ViziFlow Tutorial

About ViziFlow

Welcome to ViziFlow, a program designed to give a rapid visualization of fluid flow streamlines and pressure profiles. ViziFlow has been created with the objective of intuitive and rapid model creation, and equally rapid calculation and display of streamlines and pressure profiles. As an aid to measurement a flow rate and pressure gauge function is provided.

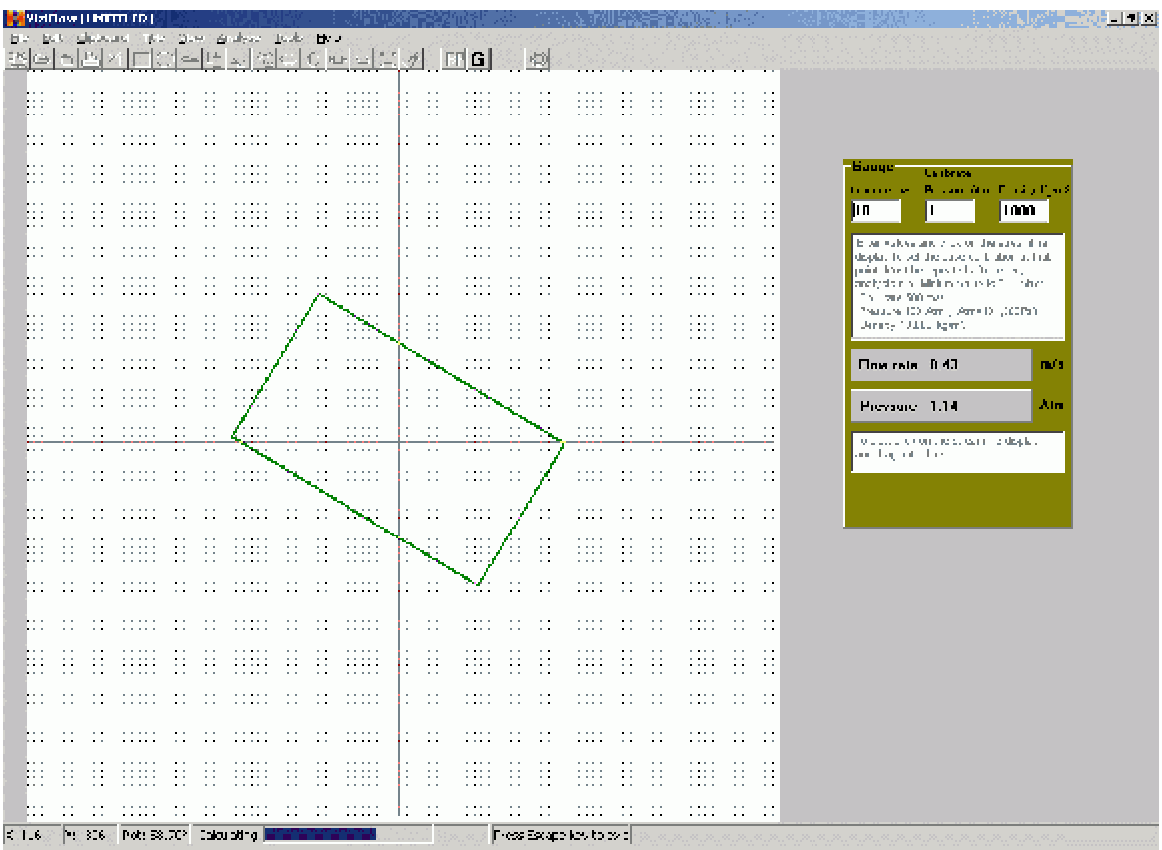
Installing.

The ViziFlow application is supplied as a compressed setup file, downloaded from the Internet. To install, double click the Setup.exe file. The installer program will run and prompt for an installation folder (or accept the default folder shown).

Uninstalling.

Use the included Uninstall program, or from the Windows Control Panel Add/Remove programmes utility.

A typical ViziFlow screen



Using ViziFlow.

