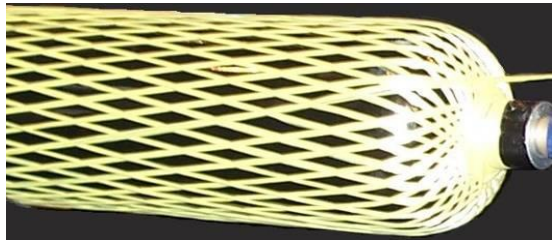
CADFIL-Lite / Lite+



Cadfil®-Lite offers many of the advantages of the more powerful CADFIL®-Axsym package and has a quick and simple ‘parametric programming’ interface for the common filament winding geometries. Much of the powerful 3D graphics and visualisation are the same as with CADFIL®-Axsym. Program creation is via the Cadfil ‘QuickCad’ user interface.

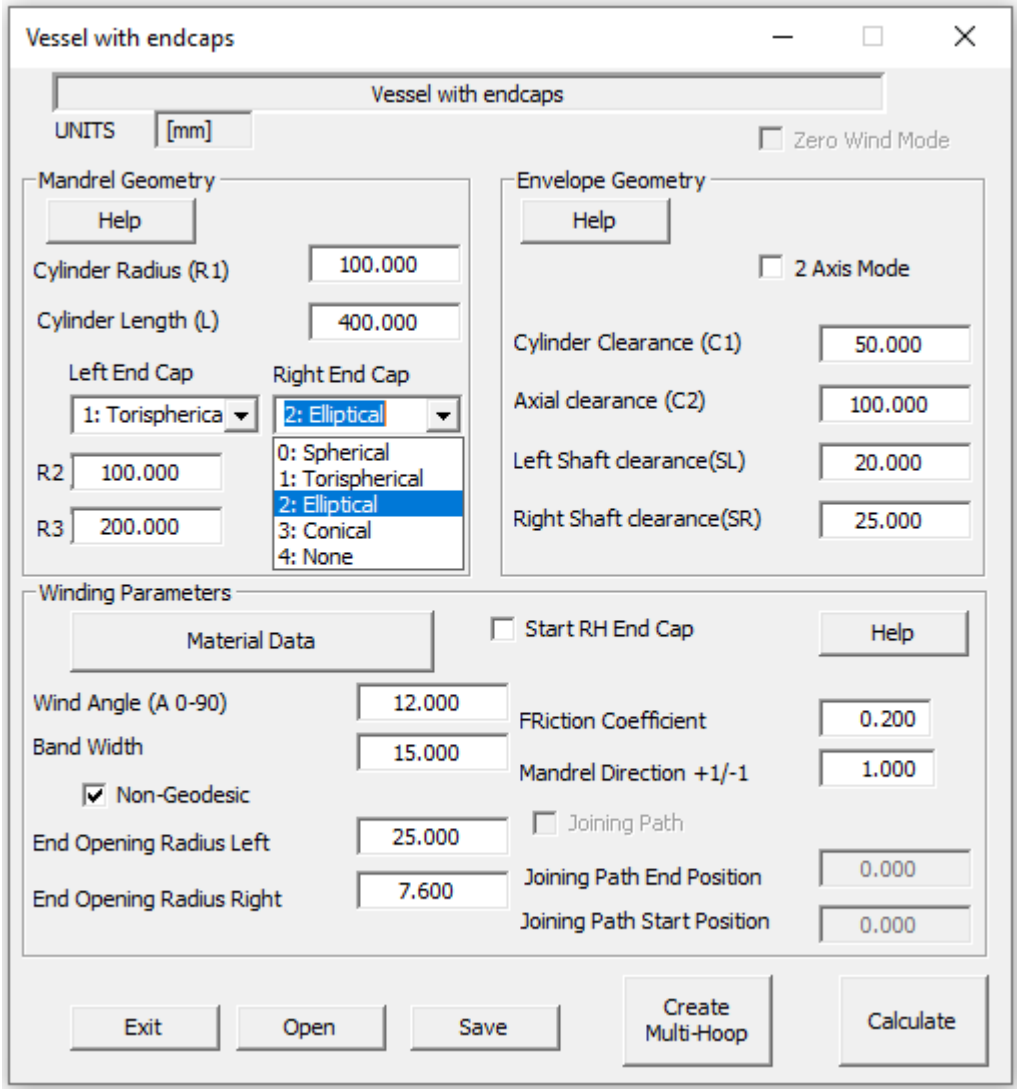
All Cadfil software operates on Windows 10 and is supplied with a USB datakey and a comprehensive online and offline manual system. Telephone/email/web support and software upgrades for the first 12 months are also included in the purchase price. Extended support can be provided.

