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### Introduction

### **CATIA Composites**

Upon completion of this course, the student should have a full understanding of the following topics:

- Defining composite parameters
- Designing with the manual ply method
- Designing with the grid method
- Designing with the zones method
- Designing with the solid slicing method
- Generating solids and IML surfaces based off of zones or plies
- Analyzing and inspecting composite parts
- Creating manufacturing models
- Swapping definition surfaces and ply boundaries for manufacturing
- Creating flat patterns
- Splicing and darting plies
- Exporting ply definitions for ply nesting, cutting and laser projection
- Incorporating manufacturing modifications for automated fiber placement
- Creating ply books

### Composites

This course will cover all of the options found in the Composites Design and Composite Manufacturing Preparation workbenches. The first portion of the book will focus on the design options. The second portion of the book will delve into the manufacturing side of composite parts and how they will be created.

Please note that some additional environment variables have been activated for the Composites Design and Composite Manufacturing Preparation workbenches. These environment variables provide additional functionality and visualizations within the two workbenches. If these environment variables are not activated in your CATIA load, your workbenches may look slightly different.

### **Review Exercises**

This section will review the concepts and operations discussed in the previous sections of this manual.

### **Manual Ply Creation Review Exercise**

In this section, manual plies will be created to define a composite part. The plies for the first half of the laminate will be created manually. Next, the user will create the plies for the top half of the laminate by creating symmetric plies. Finally, the user will rename the plies using the interactive ply table.

**Open the COMP - Manual Ply Review model.** The model contains wireframe and surface geometry for the initial definition of the composite part.



# Select the Composite Parameters icon. I The *Composites Parameters* window appears.

omposites Parameters							?	×				
Materials	Directi	ons L	.aminate	s Ros	ettes	Master s	tacking	sequence	e Ran	mp Definitions		
Add Material Reroute Material Link							Remove	Vlaterial				
Material	Mat	Mat	Cur	Unc	War	Limi	Wei	Mat	Mat	Mat		
Material ID:									1	Material name :		
											ok (	Cancel

Select the Add Material button in the Materials tab. The selection pane appears.

In the Search field, key in <u>Carbon</u> and select Enter. The results appear.

16	Results	()
----	---------	----

	Actions	Title	Туре
1	$\sim$	PAC Plain Weave Carbon	Core Material
2	$\sim$	PAC Plain Weave Carbon	Covering Material
3	$\sim$	Carbon Fiber Cloth	Core Material
4	$\sim$	Carbon Fiber Cloth	Covering Material
5	$\sim$	Raytheon Carbon 45 Braid	Core Material
6	$\sim$	Raytheon Carbon 45 Braid	Covering Material
7	$\sim$	Carbon Fiber Cloth - 36"	Core Material
8	$\sim$	Carbon Fiber Cloth - 36"	Covering Material
9	$\sim$	Newport Carbon Cloth	Core Material
10	$\sim$	Newport Carbon Cloth	Covering Material
11	$\sim$	Raytheon Carbon 30 Braid	Core Material
12	$\sim$	Raytheon Carbon 30 Braid	Covering Material
13	$\sim$	Raytheon Carbon 60 Braid	Core Material
14	$\sim$	Raytheon Carbon 60 Braid	Covering Material
15	$\sim$	Carbon Fiber Cloth - 60"	Core Material
16	$\sim$	Carbon Fiber Cloth - 60"	Covering Material

**Select** *Carbon Fiber Cloth* **core material from the list.** You are returned to the *Composites Parameters* window. Only one material will be used in this exercise.

Select the *Rosettes* tab and select the *Add Rosette* button. The *Rosette Definition* window appears.

Rosette Definition		?	$\times$
Rosette name: Rosette.1			
Axis system: No selection	n		
Transfer Type			
Cartesian			
○ 0° guided by curve:	No selection		
O 90° guided by curve:	No selection		
O External		$\sim$	Edit
Previe	w Rosette Tranfer		
- 3D Display			
O Constant pixel size:	1	-	
Onstant model size:	39.37in	-	
	OK	Car	ncel

Select the axis system from the display to define the *Axis system* for the rosette. Adjust the size of the rosette and select *OK*. The rosette is created.

Select OK to the Composite Parameters window. The parameters are defined.

First a ply group will need to be created to define the location for the plies to be stored.

Select the Plies Group icon. The *Plies Group* window appears.

Plies Grou	p			?	$\times$	
Plies grou	up name Plies	Group.1				
Surface	No selection					
Draping direction Reverse Direction						
Rosette	Rosette.1				~	
Plane for	flatten :		No sele	ection		
□ For non structural plies						
🗌 Lock p	lies draping dir	ection				
		0	K	Car	ncel	

**Select the surface from the display to define the** *Surface* **option.** The draping direction should be pointing upwards.