The first three toolbar icons have the usual functions of NEW FILE, OPEN FILE and SAVE FILE. When the application is first opened, the drawing area comes up in NEW FILE mode, with a grid pattern of dots and center lines. The TOOLS menu can be used to apply a line grid, or remove the grid and center lines. TOOLS - PREFERENCES can be used to define the default state when the application is next run. Help panels display when functions are selected, and an instruction line shows during object entry or editing.

To enter objects on the drawing area, first select an object type from the EDIT menu or toolbar. After selecting a rectangle or circle object type, click *and release* the mouse button to define the first object point on the screen. Then move the mouse to the next point (a black line or circle will be drawn, following the mouse pointer). Click and release the mouse button to define the next point. Simply repeat until all points are complete.

Repeat with new objects until the desired configuration is complete. Clicking on an object will select it and change the colour to red, and clicking away from an object will deselect it and change the colour to green.

The instructions for object entry appear on the screen instruction line. An object may be edited by first selecting it (by clicking on it and changing the colour to red) and then using the EDIT menu or one of the toolbar icons.

- Rectangular objects may be moved, copied, stretched, made trapezoidal or changed in size.
- Circles may be moved, copied or sized.
- Aerofoils can only be moved in edit mode.

VIEW has an option to display the object with a solid fill. After selecting this option, ANALYSE-SET UP MESH will cause objects to be filled.

Guidelines are provided as an aid to model creation, but are not stored when the model is saved.

ANALYSE - ANALYSE will then compute and plot the fluid flow streamlines, or the the RUN toolbar icon will perform both operations.

If a file is opened with FILE OPEN, it will automatically display the streamlines. Streamlines may be removed by ANALYSE - SETUP MESH. In the TOOLS menu is an option for the number of streamlines displayed, which may be selected as high, low or normal.

The F>P toolbar icon changes the display from streamlines to pressure. Note that the display must be changed back to streamlines to permit further editing. Options for color or mono, linear or log pressure plots are provided.

The FILE - PRINT or the PRINT icon will print out whatever is displayed on the drawing area of the screen (except guidelines). Thus the GRID and centerline options should be set before printing.

The CLIPBOARD menu will copy the screen display to the clipboard in bitmap format (.BMP file extension), to allow pasting into other applications such as word processors.

On-line help

In addition to standard context sensitive help, there is the option to display on-line help text panels when a function is selected from the menu or from the tool bar. These give a brief overview of each function, and are useful when first using Viziflow. In addition an instruction prompt line is shown to act as a guide through each step in an edit function. TOOLS-TUTORIAL will bring up this tutorial.

Hints and tips on using ViziFlow.

By following a few simple common-sense guidelines, ViziFlow will make model building simple and uncomplicated. The key things to bear in mind when creating a model are ***resolution and symmetry.***

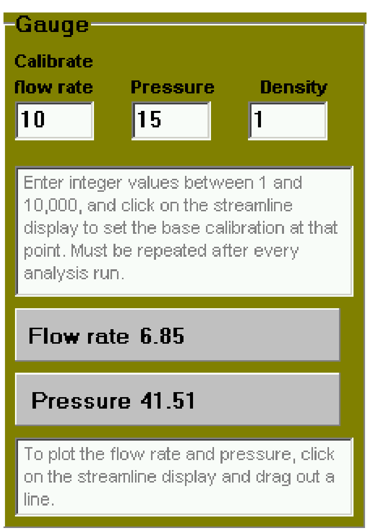
Resolution refers to the need for a sensible number of mesh elements in a model. For good results aim at 5 meshes (i.e. grid squares) across any dimension of an object. Too few elements will cause distortion in the streamline pattern.

Symmetry refers to the distorting effects caused by a finite boundary region. This is not usually a problem, but it is wise to create models balanced as symmetrically as possible around the centerlines.

