.11: Comparing Contour Plots of Temperature on Two Mesh Densities You can now compare the differences between the coarse and refined meshes: 1. In the Outline tree view, double-click Cases > Case Comparison. 2. In the Case Comparison Details view, select Case Comparison Active and click Apply. The differences between the values in the two cases appear in a third view. Click the Z axis of the triad to restore the orientation of the views. 3035 Display the Solution in CFD-Post Figure 2.12: Displaying Differences in Contour Plots of Temperature on Two Mesh Densities Now, revert to a single view that shows the original case: 1. To remove the Difference view, clear Case Comparison Active and click Apply. 2. To remove the refined mesh case, in the Outline tree view, right-click elbow3 and select Unload. 3. In the Outline view, right-click User Locations and Plots > Contour 1 and select Hide All, then select Wireframe and Refresh Default Legend View 1 to make them visible again. 3136 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Display Particle Tracks You can export an XML file of Particle Tracks from Fluent and display the tracks in CFD-Post. Note For your convenience, a sample file (elbow_tracks.xml) is available in the examples directory. At the beginning of this tutorial you may have copied that file to your working directory; if not, do that now. To display particle tracks: 1. With only elbow1.cdat loaded, from the menu bar select File > Import > Import Fluent Particle Track File. 2. In the Import Fluent Particle Track File dialog box, select: elbow_tracks.xml 3. Click Open. 4. Click OK. Particle tracks appear in the 3D Viewer. The tracks stretch from the two inlets to the outlet. 3237 Display the Solution in CFD-Post Make only the particle tracks from the large inlet visible: 1. In the Outline view, double-click User Locations and Plots> Fluent PT for Anthracite to see the Details view for the particle tracks. 2. In the Details view, click the drop-down arrow beside the Injections field so that you can see the names of the two sets of particle tracks. 3. Select injection Click Apply. 3338 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow Display both sets of particle tracks, each set in a different color: 1. First, display both sets of particle tracks again: a. Click the drop-down arrow beside the Injections field. b. Select injection-0,injection-1. c. Click Apply. 2. On the Color tab: 3. Set Mode to Variable. 4. Set Variable to Anthracite.Injection. 5. Click Apply. 3439 Display the Solution in CFD-Post Show fewer particle tracks: 1. Click the Geometry tab. 2. Click the drop-down arrow beside the Reduction Type field and select Reduction Factor. 3. To display only half of the tracks, set Reduction Factor to 2. 3540 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 5. Display all tracks again by setting Reduction to 1 and clicking Apply. Animate symbols running along the particle track lines: 1. Right-click a particle track and select Animate. The animation begins automatically. 2. Click the Stop the animation icon, then click Options. 3. On the Options dialog box, set Symbol Size to 2 and set Symbol to Fish3D. Click OK. 4. On the Animations dialog box, click the Play the animation icon. 3641 Display the Solution in CFD-Post 5. When you have finished viewing the animation, click the Stop the animation icon, then close the Animation dialog box. 6. Create a vector plot: 1. Select Insert > Vector. 2. In the Insert Vector dialog box, click OK to accept the default name for the vector. 3. On the Geometry tab, set: Locations to Fluent PT for Anthracite Reduction to Reduction Factor Factor to 20 Variable to Anthracite.Particle Velocity. Tip You need to click the More Variables icon to see Anthracite.Particle Velocity. 3742 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 4. Click the Symbol tab, and set Symbol Size to 2. Click Apply. 6. In the Outline tree, clear User locations and Plots > Fluent PT for Anthracite. 4. After viewing the vector plot, clear User Locations and Plots > Vector 2 and select User Locations and Plots > Fluent PT for Anthracite in order to view the particle tracks once more. Color the particle tracks by particle time: 1. Click the Color tab. 2. Ensure the Mode is set to Variable. 3. Set Variable to Anthracite.Particle Time. 4. Click Apply. 3843 Display the Solution in CFD-Post Create a chart of particle time vs. particle velocity Y for a single track: 1. On the Geometry tab, click the drop-down arrow beside the Injections field and select injection Click Apply. 2. On the Symbol tab, select Show Track Numbers and click Apply. 4. On the Geometry tab: a. Enable the Filter option. b. Select Track. c. In the Track field, type 54. d. Click Apply. 3944 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 5. Create a chart of a particle's velocity over time: a. From the menu bar, select Insert > Chart. b. In the Insert Chart dialog box, type: Particle 54 and click OK. The details view for the chart appears, and the Chart Viewer opens. c. In the Title field, type: Particle Time vs. Particle Velocity d. On the Data Series tab, highlight Series 1 and set the Location to Fluent PT for Anthracite. e. On the X Axis tab, set Variable to Anthracite.Particle Time. f. On the Y Axis tab, set Variable to Anthracite.Particle Y Velocity. g. Click Apply. 4045 Display the Solution in CFD-Post Interpolate a field variable onto the track: 1. On the Y Axis tab, set Variable to Pressure. 2. On the General tab, change the Title to Particle Time vs. Pressure. 3. Click Apply. Use the Function Calculator to calculate lengthave of Pressure on the track: 1. From the menu bar, select Tools > Function Calculator. 2. In the Function Calculator, set Function to lengthave. 3. Ensure that Location is set to Fluent PT for Anthracite. 4. Ensure that Variable is set to Pressure. 4146 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 5. Enable Show equivalent expression. 