Select *Rosette*.1 to define the *Rosette*.

Select OK. The plies group is created.

Now the plies will be created for the composite part.

**Select the Ply icon and select the** *Plies Group.1* **branch in the specification tree.** Stress *Ply Definition* window appears.

Ply Definition		? ×
Ply name: Ply	1	
Geometry	Attributes	Flatten
Contours		Curves of Contour.1
Contour.1		No selection
		Insert:  After O Before Remove X
Add Rem	ove Edit	Extrapol Distance: 0.008in
		OK Cancel

Select the curve in the display to define the contour. A green checkmark should appear in the window, specifying it is a closed contour.



Select the *Attributes* tab and set the *Material* to be *Carbon Fiber Cloth* and the *Direction* to be 0. This will define the first ply.

Select OK. The ply is created.



**Right select on** *Sequence.1* **in the specification tree and select** *Copy* **from the contextual menu.** 

**Right select on** *Plies Group.1* and select *Paste* from the contextual menu. A second sequence and ply has been created.



Notice the name of the ply matches the original ply. This will be fixed eventually. The new ply will use the same contour and the same attributes as the original. The attributes will also need to be adjusted eventually.

### Create three more copies as shown.



Select the Limit Contour icon. D The Limit Contour window appears.

Select Sequence.5 to define the Entity. This ply will be relimited.

Select the curve as shown to define the *Relimiting Curve*.



**Be sure the arrow is pointing towards the lower portion of the surface and select** *OK***.** This specifies the lower side of the ply will be kept.

The ply should appear as shown now.



Now the attributes of the plies need to be updated.

**Select the Stacking Management icon.** It is located in the *Review* section. The *Stacking Management* window appears. You may have to adjust the options in the *Column* button to get the window to appear exactly the same.

Stackir	ng management							?	×
Entit O Pli	ty Level es Group 💿 Seque	ence O Ply O	Cut Piece	Display Filt Columns	ers Rows O ON O	OFF 🔶	Check Contours     BD Contours Full C	heck	
	Plies Group	Sequence	Ply/Core	Material ID	Orientation Name	Rosette	Surface		^
1	Plies Group.1	Sequence.1	Ply.1	Carbon Fiber Cloth	0	Rosette.1	Base Laminate Surface		
2	Plies Group.1	Sequence.2	Ply.1	Carbon Fiber Cloth	0	Rosette.1	Base Laminate Surface		
3	Plies Group.1	Sequence.3	Ply.1	Carbon Fiber Cloth	0	Rosette.1	Base Laminate Surface		
4	Plies Group.1	Sequence.4	Ply.1	Carbon Fiber Cloth	0	Rosette.1	Base Laminate Surface		
5	Plies Group.1	Sequence.5	Ply.1	Carbon Fiber Cloth	0	Rosette.1	Base Laminate Surface		
									~
<									>
5	C	🗌 Entity P	review	_ <b></b>					
							OK	Car	ncel

Modify the *Orientation Name* for each ply as shown. You will use the Multiple Row Edition icon or the contextual menu.

Sequence	Ply/Core	Material ID	Orientation Name
Sequence.1	Ply.1	Carbon Fiber Cloth	0
Sequence.2	Ply.1	Carbon Fiber Cloth	45
Sequence.3	Ply.1	Carbon Fiber Cloth	
Sequence.4	Ply.1	Carbon Fiber Cloth	-45
Sequence.5	Ply.1	Carbon Fiber Cloth	

Select OK. This defines the bottom half of the laminate.

Now the plies will be symmetried to create the other half of the laminate.

Select the Symmetric Plies Stacking icon. The *Ply Symmetry* window appears.

Sym	-		$\times$
Selection	:		
O Pivot	O No	n pivot	
	ОK	Ca	ncel

Select the *Plies Group.1* to define the *Selection* for the operation.

Be sure the *Non pivot* option is selected and select *OK*. The plies are symmetried as shown.



Now the names of the plies need to be fixed.

Select the Stacking Management icon. The *Stacking Management* window appears.

Select the *Ply* option for the *Entity Level* and select all of the plies in the window. You will want to use the Shift key.

**Right select on the selected plies in the window and select** *Multiple Row Edition*. The *Rows Edition* window appears.

In the *Rename* section, set the *Name* to be <u>PLY-</u> and the *Nb of Digits* to be 3 as shown.