Using the Flow rate and pressure gauge

Once a streamline plot has been created, the gauge function is available by clicking **Gauge** in the **View** menu, or the 

toolbar icon. A gauge panel opens:



Move the mouse cursor over the streamline display, and the flow rate and pressure at that point are displayed. The values shown will depend on the calibration of the gauge, although ViziFlow will initially select default values.

The gauge theory

The gauge works on the principles of two basic equations of fluid flow.

The continuity equation

$A_1v_1 = A_2v_2$ meaning that the volume flow rate is constant, so that a smaller area for the fluid to flow will result in a higher velocity. Although ViziFlow is a 2D program, for the purposes of the equation the display is assumed to show a cross section through a circular tube.

Bernoulli's equation

This equation relates the pressure, flow velocity, fluid density and fluid height.

$$P_1 + \rho g y_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \tfrac{1}{2}\rho v_2^2$$

The second term on each side of the equation represents the *potential energy* due to the height of the fluid, but since the height is constant in ViziFlow, these terms cancel and the equation reduces to:

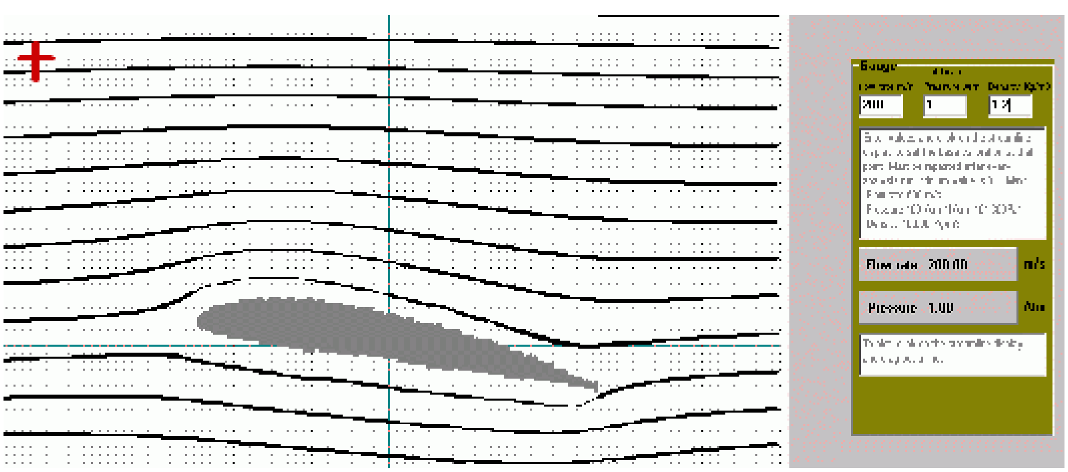
$$P_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \tfrac{1}{2}\rho v_2^2$$

P is the pressure, v the velocity and ρ the density of the fluid. To find the pressure P_2 the equation is rearranged:

$$P_2 = \tfrac{1}{2}\rho(v_2^2 - v_1^2) - P_1$$

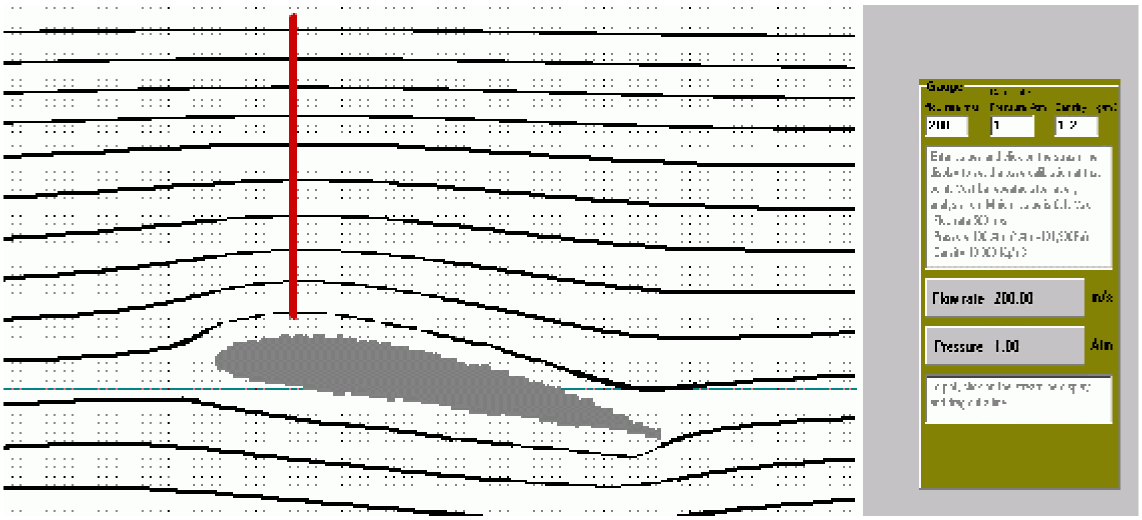
Calibration

Thus to find the pressure or flow rate at point 2, the gauge must be calibrated at point 1 with pressure, flow rate and density. Taking an aerofoil as an example:

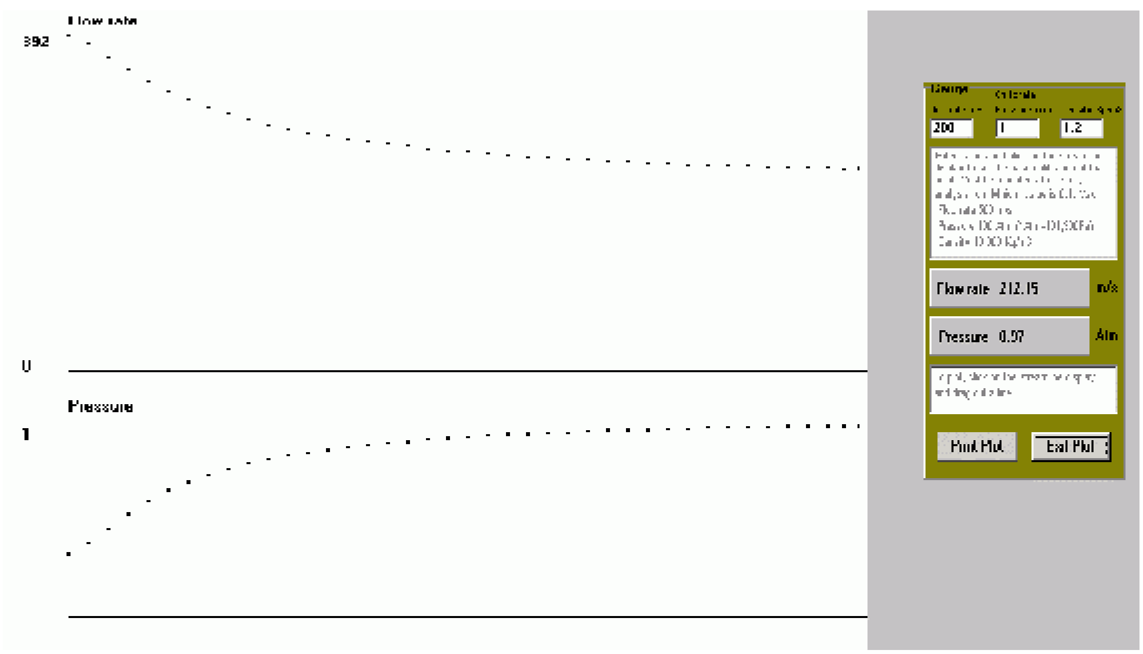


The flow rate has been set to 200m/s (447 mph), the pressure at 1 Atmosphere and the density to that of air, 1.2 Kg/m^3. The calibration point was then set by clicking at the red cross, which was chosen as a point where the air would be expected to be free of disturbance from the aerofoil, and hence at normal atmospheric pressure. Moving the cursor over the display now allows flow rate and pressure to be monitored at other points.

By clicking and holding the left mouse button a line can be dragged out, as shown below (the line is black, but has been shown in red here for clarity):



When the button is released the flow rate and pressure along the line will be plotted.



