WIS Modeller Software

User Manual

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Contents

1 Introduction

Windscreen (WIS) modeller is a software tool to assist in the design of heated windscreens for aircraft and locomotive applications. It can also be used as a more general tool for calculating the transmission properties of unheated glazings.

WIS brings together three separate design functions into one software package:

- Anti-icing and thermal performance

  WIS Modeller predicts dynamic temperatures throughout a coated laminated windscreen based on user-definable environment and boundary conditions. The mathematical model uses a 1D mesh approach, solving the heat transfer linear equations using the tri-diagonal method.

- Transmission performance

  WIS Modeller predicts the spectral transmission, reflection and absorption properties of coated laminated windscreens, based on the library of materials available. The mathematical model solves the Fresnel Equations for multiple optical surfaces using the transfer-matrix method.

- Grading target and for anti-icing coatings on non-rectangular heated areas

  WIS Modeller predicts the required resistivity grading for anti-icing coating on non-rectangular heated areas, both for non-flow lined and flow lined designs. The mathematical model is based on a 2-D finite element approach with an iterative numerical method for minimising the power density variation between elements.

WIS Modeller is designed and written to run on a modern pc platform with the following minimum requirements:

- Processor speed: >2 GHz; Intel Pentium or equivalent
- Available RAM: >256MB
- Available Disc space: > 100 MB
- CD Reader: >48x
- Screen Resolution > 1024 x 768

WIS Modeller relies on a number of system and supporting software being installed on the pc platform, as follows:

- Operating system: Microsoft Windows (8, 7, Vista or XP)
- Enabled software: Microsoft .NET Framework version 4.0 or higher
- Enabled software: Microsoft Internet Explorer version 6 or higher

2 Software Installation

WIS Modeller is supplied as a CD with a number of USB license dongles. The contents of the CD are not protected and can be freely copied and distributed.

The CD contains all the files necessary to automatically install and operate the software on a pc platform as specified in section 1. After installation, The USB dongle is required to enable any calculations to be performed. Without the USB dongle in place, the software will operate but not perform any of the mathematical modelling available.

IMPORTANT: DO NOT install the USB Key before the installation of the WIS Modeller software

IMPORTANT: UNINSTALL any existing versions of WS or WIS Modeller software before installing or re-installing this WIS Modeller software

To install the software, insert the CD into the disk drive. The AUTORUN feature will automatically install the program and load the associated files on the computer. This will copy all the required resources into the Programs File Directory on the main hard disk drive. The application is called WIS Modeller.

The installer software will also create a Start Menu entry and also set up a desk-top icon called WIS Modeller to launch the application.

When the application is first launched, it will create WIS Modeller directory in the user's home account. This directory will create all permanent and temporary data files, such as materials libraries, needed during the operation of the application.

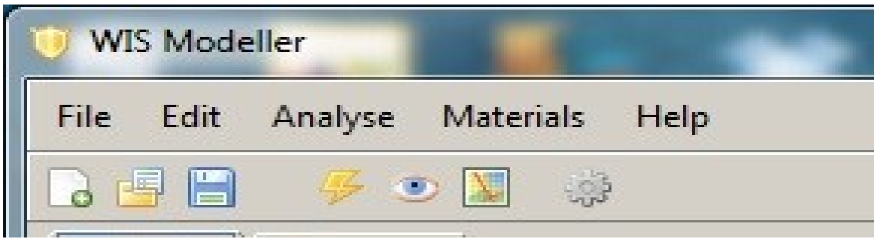
All files created or accessed by the application software are not encoded or protected. Since the data structure within the files are fixed format, bespoke to the software, it is not advisable to manually alter their contents. Editing or manipulating these files manually, could result in software instability, incorrect functionality or the production of erroneous results.

To uninstall the software, select the uninstaller application in the WIS Modeller folder in Program Files. This will remove the program and all its associated files, leaving only the data files residing in the user's home directory.

3 Using the Software

3.1 Main Menu

WIS Modeller software is organised in standard Microsoft Windows format and the main functions are provided along a menu bar at the top of the screen, as shown below.



Functions from the Menu bar include

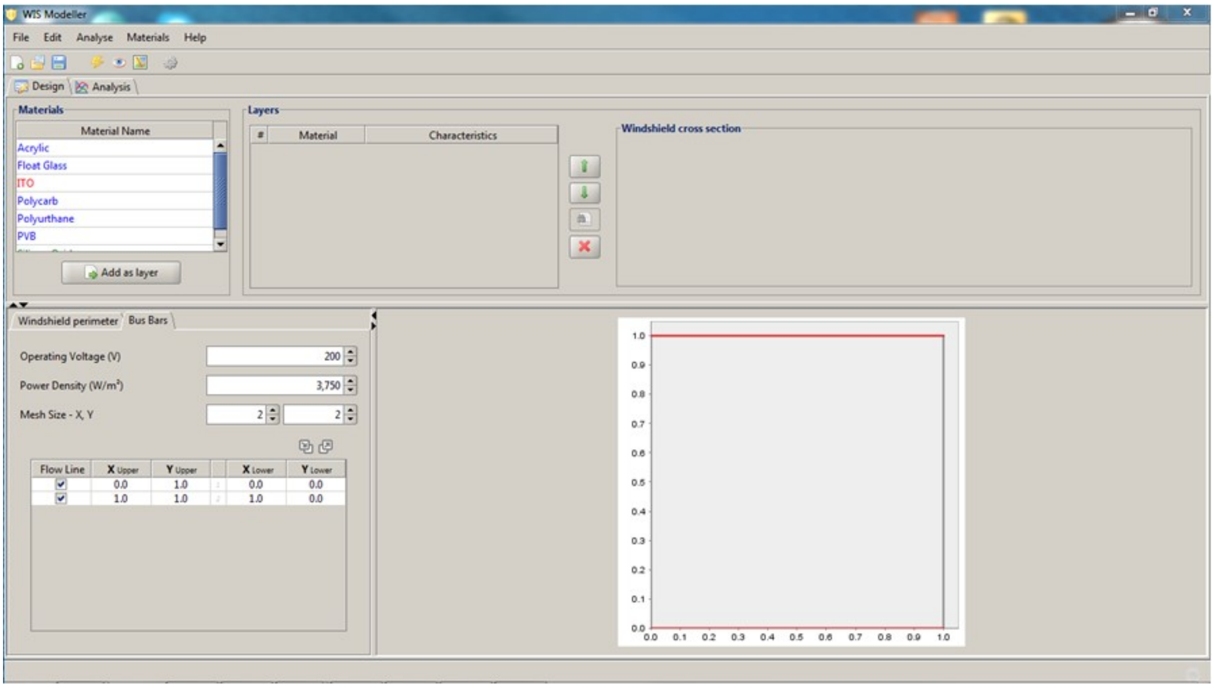
File	Edit	Analyse	Materials	Help
New	Cut	Show Design Panel	Show Materials	About
Open	Copy	Show Analysis Panel	Library	Tabbed Results
Save	Paste	Thermal Properties	Add New Material	
Save As		Optical Properties	Import Materials	
Exit		Grading Properties	Export Materials	
		Analyse Window		

CAUTION: The Edit and Materials are not available in the current version of the software and they are a pre-planned feature for future software upgrades.

TIP: Several Hot Keys and Icons are provided to allow quick navigation throughout the software. A quick reference guide to these is provided in Annex 1.

3.2 Design Panel

After the application software is launched, the Design Panel, shown below, is displayed by default. This is the main working area for constructing the windscreen by layers and busbar geometry, prior to performing the calculations and analysis.

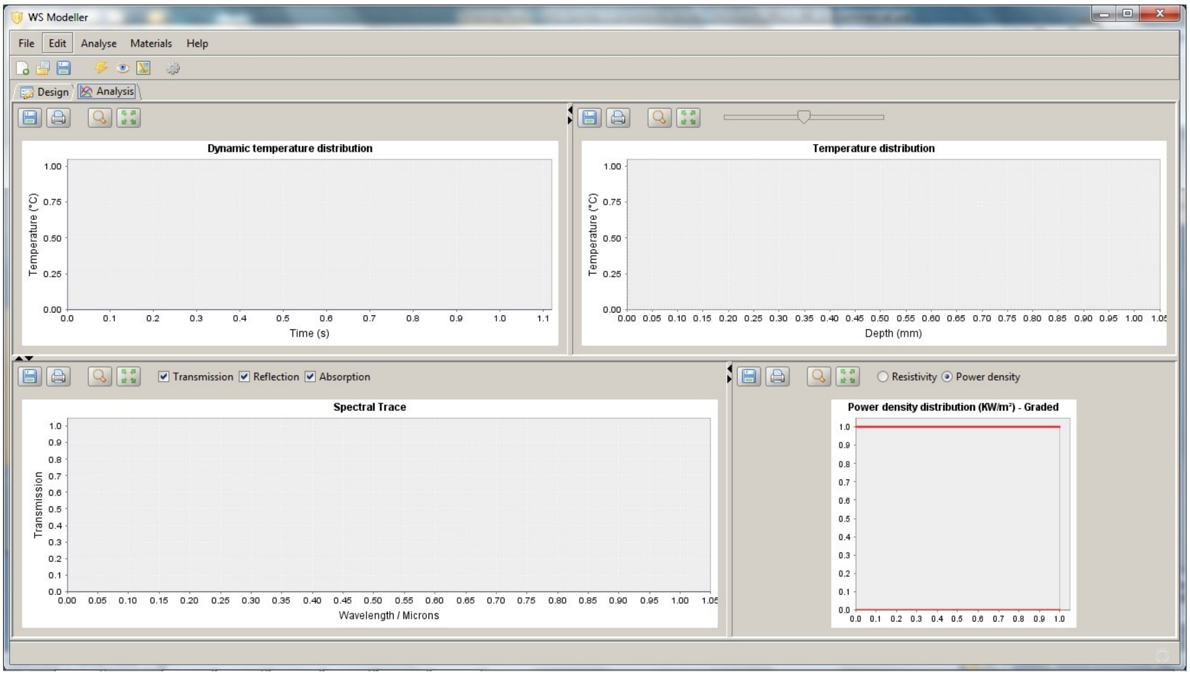


The design screen is divided in to five (5) main areas:

Materials:	This area lists the materials available for constructing the windscreen design. Bulk materials, such as Float Glass, are shown in black. Heating film materials, such as ITO, are shown in red. Other coatings are shown in blue.
Layers:	This area details the construction of the windscreen design as it is being prepared. It provides an editing function for deleting or re-ordering layers after they have been created.
Window cross section:	This area shows the windscreen construction in cross-section in a pictorial fashion. This cross-section picture will be used in the analysis.
Busbars:	This area is for entering the operating voltage, power density, mesh size, flow lines, and busbar (x,y) co-ordinates. It also allows the user to enter the windscreen perimeter coordinates, although this data takes no part in any of the calculations.
Graph area:	This area shows the finite element mesh created for the graded coating calculation.

3.3 Analysis Panel

The Analysis panel, shown below prior to any modelling, is the main working area for viewing the results of the mathematical modelling calculations.



There are four (4) main areas presented after the analysis is completed:

Dynamic temperature distribution:	This area presents the calculated temperature at each surface as a function of time, from time zero. It helps to identify when the external surface will reach above-icing temperatures.
Temperature distribution:	This area presents the calculated temperature at each surface at a given time overlaid onto a 1-D cross-section of the windscreen construction. This helps to visualise the temperature gradients within the windscreen.
Spectral Trace:	This area presents the calculated transmission, reflection and absorption of the windscreen as a function of wavelength. It also provides the calculated Integrated Visible Photopic Transmission (IVPT), reflection (IVPR) and absorption (IVPA) for Illuminant A (tungsten filament).
Grading distribution:	This area presents the calculated distribution of resistivity (Ω/□) and power density (W/m2) on a 2-D finite element mesh based on the busbar geometry and the electrical requirements of the windscreen. It also provides the calculated nominal power constants (Km and Kmc) for the power distribution

4 Designing a Windscreen

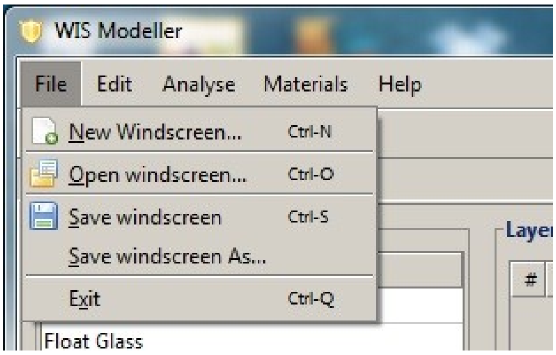
A description of all the software function and features is provided through the use of an example throughout.