Row(s) edition	?	×
Properties         Material ID:       Carbon Fiber Cloth       Orientation Name:       V       Rosette:       Rosette:       TRUE         Modifications of properties will be applied to all Cut Pieces contained in the selected Ply(ies).       TRUE		~
Rename       Name       PLY-       OK	Digits: 3	:el )

Select OK. The plies are renamed as shown.

Sequence	Ply/Core
Sequence.1	PLY-001
Sequence.2	PLY-002
Sequence.3	PLY-003
Sequence.4	PLY-004
Sequence.5	PLY-005
Sequence.6	PLY-006
Sequence.7	PLY-007
Sequence.8	PLY-008
Sequence.9	PLY-009
Sequence.10	PLY-010

Select OK. The laminate is finished. Now we will take a quick look at the cross section.

Select the Plies Section ic	on. 述 The Plies Sectio	n window appears.
	Plies Section ?	×
	<ul> <li>Section plies from</li> <li>Complete Stacking</li> <li>Selection of groups</li> </ul>	
	- Sectioning planes or curves -	
	No selection	
	Remove	
	Section type	
	Display type	
	Options	
	Scale factor 1	<b></b>
	Din	-
	Keep core position	
	Apply scale to cores	
	OK Apply	Cancel

Select the *Complete Stacking* option.

Select the Cross Section Plane from Geometrical Set.1 to define the Sectioning planes or curves.

Select the Realistic and Surfacic types.

Set the Scale factor to be 2 and select OK. The cross section should appear as shown.



Notice the laminate is completely symmetric. This provides an easy method for creating a very simple layup of plies without having to use an advanced design method. Keep in mind that if you wanted to have any staggering in the plies that are dropped off, you would have to create wireframe curves to be able to manually select the shape of each ply. For this reason, this method only works well for pretty simple laminates.

### Save and close the document.

### **Composite Grid Design Review**

This exercise will review the grid design method in more of a process based manner.

**Open the COMP - Grid Design Review document.** The model contains a surface and wireframe elements.



Select the Composites Parameters icon. E The *Composites Parameters* window appears.

Define Graphite Unitape for the material.

Create a rosette using the axis system in the display.

Select *OK* to finalize the parameters.

Select the Grid Panel icon and define the *Surface* option with the surface in the display. Select *Rosette.1* for the *Rosette.* Be sure the *Draping direction* is pointing upward.

Next, the reference elements will be defined with the necessary default offsets and staggering.

The following picture explains how the plies should eventually drop off. Three different drop off values will be used: 0.25in, 0.375in and 0.5in. In this case, a default drop off will be set to begin with for all reference elements and then eventually the individual reference elements will be modified to obtain the correct drop offs at each location.



Select all of the curves from the display as shown to define the first reference element group. The curves could be split into multiple reference element groups if necessary. In this case, only one group will be used.



Edit the group and create a new ramp definition with the *Offset* set to 0 and the *Step* set to 0.25 for both the positive and negative directions. This will not work for all of the ply drops, but since it is the most common for this model, it will be used as the default. The other drops will be individually modified later. The window should appear as shown.

Ramp def+	Ramp def-	Add
0in / 0.25in	0in / 0.25in	Edit
	Ramp def+ 0in / 0.25in	Ramp def+Ramp def-0in / 0.25in0in / 0.25in

Select OK. The grid panel definition is completed.

**Select the Grid icon.** The *Grid Definition* window appears. The computed cells should appear in the display as well. Keep in mind the cell names may be different based on the order the reference elements were selected in. This shouldn't matter.



First, the cells that will be a common thickness will be merged together to simplify the panel definition. Keep in mind this is typically not recommended. Leaving the cells in their default definition will yield more robustness to the design.

Merge the cells together as shown to define the three constant thickness areas. Keep in mind that your cell names may not match.



Select the cell as shown and select the *Edit* button. The name and stacking sequence for the cell will be modified.



The Cell Definition window appears.

Cell Definit	ion		?	×
Cell name: Cell Cont Version	C1 our Definition			
Laminate	e			
Laminate	<none></none>		~ Nev	N
Stacking				
		ОК		ancel

Change the *Cell name* to be <u>9 Ply Zone</u> and select the *New* button for the *Laminate* option. The *Laminate* window appears.

Laminate				?	$\times$
Name: Laminate.1 Color:	2	√ (color	· #1)		
Material :				$\sim$	
Orientation :				$\sim$	Add
Material	Orienta	tion			
Symmetry :  None	: O Pivo	ot <b>O</b> No	ın Pivo	t	Ţ
Thickness law:					
~	0 🌻	0 🌲	0	÷ 0	-
	0	45	-45	90	
	1	0	ĸ	Ca	ancel

Change the *Name* to be <u>LAM001</u> and select the *Stacking sequence* option.