<u>In Cadfil-Lite Winding programs can be created for:</u>

- ❖ Helical Winding on cylindrical parts, e.g. pipes, drive shafts
- ❖ Includes Cadfil-PipeWinder+ Package
- ❖ Hoop winding and multi-stage hoop winding on cylindrical parts
- ❖ Helical geodesic winding (equal end openings) on cylinders with dome ends
- ❖ Helical geodesic winding on cylinders with elliptical. torispherical and other standard end caps
- ❖ Joining Paths for cylindrical parts to allow continuous (non-stop) multi-angle winding

<u>In addition for Cadfil Lite+ there is:</u>

- ❖ Helical non-geodesic winding (unequal end openings) on cylinders with dome ends
- ❖ Joining Paths for dome ended cylinders for non-stop multi-angle winding



Vessels With End Caps

Overview

This software options forms part of the **Cadfil Lite systems** (and higher systems). Cadfil Lite has the geodesic options whilst Cadfil-Lite+ has the non-geodesic and joining paths options also. Options that are not available are usually 'grey' and cannot be picked.

This options is for winding a cylinder with none, one or two endcaps.

At the time of writing the endcap options are Spherical, torispherical, elliptical and none. The endcap geometries are described later in this document.

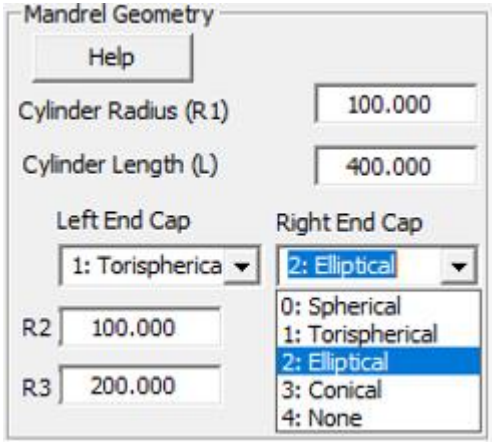
The software has a number of simple steps:

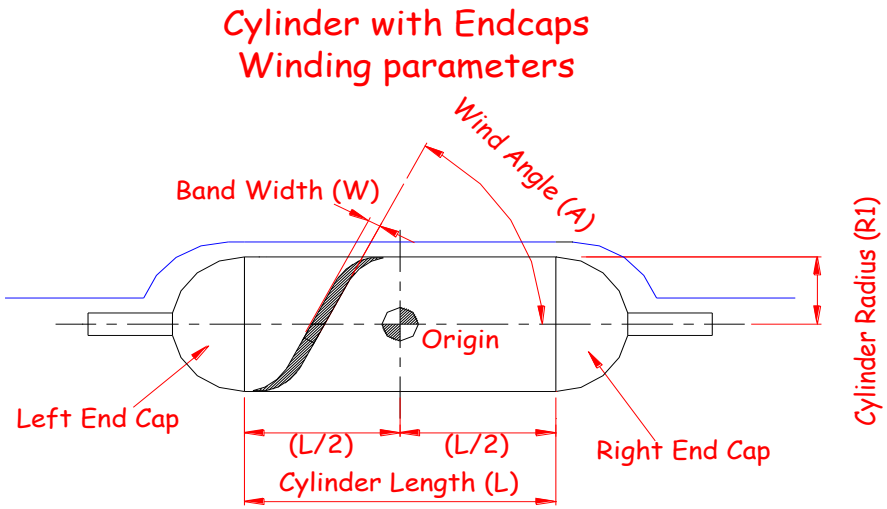
1] From the QuickCad menu select the 'Vessel with endcaps' option.
2] The Dialog box shown above will be displayed. Data entry is in three sections, mandrel, envelope and winding parameters which are described in the following pages.

Mandrel Geometry:

There are only four thing required for the mandrel definition, the Cylinder Radius (**R1**), the Cylinder Length (**L**) and the **Left** and **Right** endcap types. L and R1 can be seen in the diagram opposite.

The ‘pull’ down box can be used to select the endcap type. In the picture below the Right end is being set to ‘Elliptical’.