In this section we will design a typical aircraft windscreen construction and shape that might be used for a large commercial jet. The construction is as follows:

1. 3mm Float Glass outer face-ply
2. Anti-icing coating of ITO on inner surface of face-ply (with operating values of 3,500 KW/m^2 power density and 40°C control temperature)
3. 2mm Polyurethane interlayer
4. 10mm Float Glass main-ply
5. 1.5mm Polyurethane interlayer
6. 10mm Float Glass inner-ply

4.1 File Menu

Selecting the File pull-down menu will produce the following option list

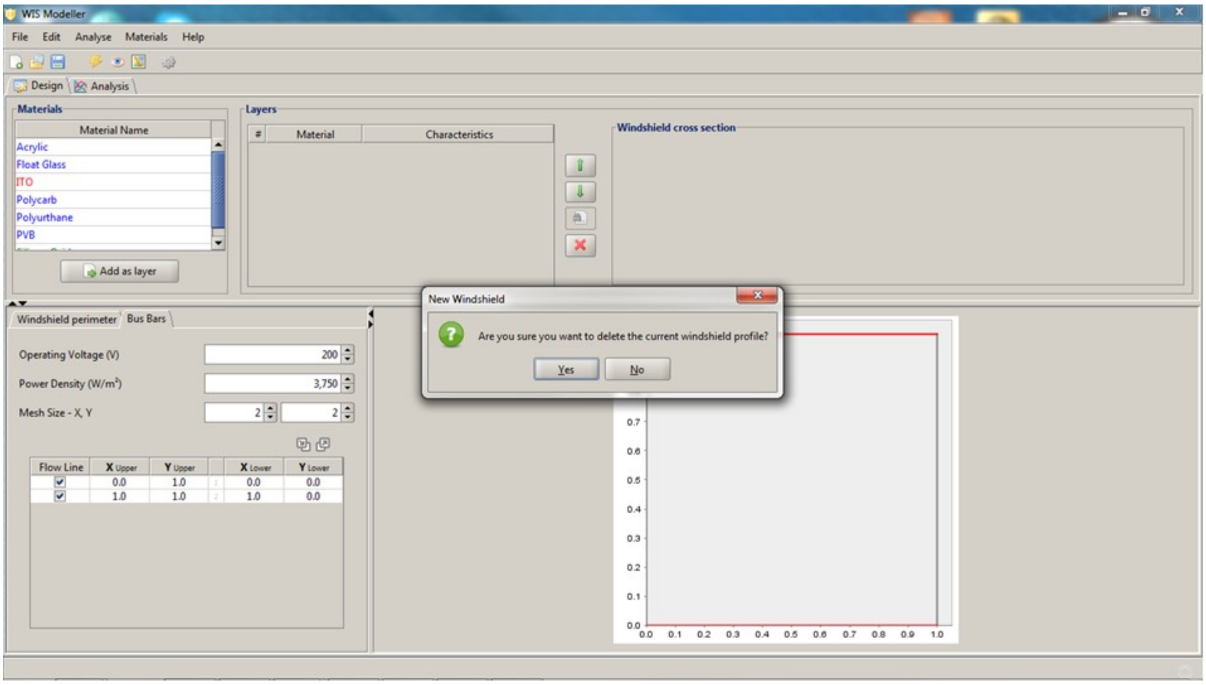


4.1.1 New Windscreen:

Select this option for constructing a new design when existing data needs to be cleared. A dialogue box will appear in the centre of the screen.

4.1.1.1 New Windscreen Dialogue Box:

Requires the user to confirm that deletion of current data is acceptable. This message will appear anytime the user selects an action that could potentially lose data that has not been saved.

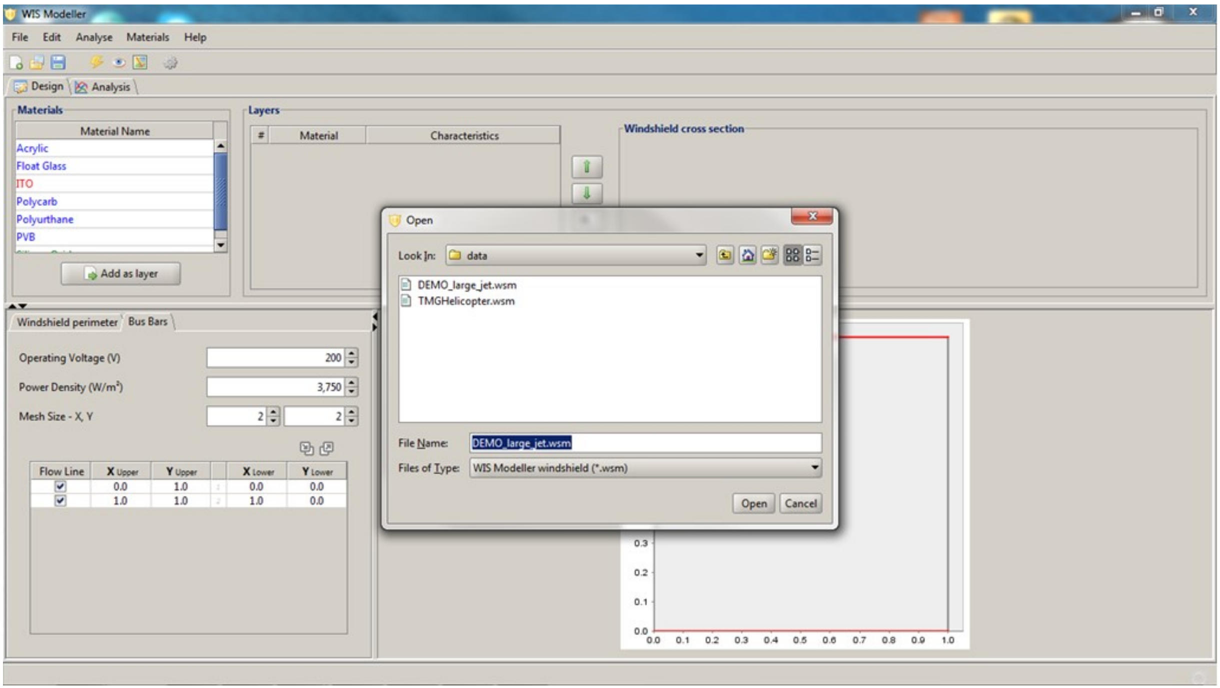


4.1.2 Open Windscreen:

Select this option to retrieve a previously saved windscreen design. A dialogue box will appear in the centre of the screen.

4.1.2.1 Open Dialogue Box

Requires the user to select a *.wsm file from a list. The default directory is User/[*username*]/WIS Modeller/data and wsm is the default file extension. The user can navigate through file directories in normal Microsoft Windows fashion.

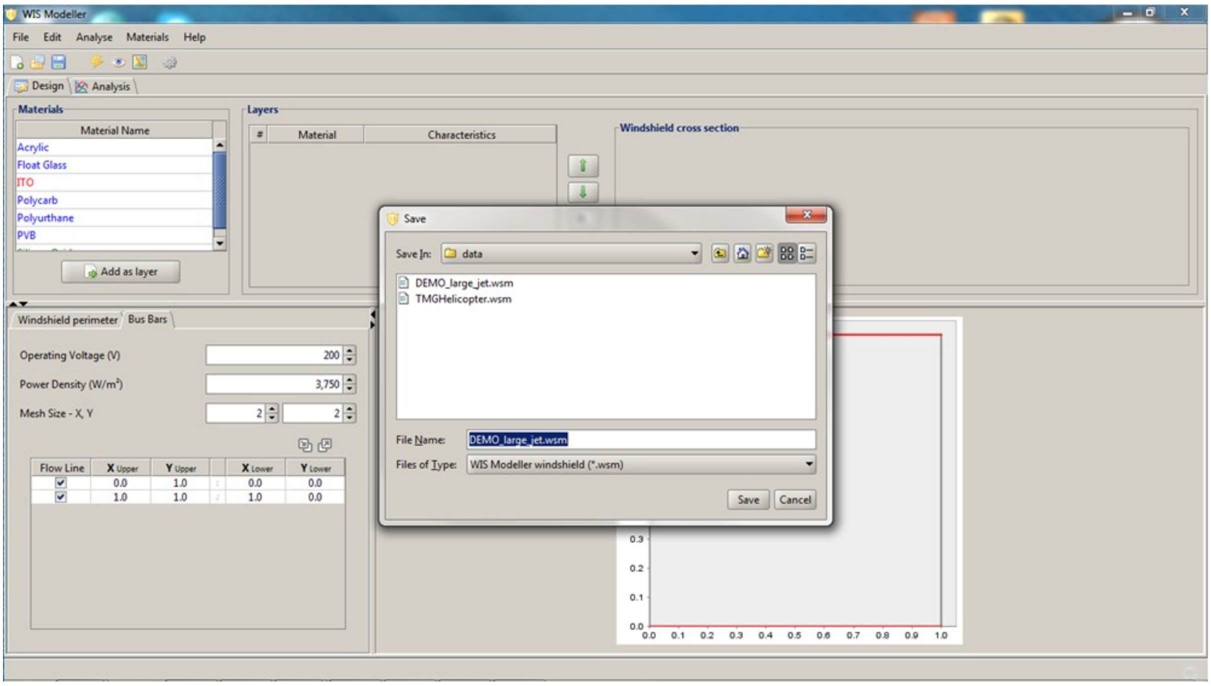


4.1.3 Save Windscreen:

Select this option to save the current windscreen design. A dialogue box will appear in the centre of the screen.

4.1.3.1 Save Dialogue Box

Requires the user to select a filename for the design to be saved. The *.wsm file extension is used the default and the default directory is User/[*username*]/WS Modeller/data. The user can navigate through file directories in normal Microsoft Windows fashion.



4.1.4 Save Windscreen As

Select this option to save the current windscreen design with a different filename from the current filename. The dialogue box, as described in 4.1.3.1 above will appear in the centre of the screen.

For our example, select “New windscreen” from the File menu. Click Yes to continue

4.2 Selecting Material Layers for a Windscreen Construction

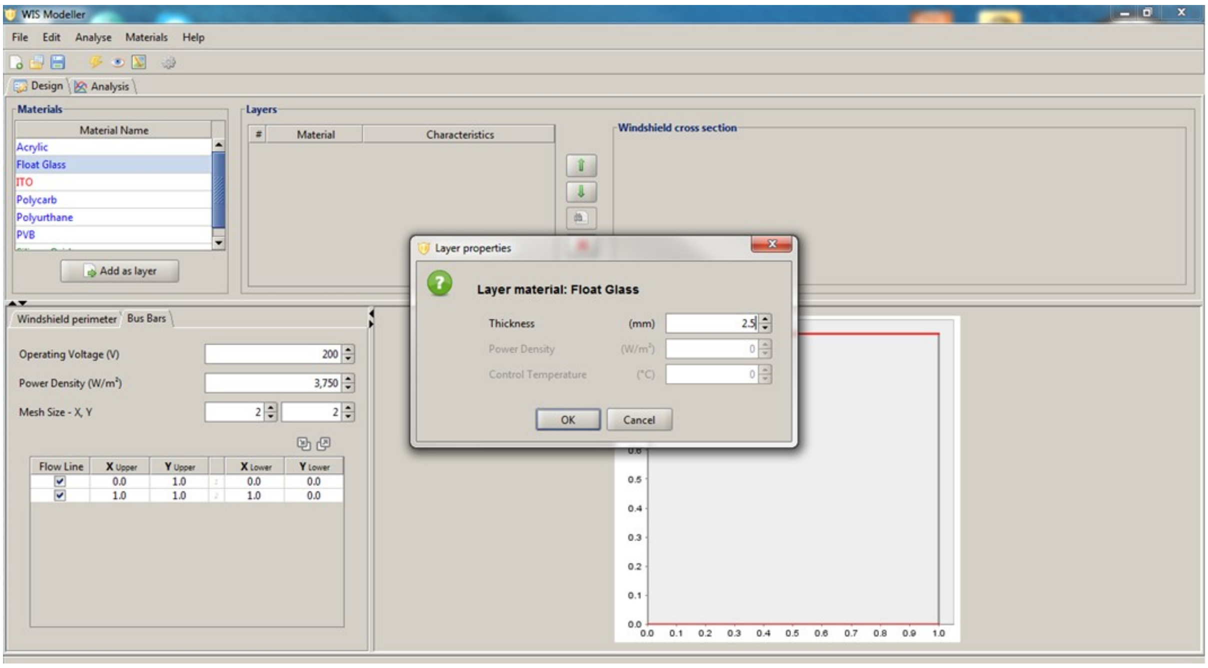
Enter a layer by selecting a material from the list in the Materials area using the mouse then clicking on the "Add this Layer" button below the list. The Layer properties dialogue box will appear in the centre of the screen.

TIP: Materials are colour coded:

- *Bulk materials, such as Float Glass, are shown in black.*
- *Heating film materials, such as ITO, are shown in red.*
- *Other coatings are shown in blue.*

4.2.1 Layer Properties Dialogue Box:

The Layer properties dialogue box allows the user to set the basic parameter variables for the particular layer in the construction. The values that can be adjusted will depend on the material type.



For bulk materials, enter the thickness of the layer in MILLIMETRES (mm) and click OK when complete.

For a heating of ITO, enter the layer thickness in NANOMETRES (nm), then enter the power density and the control temperature parameter values in KW/m^2 and °C respectively. Click OK when complete.

CAUTION: Take care to use the correct thicknesses and dimensions

The layers will build up in the Layers area and Window cross-section area. Once the layers have been added to the construction, they cannot be edited and have to be deleted and re-added correctly.

