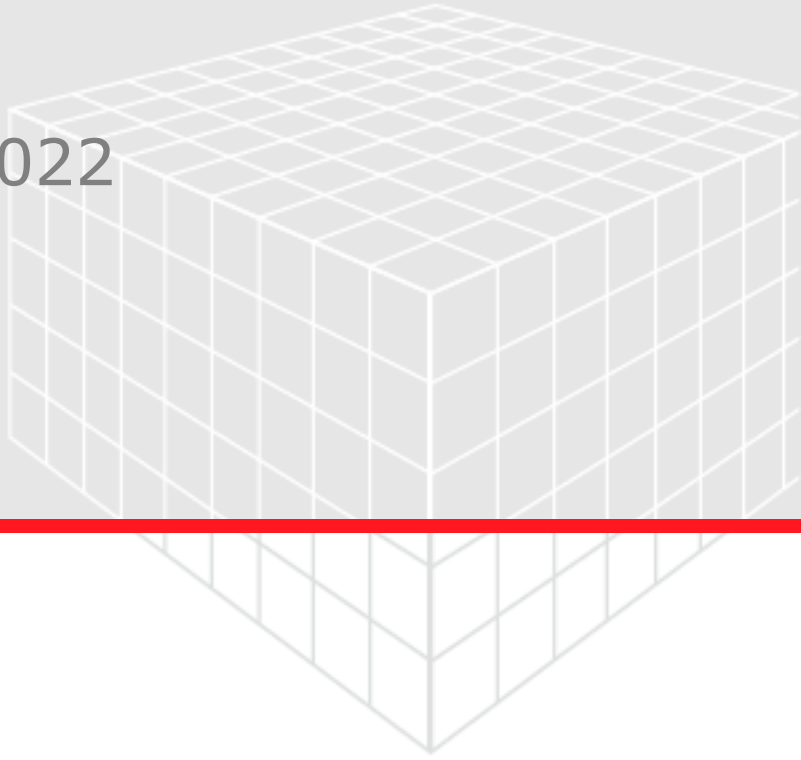
PleatGeo

User Guide

GeoDict release 2022

August 16, 2021



GeoDict

https://doi.org/10.30423/userguide.geodict2022-pleatgeo

MODELING AND DESIGNING PLEATS

Pleating refers to the practice of folding a material into homogenous parallel strips – known as pleats. Pleats are widely used in filtration applications because pleating of the filter media results in an increase of filtration surface area for a given filter volume. A well-designed pleated filter medium achieves a lower pressure drop for any given flow rate.

Pleated media are indispensable for the removal of suspended solids during air/gas and liquid filtration for a multiplicity of industrial applications, such as aerospace, pharmaceutical processing, hospitals, health care, nuclear fuels, nuclear power, and electronic micro-circuitry (computer chips).

The design of a pleated filter for a particular application needs to address crucial parameters such as flow rate (usually in cubic meter or feet per second), filter efficiency (percentage of reduction of micron particles), and filter life span.

These filter specifications depend to a great extent on the type of filtering media (paper, polypropylene - PP, polyethylene - PE, polyester - PET, fiberglass, nonwoven textile, etc.). When the filter media material cannot be pleated or easily collapses when subjected to high pressures, it is possible to laminate one or both sides of the media with wire to prevent pleat collapse under high pressures and maintain consistent flow.

PLEATGEO SECTION

A pleat is a folded filter medium that can be sandwiched between an inner and an outer support structure. These support structures can be welded-netted or woven. The support structure can be missing altogether.

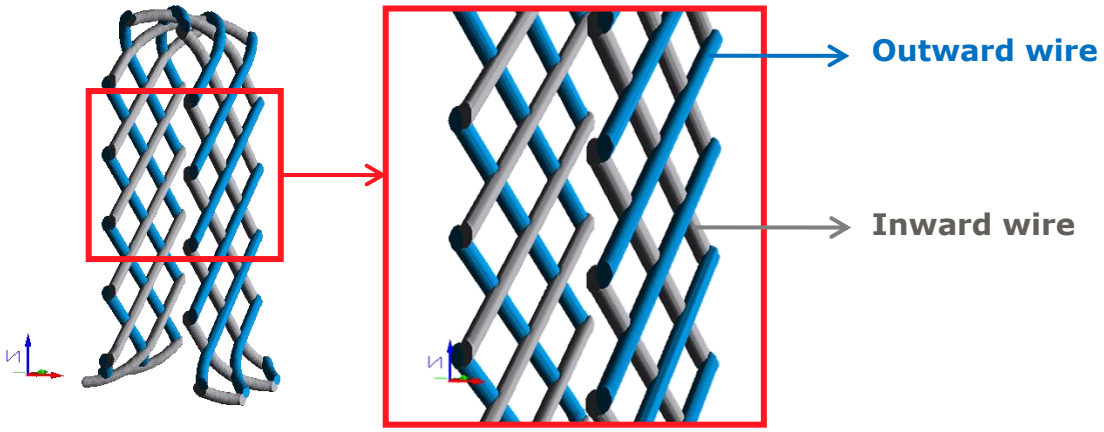
Open PleatGeo by choosing **Model** → **PleatGeo** in the Menu bar.

The two pull-down menus display the available choices for the generated pleated structures.

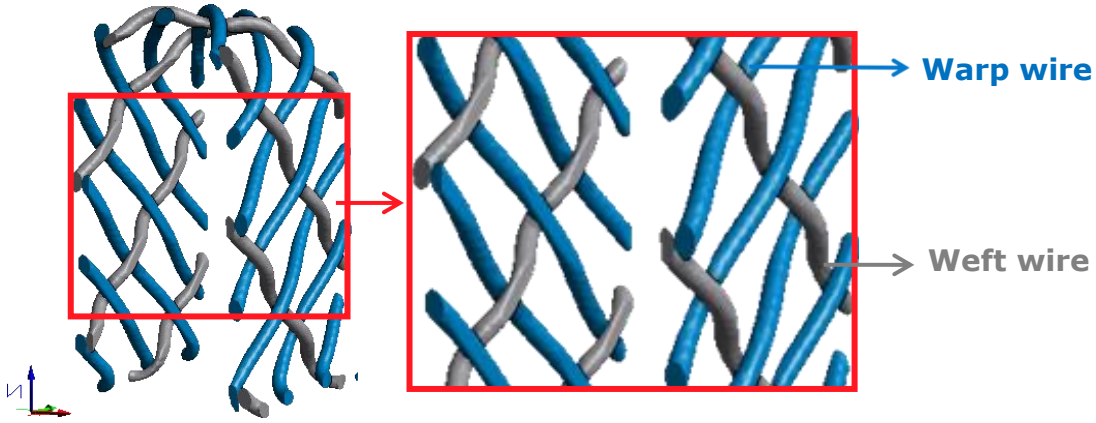
The generated pleated structures may be supported by an **Inner Netting**, an **Inner Weave,** or have **No Inner Support**, as well as by an **Outer Netting**, an **Outer Weave,** or have **No Outer Support**.

The **Inner Netting** and the **Outer Netting** are welded-melted structures consisting of inward and outward wires crossing each other at regular intervals without going over or under each other.

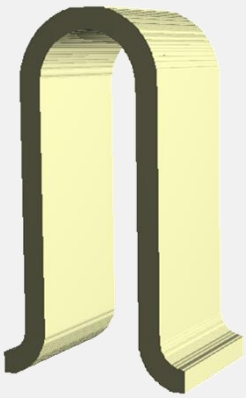
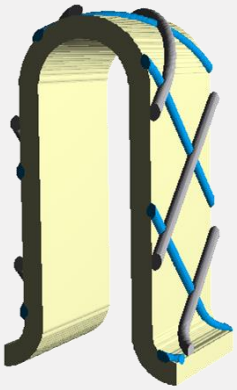
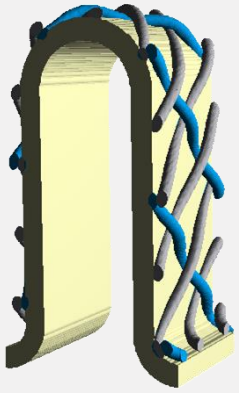
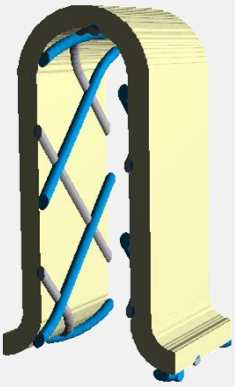
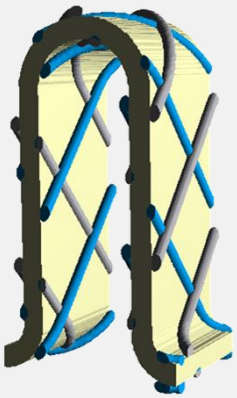
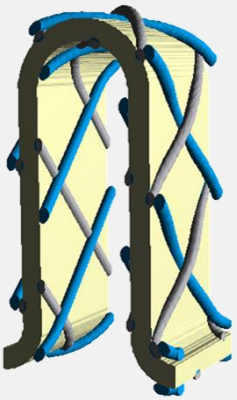
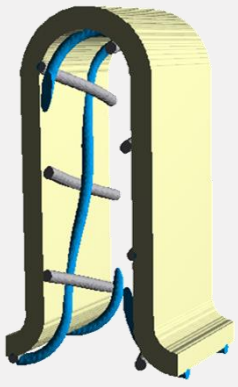
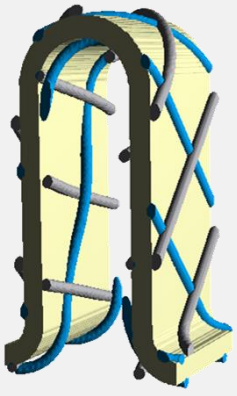
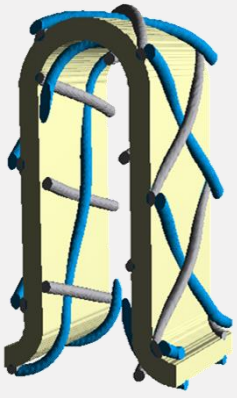
Inner, outer, inward, and outward are defined in PleatGeo assuming that the "inside" is on the upstream side of the pleat and its "outside" on the downstream side.



The **Inner Weave** and the **Outer Weave** are support structures made of woven warp and weft wires which interlace over-and-under each other in given weave pattern (Plain weave, Twill 2/1 Weave, Twill 2/2 Weave).



The nine combinations of these choices are shown below in a pleat with one layer:

No inner Support No outer Support	No inner Support Outer Netting	No inner Support Outer Weave
		
Inner Netting **No outer Support**	**Inner Netting** **Outer Netting**	**Inner Netting** **Outer Weave**
		
Inner Weave **No outer Support**	**Inner Weave** **Outer Netting**	**Inner Weave** **Outer Weave**
		

For each of the arrangements, the PleatGeo generator needs the input of pleating parameters entered through the pleat **Options' Edit...** button.

The results of every PleatGeo run are saved in a *.gdr file (GeoDict Results file) containing the data about the structure generation. Enter a suitable name for the *.gdr file or click the **Browse...** button to select one from the chosen project folder.

Clicking **Generate** in the **PleatGeo** section generates a pleat using the entered pleat **Options**. View the pleat in 3D by selecting **View → 3D Rendering** in the Menu bar.