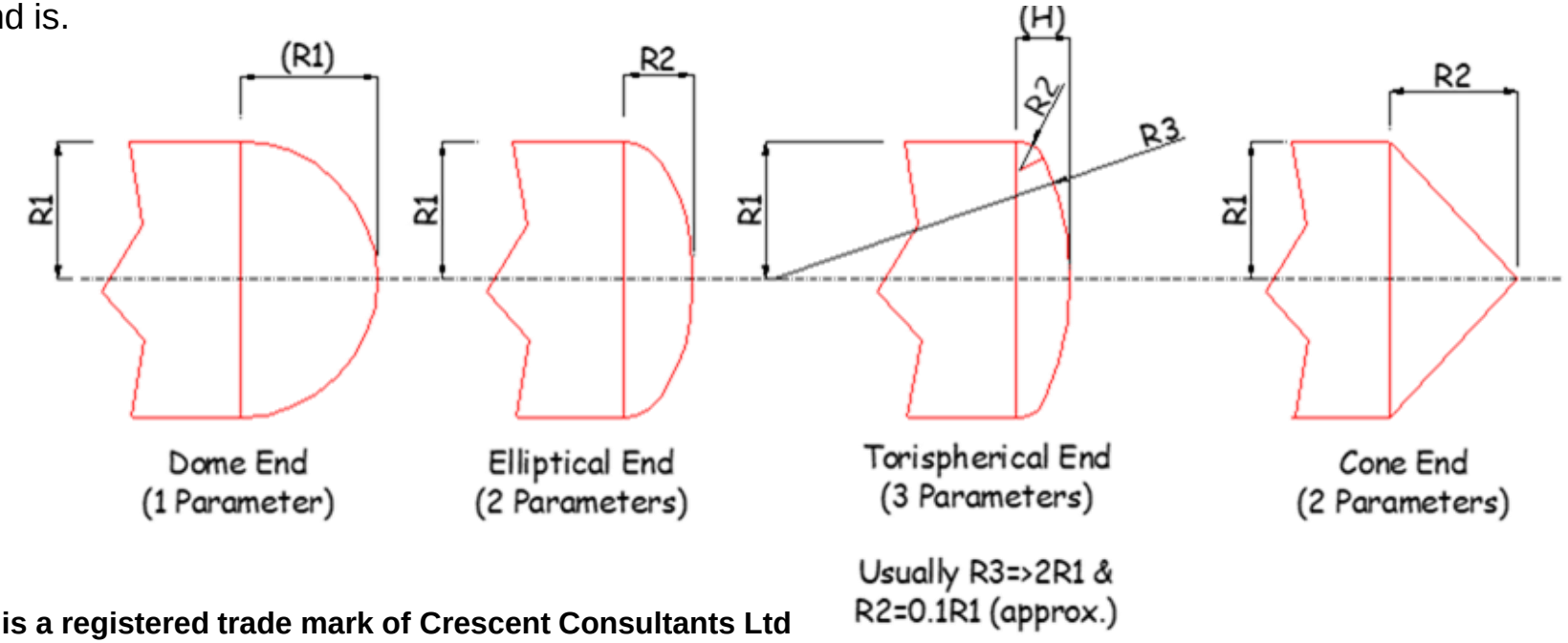


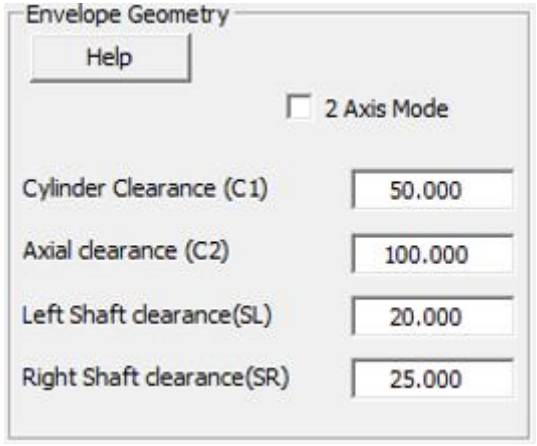
For each type of end cap other parameters **R2** and **R3** may be required. This depends in the endcap type and is described on the following page.

Mandrel Geometry. Endcap Types:

For all cases R1 is the cylinder radius.
For a true **dome** (sphere) no parameters are required so R2 & R3 are not used.
For an **Elliptical** end the ellipse height R2 is required.
For a **torispherical** end (iso-tensoid) end the two parameters are R2 the 'knuckle radius' & R3 the end radius. This is a common form for pressure vessels as it packages into a short overall length for a given volume of vessel. The stress analysis is more complex than for a true dome. For this type of vessel R2 is usually about 0.1xR1 and R3>2xR1. It is not possible for R3 to less than R1.

For endcap type **none** the fibre does not wind on the end, it turns on the cylinder with the turning position half a bandwidth from the cylinder end, so is the winds to the end of the cylinder.
To over-wind a '**flat**' mandrel end it is best to use type torispherical and set R3 large (for example R3>5xR1) as to program a totally flat end does not give smooth winding. In this case set R3=0.1xR1 or whatever the true radius on the mandrel end is.