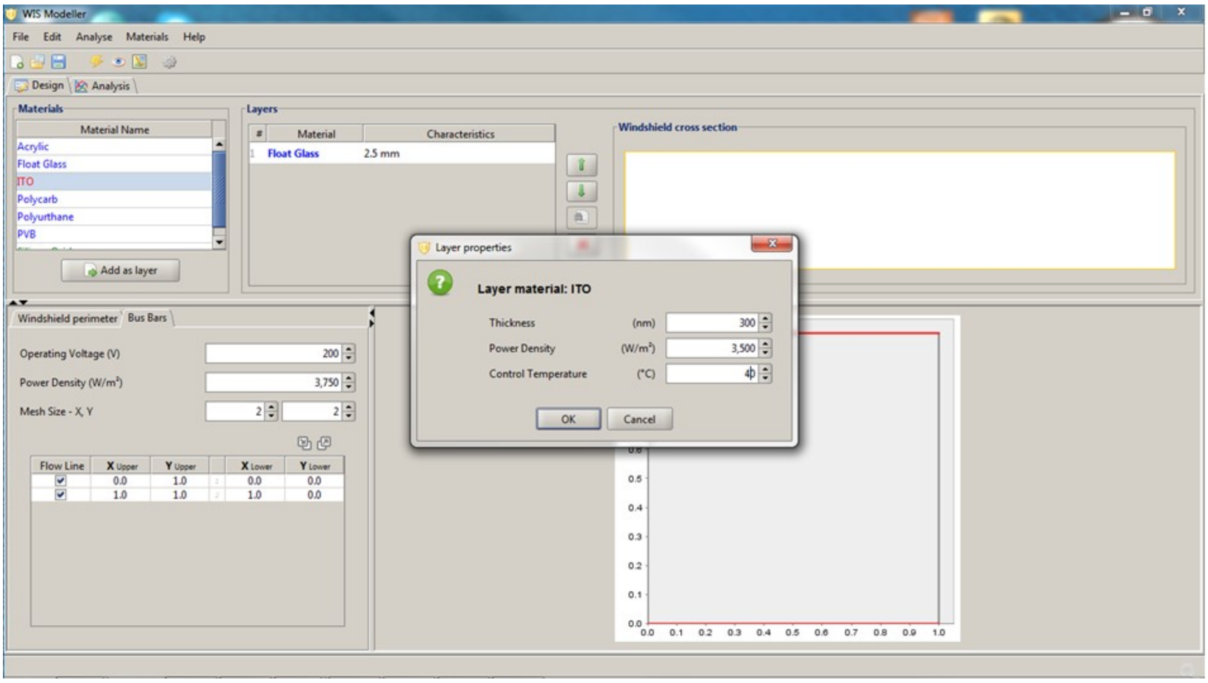
4.2.2 Layer Order and Delete Icons

Select a layer in the Layer area and select the green arrows to move this layer up and down on the order of the windscreen construction. Use the red cross to delete the selected layer.

TIP: If the parameter values for any of the layers in the construction are incorrect or need to be changed, use the red cross to delete the layer and re-add the layer with the correct parameter values. Then use the green arrows to put the new (changed) layer in the correct place.

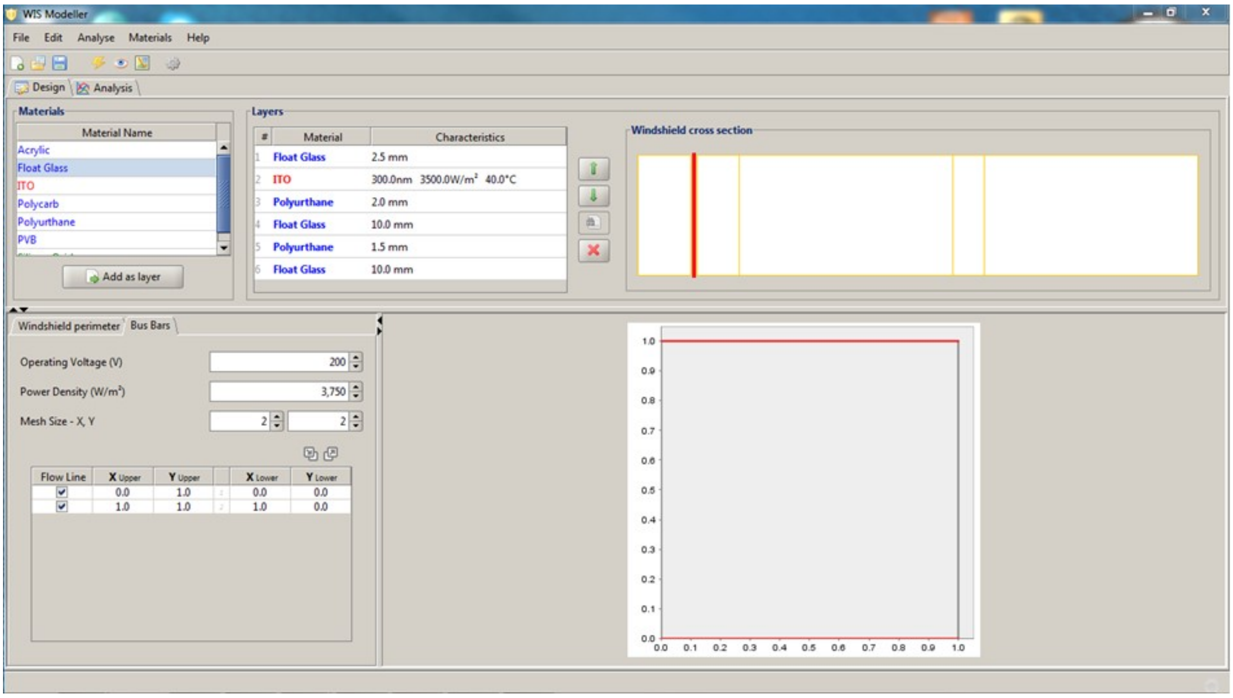
In our example, we select Float Glass first and “Add this layer”. This opens the Layer properties dialogue box. Enter 3 for the Thickness, then click OK. This will now be confirmed in the Layers area and the Window cross section will be filled.

Select the second layer, in our case the anti-icing coating, ITO and “Add to this layer”. Enter 300 for the Thickness, then 3500 for the Power Density and 40 for Control Temperature.



TIP: the thickness of the ITO coating is specified in nm. The thickness of the coating is inversely proportional to the resistivity (Ω/□) and directly related to the specific resistivity (Ω.cm) of the ITO coating. The specific resistivity of ITO is dependent on the coating process parameters and a conversion table is provided at Annex 2 for the user to complete for reference.

Continue to select the subsequent 4 layers of Polyurethane, Float Glass, Polyurethane and Float Glass in sequence, completing the layer properties dialogue box for each of the layers of the windscreen construction. For our example this will look like:



4.3 Busbar Geometry and Windscreen Perimeter

We now move over to the lower working area on the design screen to design the coating grading and resistivity.

4.3.1 Basic Set up

The mathematical model requires the operating voltage, power density and mesh size to be defined. Defualt values are provided and should be altered to suit the user's requirements.

Note that the mesh size is defined as the equal to the number of element plus one in each direction. For example, an 11 x 11 mesh size contains 100 elements.

4.3.2 Busbars

The default coordinates are simply four corner coordinates for a square heating area 1m x 1m.

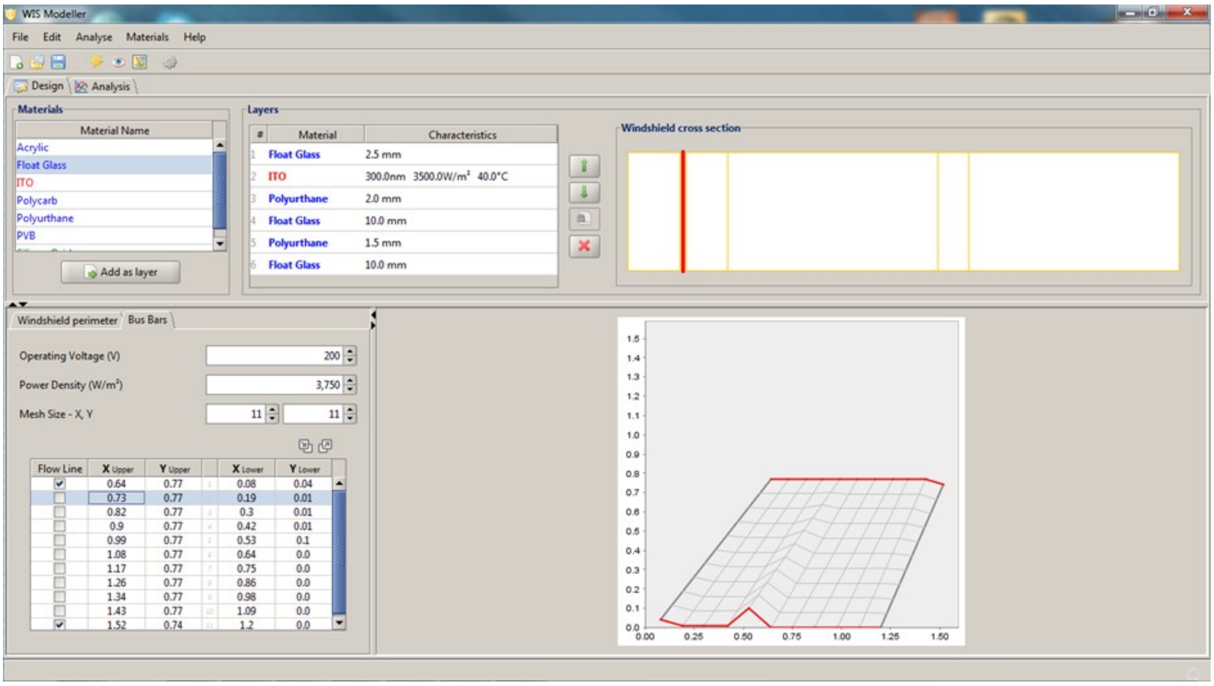
To enter busbar coordinate values, move the cursor into the busbar coordinate area and click on the x coordinate of the upper busbar on first line (current value 0). Values are entered in METRES (m). The limit to the number of coordinates that can be entered is 100, but the practical working limit recommended is 20, and more commonly 10 would be used.

The software will automatically create a mesh by sub-dividing the area between the busbars into a number of equally spaced lines, parallel to the busbars. The number of equally spaced lines is defined by the user. Similar to the busbar coordinates, the limit of entries is set to 200, but the practical working limit recommended is 10.

As the busbar coordinates are entered, a picture of the mesh will build in the lower right hand area of the Design panel.

If the windscreen is to be flow lined, either fully or partially, the user can select the flow lines based on the busbar coordinate pairs (upper and lower). These are selected using the tick boxes adjacent to the coordinates. By default, the first and last busbar coordinate pairs must be flow lines as they represent the boundary of the heated area.

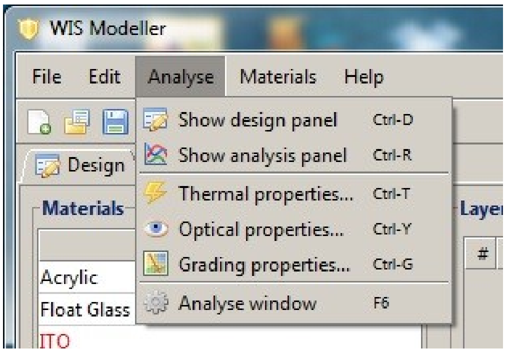
This is shown below, where the coordinates have been entered for the example being worked in this document.



TIP: The mesh also helps the user to spot data entry errors more easily than in the coordinate data columns. In the figure above, it is easy to see on the mesh that the 6th coordinate on the lower busbar must be wrong.

TIP: The busbar coordinates can be imported from a CSV format data file to assist in data transfer for cooperation between departments, such as the coating operation and the design office. Similarly the coordinates can be exported to a CSV format data file.

4.4 Analyse Menu



4.4.1 Show Design Panel

Changes the current view to the Design Panel.

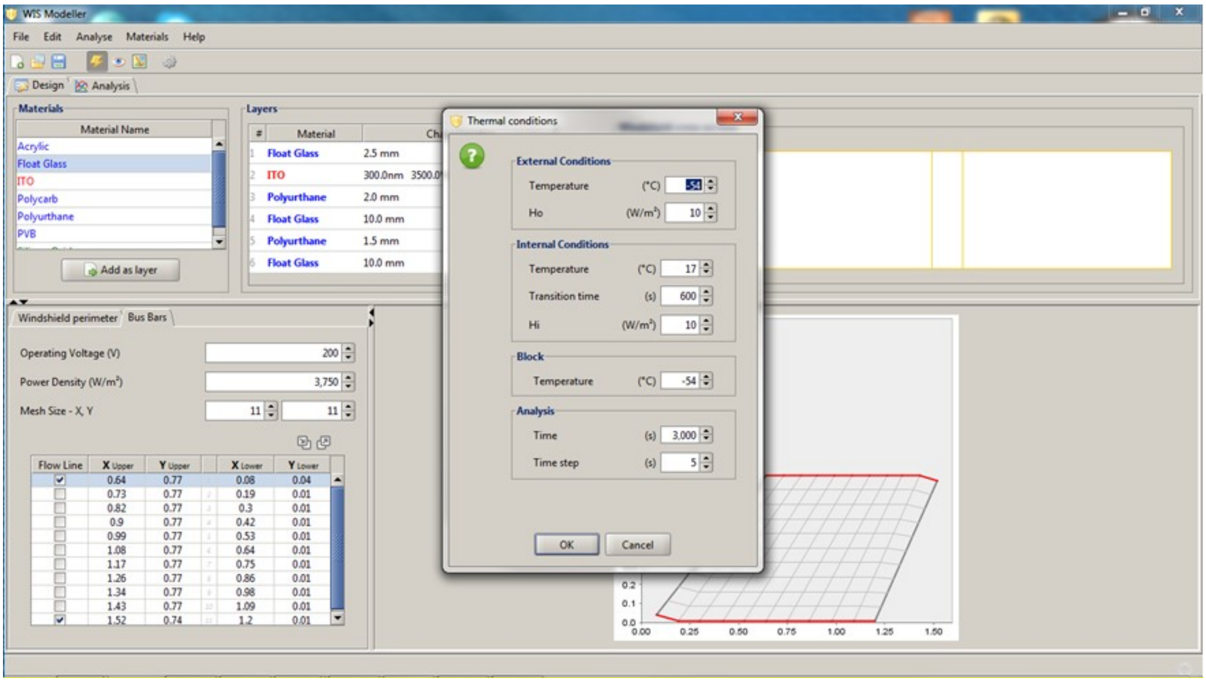
4.4.2 Show Analysis Panel

Changes the current view to the Analysis Panel.