Set the *Material* drop down to be *Graphite Unitape* and the *Orientation* to be 0 and select the *Add* button. The first ply will be a 0 degree ply.

Stacking set	equence	s		
Material :	Graphit	e Unitape	~	
Orientation :	0		~	Add
Material		Orientation		仓
Graphite Uni	tape	0		л

Change the *Orientation* to be 45 and select the *Add* button again. The second ply is defined.

Stacking s	equence	:				
Material :	Graphit	Graphite Unitape 🛛 🗸 🗸				
Orientation :	45		~	Add		
Material		Orientation		Ŷ		
Graphite Uni	tape	0				
Graphite Uni	tape	45				

Define three more plies as shown. This will complete half of the laminate.

Stacking set	equenc	e:		
Material :	Graph	ite Unitape	~	
Orientation :	0		~	Add
Material		Orientation		1
Graphite Uni	tape	0		
Graphite Uni	tape	45		
Graphite Uni	tape	90		
Graphite Uni	tape	-45		
Graphite Uni	tape	0		

**Set the** *Symmetry* **option to be** *Pivot***.** The final 0 degree ply will be the center of the laminate. The stacking should appear as shown.

Material :	Graphi	te Unitape	~	
Orientation :	0		~	Add
Material		Orientation		Ŷ
Graphite Uni	tape	0		л
Graphite Uni	tape	45		~
Graphite Unitape		90		
Graphite Uni	tape	-45		
Graphite Uni	tape	0		
Graphite Uni	itape	-45		Ī
Graphite Uni	itape	90		
Graphite Uni	itape	45		
Graphite Uni	tape	0		_
	_			

**Select** *OK.* This defines the thickness law as well as the actual order of the stacking for constant area. The *Cell Definition* should appear as shown.

Cell Definit	ion	?	$\times$
Cell name: Cell Cont Version	9 Ply Zone our Definition ice O Modified		
Laminate	LAM001	New	
Stacking	SS:0,45,90,-45,0,-45,90,45,0		, 
	ОК	Car	ncel

Select OK.

The cell should appear as shown.



Select the center cell and select the *Edit* button. The *Cell Definition* window appears.

Change the *Cell name* to be <u>7 Ply Zone</u>.

Create a new laminate called <u>LAM002</u> with the following stackup.

Material :	Graphi	te Unitape	~	
Orientation :	0		~	Add
Material		Orientation		Ŷ
Graphite Uni	tape	0		
Graphite Uni	tape	45		~
Graphite Uni	tape	90		
Graphite Uni	tape	0		
Graphite Uni	tape	90		
Graphite Uni	tape	45		
Graphite Uni	tape	0		
				_

Select OK. The cell should appear as shown.



Set the name of the final cell to be <u>5 Ply Zone</u> with a new laminate called <u>LAM003</u> with the following stackup.

Material :	Graph	ite Unitape	~	
Orientation :	0		~	Add
Material		Orientation		1
Graphite Unit	tape	0		
Graphite Unit	tape	90		~
Graphite Unit	tape	0		
				_
Graphite Uni	tape	90		
Graphite Uni	tape	0		

Set the *3D text labels* to display the *Cells name* and *Thickness law*. The panel should appear as shown.



Select the *Reference* option under *Import/Export Management* and select the Browse icon for the *Export to file* option. A *File Selection* window appears.

Browse to your area, key in <u>SS Export</u> for the *File name* and select *Open*. This will define where to create the spreadsheet.

Select the *Export* button. The file is created.

#### Open the file from your area. It should appear as shown.

	А	В	С	D	E	F	G	н	1	J	K	L
1	Cells	Laminate	1	2	3	4	5	6	7	8		
2	9 Ply Zone	LAM001	Grid Refer	Grid Refe	Grid Refe	rence Elem	ent.2					
3	7 Ply Zone	LAM002	Grid Refer	Grid Refe	rence Elem	nent.4						
4	5 Ply Zone	LAM003	Grid Refer	Grid Refe	rence Elem	nent.5						
5	#											
6	Name	LAM001										
7	ColorIdx	1										
8	Туре	SS										
9	Stacking											
10	Graphite Unitape	0										
11	Graphite Unitape	45										
12	Graphite Unitape	90										
13	Graphite Unitape	-45										
14	Graphite Unitape	0										
15	Graphite Unitape	-45										
16	Graphite Unitape	90										
17	Graphite Unitape	45										
18	Graphite Unitape	0										
19	#											
20	Name	LAM002										
21	ColorIdx	2										
22	Туре	SS										
23	Stacking											
24	Graphite Unitape	0										
25	Graphite Unitape	45										
26	Graphite Unitape	90										
27	Graphite Unitape	0										
28	Graphite Unitape	90										
29	Graphite Unitape	45										
30	Graphite Unitape	0										
31	#											
32	Name	LAM003										
33	Coloridx	3										
34	Туре	SS										
35	Stacking											
36	Graphite Unitape	0										
37	Graphite Unitape	90										
38	Graphite Unitape	0										
39	Graphite Unitape	90										
40	Graphite Unitape	0										
	1											