Macro files containing all steps of the pleat generation process can be recorded and saved in the project folder when selecting **Macro → Start Macro Recording...** in the Menu bar. When recording a macro, **Record** becomes active and **Generate** changes to **Generate & Record**.

At the end of the pleat generation process, a *.gdr result file is saved in the project folder. Besides the result file, a results folder with the same base name is created. This results folder contains a *.gdt (GeoDict Structure) file of the generated pleat.

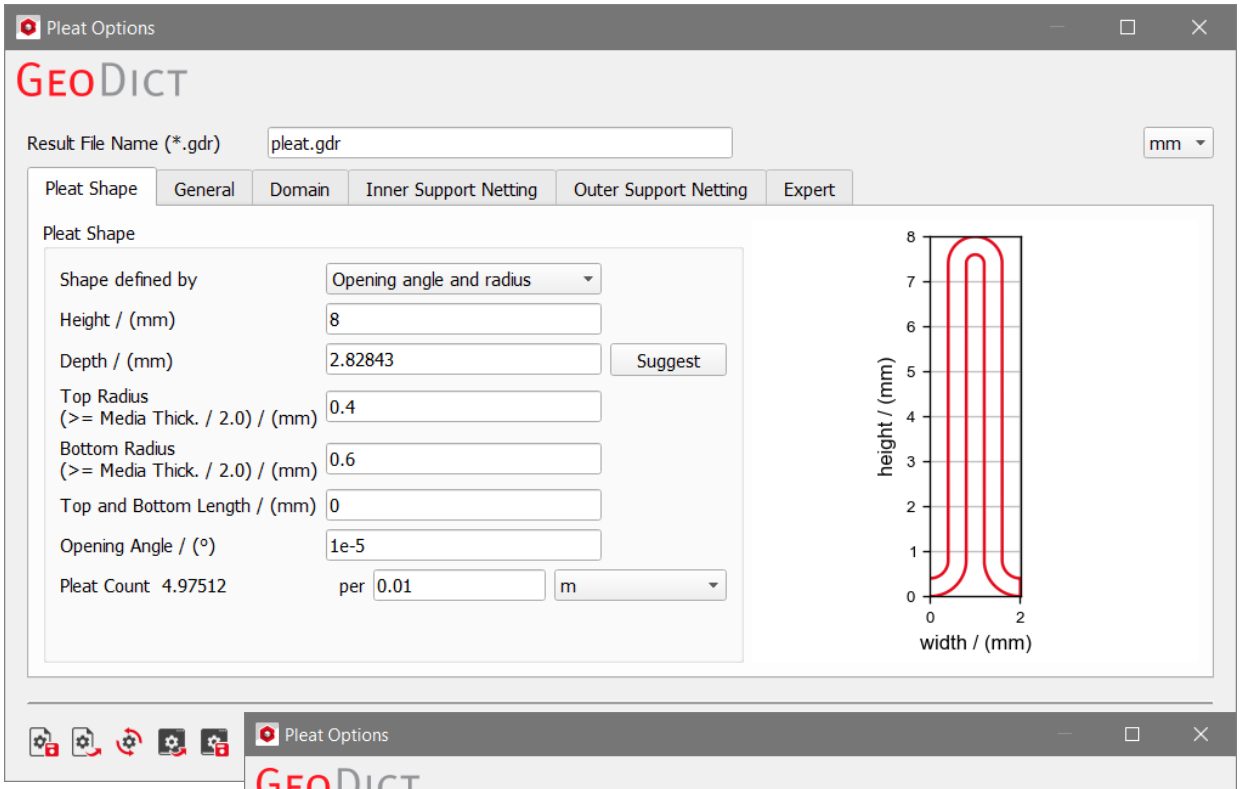
Pleat Options

After clicking the pleat **Options' Edit...** button, the **Pleat Options** dialog opens.

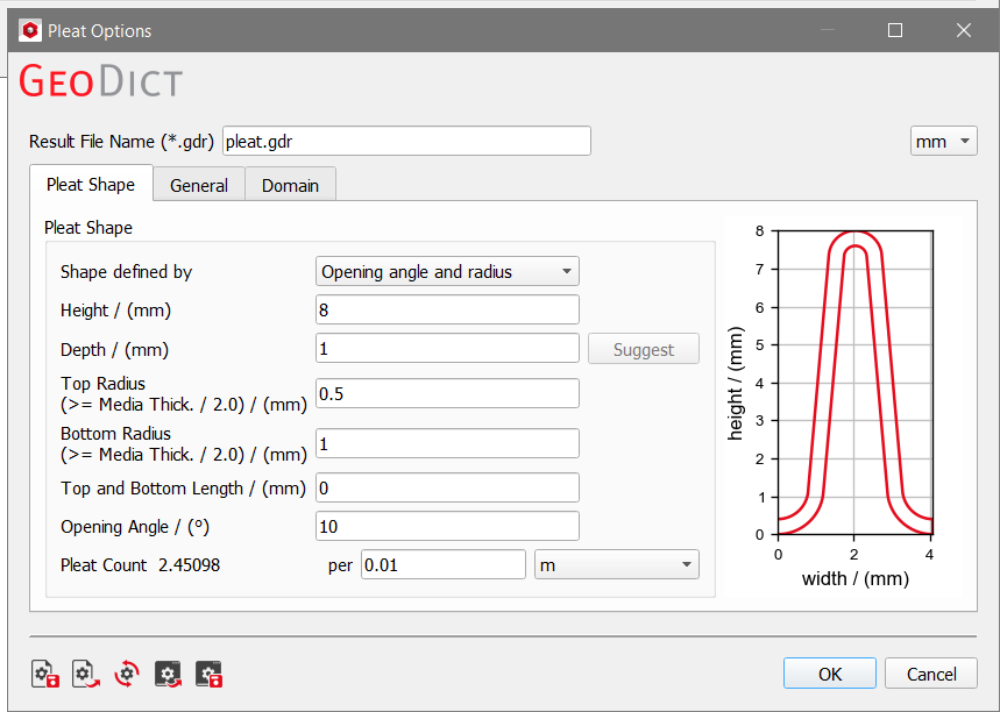
A **Result File Name (*.gdr)** must be entered. The **Result File Name** is applied to both the results file (*.gdr), and to the results folder that are saved in the project folder. The ***.gdr** (GeoDict result) files contain the complete information on the current structure generation.

At the top right of the **Pleat Options** dialog, the available **units** (m, mm, and µm) are selectable from the pull-down menu.

The parameters for the pleat generation are organized into **Pleat Shape**, **General**, **Domain, Inner Support Netting** (or **Inner Support Weave**), **Outer Support Netting** (or **Outer Support Weave**), and **Expert**, accessible through tabs.



When creating pleats without inner or outer support, only the **Pleat Shape**, **General**, and **Domain** tabs appear.

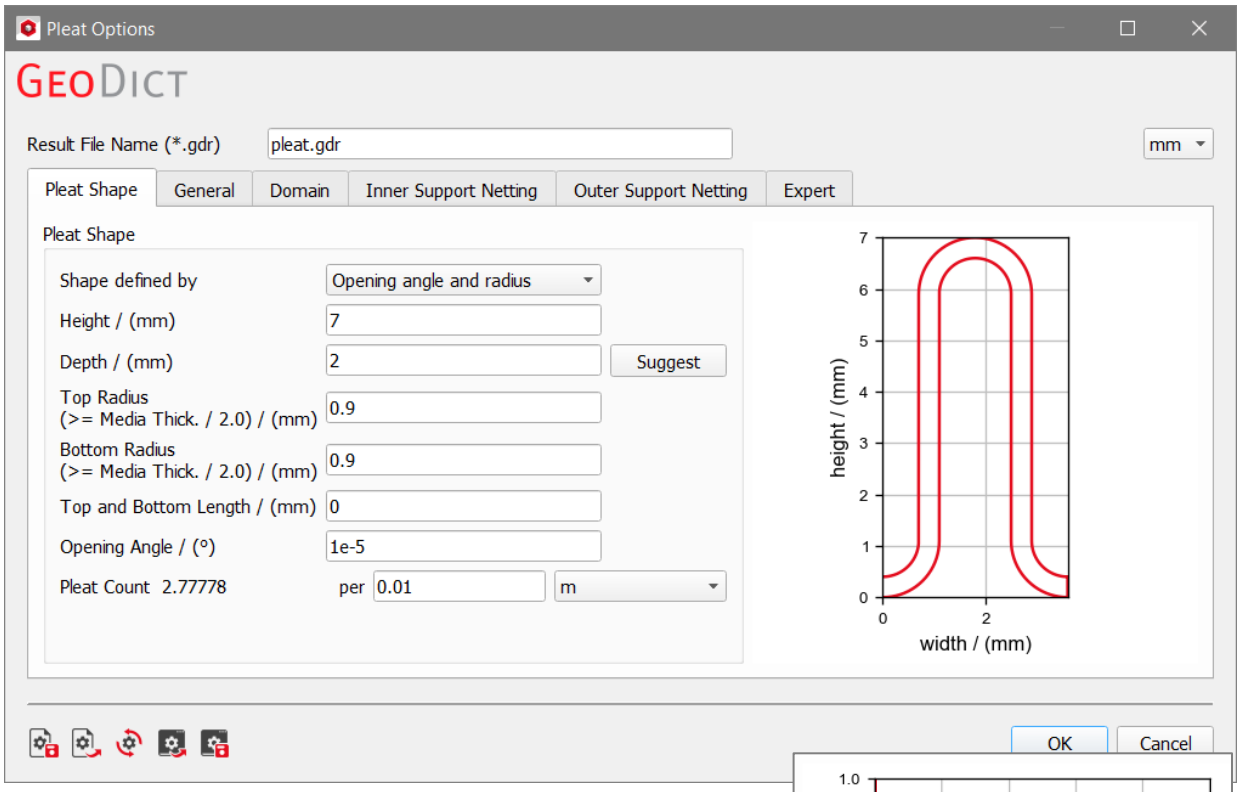


Clicking **OK** confirms the entered pleat options and clicking **Cancel** closes the **Pleat Options** dialog and discards the current modifications.

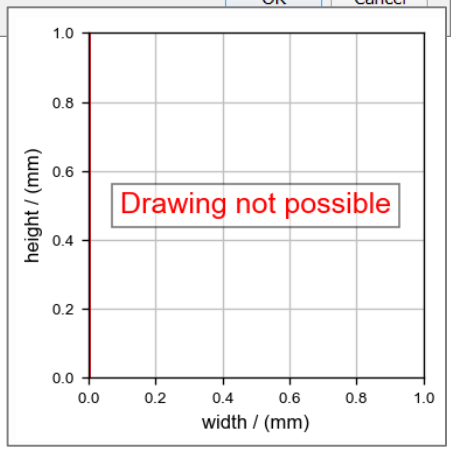
The parameters entered in the **Options** dialog can be saved into *.gps (GeoDict Project Settings) files and/or loaded from them. Remember to restore and reset your (or GeoDict's) default values through the icons at the bottom of the dialog when needed and/or before every PleatGeo run.
Resting the mouse pointer over an icon shows a ToolTip explaining its function.

PLEAT SHAPE PARAMETERS

When entering pleat shape parameter values, the pleat graph at the right of the panel changes interactively and displays the effect of these adjustments on the pleat shape.