4.4.3 Thermal Properties

Displays the Thermal condition dialogue box to allow the user to change the default settings, if required.

4.4.3.1 Thermal Conditions Dialogue Box



In this dialogue box the thermal condition parameters are set defining the assumption and boundaries for the analysis. There are eight (8) parameter variables that need to be set, unless the default is acceptable.

Values are set by clicking on the number in the appropriate box and typing in the desired number or selecting the increase/decrease buttons by the right hand side of the number.

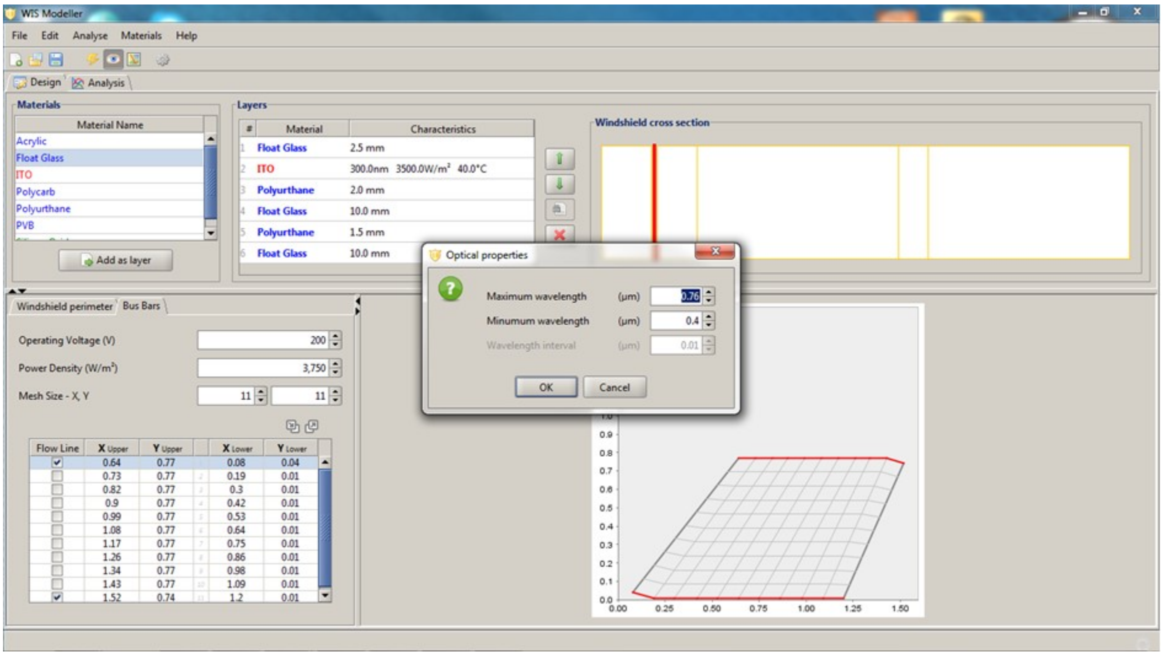
External Conditions	Temperature	The ambient external air temperature in °C
	Ho	The external heat transfer coefficient at the external surface of the window in (W/m^2)
Internal Conditions	Temperature	The ambient internal air temperature in °C
	Transition time	The time taken for the temperature to rise from the Block Temperature to the ambient internal temperature. This provides the user with a first level approximation for the use of cabin air conditioning
	Hi	The internal heat transfer coefficient at the external surface of the window in (W/m^2)
Block	Temperature	The temperature of the block at the start of the analysis (ie time = 0 secs)
Analysis	Time	The total time period for the analysis
	Time step	The time interval between each calculation of the temperatures at the interfaces

In our example, these parameter values have been left as the defaults.

4.4.4 Optical Properties

Displays the Optical properties dialogue box to allow the user to change the default settings.

4.4.4.1 Optical properties Dialogue Box



In this dialogue box the wavelength parameters are set defining the boundaries and interval for the analysis. There are three (3) parameter variables that need to be set, unless the default is acceptable.

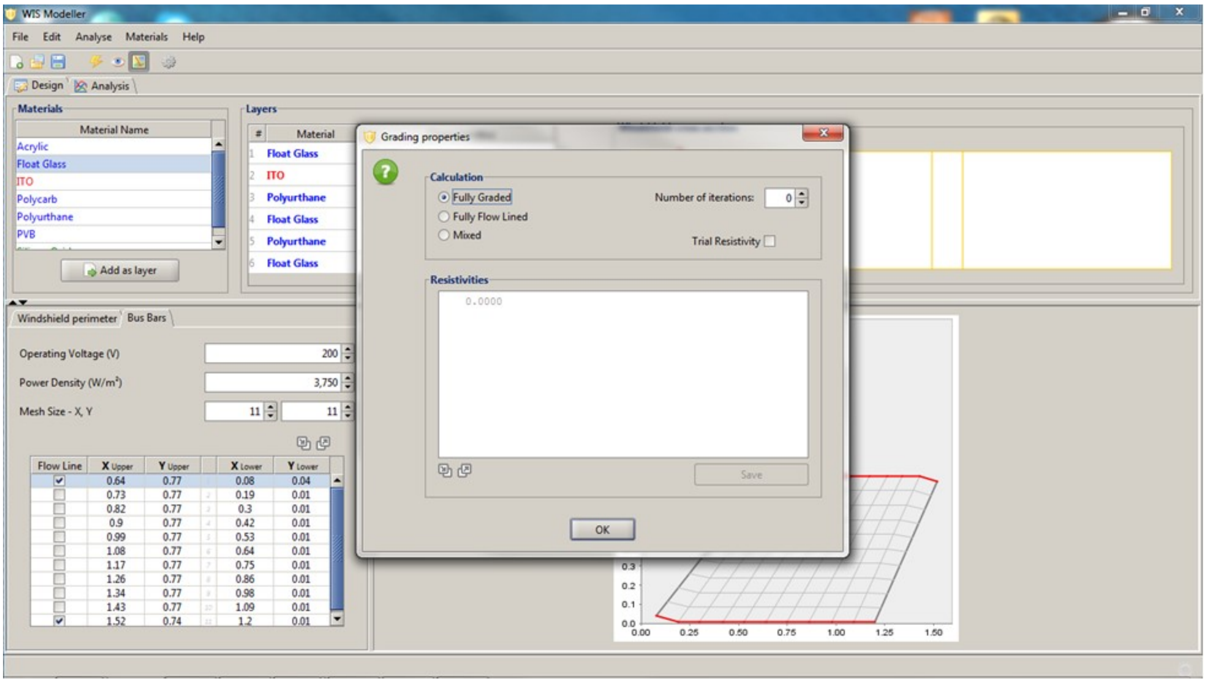
Maximum wavelength	The maximum wavelength for the spectral analysis range. The maximum wavelength is commensurate with the material database.
Minimum wavelength	The minimum wavelength for the spectral analysis range. The minimum wavelength is commensurate with the material database.
Wavelength interval	The wavelength interval required for the spectral analysis. This is fixed at 0.01μm

In our example, these parameter values have been left as the defaults.

4.4.5 Grading Properties

Displays the Grading properties dialogue box to allow the user to change the settings.

4.4.5.1 Grading Properties Dialogue Box



In this dialogue box, the user defines the type of grading sought: fully graded, fully flow lined or a mixture of the two, and the number of iterations desired. The user can also opt to simply have the model provide the power density based on a resistivity array entered by the user. This option is available for each of the three types of grading.

4.4.5.1.1 Fully Graded

For the Fully Graded option, the model will calculate the power density expected in each element of the 2-D mesh, based on the resistivity in the mesh. The user can select the number of iterations from zero (0) to eight (8). The larger the number of iterations chosen, the smaller the differences in the power density will be, between elements in the mesh.

4.4.5.1.2 Fully Flow Lined

Flow lines are electrical isolation lines in the coating. In this option, the model will automatically use all the lines on the mesh that connect the respective upper and lower busbar coordinates. The user can select the number of iterations from zero (0) to eight (8). Zero (0) iterations will calculate for a uniform coating in each region separated by the flow lines.

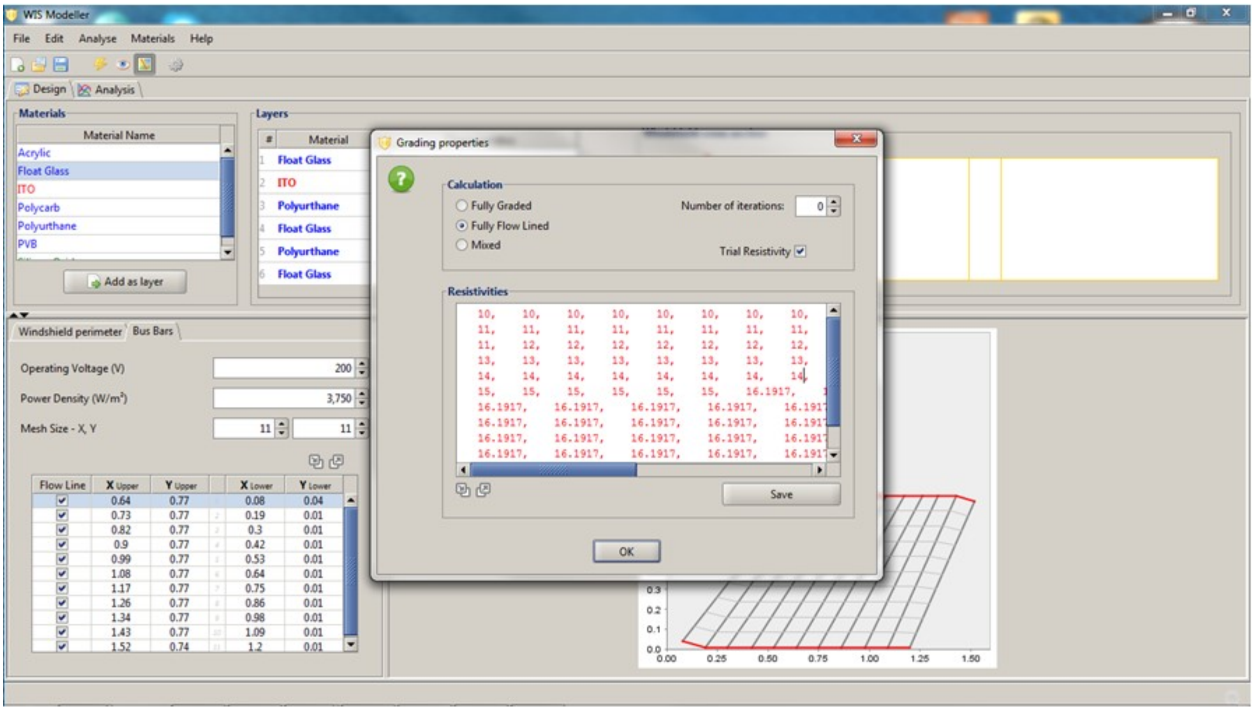
4.4.5.1.3 Mixed

This facility allows for a mix of flow lines and larger graded areas. If this mixed-mode is desired, the user must identify which of the lines in the mesh are to be defined as flow lines. This is done be selecting or de-selecting the lines using the tick box in the Flow Line column. The user can select the number of iterations from zero (0) to eight (8). Zero (0) iterations will calculate for a uniform coating in each region separated by the flow lines.

TIP: If the windscreen is powered by a three-phase supply, flow lines can be used to represent the phase isolation lines. In this way the Ohm/sq distribution for the whole windscreen can be determined in one calculation, rather than separate calculations for each phase.

4.4.5.1.4 Trial Resistivity

Selecting the trial resistivity allows the user to manually enter the resistivity in each and any element of the 2-D mesh.



Entering resistivities can be done either before executing the modelling calculation or afterwards to set up a new starting point.

Normally, this approach to grading would be done with the option of zero (0) iterations.

This facility can be used for all of the Fully Graded, Fully Flow Lined and Mixed options.

On completion of entering the data, click save and click okay.

TIP: The grading condition dialogue box can be adjusted in size in the normal Microsoft Windows fashion to view the whole array

4.4.6 Analyse Window

Select the Analyse window function to run the calculations and execute all mathematical models based on the data entered. As all the necessary parameter variables will have values, either set by the user or the defaults, all three mathematical models will produce results and automatically display them in the Analysis panel.

CAUTION: Ensure that all the parameter variables have been changed from the defaults where required. Check these in the Thermal, Optical and Grading dialogue boxes if uncertain.

5 Analysis of a Windscreen

On selecting the Analyse window action, as described in section 4.4.6 above, the results are shown on the Analysis panel. The analysis results for our example is shown below:

5.1 Analysis Area Icons

Each of the four (4) display areas has the following action icons:

5.1.1 Save

This icon saves the current results graph as a *.wsm file in the default, or last used, directory.

5.1.2 Print

This icon prints the current results graph to the installed printer choices on your computer.

5.1.3 Zoom

This icon will activate the zoom function and introduce further controls around the results graph. These allow the current results graph not only to be enlarged within the plot area, and also to be scrolled within the plot area and reset to the original size.