This is the format for using the stacking sequence option rather than the thickness law. In this case, the full stacking sequence definition was defined in CATIA so the spreadsheet may not really be necessary. However, the spreadsheet could be used to make changes in the future.

Close the spreadsheet. You should be back to the *Grid Definition* window in CATIA.

Select OK. The grid definition is created.

# **Select the Virtual Stacking icon and select** *Grid.1* **from the tree.** The *Virtual Stacking Management* window appears.

Virtua	l Stacking									?	×
Ent O Se I PI	ity level equence y O	View moo Cells Stacking	g areas	Review	₽	Symmetry	r Management mmetry Reor sh Au	der plies from seq tomatic refresh	Columns Management Prevent Auto Computation Reorder	Preview	
	Sequence	Ply	Material	Rosette	9 Ply Zone	7 Ply Zone	5 Ply Zone				^
1	Seq.1	Ply.1	Graphite Unitape	Rosette.1	0	0	0				
2	Seq.2	Ply.2	Graphite Unitape	Rosette.1	45	45					
3	Seq.3	Ply.3	Graphite Unitape	Rosette.1	90	90	90				
4	Seq.4	Ply.4	Graphite Unitape	Rosette.1	-45						
5	Seq.5	Ply.5	Graphite Unitape	Rosette.1	0	0	0				
6	Seq.6	Ply.6	Graphite Unitape	Rosette.1	-45						
7	Seq.7	Ply.7	Graphite Unitape	Rosette.1	90		90				
8	Seq.8	Ply.8	Graphite Unitape	Rosette.1	45	45					
9	Seq.9	Ply.9	Graphite Unitape	Rosette.1	0	0	0				
											~
<											>
5	C		🗹 Display 3D	Information	Options	🗌 Dis	play Info Table	2			
										M	ore
									ОК	Can	icel

Since the stacking sequences were already defined for the cells, it is not necessary to rearrange the rows in this window. If any changes were needed, they could be made though.

Select OK. Now you are ready to create the plies.

Select the Plies From Virtual Stacking icon. The *Plies Creation* window appears.

Select the Minimum Crossing & Weight Savings algorithm and the *Backslash* pattern and select *OK*. The plies are created.

Hide the *Grid.1* and *Grid Virtual Stacking.1* and show the grid ramp supports in the tree. The plies should appear as shown.



Most of the drop offs are correct, but a few need to be modified to have the correct staggering. Fortunately, the original grid panel definition can be modified and the plies will automatically update.

Double select on *Grid Panel.1* from the tree. The *Panel Definition* window appears.

**Select the reference group and select** *Parallel.***7 in the window.** It should highlight as shown in the display.



This curve should have a drop off staggering of 0.375 in the negative X direction instead of 0.25. This will be fixed now.

Select the *Edit* button in the *Structural elements* area. The *Staggering Definition* window appears for the curve.

# Turn off the *Same on both sides* option and create a new ramp definition for the positive side.

Set the Step to be 0.375 for the new ramp support. It should appear as shown.



Select OK. Notice the representation in the display updates.



Change the ramp definition for *Parallel.6* to use the 0in / 0.375in ramp definition in **both directions.** You can simply select the 0in / 0.375in ramp definition from the drop down to reuse the one you just created.

Reference Element definition Grid Reference Elements.4	?	×
Name: Grid Reference Elements.4 Surface: Laminate Surface		
Geometry: Parallel.6 Reverse Direction		
Default ramp Definitions: 🛛 Same on both sides		
Side +: 0in / 0.375in Vew Side -: 0in / 0.25in	$\sim$ N	ewv
Sub-Stag <sub>0in</sub> / 0.25in		
3D Visu N 0in / 0.375in king Drops O Combination of Both O Mir	nimal	
ОК	Can	cel

Select OK. The representation should update in the display.



Select OK.

Select the Update icon. The plies should update. The final ply manipulation will require a new grid ramp support.