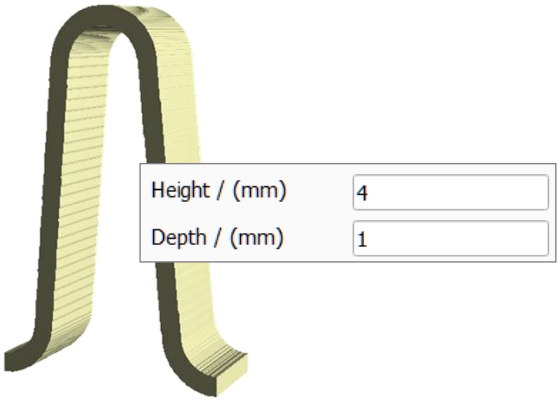
If invalid values are entered, the graph contains the error message "**Drawing not possible**" and no pleat is shown.

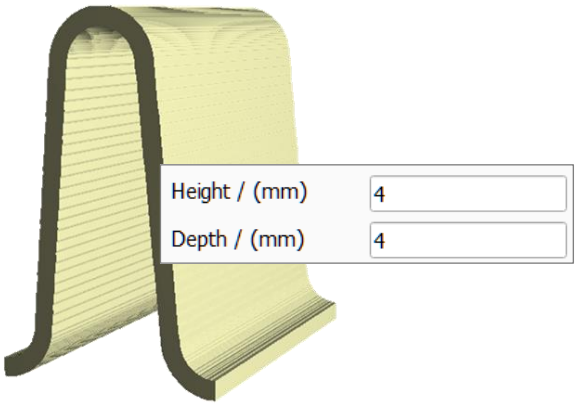


There are three different options to define the pleat's shape. The combinations **Opening angle and radius**, **Pleat count and opening angle** or **Pleat count and radius** can be chosen from the pull-down menu. As the three parameters opening angle, radius and pleat count are not independent, the respective third parameter is computed automatically from the others.

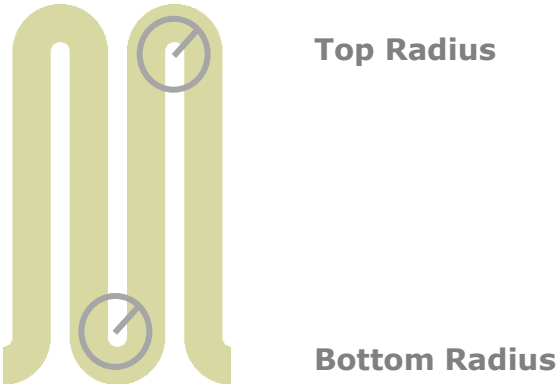
Pleat **Height** and pleat **Depth** are the physical dimensions of a single pleat in the Z- and Y-directions, respectively. Clicking the **Suggest** button shows the pleat **Depth** value that is recommended for the inner and outer support parameters. The suggested value is the minimum to generate one netting (or weave) unit cell in Y-direction. If no inner and outer support is chosen, **Suggest** is grayed out.

Only a short segment of the length of the pleat is modeled. This length in X-direction, or pleat width, is calculated automatically from the mesh parameters so that it corresponds to the period length of the mesh. This choice gives the smallest possible representative structure of the pleat that is usable for property computations.





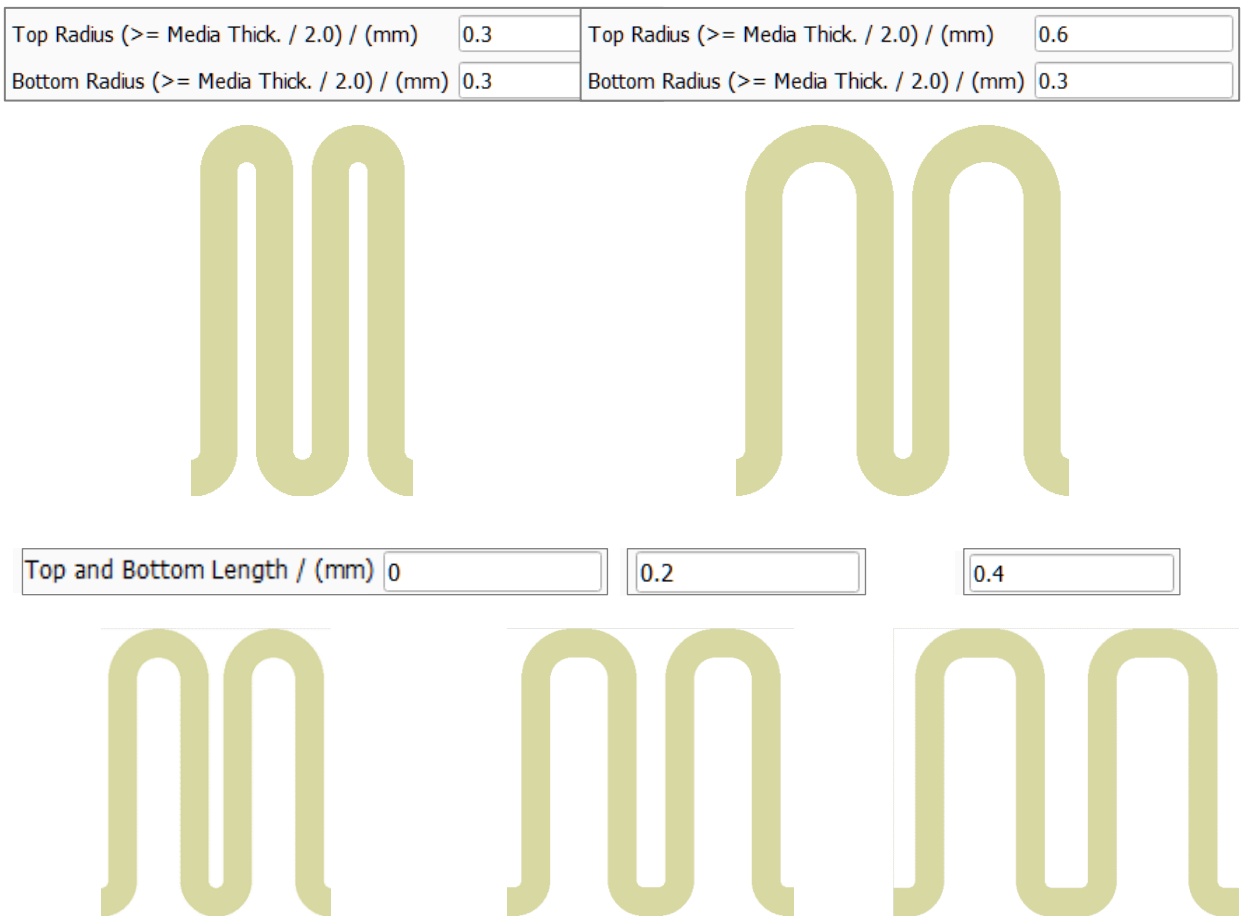
The values of pleat **Top Radius** and pleat **Bottom Radius** determine the upper pleat radius and lower pleat radius measured at the upper or the lower folds of the pleat.



If **Pleat count and radius** is chosen for defining the pleat's shape, only the top radius can be edited, as the bottom radius is set to the same value.

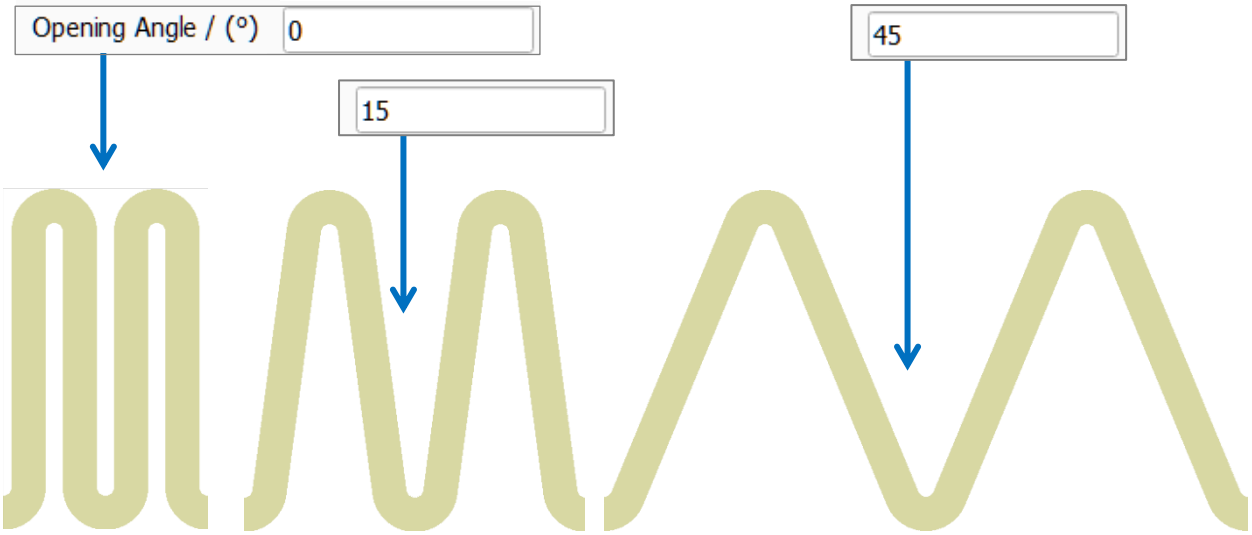
Defining the shape by **Pleat count and Opening Angle** also leads to same values for Top Radius and Bottom Radius, but then both cannot be edited.

Otherwise, if **Opening angle and radius** is chosen, the values of top radius and bottom radius can be different. Observe how the pleat (repeated using the ProcessGeo module) achieves a different form when the pleat radii vary while other pleat parameters are kept constant.

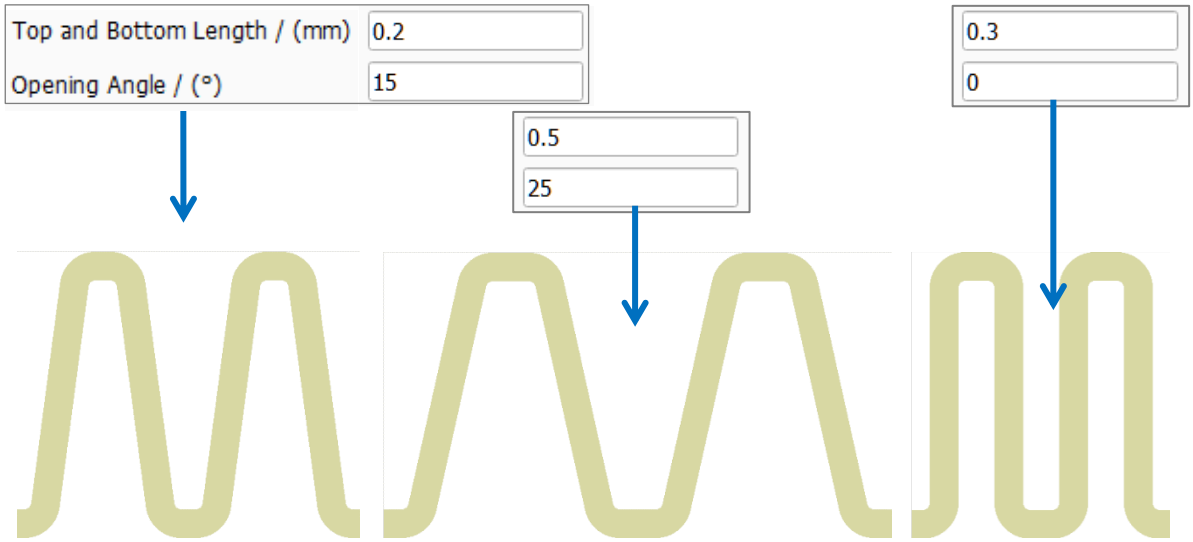


Pleat **Top and Bottom Length** controls the distance between two folds of the pleat medium in X-direction. A straight piece in the defined length is inserted both in the top and in the bottom crest.