5.1.4 Expand

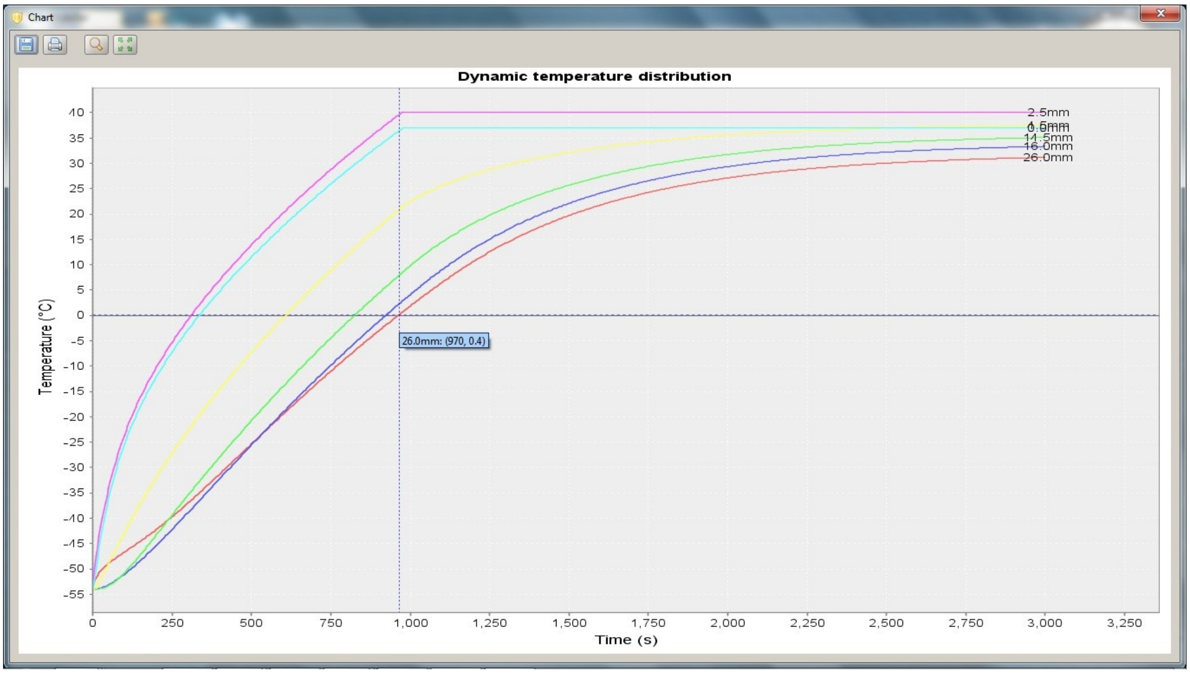
This icon will expand the current results graph to be expanded to full screen on a new panel.

TIP: The new panel maintains the action icons described above. To close this new panel simply click on the x in the top right hand corner.

5.2 Dynamic Temperature Distribution:

This graphical output automatically chooses different colours and adds a label for each curve. Each curve represents an interface and the labels reflect the distance of that interface from the front surface.

The analysis for our example has resulted in the graph which is shown below in the full screen window.

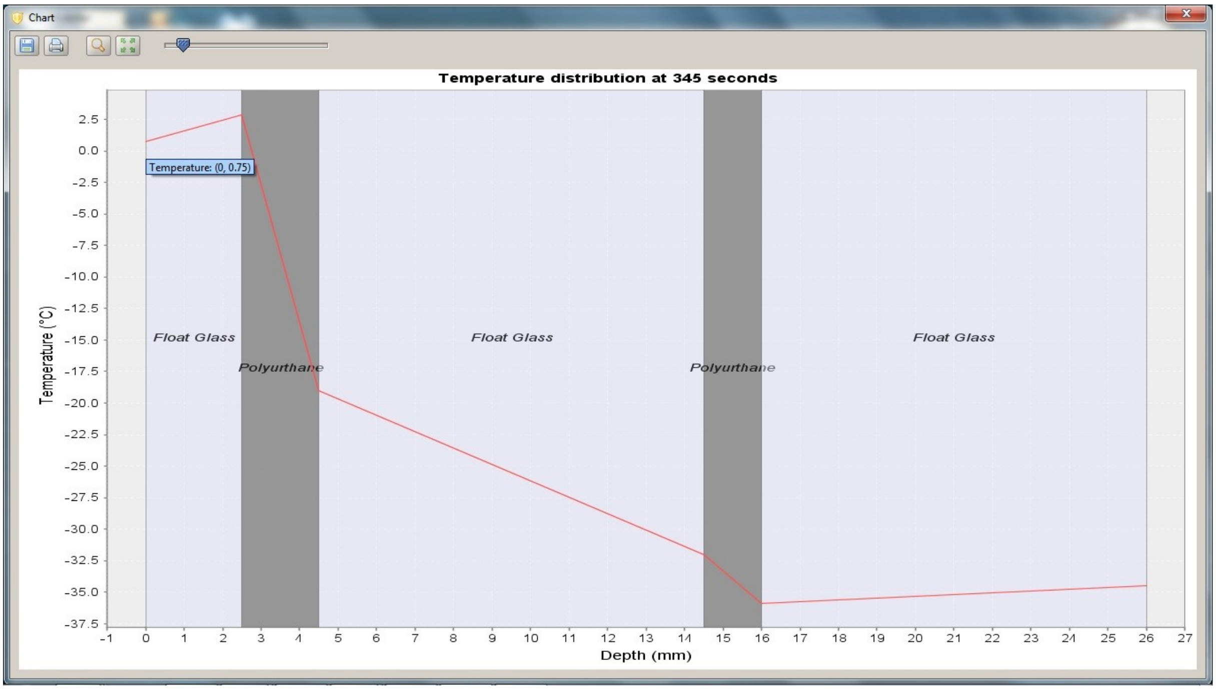


TIP: Hovering the cursor over any of the curves will display the (x,y) coordinates at that point, as shown in the example figure above.

5.3 Temperature Distribution:

In addition to the action Icons described in section 5.1 above, this result panel includes a slider bar, allowing the user to select and look at the temperature distribution at any of the time intervals during the analysis.

The analysis for our example has resulted in the following graph which is shown in the full screen window.

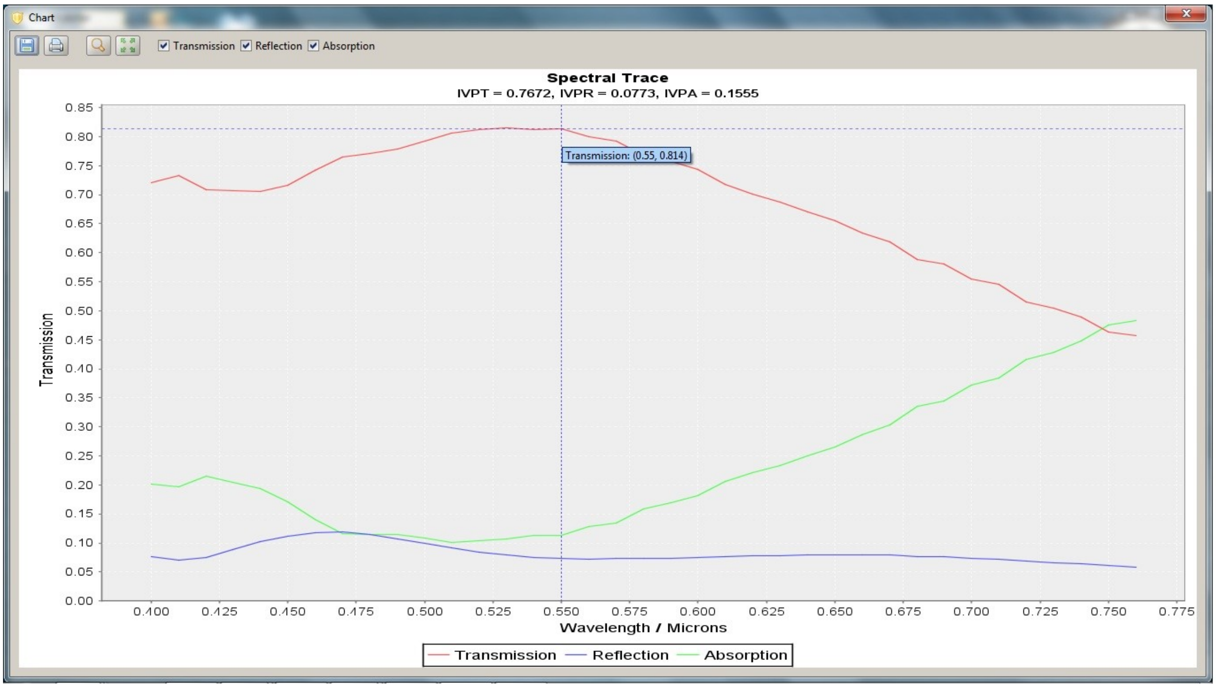


TIP: Hovering the cursor over any of the curves will display the (x,y) coordinates at that point, as shown in the example figure above.

5.4 Spectral Trace

In addition to the action Icons described in section 5.1, this result panel includes three tick boxes to display any or all of the three calculated curves – transmission, reflection and absorption. The default position is that all three curves are shown.

The analysis for our example has resulted in the following graph which is shown in the full screen window.

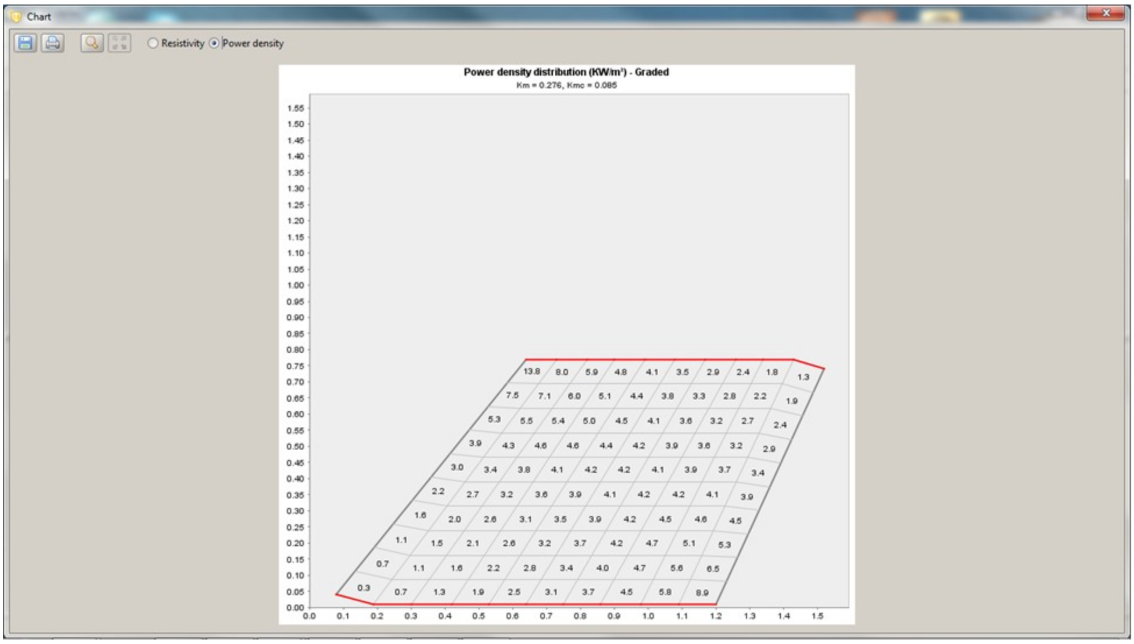


TIP: Hovering the cursor over any of the curves will display the (x,y) coordinates at that point, as shown in the example figure above.