SL and **SR** are the left and right shaft clearance position measured from the winding shaft centre (axis). If there is no shaft zero can be used at one end. Set these values to as small as is safe for the machine and mandrel.

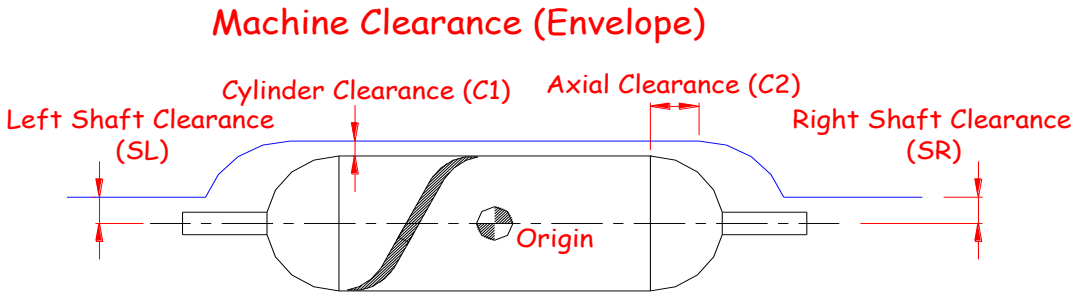
C2 is the axial clearance (at each end) the cylindrical part of the envelope is extended past the end of the mandrel cylinder to ensure that the payout eye is fully past the cylinder before any inward (radial) movement is allowed.

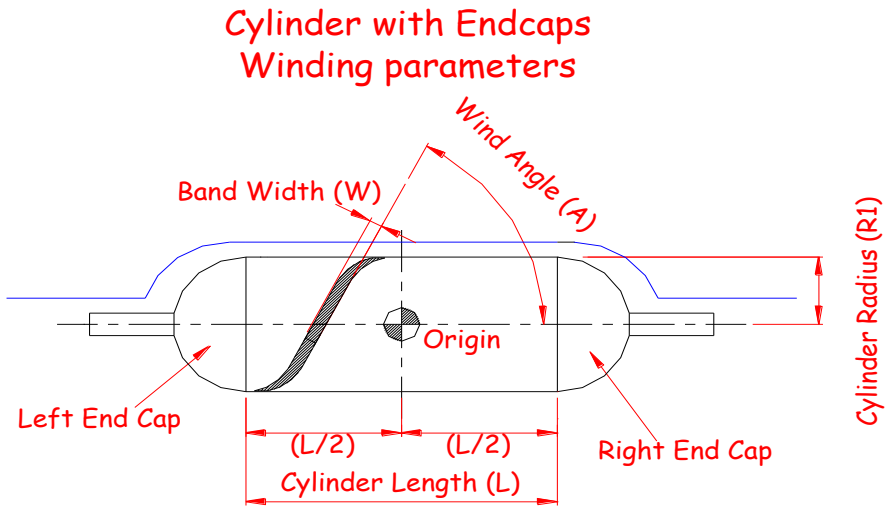
Envelope Geometry (Machine Clearance).

The clearance parameters are shown in the diagram below, these are dimensions C1,C2,SL and SR

The winding machine payout will move along the blue curve.

If the machine has only two axes or the ‘2axis mode; box is ticked (diagram to the left). Only **C1** is required and the other parameters are cannot be entered. In this case the cross-feed (radial) axis is not used. This will restrict the possibility of winding low angles on some geometries.





Winding Parameters

Wind Angle (**A**) is the winding angle along the cylinder (0º is axial). The **Band Width** (**W**) is the true width if the fibres/tape.

Friction coefficient is used to deviate the fibres from the 'geodesic' path. If there is no endcap at one or both ends its is used to determine the turning length on the cylinder. As the value get larger the turning length decreases. If it is too large the fibre will slip. Values of 0.1 to 0.2 are typical for wet winding, tow-preg can use a higher value if it has 'tack'.

The **mandrel direction** takes the value of 1 or -1. If it is -1 the mandrel will rotate in the negative direction.

If the **non-geodesic** box is ticked the user can specify the end opening radii independently of the winding angle. Non-Slippage is checked using the friction coefficient.

If the **joining path** box is ticked the user must specify the end and start positions. These are distances from the mandrel **origin** (see figure). Positions to the left of origin are negative and to the right are positive. Friction is used to generate a path that starts and finishes at 90 degree winding at the two points specified. This program can be used the make two others windings join together for continuous winding. The **origin** is always at the centre of the cylinder.