## Select the Grid Ramp Support icon.

Select the curve as shown. The *Grid Ramp Support* window appears.



**Select the** *Side* + **option and set the** *Curves count* **to be 3.** This specifies which side of the reference element and the number of curves to be created.

**Select the** *Override reference element spec with* **option and select the** *New* **button.** The *Ramp Definition* appears.

### Change the *Step* to be 0.5 and select *OK*.

Select OK. The new grid ramp supports are created.



Use the Swap Edge icon to modify the plies as shown.



This should have all of the ply drops in the correct direction and with the correct staggering.





**Explode the plies with the Shell Constant Offset option and a** *Scale* **of 10.** They should appear as shown. The plies should be symmetric.



Remove the exploded surfaces and save and close the document.

Now the producibility optimization option will be investigated.

### **Open the COMP - Producibility Optimization document.** It should appear as shown.



Select the Producibility for Hand Layup icon. The *Producibility for Hand Layup* window appears.

Select the first ply in the tree and select the *Optimize* button next to the *Seed point* **definition**. The *Optimization* window appears.

Optimization				?	×
Variable	Objective	Method	Settings		
Seed point	Shearing angle - Weighted	Equally Spaced	Target num po	ints= 50	
			OK	Cano	el

*Variable* Specifies whether the seed point locations for the selected plies can vary

*Objective* Specifies the optimization criteria: Mean Absolute, Weighted or Greatest for the shearing angle

- CATIA Composites Method Specifies the method for distributing points over the ply area
- Specifies the number of points to be analyzed over the ply during the Settings optimization

Select Shearing angle - Weighted in the window, then right select on it. The contextual menu will appear as shown.

Optimization					?	×
Variable	Objective	2	Method	Settings		
Seed point	Shear	<u>S</u> hearing angle - N S <u>h</u> earing angle - V Sh <u>e</u> aring angle - G	/ean Absolute Veighted ireatest	0ł	im points=5	ancel

This is how you can edit the various options for the optimization.

Right select under the Settings column and select Edit. The Optimization Settings window appears. This would allow you to modify the number of points to be included in the optimization.

Optimization S	?	×
Parameter Target num points	Value 50	
	Cano	el

### Select Cancel.

Select OK. The optimization is run. You may get a Diagnostic List window which you may close.

The display should appear as shown.



Notice 50 locations were analyzed for producibility. The location yielding the lowest maximum shearing angle was selected.

Select the *Results* tab and turn on the *Statistics* option. The *Producibility Statistics* window appears. Note, the values may differ if you aren't using *CFM Optimized Energy*.

Producibility Statistics			?	$\times$
Result	Minimum	Mean	Maximum	
Shearing Angle				
Mean Absolute		0.1516		
Mean		0.1516		
Weighted	0.765125		24.0844	
Greatest	0.195325		27.8388	
Deviation				
Mean Absolute		25.1456		
Mean		9.07862		
Weighted	-82.1716		67.3494	
Greatest	<b>e</b> -89.1384		<b>75.0825</b>	
			Clo	se

Notice the maximum shearing angle for the weighted computation is 24.1 degrees.

The values next to the other locations in the display correspond to what the maximum shearing angle for the weighted computation would be if the seed point were positioned at each location.

### Close the Producibility Statistics window.

Select Preview. The producibility should appear as shown.



Feel free to select any of the other locations and preview their results.

**Select** *Cancel* **when you are done.** The producibility will be computed and optimized for all plies now.

Select the Edit Producibility Table icon. The *Edit Producibility Table* window appears.

D	Plies Group	Sequence	Ply	Cut Piece	Producibility	Active	Method	Propagation	Seed Point	Thk. Offset	Result	Max. Shear	Max. Dev.	
	Top Plies Group	SEQ-TOP-01	PLY-TOP-01											
		SEQ-TOP-02	PLY-TOP-02											
		SEQ-TOP-03	PLY-TOP-03											
ŧ.		SEQ-TOP-04	PLY-TOP-04											
5		SEQ-TOP-05	PLY-TOP-05											
5		SEQ-TOP-06	PLY-TOP-06											
		SEQ-TOP-07	PLY-TOP-07											
Δ	tions									Mat	erial Pro	perties		

Select all of the plies in the window. You may use the Shift key.

Select the Producibility for Hand Layup icon in the window. Nany of the columns in the window will populate.