5.5 Grading Distribution:

5.5.1 Fully Graded

In addition to the action Icons described in section 5.1, this result panel includes two radio buttons to switch the displayed results between power density and resistivity. The default displayed result is power density. The analysis for our example has been calculated using zero (0) iterations resulted in the following graphs, which are shown in full screen mode



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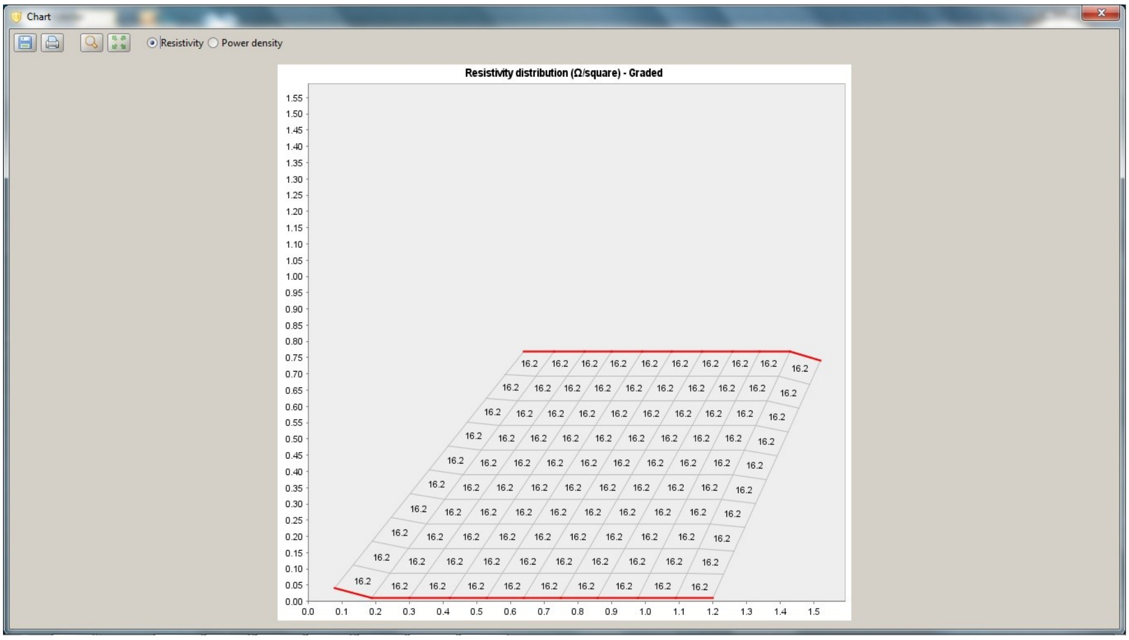
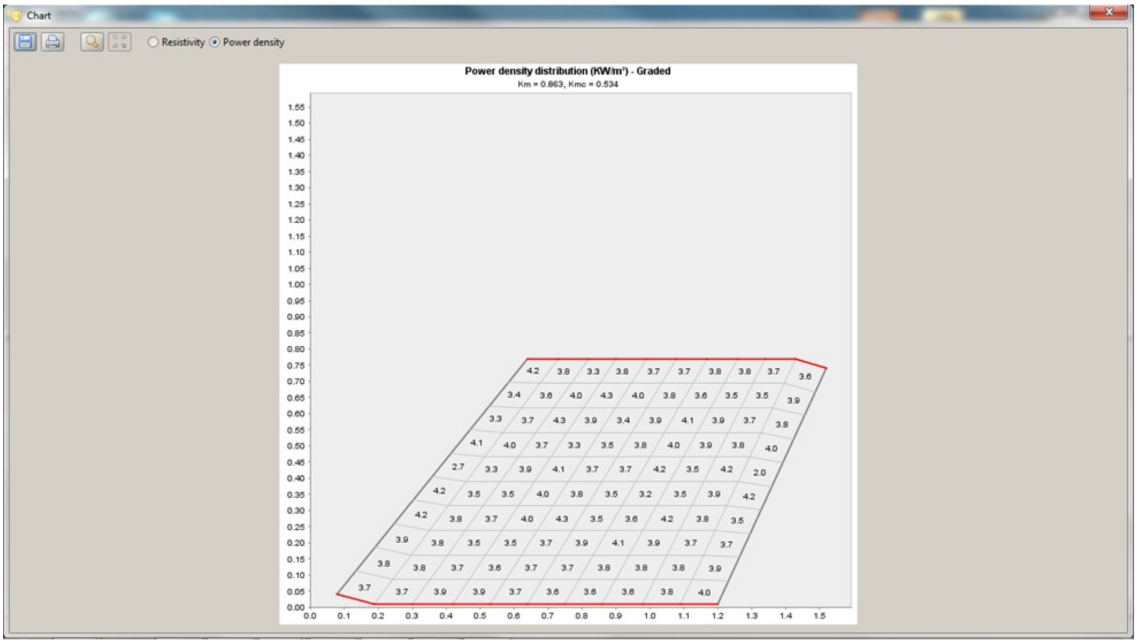


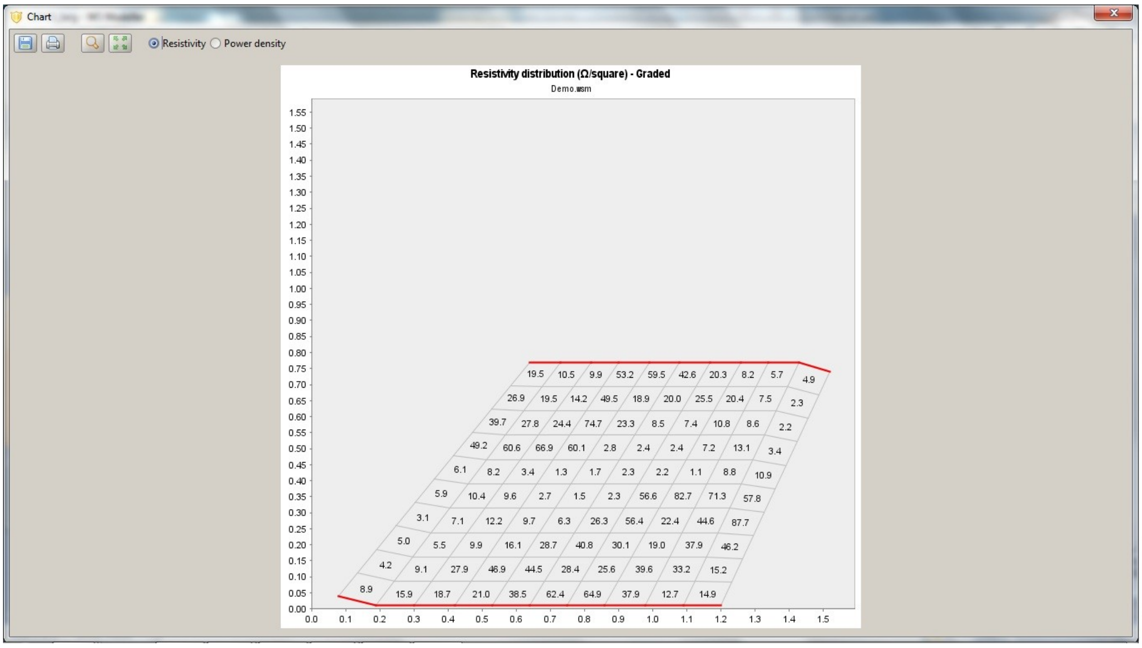
The Power Density results panel also includes the calculation of two power constants: Km and Kmc.

- Km is calculated as the average of all power density of each element in the mesh divided by the maximum power density in the mesh.
- Kmc is calculated as the minimum power density in the mesh divided by the average of all power density of each element in the mesh

TIP: In this case the number of iteration was set to zero (0) so this gives the power density distribution for a uniform coating with this windscreen and busbar geometry. The resistivities have been automatically calculated and scaled based on the voltage setting, the power density setting and the heated area.

In the following results and screens-shots for power density and resistivity, the analysis has been re-calculated using eight (8) iterations.

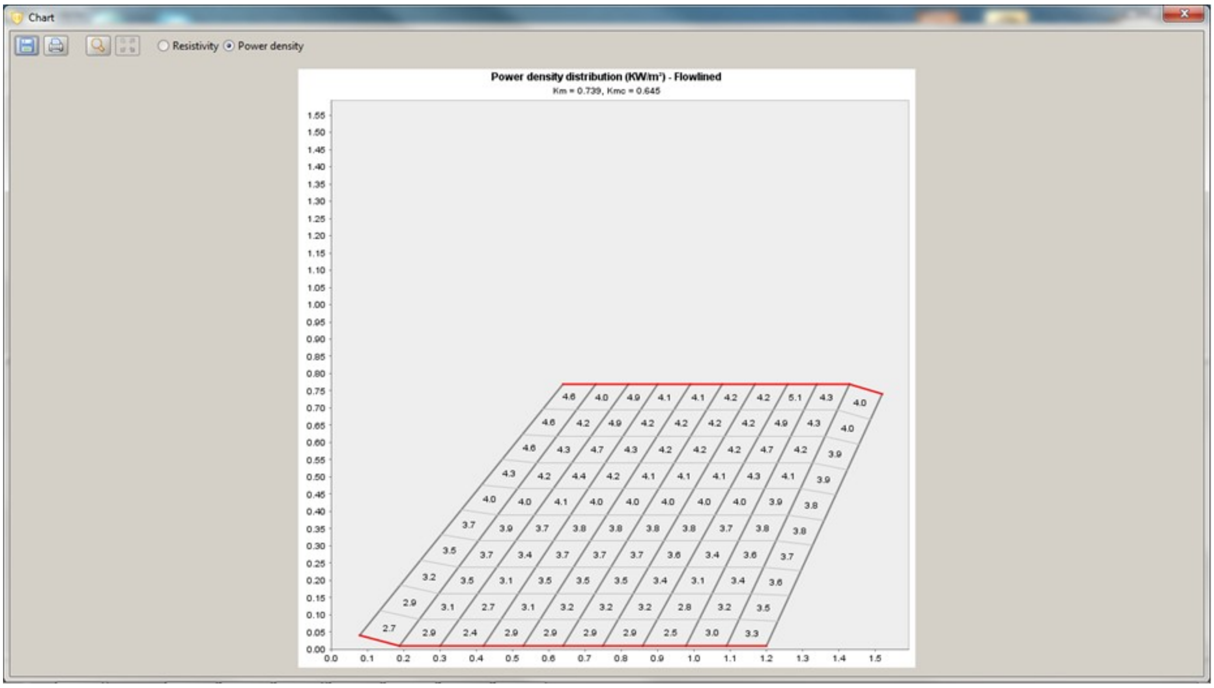


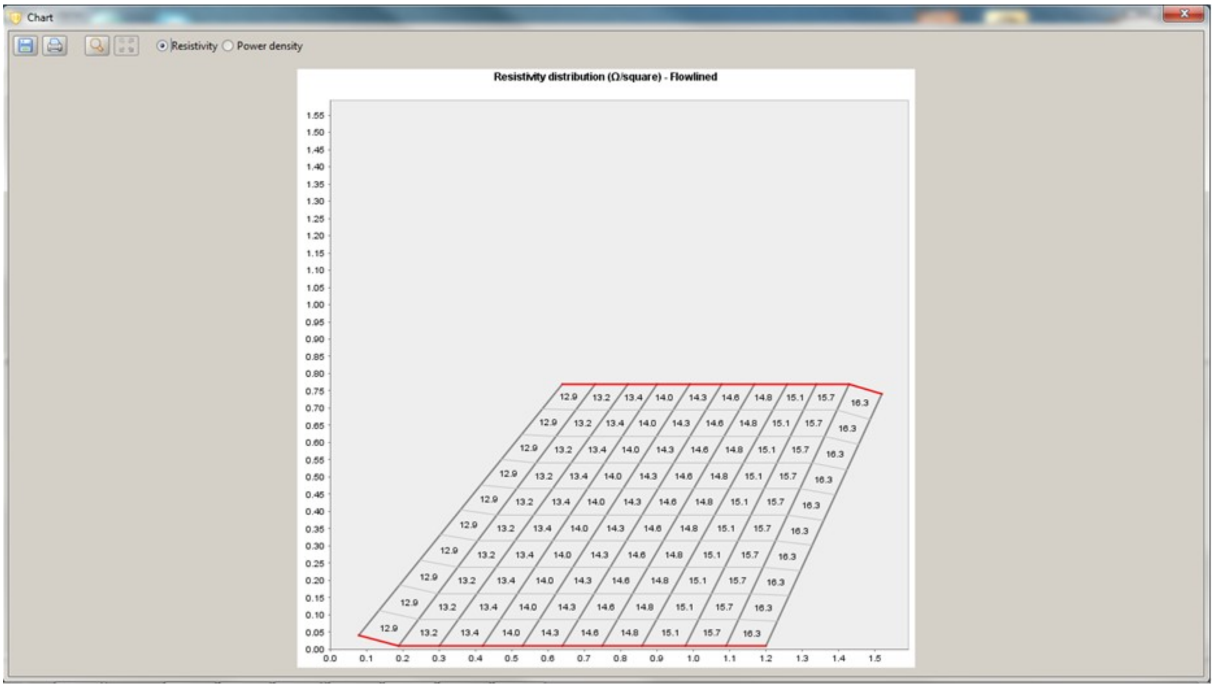


TIP: Increasing the number of iterations will continually improve the power distribution. However, in doing this, the resistivity values are not constrained and can result in impractical, or unachievable, resistivity targets with adjacent mesh elements being very different. Generally after 4 or 5 iterations, the improvement in power density distribution will be adversely offset by the resistivity impracticalities.

5.5.2 Fully Flow Lined

The analysis for our example has resulted in the following graph which has been expanded to full screen mode, for the flow lined case and zero (0) iterations.





TIP: In this case the number of iteration was zero (0) so this gives the power density distribution for a separate flow line with individual uniform resistivities over this windscreen and busbar geometry. It is clear that, in this case, the resistivities increase from the right hand side of the windscreen from the left to the right hand side.

CAUTION: The model is set up such that the finite elements are the same width as the flow lined areas. In the real case there will be hot spots and cold spots within each flow lined area.