The Action Buttons

Exit quits back to the Cadfil menu without saving**.**

Open is used to select data from a file that has previously been saved. You will get a standard windows file open dialogue and can browse to find the **'.par'** file. You can only read **'.par'** files created with this vessel program.

Save, saves all the data that has been entered in a .par file. You can name with from within a standard windows file manager style dialogue.

Create Multi-Hoop uses the mandrel created in the 'vessel with endcaps' QuickCAD and opens it in the multi-hoop QuickCAD.

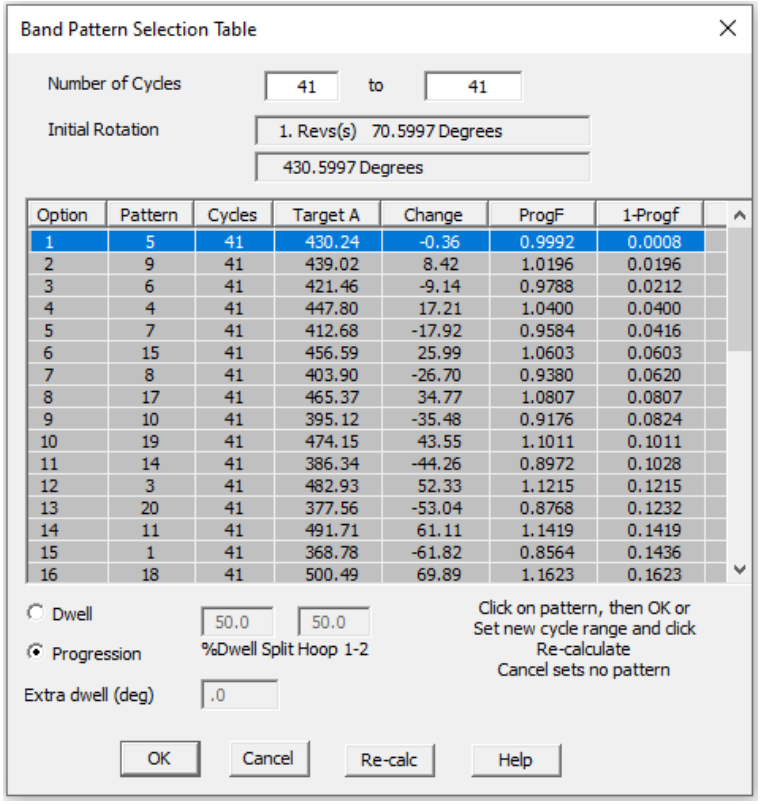
After **Calculate** is clicked the user has to select the **band pattern** from a table. The band pattern selection is described in the Cadfil help file which can be accessed from the help button on the band pattern table dialog. Having selected a band pattern the **'.pay'** file is generated and the **Cadfil graphics system** is launched to view and visually analyse the winding pattern and machine positions. This is described in detail in the cadfil help file which can be accessed by the help button on the viewing dialog.

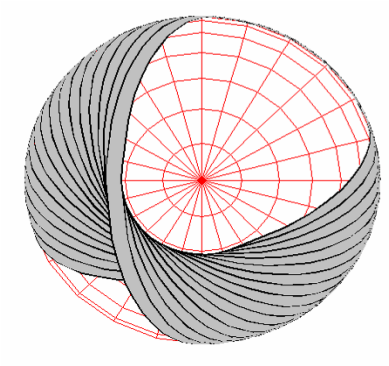
The final stage is to select the **post-process option** from the Cadfil-Main menu and post-process the **'.pay'** file that was generated to create the NC data that can be transferred to the Winding machine. This step is also described in the Cadfil help file. During post process you will be asked for the **XDAT** value which is the distance from the machine reference position (usually the chuck face) to the **mandrel origin**.

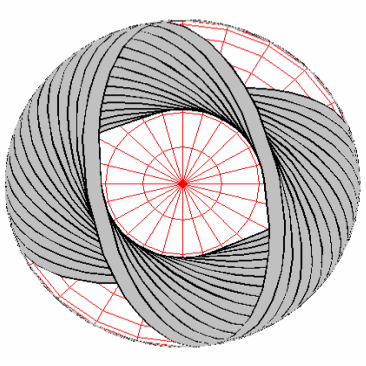
Band pattern selection

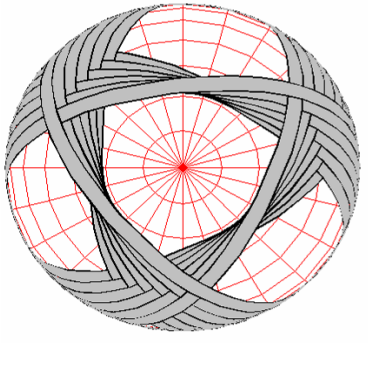
The band pattern is used to control the final laminate structure by ensuring successive repetitions of the designed fibre path circuits are placed in the correct positions relative to each other. This usually involves making a small modification to the calculated design path by the 'progression factor' though in some cases this can be done by ‘dwell winding’ where the mandrel rotates with no other motion. In the table shown to the right the user could click (for example) on the ‘option 1’ line for a band pattern of 22 or perhaps ‘option 3’ for a band pattern of 4.