6. Click Calculate. The value of PT for Anthracite appears Save Your Work When you began this tutorial, you loaded a solver results file. When you save the work you have done in CFD-Post, you save the current state of CFD-Post into a CFD-Post State file (.cst). 1. How you save your work depends on whether you are running CFD-Post stand-alone or from within ANSYS Workbench: From CFD-Post stand-alone: 1. From the menu bar, select File > Save State. This operation saves the expression, custom variable, and the settings for the objects in a.cst file and saves the state of the animation in a.can file. The.cas.gz and.cdat.gz files remain unchanged. 2. A Warning dialog box asks if you want to save the animation state. Click Yes. 3. Optionally, confirm the state file's contents: close the current file from the menu bar by selecting File > Close (or press Ctrl+W) then reload the state file (select File > Load State and choose the file that you saved in step 1.) From ANSYS Workbench: 1. From the CFD-Post menu bar, select File > Quit. ANSYS Workbench saves the state file automatically. 2. In the ANSYS Workbench Project Schematic, double-click the Results cell. CFD-Post re-opens with the state file loaded. 2. Save a picture of the current state of the simulation: In the Outline view, show Contour 1. With the focus in the 3D Viewer, select Picture from the tool bar. In the Save Picture dialog box, click Save. A PNG file of the current state of the viewer is saved to .png (elbow1.png) in your working directory. Tip To learn about the options on the Save Picture dialog box, see Save Picture Command. 3. You can recreate the animation you made previously and save it to a file: a. Click the cyan (ISO) sphere in the triad to orient the elbow to display Plane 1. b. In the Outline view, clear Contour 1 and Fluent PT for Anthracite; show Plane 1. 4247 c. In the 3D Viewer, right-click Plane 1 in the 3D Viewer and select Animate. The Animation dialog box appears and the plane moves through the entire domain. d. Click the stop icon. e. If necessary, display the full animation control set by clicking. Save Your Work f. The Repeat is set to infinity; change the value to 1 by clicking the infinity button. The Repeat field becomes enabled and by default is set to one. g. Enable Save Movie to save the animation to the indicated file. h. Click Play the animation. The plane moves through one cycle. You can now go to your working directory and play the animation in an appropriate viewer. 4. Close to close the Animation dialog box. 5. Close CFD-Post: from the tool bar select File > Quit. If prompted, you may save your changes. 4348 Post-processing Fluid Flow and Heat Transfer in a Mixing Elbow 2.5. Generated Files As you worked through this tutorial you generated the following files in your working directory (default names are given): elbow1.cst, the state file, and elbow1.can, the animation associated with that state file elbow1.wmv, the animation elbow1.png, a picture of the contents of the 3D Viewer Report.htm, the report. 4449 Chapter 3: Turbo Post-processing This tutorial demonstrates the turbomachinery post-processing capabilities of CFD-Post. In this example, you will read Fluent case and data files (without doing any calculations) and perform a number of turbomachinery-specific post-processing operations. This tutorial demonstrates: Display the Solution in CFD-Post (p. 51) Initialize the Turbomachinery Components (p. 53) Compare the Blade-to-Blade, Meridional, and 3D Views (p. 55) Display Contours on Meridional Isosurfaces (p. 56) Display a 360-Degree View (p. 58) Calculate and Display Values of Variables (p. 58) Display the Inlet to Outlet Chart (p. 61) Generate and View Turbo Reports (p. 63) 3.1. Problem Description This tutorial considers the problem of a centrifugal compressor shown schematically in Figure 3.1: Problem Specification (p. 46). The model comprises a single 3D sector of the compressor to take advantage of the circumferential periodicity in the problem. The flow of air through the compressor is simulated and the post-processing capabilities of CFD-Post are used to display realistic, full 360 images of the solution obtained. 4550 Turbo Post-processing Figure 3.1: Problem Specification 3.2. Create a Working Directory CFD-Post uses a working directory as the default location for loading and saving files for a particular session or project. Before you run a tutorial, use your operating system's commands to create a working directory where you can store your sample files and results files. By working in that new directory, you prevent accidental changes to any of the sample files. Copying the Sample Files Sample files are provided so that you can begin using CFD-Post immediately. You may find sample files in a variety of places, depending on which products you have: If you have CFD-Post or ANSYS CFX, sample files are in /examples, where is the installation directory for ANSYS CFX. Copy the sample files (turbo.cdat.gz and turbo.cas.gz) to your working directory. If you have Fluent 12 or later: 1. Download cfd-postturbo.zip (or a zip file that contains it) from the Customer Portal. To access tutorials and their input files on the ANSYS Customer Portal, go to 4651 Launch CFD-Post 2. Extract the CAS files and DAT files (turbo.cas.gz and turbo.dat.gz) from cfd-postturbo.zip to your working directory Launch CFD-Post Before you start CFD-Post, set the working directory. The procedure for setting the working directory and starting CFD-Post depends on whether you will run CFD-Post stand-alone, from the ANSYS CFX Launcher, from ANSYS Workbench, or from Fluent: To run CFD-Post stand-alone, from the Start menu, right-click All Programs > ANSYS 15.0 > Fluid Dynamics > CFD-Post 15.0 and select Properties. Type the path to your working directory in the Start in field and click OK, then click All Programs > ANSYS 15.0 > Fluid Dynamics > CFD-Post 15.0 to launch CFD-Post. To run ANSYS CFX Launcher 1. Start the launcher. You can run the launcher in any of the following ways: On Windows: From the Start menu, go to Start menu, go to All Programs > ANSYS 15.0 > Fluid Dynamics > CFX In a DOS window that has its path set up correctly to run CFX, enter cfx5launch (otherwise, you will need to type the full pathname of the cfx command, which will be something similar to C:\Program Files\ANSYS Inc\v150\CFX\bin). On Linux, enter cfx5launch in a terminal window that has its path set up to run CFX (the path will be something similar to /usr/ansys_inc/v150/cfx/bin). 