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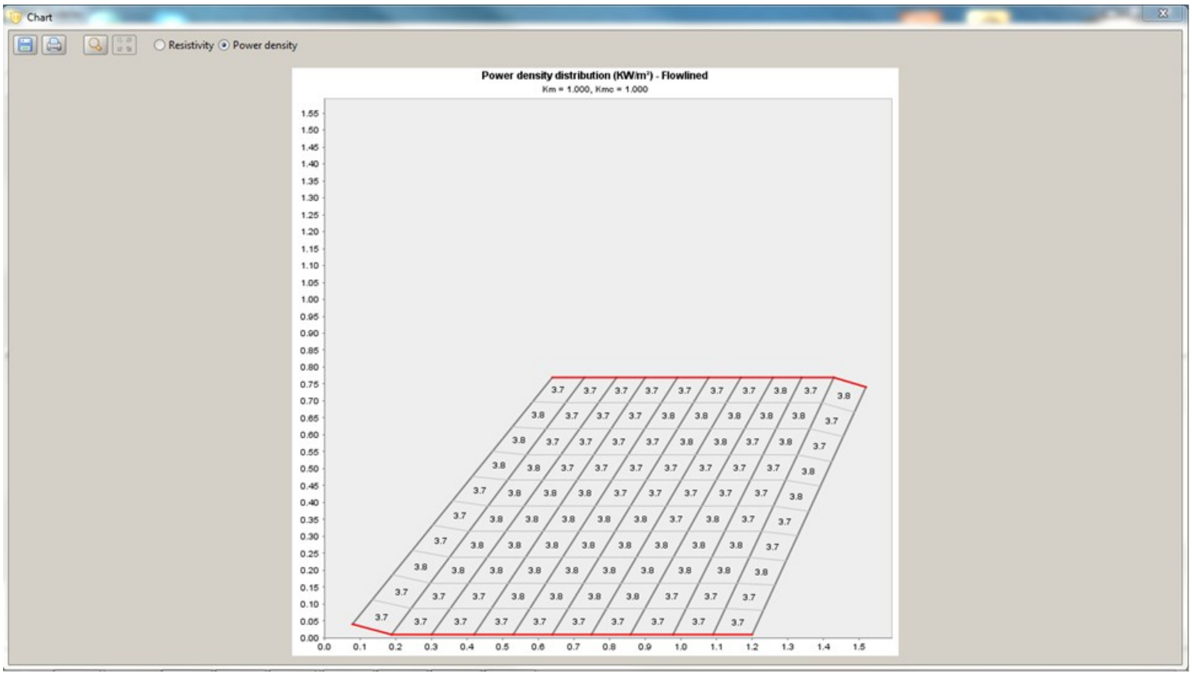
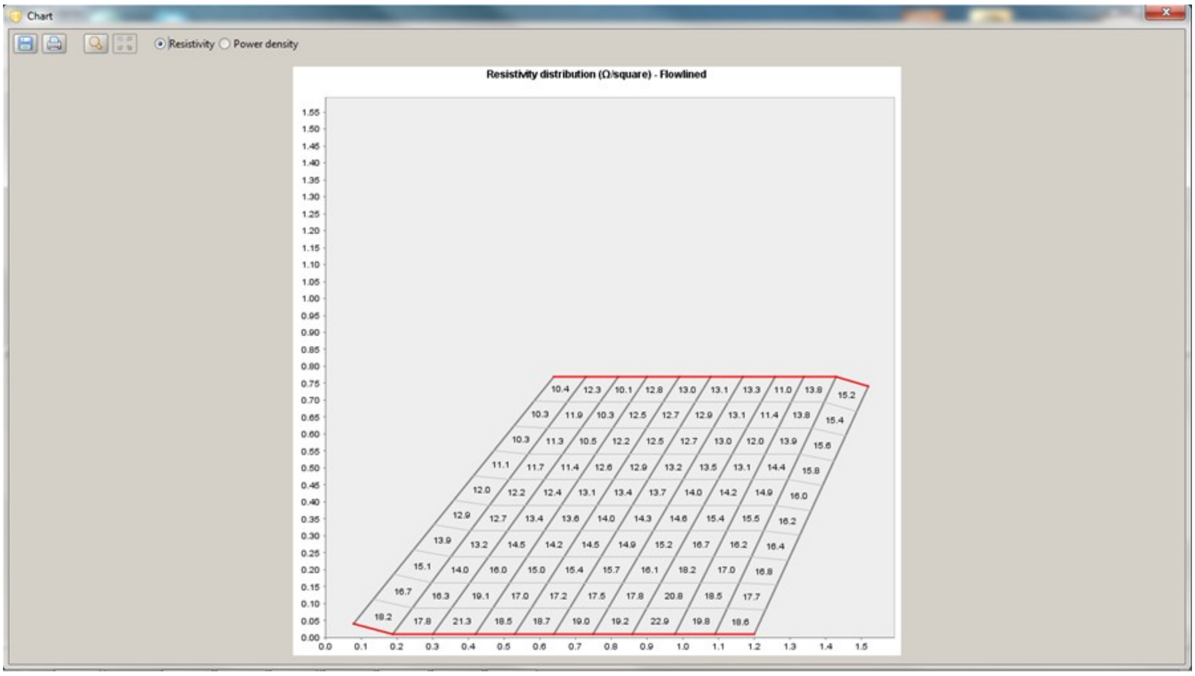
In the same way as the Fully Graded option, the analysis can be optimised by increasing the number of iterations. Below the results are given for our example with eight (8) iterations.

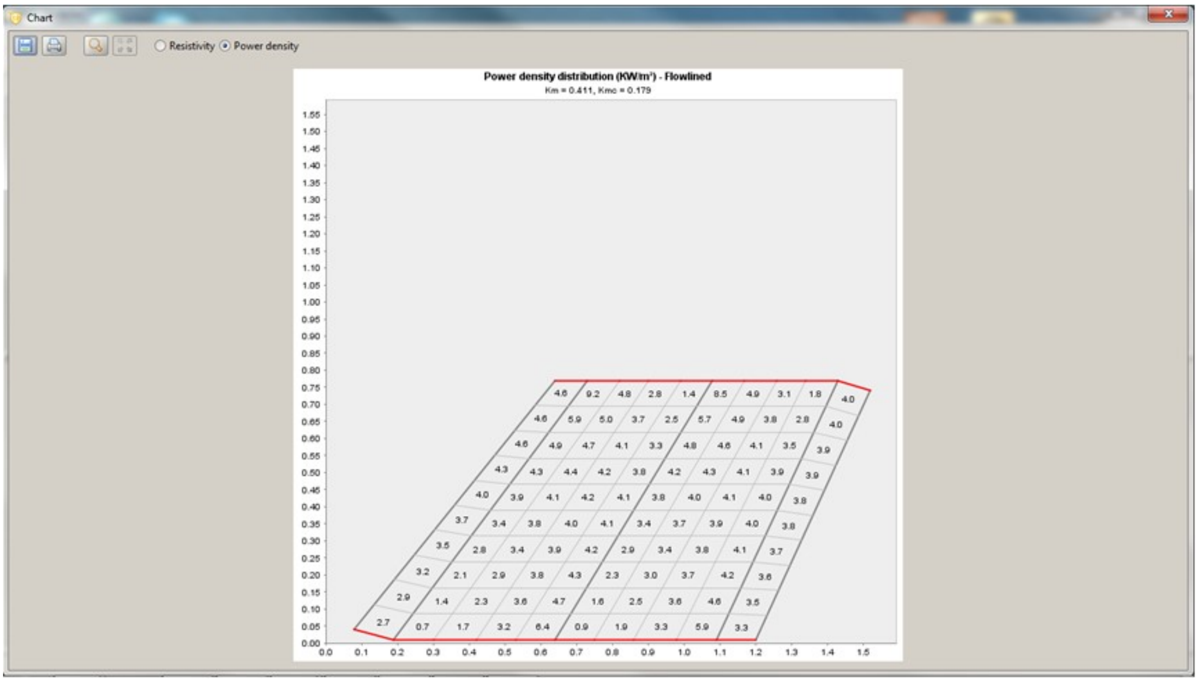


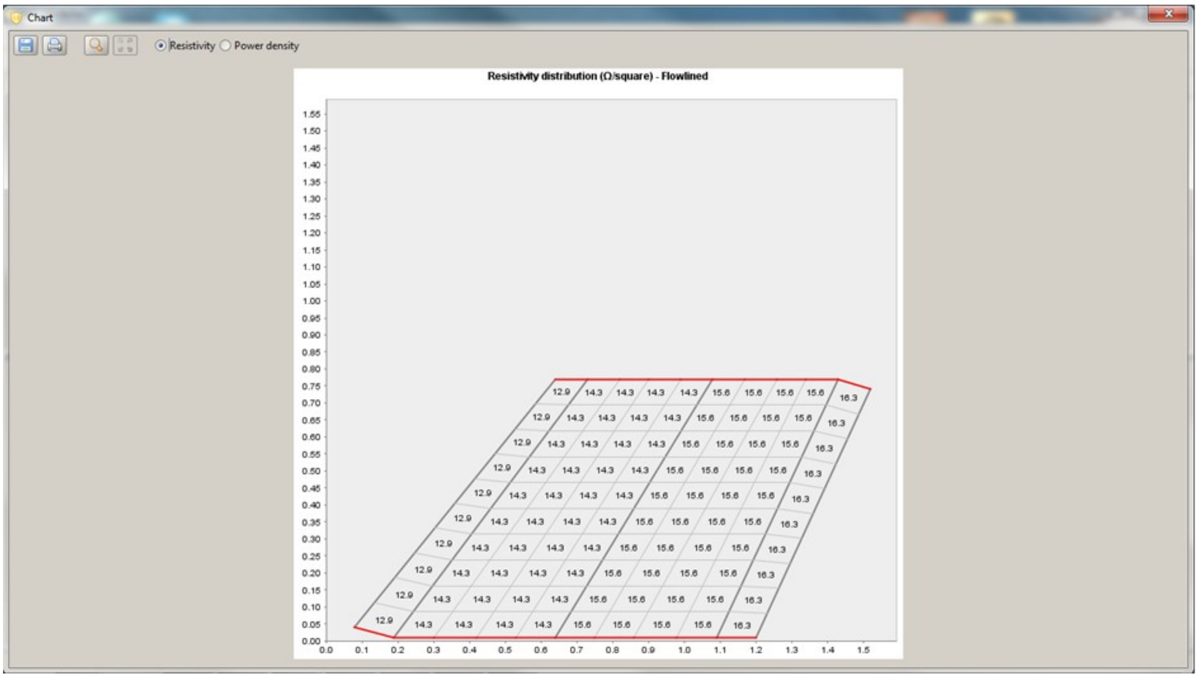


TIP: Compare this resistivity distribution with that of the fully graded case in Section 5.5.1. This resistivity distribution is relatively easier and much more practical to achieve.

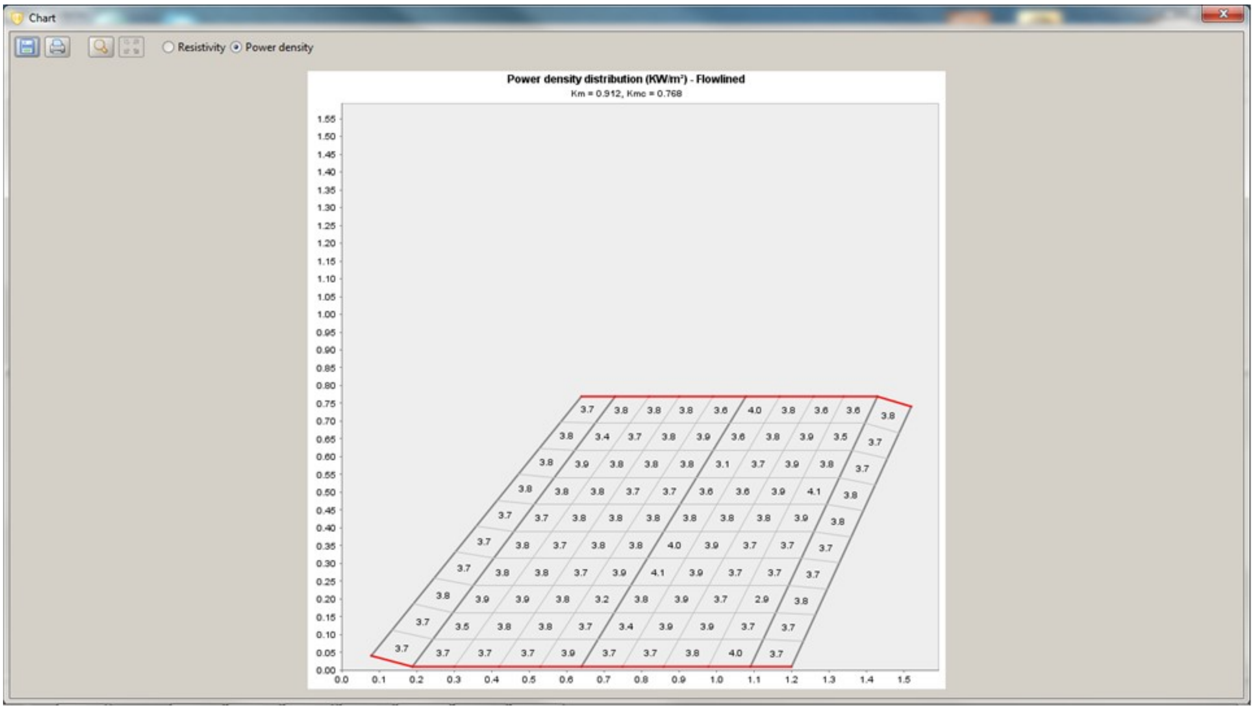
5.5.3 Mix of Flow Lined and Graded Areas