The screen grabs from Cadfil show an end view of a dome ended cylinder part way though winding with a band pattern of 1, 2 and 3 (furthest right).





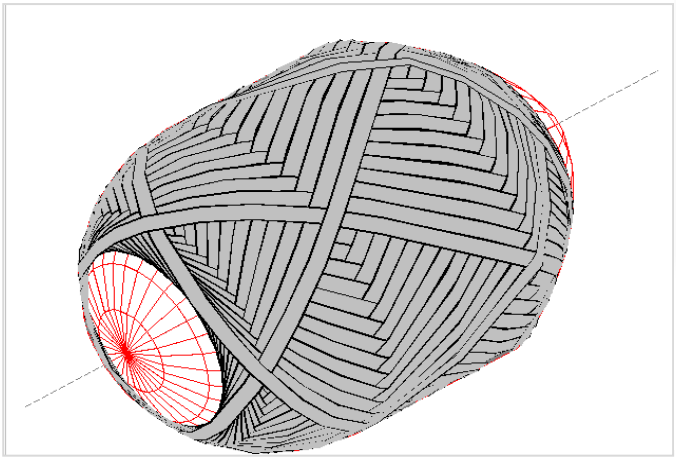


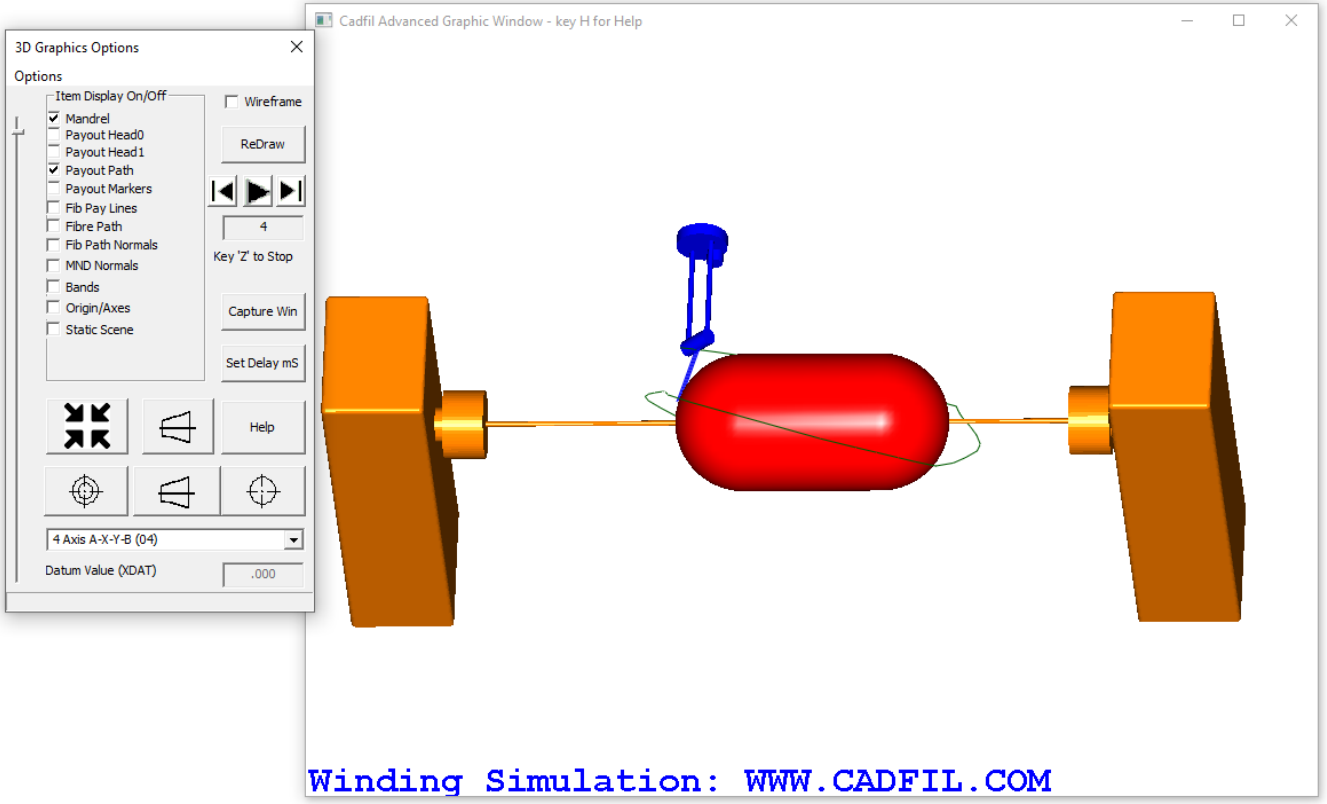


Cadfil Graphics System

The final band structure can be viewed and rotated in 3D and the winding machine positions can displayed and analysed using the 3D graphics engine. If required the user can define the