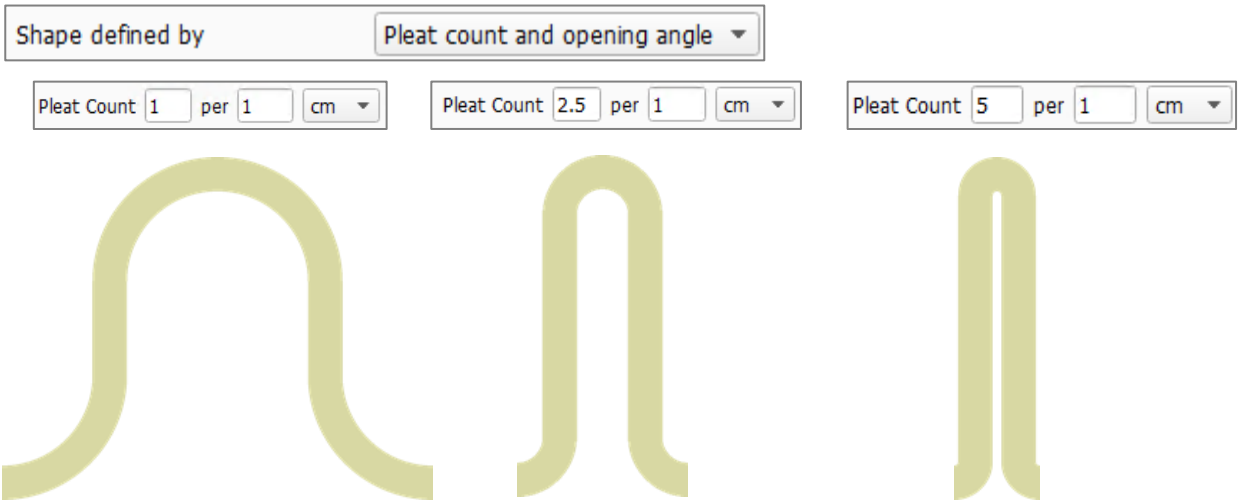
The **Opening Angle** determines the angle between the pleats in the ZY-plane.



Variations of the **Top and Bottom Length** and the **Opening Angle** allow many different pleat geometries.

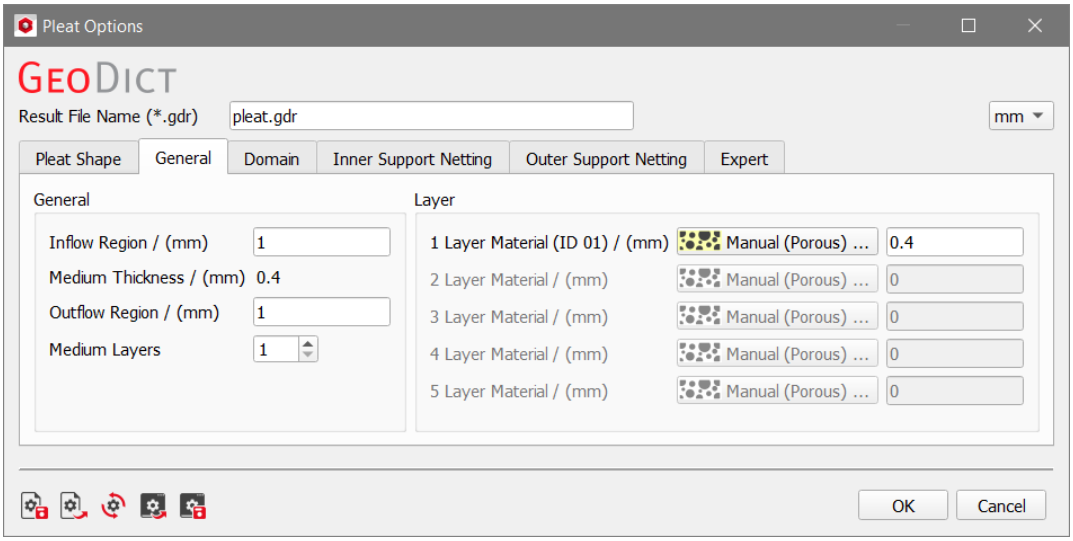


Pleat Count defines the number of pleats in the specified distance. The values for number and distance can be entered in the boxes. The available units are m, cm, or inch. Observe the variation in pleat shape for different pleat counts after selecting **Pleat count and opening angle** (for **Shape defined by**).



General parameters

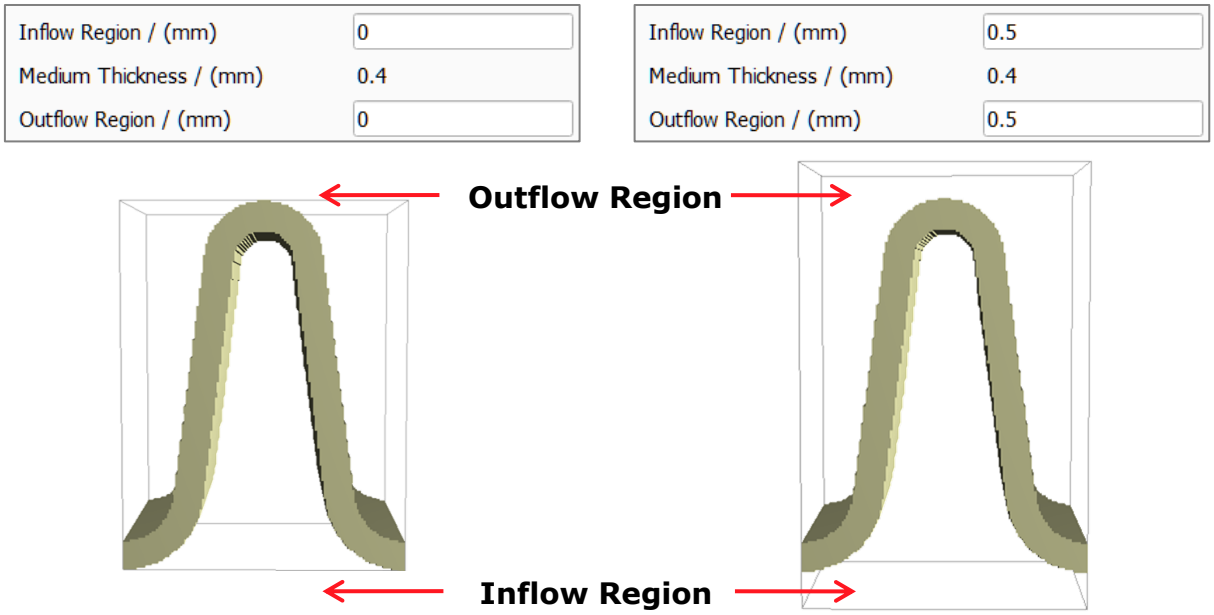
The general parameters are organized into the **General** panel and the **Layer** panel.



General

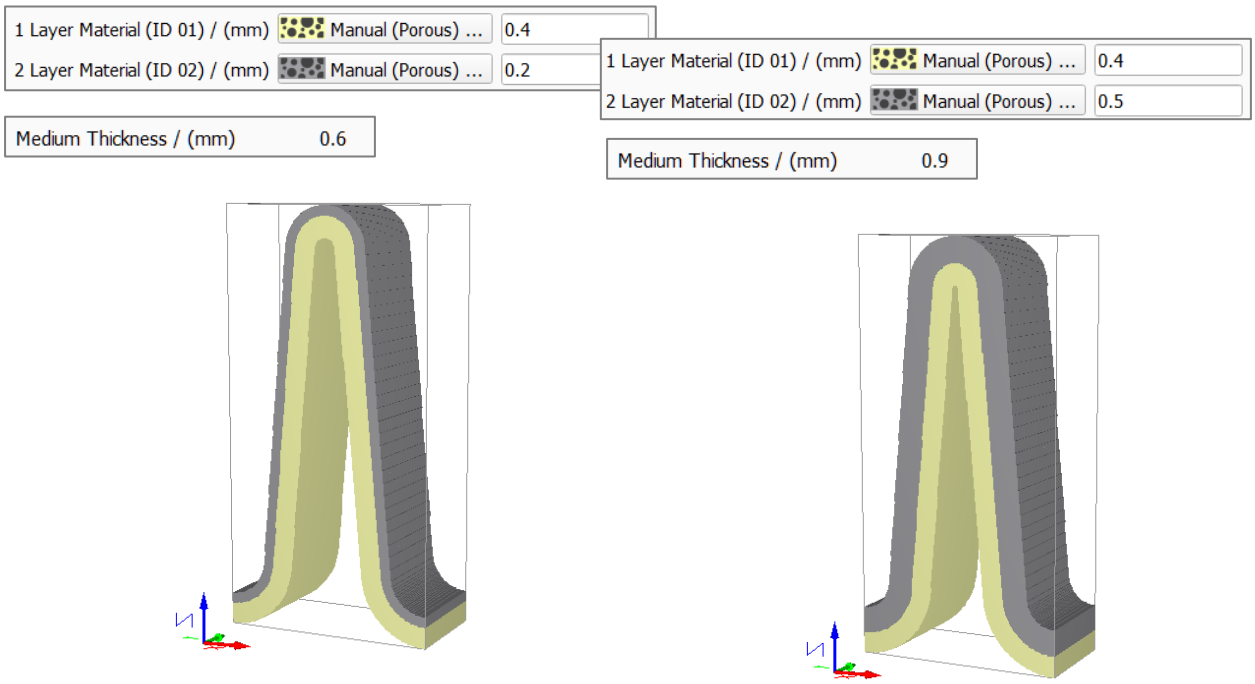
Inflow Region and **Outflow Region** of the pleat are the empty regions above and below the pleat in Z-direction.

The inflow region (large Z-values, high pressure region) and outflow region (small Z-values, low pressure region) should be chosen large enough so that the influence of boundary conditions in flow direction is reduced in flow simulations.

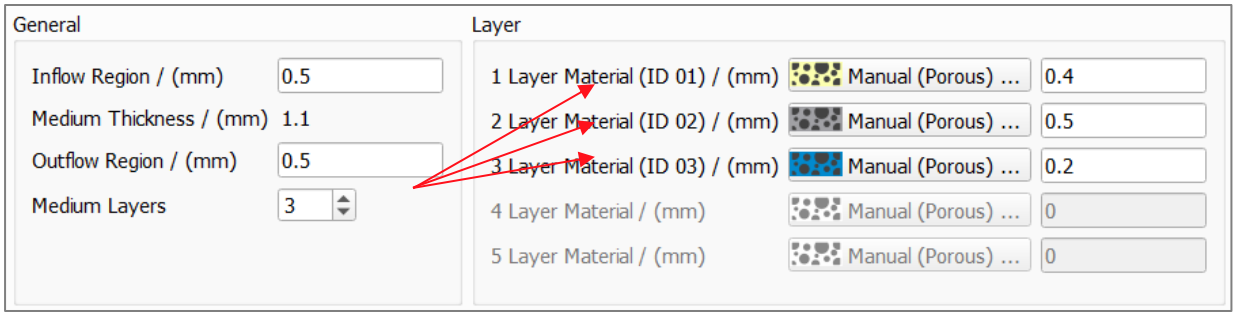


Medium Thickness defines the total thickness of the pleat medium and corresponds to the sum of the thickness of all layers.