The plots can then be printed.

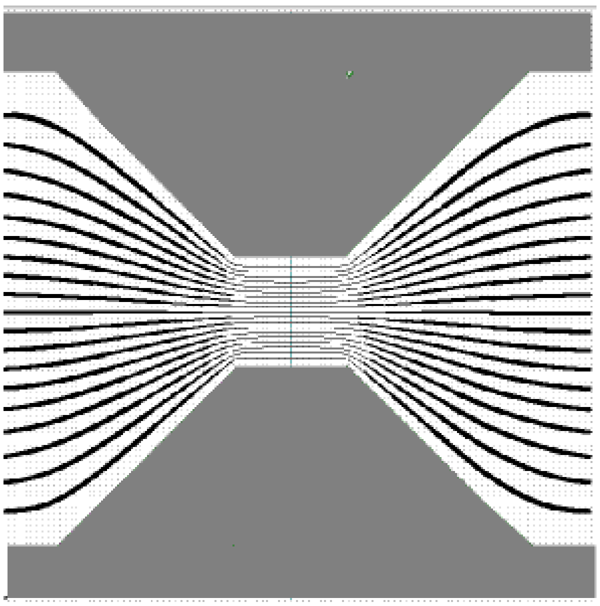
By changing calibration values, the effects on lift (the reduced pressure region over the aerofoil) caused by air speed, altitude and aerofoil angle can be explored.

Editing

Be sure to turn off the gauge display when editing the model.

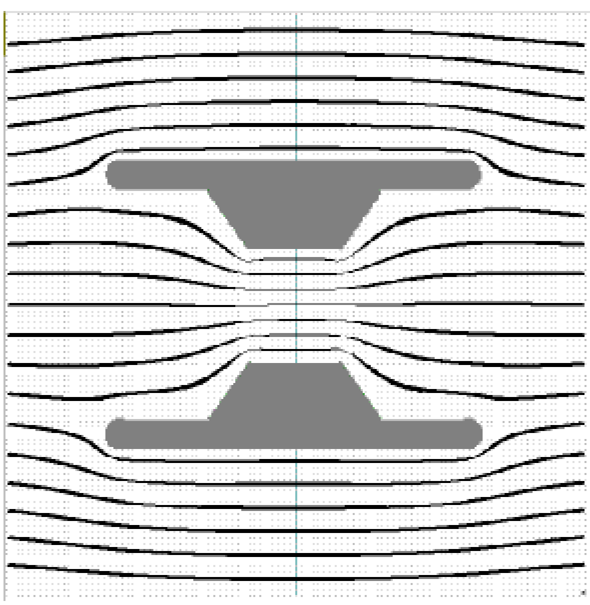
Accuracy of modelling

The model itself will determine the accuracy of the results, and thought must be given to this in the same way as when making a real life model. As an example, take the Venturi meter shown below:



This picture gives a good visualization of the flow rate variation through a typical Venturi meter. However, with an entrance to throat diameter ratio of 4:1, the flow rate at the throat would be expected to be 16 times the entrance value, whereas the gauge measured 13.33 times, an error from theory of 20%.

Compare this with the model below:



This is less visually impressive, but the flow rate at the throat measured 4.1, a departure from theory of only 2.5% with the 2:1 entrance to throat diameter.

The improved accuracy is a result of this model giving a much smaller disturbance to the steady state flow.

Dimensions

Viziflow does not calculate boundary layers or friction, and hence dimensions are all relative. For example, the throat diameter of the Venturi tube shown above may be defined as 1 meter, and the entrance diameter will then be in ratio – 2 meters in this case.

Some basic physical values

Pressure: 1 Atmosphere = 1.013×10^5 Pa = 2117 1b/ft^2

Flow rate: 100 mph = 44.72 m/s

Density: Water at 20°C = 9.982×10^2 Kg/m^3
Air at 20°C = 1.204 Kg/m^3 (sea level)