Pro	oducibility Compo	onents												
ID	Plies Group	Sequence	Ply	Cut Piece	Producibility	Active	Method	Propagation	Seed Point	Thk. Offset	Result	Max. Shear	Max. Dev.	
	Top Plies Group	SEQ-TOP-01	PLY-TOP-01		Producibilit	<u> </u>	Hand L	CFM Optim	Automatic					
2		SEQ-TOP-02	PLY-TOP-02		Producibilit	۶∼	Hand L	CFM Optim	Automatic					
;		SEQ-TOP-03	PLY-TOP-03		Producibilit	۶≁	Hand L	CFM Optim	Automatic					
ļ		SEQ-TOP-04	PLY-TOP-04		Producibilit	<u> </u>	Hand L	CFM Optim	Automatic					
		SEQ-TOP-05	PLY-TOP-05		Producibilit	۶≁	Hand L	CFM Optim	Automatic					
		SEQ-TOP-06	PLY-TOP-06		Producibilit	<u> </u>	Hand L	CFM Optim	Automatic					
1		SEQ-TOP-07	PLY-TOP-07		Producibilit	<u>۶</u>	Hand L	CFM Optim	Automatic					
Ac rea	tions te 🐔 Edit D	elete Cop	y Paste	Run 🗹 Sh	ow results 🔲 :	Show mu	ultiple resul	lts 🌌	<u> </u>	Mat	erial Pro	perties ——		

The producibility has been setup for all of the plies according to the last producibility analysis that you ran.

Select the Edit button. The Edit Multiple Producibilities - Hand Layup window appears.

Edit Multiple Producibili	ties - Hand Layup		?	$\times$
Propagation Type				
CFM Optimized Energy	,			~
Seed Point				
Geometrical Center		$\sim$		
Mesh Parameters				
Scaled ~	· 1			
Thickness Update				
WITHOUT Thickness U	pdate			~
Ply Group Only	1	~ 0.394in		E
Actions				
Optimize Paramet	ers			
Geometries to add for	transfer			
Transfer Geometry	Category			
Number of Dies/Cutnic	see Droducibilities 7			
Remove	ces Producibilities: 7			
Category:				~
		OK	Ca	ancel

**Turn on the** *Optimize* **option and select the** *Parameters* **button.** The *Optimization* window appears.

Optimizati	on						?	×
Variable 🛛 Seed p	Objectoint Sheari	:tive ng angle - Weigl	hted E	Method Equally Spaced	Setting Target	gs num poir	nts=50	
						OK	Cano	el.

Select Cancel. The default optimization settings will be used.

Notice you can also transfer 3D geometry to 2D for a group of plies within this window as well.

**Select** *OK***.** The optimization begins and will be computed for each ply. When it is completed, the *Edit Producibility Table* will reappear.

Select *Run*. The producibilities will be computed for each ply.

Edit	Producibility Table	e												?	×
Pr	oducibility Compo	onents													_
ID	Plies Group	Sequence	Ply	Cut Piece	Producibility	Active	Method	Propagation	Seed Point	Thk. Offset	Result	Max. Shear	Max. Dev.		
1	Top Plies Group	SEQ-TOP-01	PLY-TOP-01		Producibilit	<u> </u>	Hand L	CFM Optim	Indication		ОК	<mark>-</mark> 27.84	75.08		
2		SEQ-TOP-02	PLY-TOP-02		Producibilit	Ŷ	Hand L	CFM Optim	Indication		ОК	10.09	<mark>-</mark> 16.00		
3		SEQ-TOP-03	PLY-TOP-03		Producibilit	<u> </u>	Hand L	CFM Optim	Indication		ОК	24.88	03.42		
4		SEQ-TOP-04	PLY-TOP-04		Producibilit	<u> </u>	Hand L	CFM Optim	Indication		ок	930.17	04.64		
5		SEQ-TOP-05	PLY-TOP-05		Producibilit	2	Hand L	CFM Optim	Indication		ОК	<mark>-</mark> 22.40	129.13		
б		SEQ-TOP-06	PLY-TOP-06		Producibilit	<u> </u>	Hand L	CFM Optim	Indication		ОК	10.07	<mark>-</mark> 15.54		
7		SEQ-TOP-07	PLY-TOP-07		Producibilit	<u> </u>	Hand L	CFM Optim	Indication		ОК	<mark>-</mark> 27.84	75.08		
A	tions									Ma	terial Pro	perties —			
Crea	te 🗞 🛛 Edit 🛛 D	elete Cop	y Paste	Run 🛃 Sh	ow results 🔲	Show mu	Itiple resu	lts 🎽							
													OK	Car	ncel

Select each ply in the window to view its producibility.

### Select *OK* when finished.

The *Optimize* option is very useful for determining the best position of the seed point without manually reviewing the producibility.