machine fibre dispensing head using brick and cylinder solid shapes and perform a full 3D animation including all machine motions such as eye roll and eye yaw. Some examples of this are shown below.

Cadfil can produce an animation of a winding circuit, the still image on the right shows a section of this animation. It also has clash detection functionality built in.



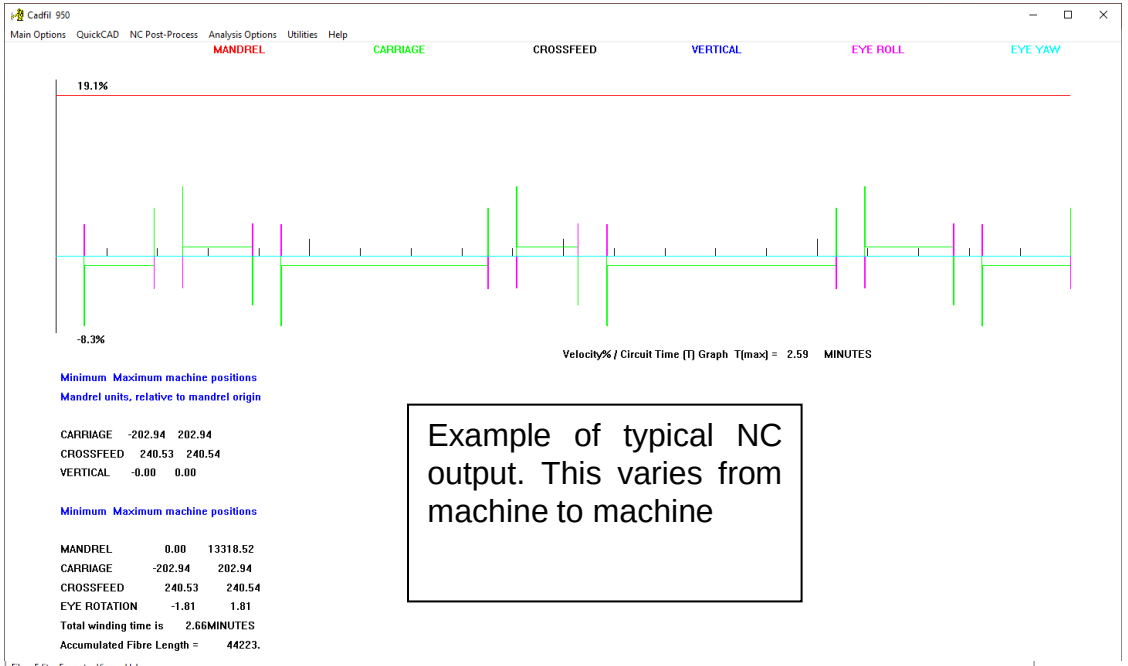


Post-Processing (NC Generation)