2. Select the Working Directory (where you copied the sample files). 3. Click the CFD-Post 15.0 button. ANSYS Workbench 1. Start ANSYS Workbench. 2. From the menu bar, select File > Save As and save the project file to the directory that you want to be the working directory. 3. Open the Component Systems toolbox and double-click Results. A Results system opens in the Project Schematic. 4. Right-click the A2 Results cell and select Edit. CFD-Post opens. Fluent 1. Click the Fluent icon ( ) in the ANSYS program group to open Fluent Launcher. 4752 Turbo Post-processing Fluent Launcher allows you to decide which version of Fluent you will use, based on your geometry and on your processing capabilities. 2. Ensure that the proper options are selected. Fluent Launcher retains settings from the previous session. a. Select 3D from the Dimension list. b. Select Serial from the Processing Options list. c. Make sure that the Display Mesh After Reading and Embed Graphics Windows options are selected. d. Make sure that the Double-Precision option is disabled. Tip You can also restore the default settings by clicking the Default button. 3. Set the working path to the directory created when you unzipped cfd-post-turbo.zip. a. Click Show More Options. b. Enter the path to your working directory for Working Directory by double-clicking the text box and typing. Alternatively, you can click the browse button ( ) next to the Working Directory text box and browse to the directory, using the Browse For Folder dialog box. 4853 Launch CFD-Post 4. Click OK to launch Fluent. 4954 Turbo Post-processing 5. Select File > Read > Case & Data and choose the turbo.cas.gz file. 6. Select File > Export to CFD-Post. 7. In the dialog box that appears, highlight the variables required by turbo reports, which are below: Fluent Variables Required by Turbo Reports Density Static Pressure Total Pressure X Velocity Y Velocity Z Velocity Static Temperature Total Temperature Enthalpy Total Enthalpy Specific Heat (Cp) 5055 Display the Solution in CFD-Post Entropy Rothalpy Mach Number 8. Click Write. CFD-Post starts with the tutorial file loaded Display the Solution in CFD-Post In the steps that follow, you will visualize various aspects of the flow for the case using CFD-Post. You will: Prepare the case and set the viewer options Initialize the turbomachinery components Compare the blade-to-blade, meridional, and 3D views Compare contours on meridional isosurfaces Calculate and display the values of variables Display a 360-degree view Display the inlet-to-outlet chart Generate and view a Turbo report Prepare the Case and Set the Viewer Options 1. If CFD-Post has not been started from Fluent, load the CDAT file (turbo.cdat.gz) from the menu bar by selecting File > Load Results. In the Load Results File dialog box, select turbo.cdat.gz and click Open. 2. If you see a message that discusses Global Variables Ranges, it can be ignored. Click OK. The turbo blade appears in the viewer in an isometric orientation. The Wireframe appears in the 3D Viewer and there is a check mark beside Wireframe in the Outline workspace; the check mark indicates that the wireframe is visible in the 3D Viewer. 3. Set CFD-Post to display the units you want to see. These display units are not necessarily the same types as the units in the results files you load; however, for this tutorial you will set the display units to be the same as the solution units. a. Right-click the viewer and select Viewer Options. Tip The Options dialog box is where you set your preferences; see Setting Preferences with the Options Dialog for details. 5156 Turbo Post-processing b. In the Options dialog box, select Common > Units. c. Set System to SI and click OK. Note The display units you set are saved between sessions and projects. This means that you can load results files from diverse sources and always see familiar units displayed. 4. Double-click Wireframe in the Outline workspace to see the details view. To display the mesh, set Edge Angle to 0 degrees and click Apply. The edge angle determines how much of the surface mesh is visible. If the angle between two adjacent faces is greater than the edge angle, then that edge is drawn. If the edge angle is set to 0, the entire surface mesh is drawn. If the edge angle is large, then only the most significant corner edges of the geometry are drawn. Tip With the mouse focus on CFD-Post and the mouse over the Details of Wireframe editor, press F1 to see help about the Wireframe object. On the Wireframe details view, click Defaults and Apply to restore the original settings. 5. Optionally, set the viewer background to white: a. Right-click the viewer and select Viewer Options. b. In the Options dialog box, select CFD-Post > Viewer. c. Set: Background > Color Type to Solid. Background > Color to white. To do this, click the bar beside the Color label to cycle through 10 basic colors. (Click the right-mouse button to cycle backwards.) Alternatively, you can choose any color by clicking Text Color to black (as above). Edge Color to black (as above). icon to the right of the Color option. d. Click OK to have the settings take effect. 