### Save and close the document.

### Flattening

The Flattening option allows you to generate a flat pattern for each of the plies.

**Open the COMP - Flattening document.** The producibility has already been computed for all of the plies.

Select the Flattenir	<b>ng icon.</b> The <i>Flattening</i> window appears.	
	Flattening ? ×	
	Entities: No selection	]
	<ul> <li>Unfold assembly</li> <li>Along weft</li> <li>Create Flatten as Sketch</li> <li>Rosette Size: 0.394in</li> <li>Smoothing</li> </ul>	_
	Continuity: No smoothing ~	
	Tangency threshold: 0deg	
	Curvature threshold:	
	Maximun deviation: 0.008in	
	Topology simplification	
	OK Apply Cancel	]

Entities Specifies	the plies	to flatten
--------------------	-----------	------------

Only consider	Specifies if cut-pieces exist, only they will be used
Plane	Specifies the plane to create the flat patterns on
Location Point	Specifies the location each flat pattern will be located at on the flattening plane
Transfer draping	Allows you to flip the flat patterns on the flatten plane

Flatten type		
Material rol	l	Flat patterns are positioned on the flattening plane according to the fiber directions of the ply and the axis of the plane. This is typically what will be needed for exporting the dxf files correctly for a cutting software.
Unfold assembly		Flat patterns are positioned according to the 3D positioning of the ply
Check material	Perfo speci appea	rms a material width analysis to be sure the ply will fit on the fied material. If any ply ever fails this analysis, a mask will ar on the features in the tree as shown. In this case <i>Ply.1</i> is



- *Create Flatten...* Specifies the flat pattern will be created as a sketch rather than a wireframe curve
- *Rosette Size* Specifies the rosette size in the flat pattern
- *Smoothing* Allows the flat patterns to be smoothed for optimization

failing the material width check.

Select the *Sequence.1* to define the ply to flatten. Select the *Flattening Plane* from *Geometrical Set.1* and select the point from the *Flattening Points* geometrical set.

With the *Unfold assembly* option selected, select *Apply*. The flattened ply appears in the display.



Notice the original point that was selected during the producibility operation is positioned at the specified point from the flattening operation.

Select the *Material roll* option in the *Flattening* window and select *Apply*. The flattened ply is repositioned on the plane.



**Select** *Cancel* in the window. Since you want to create a flat pattern for all of the plies, you will do it all at once.

Select the Flattening icon. The *Flattening* window appears.

Select *Plies Group.1* to define the *Entities* to flatten.

Select the same *Flattening Plane* again and select the rectangular pattern in the *Flattening Points* geometrical set to define the *Location Point* for the operation. The *Flattening* window should appear as shown.

Flattening		?	$\times$
Entities: Plies Group.1 Number of Plies: 9 N	umber of Cut-pied	谢 :es: 0	
Only consider cut-piece     Plane: Flattening Plane     Location Point: 9 entities	5		]
Transfer draping directio Flatten type: C Material roll Unfold assembly Create Flatten as Sketch Rosette Size: 0.394in Smoothing	n to plane normal heck material widt Along warp Along weft	:h	
Continuity: No smoothing			$\sim$
Tangency threshold:	0deg		E
Curvature threshold:	0		
Maximun deviation:	0.008in		÷
Iopology simplification     OK	Apply	Can	cel

Notice there are 9 plies selected and 9 point locations as well. Selecting a pattern will automatically assign the plies or cut pieces to each point in the pattern.



Location Points				?	×
Entities	Material	Direction	Points	^	仓
Ply.1	Fiberite Graphite Fal	o 90	Point.3		
Ply.2	Fiberite Graphite Fal	o 0	Vertex.1		
Ply.3	Fiberite Graphite Fal	o45	Vertex.2		
Plv.4 ≮	Fiberite Graphite Fal	n 45	Vertex.3	>	
Remove					
				Clos	e

Notice all of the plies are listed and each ply was assigned a location point. You can manually specify which ply is assigned to which point from this window if you wanted to.

Select Close. You are returned to the Flattening window.

Select the *Material roll* option and select *Apply*. The flattened plies are created, but are randomly located at the points.



Select the *Unfold assembly* option. Set the *Continuity* to *Threshold* and the *Tangency threshold* to 10, turn on the *Curvature threshold* and select *OK*. The plies are positioned in a more uniform manner this time. The plies were also smoothed in tangency.



Expand the first ply in the tree as shown.



Notice the categories under the *Flatten Body* allow you to organize the contents of the flattening. This is important when it comes to exporting the flat patterns. This will be discussed in more detail in the Exporting section.