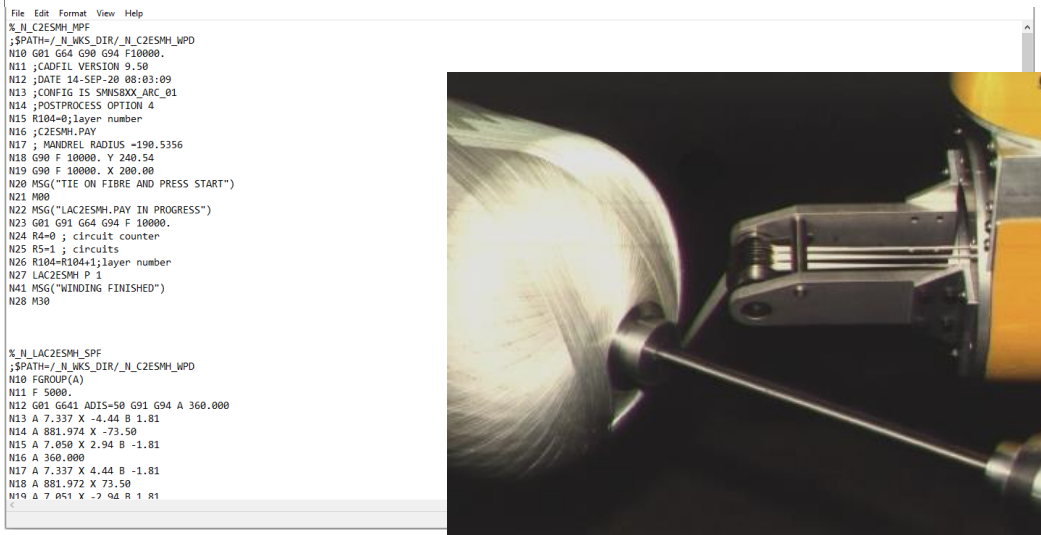
The last stage of Cadfil is post-processing where the path is converted to machine control data. Numerous control options can be set dependant on the axes available on the machine. Different speed control options can be set to reduce winding time or limit axis accelerations. The software calculates the winding time and material usage.

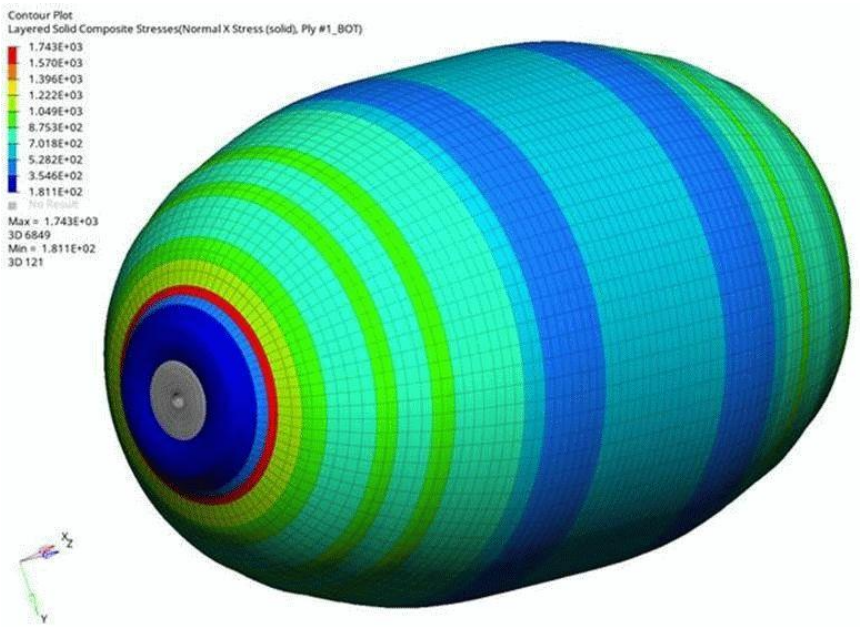
Cadfil can be user configured for any NC winding machine with 2-6 axes of control including many 6 axis robots such as ABB and Kuka. There can be multiple machine configurations so that the user can select which machine is to be used.

The picture opposite shows Cadfil in action on a 6-axis machine. The Cadfil 6 axis control strategy can fully eliminates band narrowing over the ends of the vessel. For Lite+ up to 5 axis is standard and 6 axis/robot is a cost option.



Example of typical NC output. This varies from machine to machine





Cadfil can be used to create finite element geometry and data for import into your analysis package. Finite element interfaces are an add on package to Cadfil Lite, more details can be found at https://www.cadfil.com/help/html/cadfil-fea-interface.html .

On a doubly curved surface such as a dome, the angle and thickness are continuously variable. With multi-layer windings it is difficult and time consuming to create fibre architecture in analysis packages. Cadfil offers a number of solutions, customers successfully produce Cadfil data for use in Nastran, Patran, Femap, Hyperworks, Optistruct, ABAQUS and ANSYS and others.

Cadfil deals with winding geometry and fibre architecture and also for some cases can create boundary conditions and load cases. It is possible to specify Orthotropic material data directly from the Cadfil database which is open for the user to add or remove materials as needed.

All Cadfil software is complete with USB datakey and a comprehensive online or offline help. Telephone support and software upgrades for the first 12 months are also included in the purchase price. Cadfil-Lite also includes Cadfil Pipe-winder options. Cadfil Axsym contains the Cadfil Lite options.

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