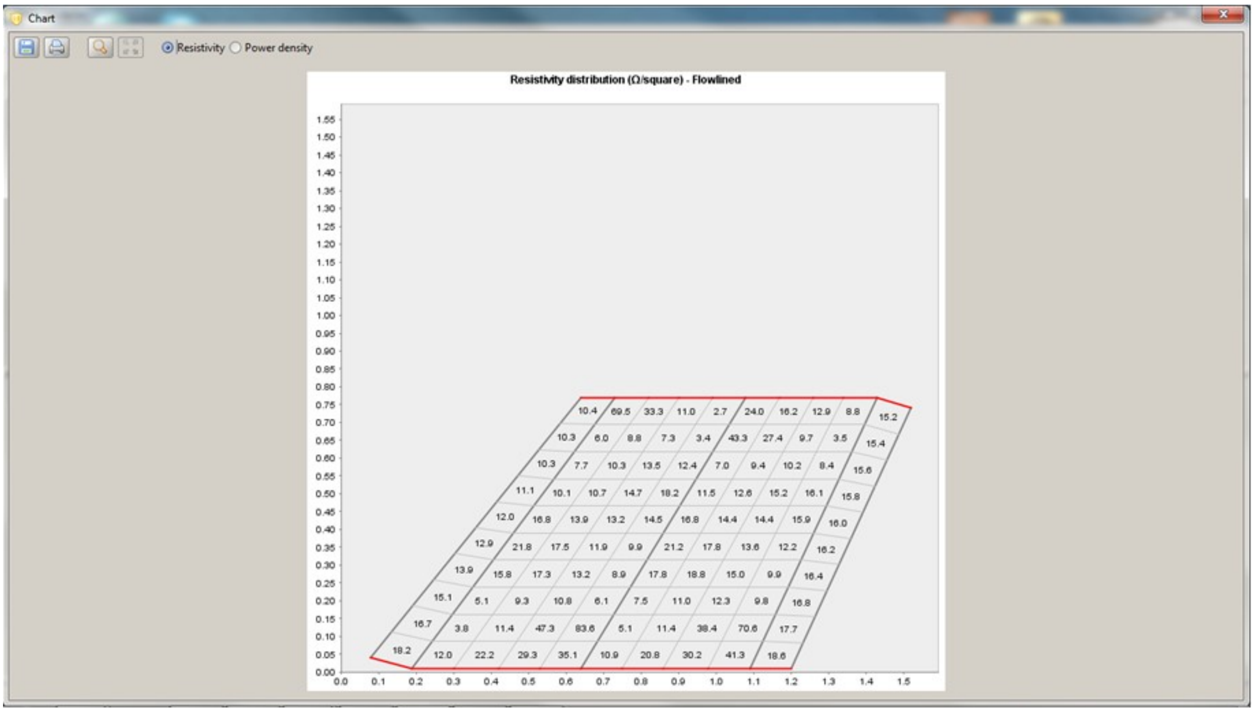
The flow lining and grading for our example has modified to demonstrate the ability of WIS Modeller to calculate mixed scenarios and requirements. The results for zero (0) iterations are shown in the following graph, where the location of the user-chosen flow lines are clearly identifiable.





In the same way as the Fully Graded and Fully Flow Lined options described previously, the analysis can be optimised by increasing the number of iterations. Below the results are given for our example with eight (8) iterations.



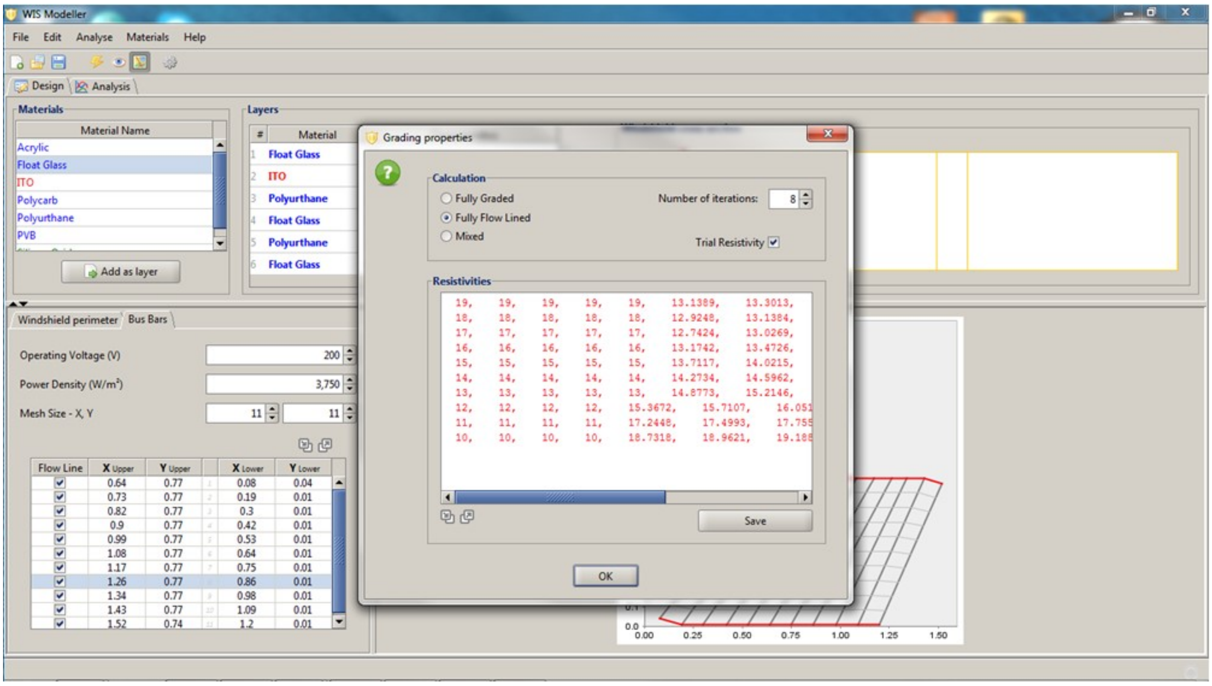


5.5.4 Trial Resistivity

The analysis for our example continues in this section and demonstrates the use of the trial resistivity function to manually enter the desired resistivities in each element of the array. This is captured in the screen shot below, where about half of the manual entries have been completed.

In addition, for this analysis, the Flow Lined option and zero (0) iterations have been selected.

On completion of entering the data, click save and okay.



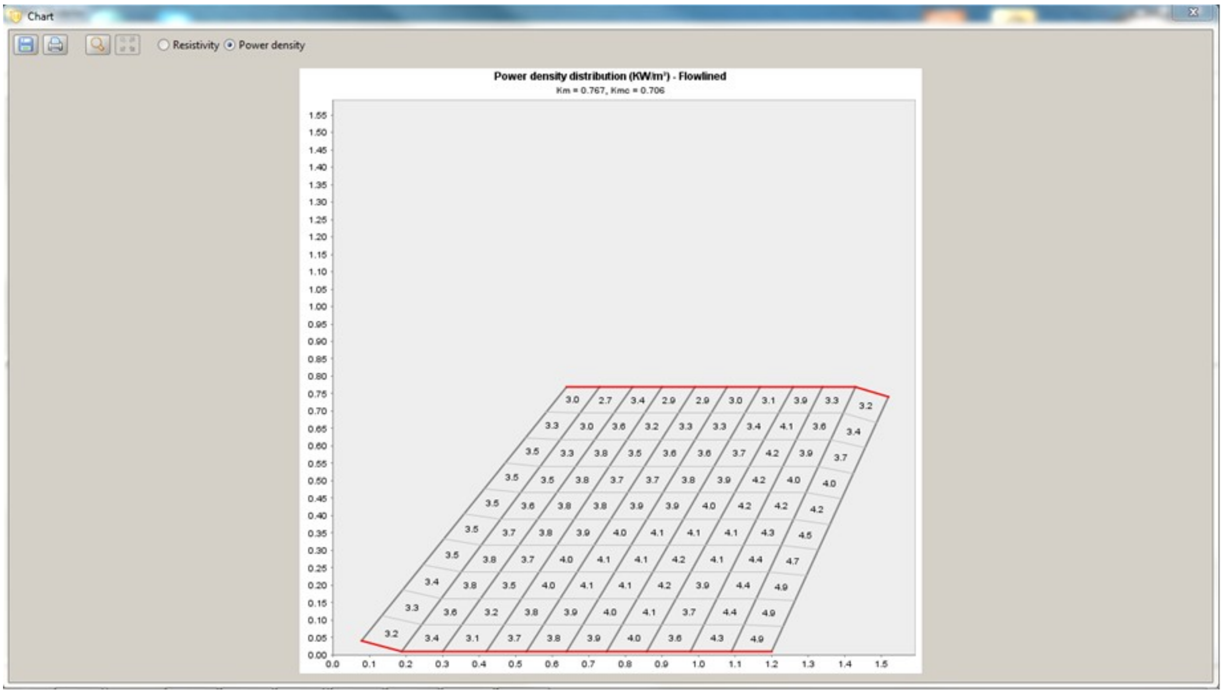
TIP: The resistivity values can be imported from a CSV format data file using the icon underneath the Resistivities table. Similarly the resistivity values can be exported to a CSV format data file.

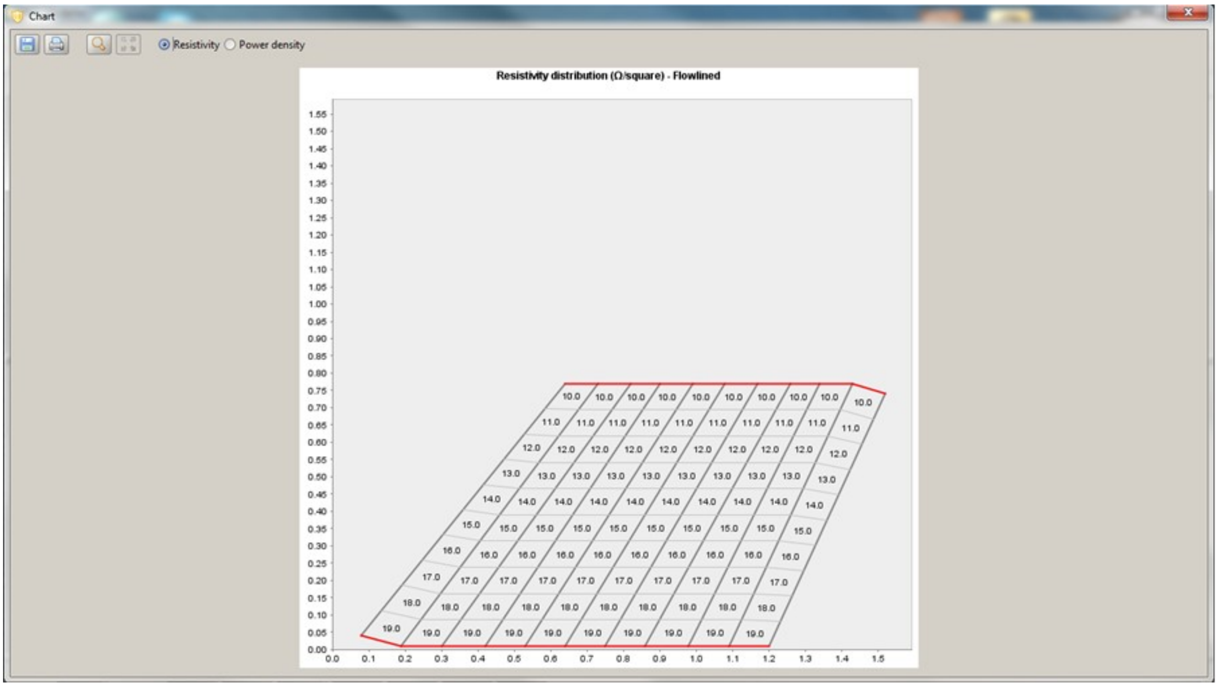
CAUTION: When the trial resistivity option is selected and the number of iterations is selected to be zero (0), the calculation must be performed TWICE, ie click on the Analyse Window icon TWICE. Each time, the model will provide the power density results for the resistivities in a flipped-over orientation (flip is based on the central horizontal data row).

TIP: Selecting Analyse Window for subsequent calculations, without changing any of the parameters or resistivities and leaving the number of iteration set to zero (0), the model will automatically flip back and forth between the original as-entered orientation and the flipped orientation

TIP: The flipping feature is only available when the number of iterations is set to zero (0). If the number of iteration is set to 1 or higher, flipping will no longer occur.

The analysis for our example has resulted in the following graphs which has been expanded to full screen using the expand icon, for the flow lined case and using the default zero (0) iterations.





TIP: This facility allows the user to model the effect of simple and practical grading techniques on the power density distribution prior to attempting the coating.

TIP: This facility is also the most appropriate method for modelling the effect of flow-lining a uniform coating on the power density distribution.

ANNEX 1: Quick Reference Guide

Function	Icon	Hot Key	Description
New windscreen		Ctrl-N	Start new windscreen design Clears existing data
Open windscreen		Ctrl-O	Retrieve and open windscreen design from file
Save windscreen		Ctrl-S	Save windscreen design to file with existing file name
Save windscreen as			Save windscreen design to file with the opportunity to change file name
Show design panel		Ctrl-D	Move from current screen to Design panel
Show analysis panel		Ctrl-R	Move from current screen to Analysis panel
Thermal properties		Ctrl-T	Enter or amend the Thermal condition parameter variables
Optical Properties		Ctrl-Y	Enter or amend the wavelength parameter variables
Grading properties		Ctrl-G	Enter or amend the Grading parameter settings and variables
Analyse window		F8	Run the mathematical models and performs the calculations
Import Data			Import data from a CSV file. Facility can be used for busbar coordinates and resistivities
Export Data			Export data to a CSV file. Facility can be used for busbar coordinates and resistivities

ANNEX 2: ITO Ω/□ and Thickness Reference Guide

ITO Sheet Resistance (Ω/□)	ITO Thickness Conventional Data (nm) Specific Resistivity = $2.25.10^{-4}$ Ω.cm	ITO Sheet Resistance Measured Data (Ω/□) Ref:…………………. ………………………. ………………………. ……………………….	ITO Thickness Measured Data (nm) Ref:…………………. ………………………. ………………………. ……………………….
2	1130		
3	750		
4	563		
6	375		
8	281		
10	225		
12	188		
15	150		
17.5	129		
20	113		
25	90.0		
30	75.0		
40	56.3		
60	37.5		
80	28.1		
100	22.5		
120	18.8		
150	15.0		
175	12.9		
200	11.3		