The value of **Medium Thickness** changes automatically when modifying the thickness of the layers.

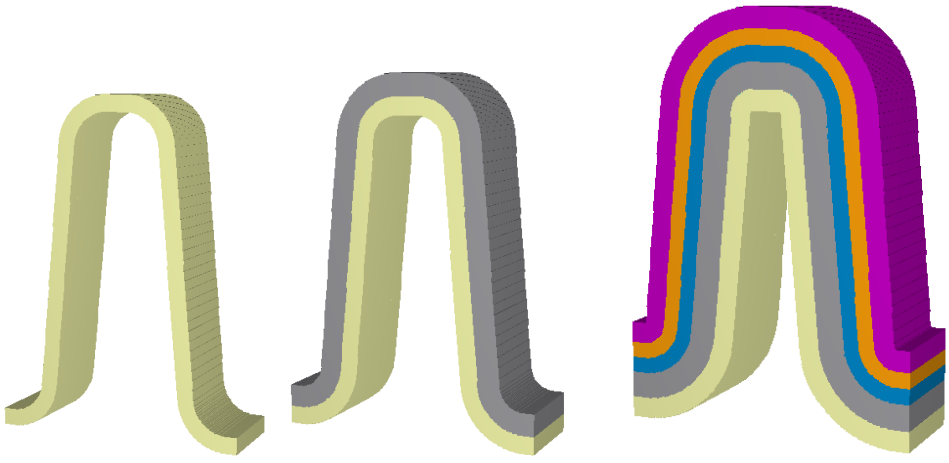


The value entered in **Medium Layers** determines the number of layers that form the pleat medium. Up to five layers of varying thickness may form the pleat.



LAYER

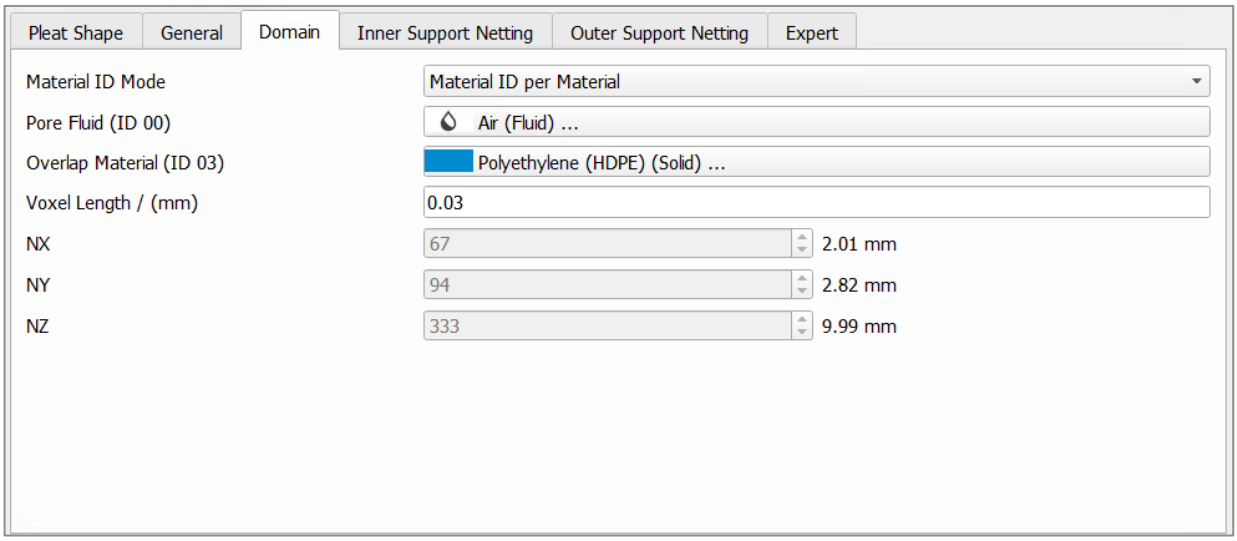
1, **2**, **3**, **4**, and **5 Layer Material** define material ID and the thickness of each layer material forming the pleat medium.

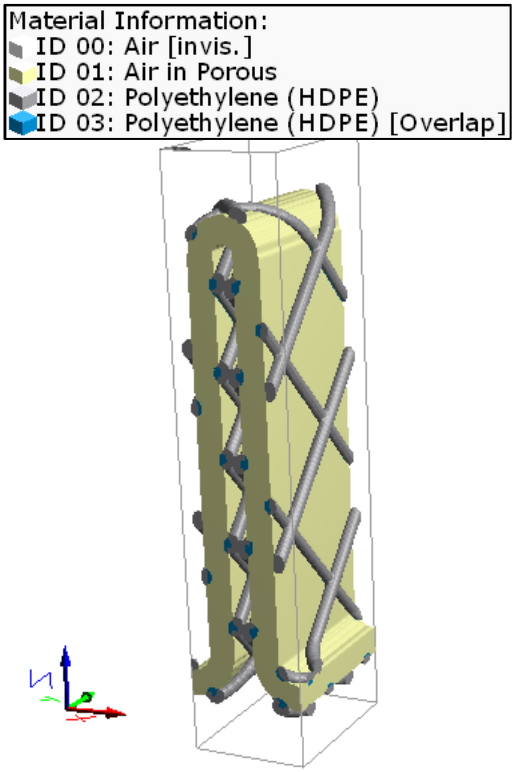


DOMAIN PARAMETERS

Material ID Mode allows choosing between:

- **Material ID per Material**: each constituent material gets a material ID
- **Material ID per Object-Type**: each object type gets a material ID.

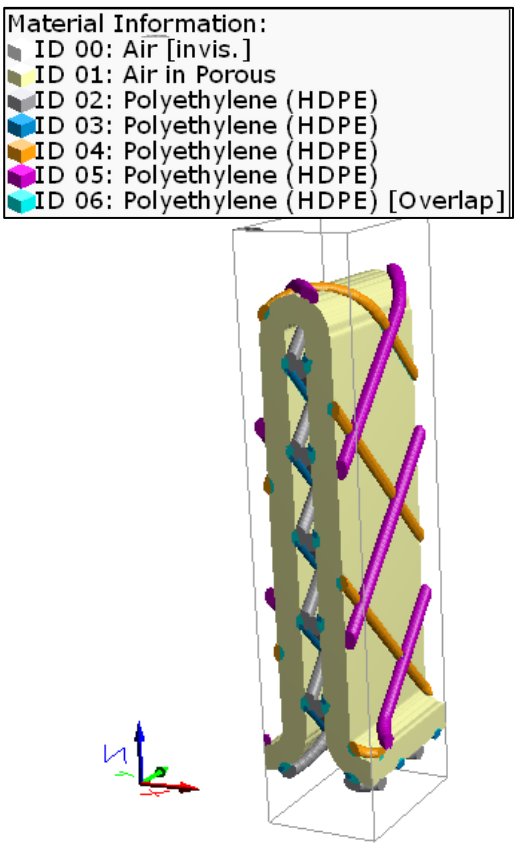




Here, **Material ID per Material** has been chosen to create a pleat with inner netting and outer netting.

The materials for the inner and outer nettings are the same. We obtain a pleat with the following Material IDs:

- ID 00 for air (invisible)
- ID 01 for the porous layer
- ID 02 for all netting material
- ID 03 for overlapping material

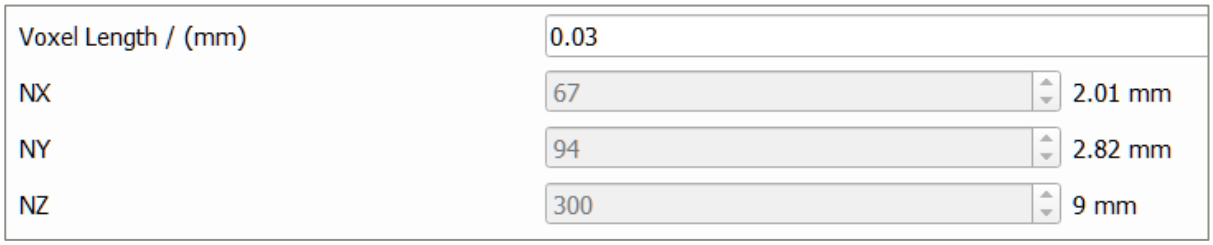


With **Material ID per Object-Type** chosen, more material IDs are present.

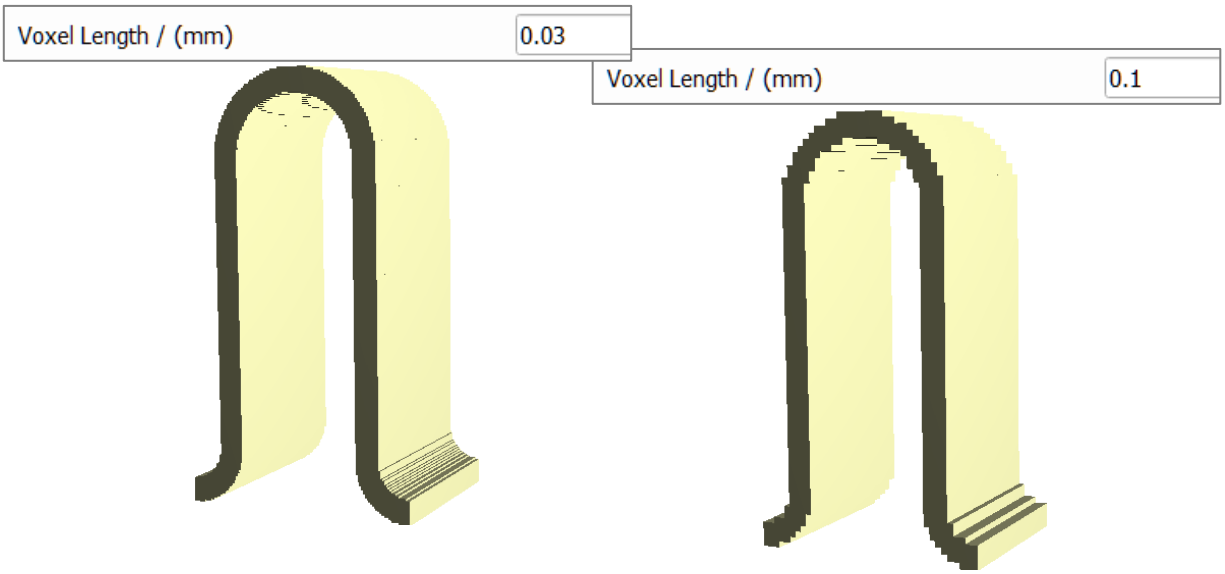
The pleat consists of the following Material IDs:

- ID 00 for air (invisible)
- ID 01 for the porous layer
- ID 02 for the inward wire of inner netting
- ID 03 for the outward wire of inner netting
- ID 04 for the inward wire of outer netting
- ID 05 for the outward wire of outer netting
- ID 06 for the overlap material.

The internal representation of a structure in GeoDict consists of rectangular 3D arrays of equally sized boxes, called volume elements or **Voxels**. The **Voxel Length** is the size of the voxels in the chosen units.