5257 Initialize the Turbomachinery Components 3.5. Initialize the Turbomachinery Components Before you can start using the Turbo workspace features, you need to initialize the components of the loaded case (such as hub, blade, periodics, and so on). Among other things, initialization generates span, a (axial), r (radial), and Theta coordinates for each component. You need to initialize Fluent files manually (automatic initialization is available only for CFX files produced by the Turbo wizard in CFX-Pre). To initialize the components: 1. Click the Turbo tab in the upper-left pane of the CFD-Post window. The Turbo workspace appears as does a Turbo initialization dialog box that offers to auto-initialize all turbo components. Click No. 2. In the Turbo workspace under Initialization, double-click fluid (fluid). The details view of Fluid appears. 3. On the Definition tab, the regions of the geometry are listed in the Turbo Regions areas. However, not all regions are listed; correct this as follows: a. Click Location editor to the right of the Hub region. 5358 Turbo Post-processing b. Hold down the Ctrl key and in the Location Selector select wall diffuser hub, wall hub, and wall inlet hub. c. Click OK. The Hub field now lists all three hub locations. d. Repeat the previous steps for the Shroud region, selecting wall diffuser shroud, wall inlet shroud, and wall shroud. e. Repeat the previous steps for the Blade region, selecting only wall blade. f. Repeat the previous steps for the Inlet region, selecting only inlet. g. Repeat the previous steps for the Outlet region, selecting only outlet. h. Repeat the steps for the Periodic 1 region, selecting periodic.33, periodic.34, and periodic.35. You do not need to initialize the periodic.*shadow regions; the periodic.* nodes provide the information that the turbo reports require. i. Click the Instancing tab. i. Ensure that the Number of Graphical Instances is set to 1. ii. iii. iv. Ensure that Axis Definition is set to Custom, that Method is set to Principal Axis, and that Axis is set to Z. Set Instance Definition to Custom Select Full Circle. j. Click Initialize. This generates variables that you will use later to create reports. Tip If the turbo topology is not correctly defined, an error message is generated and the initialization does not occur. To resolve such an error: 1. Ensure that the rotational axis is correct. 2. Ensure that the turbo regions are correctly set, and that they enclose the passage without any gaps. k. Double-click Initialization at the top of the Turbo tree view. The Initialization editor appears. l. Click the Calculate Velocity Components button. This generates velocity variables that you will also use in your reports. The initialization process has created a variety of plots automatically; you will access these from the Turbo tab in the sections that follow. 5459 3.6. Compare the Blade-to-Blade, Meridional, and 3D Views To compare the Blade-to-Blade, Meridional, and 3D Views: Compare the Blade-to-Blade, Meridional, and 3D Views In the Turbo workspace, select the Three Views option at the bottom of the Initialization editor. In the 3D Viewer you can see the Turbo Initialization View, the Blade to Blade View, and the Meridional View. The CFD-Post Blade to Blade View is equivalent to the Fluent "2D contour on a spanwise surface". By default, the variable shown is Pressure. To change this to velocity and to make the image more like the default Fluent equivalent: 1. In the Blade to Blade View, right-click the colored area shown in the viewport and select Edit. 2. In the details view for the Blade-to-Blade Plot, change the Plot Type from Color to Contour (this changes the continuous gradation found in Color to the discrete color bands found in Contour). 3. Change Variable to Velocity. 4. Change the # of Contours to Click Apply. 5560 Turbo Post-processing The CFD-Post Meridional View is equivalent to the Fluent "contour averaged in the circumferential direction. To make the image more like the default Fluent equivalent: 1. In the Meridional View, right-click the colored area shown in the viewport and select Edit. 2. In the details view for the Meridional Plot, change the Plot Type from Color to Contour. 3. Change the # of Contours to Click Apply Display Contours on Meridional Isosurfaces You can display contours on meridional isosurfaces that you define. In this example you will define six meridional isosurfaces and display the pressure distribution on each. 1. Return to the original orientation of the case: a. In the Tree view, double-click Plots and select Single View. b. Double-click 3D View. 2. From the menu bar select Insert > Location > Isosurface and accept the default name. 3. Set the following values on the details view for the isosurface: Tab Geometry Color Render Field Domains Variable Value Mode Variable Range Min Max Lighting Value fluid Linear BA Streamwise Location [1].01 Variable Pressure User Specified [Pa] [Pa] (clear) Footnote 1. Click the Variable Editor to access this variable. 4. Click Apply to define the isosurface. 5. Repeat the previous steps for the following Geometry values: 5661 Display Contours on Meridional Isosurfaces.2,.4,.6,.8, and.99 Tip To save time, right-click Isosurface 1 in the Tree view and select Duplicate. In this way you need change only the Geometry > Value setting. Be sure to click Apply after defining each new isosurface. Note You can set locator variables other than Linear BA (Blade Aligned) Streamwise Location. For example, edit Isosurface 5 and change Linear BA Streamwise Location to M Length Normalized to see how the contour changes. The locator-variable options are described in Turbo Charts in the CFD-Post User's Guide. 5762 Turbo Post-processing 3.8. Display a 360-Degree View To display a 360 view of the turbomachinery: 1. In the Outline view, right-click and select Hide All. The 3D Viewer is cleared. 2. Under User Locations and Plots, select the check box beside Wireframe. 3. Under Cases > turbo, double-click fluid to edit that domain. 4. On the Instancing tab: a. Set Number of Graphical Instances to 20. b. Ensure that Instance Definition is set to Custom and that Full Circle is selected. c. Ensure that Axis Definition is set to Custom, that the Method is set to Principal Axis, and that the Axis is set to Z. 5. Click Apply. 6. If necessary, click the Fit View icon so that you can see the whole case Calculate and Display Values of Variables You can calculate the values of variables at locations in the case and display these results in a table. First, use the Function Calculator to see how to create a function. 1. From the menu bar, select Tools > Function Calculator. The Calculators tab appears with the Function Calculator displayed. 2. Use the Function Calculator to calculate the mass flow average of pressure at the inlet as follow: a. Use the Function drop-down arrow to select massflowave. b. Use the Location drop-down arrow to select inlet. c. Use the Variable drop-down arrow to select Pressure. d. At the bottom of the Function Calculator select Show equivalent expression. e. Click Calculate and the expression and results appear: 5863 Calculate and Display Values of Variables The Function Calculator not only makes it easy to create and calculate a function, it also enables you to see the syntax for functions, which you will use in the subsequent steps. 3. To display functions like this in a table, click the Table Viewer tab (at the bottom of the viewer area). The Table Viewer appears. 4. In the tool bar at the top of the Table Viewer, click New Table. The New Table dialog box appears. Type in Inlet and Outlet Values and click OK. 5. Type the following text to make cell headings: In cell B1: Inlet In cell C1: Outlet In cell A2: Mass Flow In cell A3: Average Pressure 6. Now, create functions: a. Click in cell B2, then in the Table Viewer tool bar select Function > CFD-Post > massflow. The definition appears. 5964 Turbo Post-processing b. With the text cursor after symbol, click Location > inlet. c. Press Enter; the value of the mass flow at the inlet appears. d. Repeat the above steps for cell C2, but use Location > outlet. e. For cell B3, select Function > CFD-Post > massflowave. With the text cursor between the parentheses, select Variable > Pressure. With the text cursor after symbol, click Location > inlet. Press Enter; the value of the mass flow average of pressure at the inlet appears. f. Repeat the previous step for cell C3, but use Location > outlet. Your table should be similar to this: 7. Format the cells to make the table easier to read. a. Click in cell A1 and, while holding down Shift, click in cell C1. Now the operations you perform will apply to A1 through C1. b. Click to make the heading font bold, then click to center the heading text. Click to apply a background color to those cells. c. Click in cell A2 and, while holding down Shift, click in cell A3. Click to make the row description bold, then click to right-align the text. d. Manually resize the cells. Your table should be similar to this: 6065 Display the Inlet to Outlet Chart 8. Click the Report Viewer tab and then click Refresh in the Report Viewer toolbar. The table data appears at the bottom of the report. Note The background color that you applied in the Table Viewer does not appear in the Report Viewer. However, when you click Publish to create an HTML version of the report, the color will be visible in that report Display the Inlet to Outlet Chart In CFD-Post, displaying the Inlet to Outlet chart is equivalent to displaying averaged XY plots in Fluent. To display the Inlet to Outlet chart: 1. In the Turbo workspace's Turbo Charts area, double-click Inlet to Outlet. 2. Now, change the chart to compare temperature to streamwise location (the latter being called meridional location in Fluent) and make the chart look more like the Fluent default: a. Set the following: fluid Samples/Comp 60 Y Axis Domains Temperature b. Click Apply. The chart appears: 6166 Turbo Post-processing 3. Click the Report Viewer tab at the bottom of the viewer area. 4. In the Report Viewer toolbar, click the Refresh button. The Inlet to Outlet Chart appears in the User Data section of the report. Tip You can also explore the other Turbo Charts: Blade Loading Circumferential Hub to Shroud 6267 Generate and View Turbo Reports Generate and View Turbo Reports Turbo reports give performance results, component data summary tables, meanline 1D charts, stage plots, and spanwise loading charts for the blade. Note The Turbo report is generated from the values set when you initialized the case, so if there were any changes required to those values, you would make them now and run the initialization procedure again. For this tutorial, that will not be necessary. To generate a Turbo report: 1. Create a new variable that the report expects (which would be available with CFX results files for rotating machinery applications, but which is not available from Fluent files). a. From the tool bar, click Variable. The Insert Variable dialog box appears. b. In the Name field, type Rotation Velocity and click OK. The Details view for Rotation Velocity appears. c. In the Expression field, type Radius * abs(omega) / 1 [rad] and click Apply. This expression calculates the angular speed (in units of length per unit time) as a product of the local radius and the rotational speed. 2. In the 3D Viewer's tool bar, click Fit View. This ensures that the graphics will not be truncated in the report you are about to generate. 3. In the Outline tree view, right-click Report and select Report Templates. The Report Templates dialog box appears. 4. Select an appropriate report template; in this case, Centrifugal Compressor Report. (The Centrifugal Compressor Report is an improved version of the Centrifugal Compressor Rotor Report.) Click Load. The Report Templates dialog box disappears and you can watch the report's progress in the status bar in the bottom-right corner of CFD-Post. Note A dialog box appears that warns that hybrid values do not exist and that conservative values will be used. This is expected behavior when using data loaded from Fluent. An error about Mach Number in Stn Frame is also mentioned; this prevents a line in the report from appearing. Click OK. When the report has been generated, there are new entries in the Outline tree view under Report. 