Low values for the **Voxel Length** result in a higher resolution but lead also to longer computational times.



The values for **NX**, **NY** and **NZ** indicate the number (N) of voxels in **X**, **Y** and **Z**-direction. Although it is possible to see the structure size values, they cannot be directly changed in the **Domain** panel.

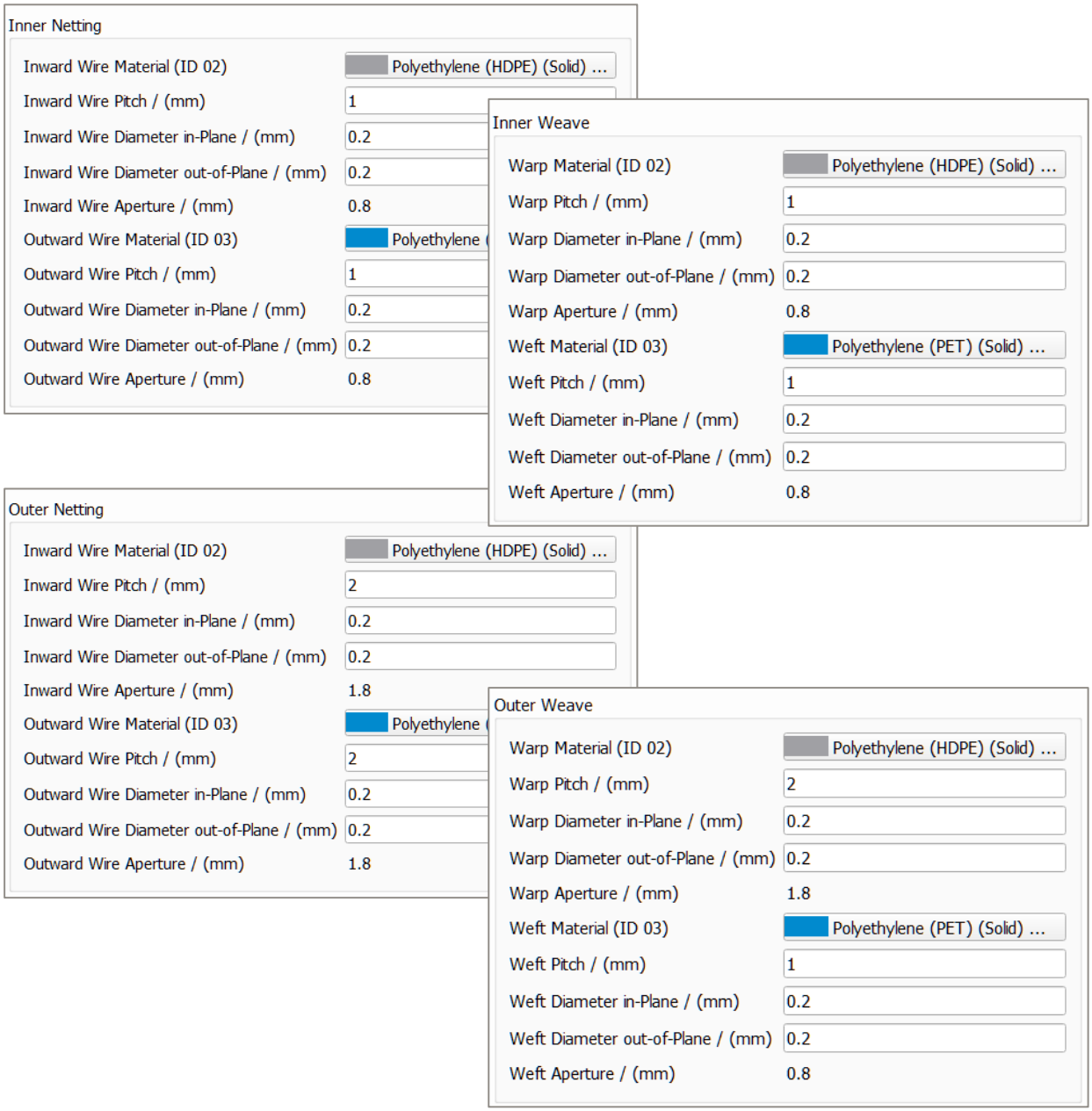
When entering a **Voxel Length**, the number of voxels corresponding to the pleat size in the three spatial dimensions (**NX**, **NY** and **NZ**) is calculated automatically, and displayed in the **Domain** panel. As a guideline, the smallest wire diameter and the media thickness should be resolved by at least 5 voxels.

Inner (and Outer) Support Netting and Weave parameters

After selecting **Inner Netting**, **Inner Weave**, **Outer Netting**, or **Outer Weave** from the pull-down menus in the **PleatGeo** section, two tabs appear in the **Pleat Options** dialog. In these tabs, you can enter the parameters for the supporting net or woven structures.

Inner (or Outer) Netting and Inner (or Outer) Weave

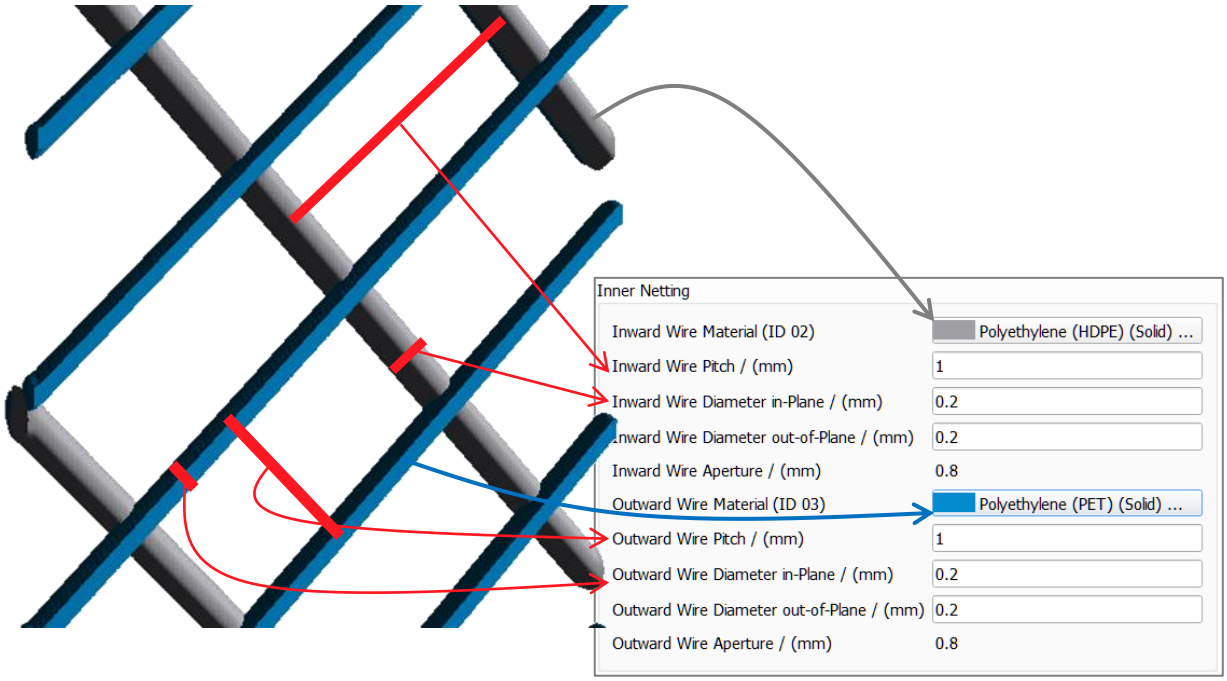
In the Inner or Outer Netting and/or the Inner or Outer Weave panels, click on the material button for the **Inward Wire Material**, **Outward Wire Material**, **Warp Material**, and **Weft Material** to select the desired material from the material data base .

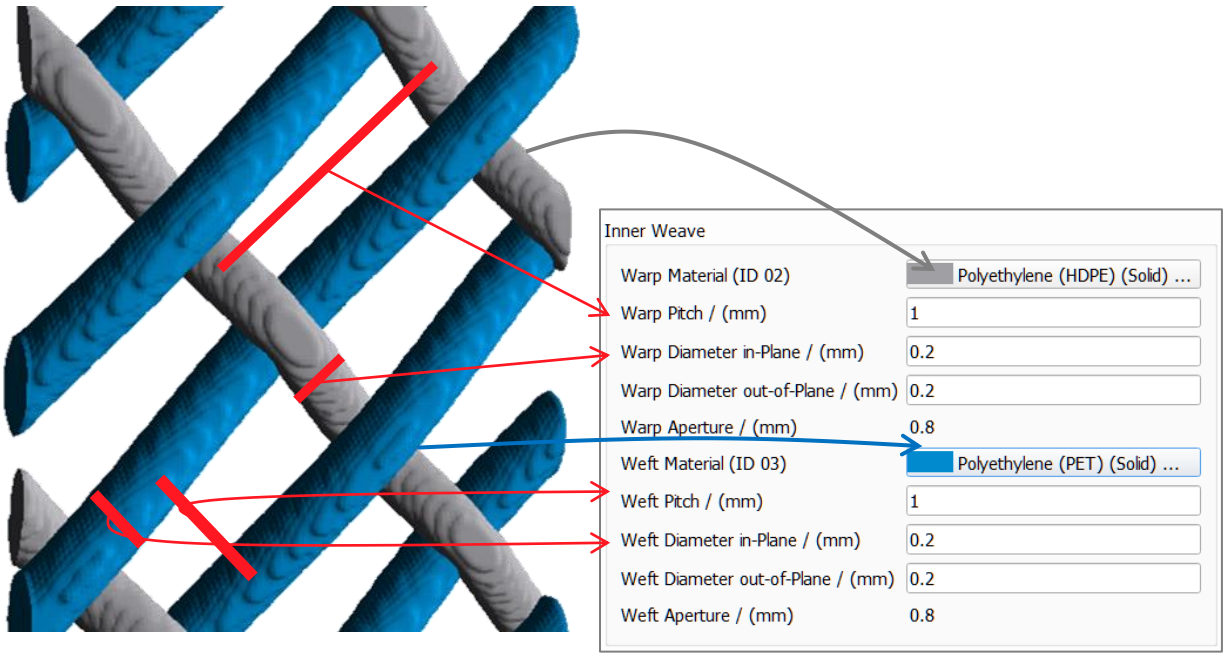


Inward Wire Pitch, **Outward Wire Pitch**, **Warp Pitch**, and **Weft Pitch** correspond, respectively, to the distance between the middle points (centers) of the inward wires, the outward wires, the warp wires, or the weft wires. The pitch is equivalent to the sum of the wire **Aperture** and the wire **Diameter in-Plane**.

Inward, outward, warp, and weft wires do not necessarily have a circular cross section. When the wires have an ellipsoid cross-section, one of the axes is oriented with the plane of the pleat (in-plane), while the other is perpendicular to the pleat and, therefore, out-of-plane. In mesh wire, **Diameter in-Plane** and **Diameter out-of-Plane** determines the wire thickness.

Inward Wire Aperture, **Outward Wire Aperture**, **Warp Aperture**, and **Weft Aperture** describe the distance between two neighboring wires, measured in the center of the aperture. The aperture is automatically calculated from the entered pitch and diameter in-Plane values.