5. Under User Locations and Plots, double-click fluid Instance Transform. This is an instance transform generated by the report to facilitate showing two blades in the figures that show blade-toblade views. 6. Ensure that Number of Passages is set to 20 and click Apply. 6368 Turbo Post-processing 7. Click the Expressions tab. Double-click the expression fluid Components in 360 to edit it. Change the definition to 20 and click Apply. To view the Turbo report: 1. On the Report Viewer tab, click Refresh. The turbo report appears. 2. Optionally, you can remove pieces from the report by clearing the appropriate check boxes in the Report section of the Outline tree. When you have made your selections, return to the Report Viewer tab and click Refresh (in the Report Viewer toolbar). The edited version of the turbo report appears. 3. To produce an HTML version of the report that you can share with others, click Publish (at the top of the viewer area). The report is saved in a file name of your choosing in your working directory (by default). 6469 Chapter 4: Quantitative Post-processing This tutorial demonstrates the quantitative post-processing capabilities of CFD-Post using a 3D model of a circuit board with a heat-generating electronic chip mounted on it. The flow over the chip is laminar and involves conjugate heat transfer. The heat transfer involves conduction in the chip and conduction and convection in the surrounding fluid. The physics of conjugate heat transfer such as this is common in many engineering applications, not just the design and cooling of electronic components. In this tutorial, you will read the case and data files and perform a number of post-processing exercises. This tutorial demonstrates how to do the following: 4.1. Create a Working Directory 4.2. Launch CFD-Post 4.3. Prepare the Case and CFD-Post 4.4.View and Check the Mesh 4.5.View Simulation Values Using the Function Calculator 4.6. Create a Line 4.7. Create a Chart 4.8. Add a Second Line 4.9. Create a Chart Create a Table to Show Heat Transfer Publish a Report Note These tutorials are prepared on a Windows system. The screen shots in the tutorials may be slightly different than the appearance on your system, depending on the operating system or graphics card. Problem Description The problem is shown schematically in Figure 4.1: Problem Specification (p. 66). The configuration consists of a series of side-by-side electronic chips, or modules, mounted on a circuit board. Air flow, confined between the circuit board and an upper wall, cools the modules. To take advantage of the symmetry present in the problem, the model will extend from the middle of one module to the plane of symmetry between it and the next module. As shown in the figure, each half-module is assumed to generate 2.0 Watts and to have a bulk conductivity of 1.0 W/m 2 K. The circuit board conductivity is assumed to be one order of magnitude lower: 0.1 W/m 2 K. The air flow enters the system at 298 K with a velocity of 1 m/s. The Reynolds number of the flow, based on the module height, is about 600. The flow is therefore treated as laminar. 6570 Quantitative Post-processing Figure 4.1: Problem Specification 4.1. Create a Working Directory CFD-Post uses a working directory as the default location for loading and saving files for a particular session or project. Before you run a tutorial, use your operating system's commands to create a working directory where you can store your sample files and results files. By working in that new directory, you prevent accidental changes to any of the sample files. Copying the Sample Files Sample files are provided so that you can begin using CFD-Post immediately. You may find sample files in a variety of places, depending on which products you have: If you have CFD-Post or ANSYS CFX, sample files are in /examples, where is the installation directory for ANSYS CFX. Copy the sample files (chip.cdat.gz and chip.cas.gz) to your working directory. If you have Fluent 12 or later: 1. Download ANSYS_Fluid_Dynamics_Tutorial_Inputs.zip (or a zip file that contains it) from the ANSYS Customer Portal. To access tutorials and their input files on the ANSYS Customer Portal, go to 2. Extract the CAS files and DAT files (chip.cas.gz and chip.dat.gz) from postprocess.zip to your working directory Launch CFD-Post Before you start CFD-Post, set the working directory. The procedure for setting the working directory and starting CFD-Post depends on whether you will run CFD-Post stand-alone, from the ANSYS CFX Launcher, from ANSYS Workbench, or from Fluent: 6671 To run CFD-Post stand-alone, from the Start menu, right-click All Programs > ANSYS 15.0 > Fluid Dynamics > CFD-Post 15.0 and select Properties. Type the path to your working directory in the Start in field and click OK, then click All Programs > ANSYS 15.0 > Fluid Dynamics > CFD-Post 15.0 to launch CFD-Post. To run ANSYS CFX Launcher 1. Start the launcher. You can run the launcher in any of the following ways: On Windows: From the Start menu, go to Start menu, go to All Programs > ANSYS 15.0 > Fluid Dynamics > CFX In a DOS window that has its path set up correctly to run CFX, enter cfx5launch (otherwise, you will need to type the full pathname of the cfx command, which will be something similar to C:\Program Files\ANSYS Inc\v150\CFX\bin). On Linux, enter cfx5launch in a terminal window that has its path set up to run CFX (the path will be something similar to /usr/ansys_inc/v150/cfx/bin). 2. Select the Working Directory (where you copied the sample files). 3. Click the CFD-Post 15.0 button. Prepare the Case and CFD-Post ANSYS Workbench 1. Start ANSYS Workbench. 2. From the menu bar, select File > Save As and save the project file to the directory that you want to be the working directory. 