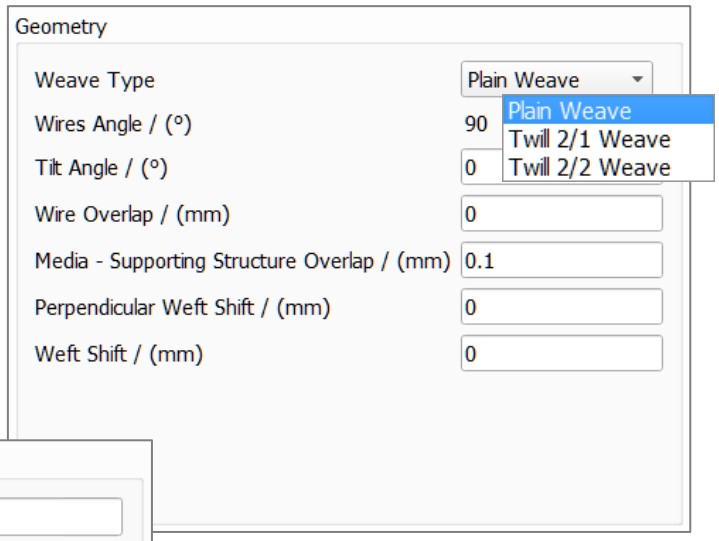


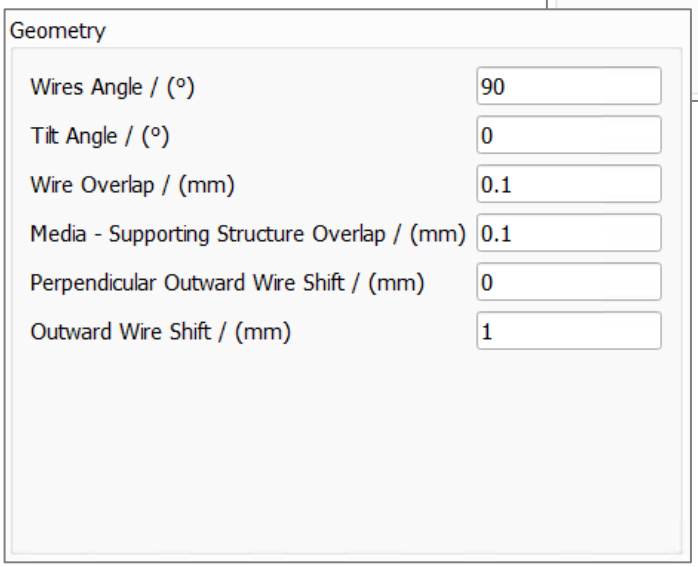


GEOMETRY

For **Inner Support Weave** or **Outer Support Weave**, one of the available **Weave Type**s can be chosen from the pull-down menu:

Plain Weave, Twill 2/1 Weave, or Twill 2/2 Weave. See the [WeaveGeo2022 handbook] for more information on weave types.

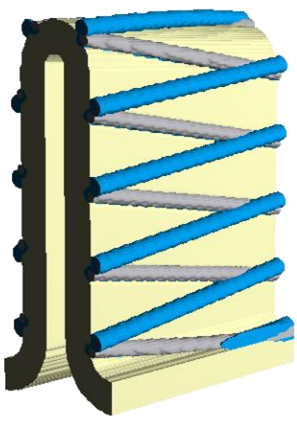


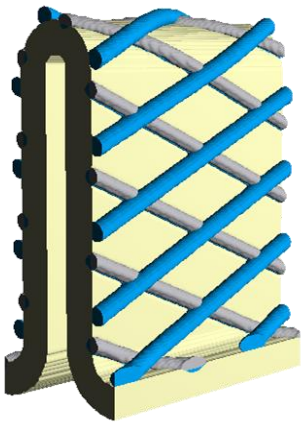


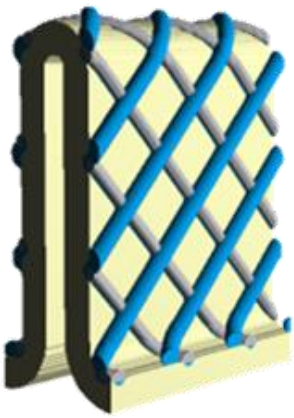
For **Inner Support Netting** or **Outer Support Netting**, **Wires Angle** is the angle between the inward and the outward wires or the warp and the weft wires.

The **Wires Angle** can only be chosen for support nettings, not for support weaves.

For weaves, the wires angle is always 90°.

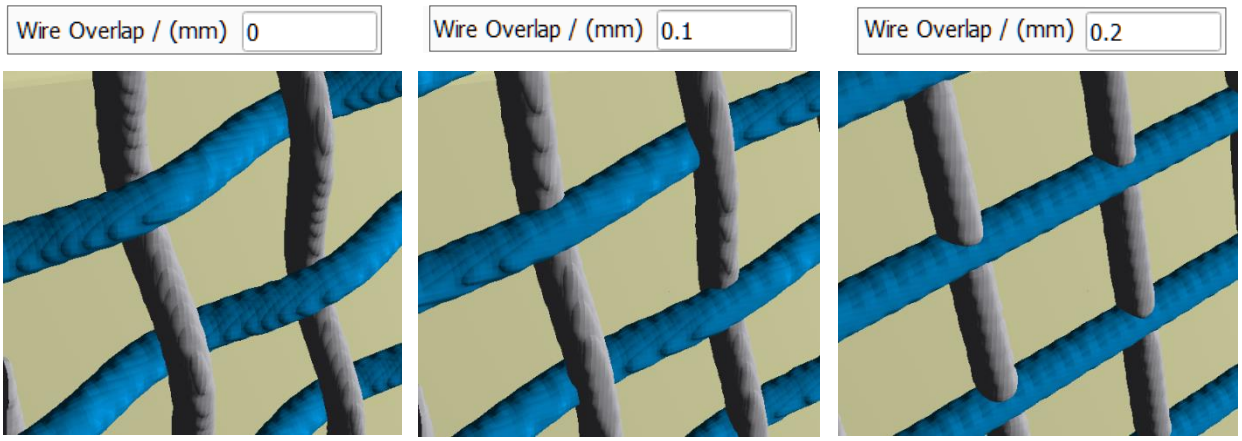




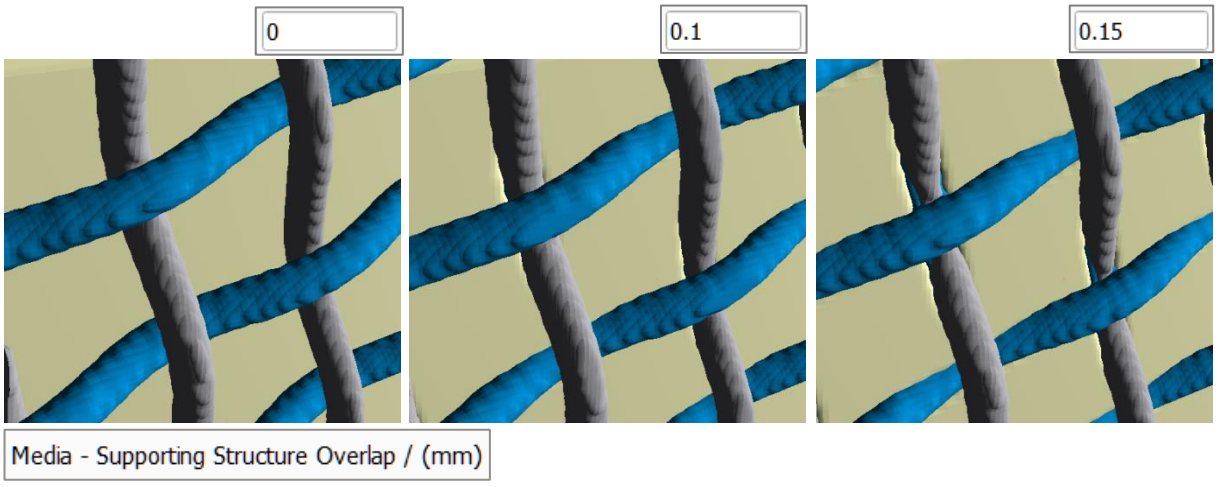


The netting or weave **Tilt Angle** is the angle of incline of the netting or the weave supporting structure with respect to the pleat medium along the pleat depth. The valid tilt angle values range from 0° to 45°.

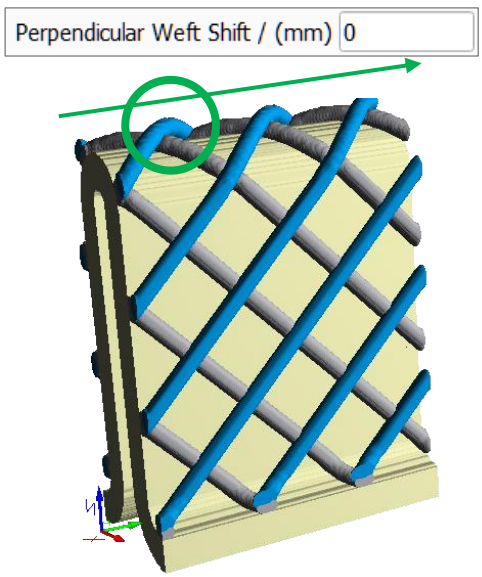
Wire Overlap establishes the percentage of overlap of the inward wire with the outward wire, or the warp wire with the weft wire. In the model, the wires of the netting (or weave) may be generated to partly cover each other to account for plastic deformations during the welding or the weaving. Observe how the warp and the weft wires increasingly overlap in the figure below.

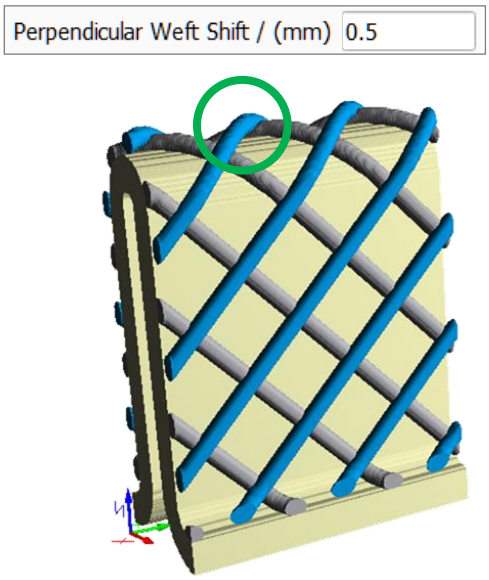


Media–Supporting Structure Overlap is the amount of overlap between the pleated media, and the netting or weave supporting structure. Observe how increasing the **Media–Supporting Structure Overlap** from 0 mm to 0.1 mm, and to 0.15 mm gradually embeds the support structure into the pleated media.



Perpendicular Outward Wire Shift and **Perpendicular Weft Shift** are, respectively, the shift of the outward wire and the weft wire on the pleat surface, perpendicular to the XZ plane, i.e. in Y-direction.

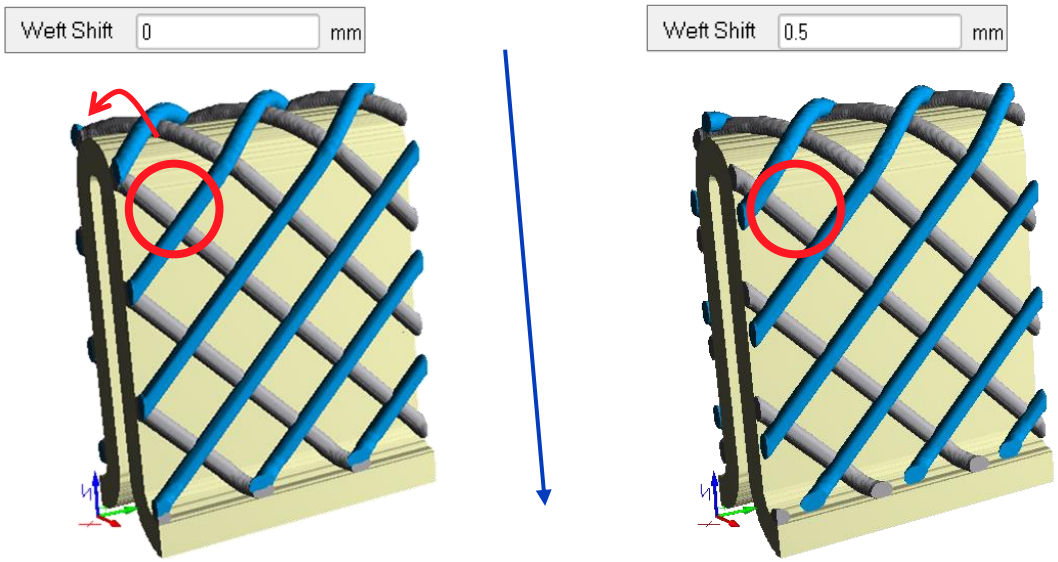




The shift in position of the blue weft wire along the Y-direction can be observed on the crest of the pleat when increasing the value of **Perpendicular Weft Shift**. The grey warp wires remain at the initial position.

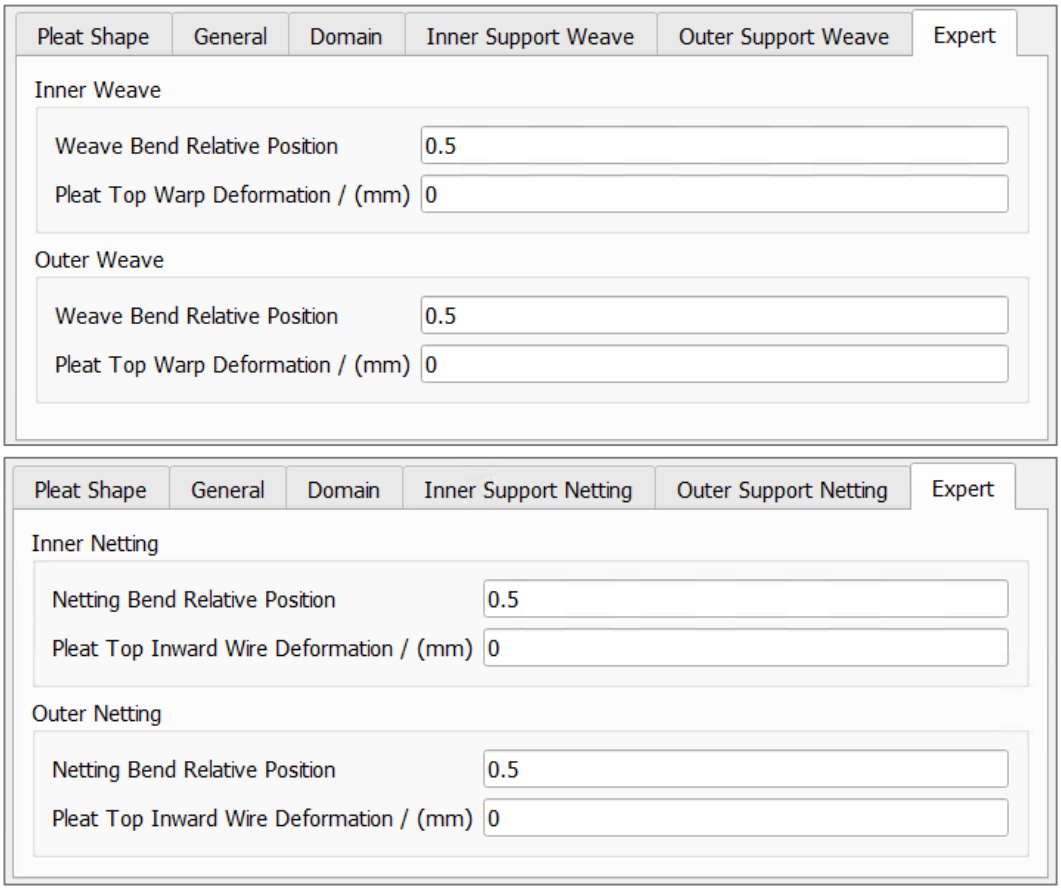
Outward Wire Shift and **Weft Shift** are, respectively, the shift of the outward wire and the weft wire on the pleat surface in the XZ-plane.

Observe how the blue weft wires shift in position along the crest of the pleat when setting the **Weft Shift** value to 0.5mm (half the weft pitch). The grey warp wires remain at the initial position.



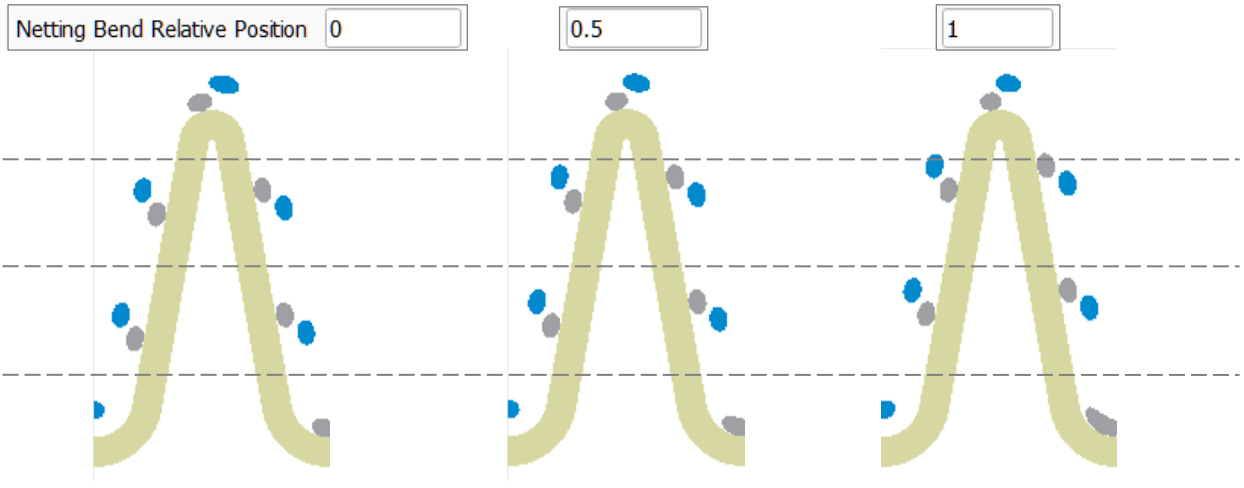
EXPERT PARAMETERS

The **Expert** tab is present in the **Pleat Options** dialog whenever the pleat has an inner or outer support structure. The expert tab may include panels for inner supporting structure parameters (netting or weave), for outer supporting structure parameters (netting or weave), or for both.



NETTING (OR WEAVE) BEND RELATIVE POSITION

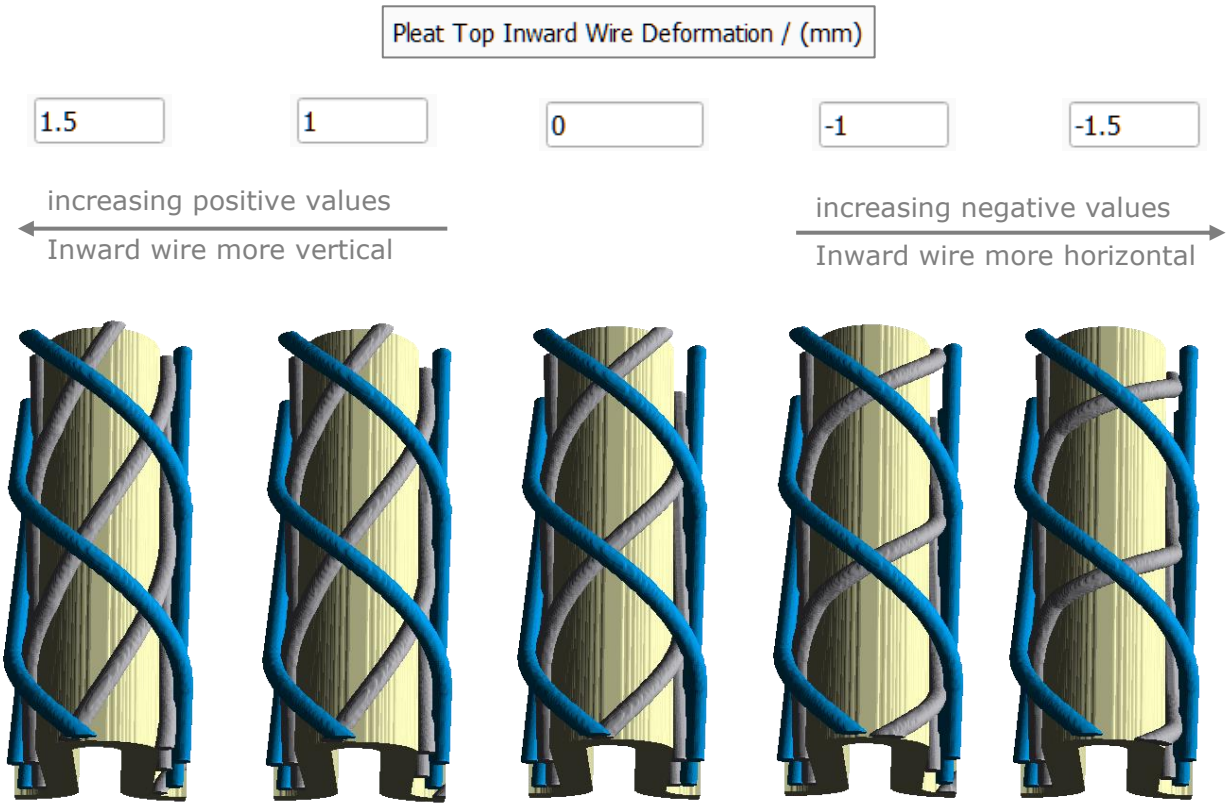
At the sharp folds of the pleat, the wires of the supporting structure kink and deform during the pleating process. The **Bend Relative Position** models the effect of this support structure deformation. The bending relative position value must be between 0 and 1. Observe how the wires of the outer netting structure glide up on the right- and the left-side of the pleat, with increasing values of **Bend Relative Position**.



Pleat Top Inward Wire (or Warp) Deformation

The **Pleat Top Inward wire (or Warp) Deformation** simulates the distortion of the inward or the warp wire at the crest of the pleat during welding (or weaving) in the pleating process. The deformation values can be positive or negative and are entered in the chosen length values.

The effect of the deformation can be observed in the following examples, where the Inward wire (grey) at the top of the pleat runs increasingly vertical with increasing positive values of **Pleat Top Inward Wire Deformation** or horizontal with increasing negative values of **Pleat Top Inward Wire Deformation**.



https://doi.org/10.30423/userguide.geodict2022-pleatgeo

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