3. Open the Component Systems toolbox and double-click Results. A Results system opens in the Project Schematic. 4. Right-click the A2 Results cell and select Edit. CFD-Post opens Prepare the Case and CFD-Post Before you perform various quantitative analyses of the case, prepare the case and CFD-Post: 1. Start CFD-Post now and load the CDAT file (chip.cdat.gz) from the menu bar by selecting File > Load Results. In the Load Results File dialog box, select chip.cdat.gz and click Open. 2. Set CFD-Post to display the units you want to see. These display units are not necessarily the same types as the units in the results files you load; however, for this tutorial you will set the display units to be the same as the solution units. 6772 Quantitative Post-processing a. Right-click the viewer and select Viewer Options. Tip The Options dialog box is where you set your preferences; see Setting Preferences with the Options Dialog for details. b. In the Options dialog box, select Common > Units. c. Set System to SI and click OK. Note The display units you set are saved between sessions and projects. This means that you can load results files from diverse sources and always see familiar units displayed. 3. Optionally, set the viewer background to white: a. Right-click the viewer and select Viewer Options. b. In the Options dialog box, select CFD-Post > Viewer. c. Set: Background > Color Type to Solid. Background > Color to white. To do this, click the bar beside the Color label to cycle through 10 basic colors. (Click the right-mouse button to cycle backwards.) Alternatively, you can choose any color by clicking Text Color to black (as above). Edge Color to black (as above). icon to the right of the Color option. d. Click OK to have the settings take effect View and Check the Mesh There are two ways to view the mesh: you can use the wireframe for the entire simulation or you can view the mesh for a particular portion of the simulation. To view the mesh for the entire simulation: 1. Right-click a line of the wireframe in the 3D Viewer and select Show surface mesh to display the mesh. 6873 View and Check the Mesh 2. Click the Z axis of triad in the viewer to get a side view of the object. Note The 3D Viewer toolbar has to be in viewing mode for you to be able to select the triad elements. Figure 4.2: The Hexahedral Grid for the Simulation 3. In the Outline tree view, double-click User Locations and Plots > Wireframe to display the wireframe's editor. Tip Click the Details of Wireframe editor and press F1 to see help about the Wireframe object. 4. On the Wireframe details view, click Defaults and Apply to restore the original settings. To view the mesh for a particular portion of the simulation (in this case, the chip (wall 4 shadow)): 1. In the Outline tree view, select the check box beside Cases > chip > fluid 8 > wall 4 shadow, then double-click wall 4 shadow to edit its properties in its details view. 2. In the details view: a. On the Render tab, clear the Show Faces check box. b. Select the Show Mesh Lines check box. 6974 Quantitative Post-processing c. Ensure that Edge Angle is set to 0 [degree]. d. Click Apply. The mesh appears and is similar to the mesh shown by the previous procedure, except that the mesh is shown only on the chip. e. Now, clear the display of the chip wireframe. In the details view: i. Clear the Render > Show Mesh Lines check box. ii. iii. Select the Show Faces check box. Click Apply. The chip reappears. 7075 3. In the Outline tree view, clear the check box beside Cases > chip > fluid 8 > wall 4 shadow. To check the mesh: View Simulation Values Using the Function Calculator 1. Select the Calculators tab at the top of the workspace area, then double-click Mesh Calculator. The Mesh Calculator appears. 2. Using the drop-down arrow beside the Function field, select a function such as Maximum Face Angle. 3. Click Calculate. The results of the calculation appear. 4. Repeat the previous steps for other functions, such as Mesh Information View Simulation Values Using the Function Calculator You can view values in the simulation by using the Function Calculator: 1. In the Calculators view, double-click Function Calculator. The Function Calculator appears. 2. In the Function field, select minval as the function to evaluate. 3. In the Location field, select wall Beside the Variable field, select X in the Variable Selector dialog box. 5. Clear the Clear previous results on calculate setting and enable Show equivalent expression. 6. Click Calculate to see the result of the calculation of the minimum X value of the chip. 7. Repeat the operation, but in the Function field, select maxval as the function to evaluate. Click Calculate to see the result of the calculation of the maximum X value of the chip. 7176 Quantitative Post-processing You will use these values in subsequent steps Create a Line Lines can be used to display quantitative results of your CFD simulations. Here, you will create a line along which to plot the temperature distribution along the top center of the chip. 1. Select Insert > Location > Line. 2. For the name, type topcenterline and click OK. 3. On the Details of topcenterline > Geometry tab: a. Set Method to Two Points. b. Set Point 1 to , 0.01, 0. c. Set Point 2 to , 0.01, 0. d. Ensure that Line Type is set to Sample 1. 1 For details on line type options, see Cut/Sample Options in the CFD-Post User's Guide. 7277 Create a Chart Those coordinates define a line along the top center of the chip. 4. On the Color tab: a. Set Mode to Variable. b. Set Variable to Temperature. These steps will color the line by temperature and cause the legend to be displayed. 5. Click Apply Create a Chart Here you will plot the temperature distribution along a line along the top center of the chip. 1. Select Insert > Chart. 2. For the name, type Chip Temperatures and click OK. The Details of Chip Temperatures view appears. 3. On the General tab: a. Set Title to be Temperature Along the Top of the Chip. 7378 Quantitative Post-processing b. Set Caption to be Graph of the Temperature Along the Top of the Chip. 4. On the Data Series tab a. Set Location to topcenterline. b. Change the name Series 1 to Chip-Top Temperatures. 5. On the X Axis tab, set Variable to Chart Count. 6. On the Y Axis tab, set Variable to Temperature. 7. On the Line Display tab, highlight Chip-Top Temperatures and set Symbols to Rectangle. 8. Make the Symbol Color a darker shade of green: beside the Symbol Color field, click Color Selector, select a new shade of green, and click OK. 9. Click Apply. 7479 Create a Chart 4.8. Add a Second Line Here you will create a second line near the bottom of the chip so that you can compare that to the temperature distribution along the top center of the chip. 1. Select Insert > Location > Line. 2. For the name, type bottomsideline and click OK. 3. On the Details of bottomsideline > Geometry tab: a. Set Method to Two Points. b. Set Point 1 to , , 0. c. Set Point 2 to , , 0. d. Set Line Type to Sample. Those coordinates define a line near board level beside the chip. 4. Click Apply Create a Chart Here you will plot the temperature distribution along the second line. 1. In the Report area of the Tree view, double-click Chip Temperatures. 2. On the General tab, change the Title to Temperature Differences on the Chip and change the Caption to Graph of the Temperature Along the Top and Bottom of the Chip. 3. On the Data Series tab: a. Click the New icon to create Series 2. b. Set Location to bottomsideline. c. Change the name Series 2 to Board-Level Temperatures. 4. On the Line Display tab, highlight Board-Level Temperatures and set Symbols to Rectangle. 5. Beside the Symbol Color field, click Color Selector, select a new shade of green, and click OK. 6. Click Apply. 7580 Quantitative Post-processing Create a Table to Show Heat Transfer You can create a table to show how values change at different locations, provided that the locations have been defined. In this section you will create three planes along the mixing region and measure the temperatures on those planes. You will then create a table and define functions that show temperature minimums and maximums, and the differences between those values. 1. In the 3D Viewer, ensure that only the wireframe is visible. 2. Click the cyan-colored ball on the triad to make it easier for you to see the temperature planes that you will create. 3. From the tool bar, select Location > Plane. In the Insert Plane dialog box, type Table Plane 1 and click OK. 4. In the details view for Table Plane 1, set the following values: Tab Variable Color Field Domains Definition > Method Definition > X Mode Value fluid 8 YZ Plane [m] Geometry 7681 Create a Table to Show Heat Transfer Tab Render Field Variable Range Lighting Value Temperature Local (clear) 5. Click Apply. 6. Right-click Table Plane 1 and select Duplicate. The Duplicate dialog box appears. In the Duplicate dialog box, accept the default name Table Plane 2 and click OK. In the Outline view, double-click Table Plane 2 and on the Geometry tab change Definition > X to Click Apply. 7. Repeat the previous step, duplicating Table Plane 2 to make Table Plane 3 and changing Definition > X to Click Apply. Now, create a table: 7782 Quantitative Post-processing 1. From the menu bar, select Insert > Table. Accept the default table name and click OK. The Table Viewer opens. 2. Type in the following headings: A B C D 1 Distance Along Chip Min. Temperature Max. Temperature Difference 3. For the "Distance Along Chip" column, create an equation that gives the distance from the beginning of the chip (which is available from "wall 4" in "solid 2"). Click cell A2, then in the Table Viewer's Insert bar, select Function > CFD-Post > minval. In the cell definition field you see which will be the base of the equation. With the cursor between the parentheses, type X. Move the cursor after sign and either type Table Plane 1 or select Insert > Location > Table Plane 1. Plane When you click away from cell A2, the equation is solved. Note The expressions in the equation are what you created in the Function Calculator. You can copy expressions from the Function Calculator and paste them into table cells, adding other characters in the cell definition field as required. 4. Complete the rest of the table by entering the following cell definitions: Cell A2 Plane Cell A3 Plane Cell A4 Plane Cell B2 Plane 1 Cell B3 Plane 2 Cell B4 Plane 3 Cell C2 Plane 1 Cell C3 Plane 2 7883 Create a Table to Show Heat Transfer Cell C4 Plane 3 Cell D2 Plane 1 - Plane 1 Cell D3 Plane 2 - Plane 2 Cell D4 Plane 3 - Plane 3 As you complete the table, notice that the minimum temperature values stay constant, but the maximum values increase as the chip heats the passing air. 5. The default format for cell data is appropriate for some variables, but it is not appropriate here. Click cell A2, then while depressing the Shift key, click in the lower-right cell (D4). Click the Number Formatting icon in the Table Viewer toolbar. In the Cell Formatting dialog box, set Precision to 2, change Scientific to Fixed, and click OK. 6. Optionally, apply some formatting to the table 2. To format the table as shown above: 1. For cells A1-D1: Apply bold font, background color, and text centering. Manually resize cell widths individually. 2 You can view the table in three places: in the Table Viewer (where you can apply formatting), in the Report Viewer (where some of the formatting you applied in the Table Viewer will be visible), and in the published report (which has default formatting for tables that you cannot see in either the Table Viewer or Report Viewer, but which are overridden by any formatting changes you make in the Table Viewer). It is useful to view the published report (see Publish a Report (p. 80)) before applying formatting in the Table Viewer. 79

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