pusiness Pride



Resin Infusion Best Practices

Advanced Composites Institute

Home of the Marvin B. Dow Stitched Composites Development Center

Mississippi Advanced Composites Training Center

Wayne Huberty, PhD Associate Director, ACI whuberty@aci.misstate.edu

Confidential

The Project that brought me here! 4'x4' wing box

FAA - Technology Readiness for Un/Stitched Resin Infusion



SISSIPPISTATE 6/4/2025 Confidential
6/4/2025
Confidential
6/4/2025

Wing Box Progression -- Manufacturing

Race tracking caused a vacuum cut-off, causing a large dry area on the back of the spar.

Pressure pot/Saertex NCF

MISSISSIPPI STATE

UNIVERSITY

High resin viscosity due to low ambient temperatures prevented fully wet out.

Pressure pot/ Saertex NCF

First successful infusion. Ambient and resin temps were increased to 85°F. ~ 50 min infusion time.

3

Isojet/ Saertex NCF

Second successful infusion. Ambient and resin temps were 85°F. Braided material with binder.

Δ

Isojet/ Braided fiber

Confidential



- Realistic ply schedule
- One design for 8' and 16'
- Choose the hard area!



History education Research community Tradition pride



UNIVERSITY.



MISSISSIPPI STATE 6/4/2025

History education Research community Tradition pride



Ply Number	Orientation
1	[0/90]
2a	[0]
2b	[0]
3	[+45/-45]
4a	[0]
4b	[0]
5	[+45/-45]
6a	[0]
6b	[0]
7	[0/90]
8a	[0]
8b	[0]
9	[+45/-45]
10a	[0]
10b	[0]
11	[+45/-45]
12a	[0]
12b	[0]
13	[0/90]
14a	[0]
14b	[0]
15	[+45/-45]
16a	[0]
16b	[0]

	-		
\rightarrow	17		[+45/-45]
		18a	[0]
		18b	[0]
	19		[0/90]
		20a	[0]
52		20b	[0]
162	21		[+45/-45]
		22a	[0]
		22b	[0]
	23		[+45/-45]
5		24a	[0]
		24b	[0]
14	25		[0/90]
2		26a	[0]
227		26b	[0]
	27		[+45/-45]
199		28a	[0]
		28b	[0]
128	29		[+45/-45]
577		30a	[0]
		30b	[0]
87	31		[0/90]

Web: 20% [0] Plies 60% [+/-45] Plies 20% [90] Plies

Cap:

60% [0] Plies 30% [+/-45] Plies 10% [90] Plies

MISSISSIPPI STATE 6/4/2025 UNIVERSITY.

History education Research Chris Bounds, PhD, JAMS Technical Review dition pride



MISSISSIPPI STATE UNIVERSITY_®

UD panels are more difficult.....

Layup	Material	# of plies (actual ply number, not stacks)	Process Spec	Resin temp (F)	Oven Temp (F)	Infusion time (min)	FVF (%)
UD	Teijin	24 plies	MSU	170	190	9 min – 10 min lean	55.7%
UD	Teijin	24 plies	<u>NPS</u>	170	190	42 min	60.1%
BD	Teijin	24 plies	MSU	165	190	3 min – 10 min lean	
NCF	Seartex	40 plies	MSU	172	190	< 1 min – 10 min lean	57%

History education Research community Tradition pride

6/4/2025

MISSISSIPPI STATE

Confidential

Thickest Section View

Thinnest Section View



MISSISSIPPI STATE 6/4/2025

History education Research community Tradition pride



MISSISSIPPI STATE 6/4/2025 History education Research UNIVERSITY. 6/4/2025 community Tradition Pride



History education Research community Tradition pride

MISSISSIPPI STATE 6/4/2025

Simulation

FAA 8ft Wingbox\Spar8FtEndOutlet_RESULT.erfh5		1 / 0.00000
NODE : FILLING_FACTOR Min = 0 at Node 7936	4	
Max = 0 at Node 7936		
0.0000e+00		
. 0.0000e+00		
. 0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
0.0000e+00		
× **		

History education Research community Tradition pride

600cc/min target injection rate Max 14.5psi injection pressure Vacuum outlets on either end Full wet-out in ~7min

MISSISSIPPI STATE 6/4/2025







MISSISSIPPI STATE 6/4/



Layup



MISSISSIPPI STATE



UNIVERSITY

Resin	Temperature (F)
1078-1	190
EP2400	220

- Increasing the temperature to 220 F softened the BST (tacky tape), which caused it to be pulled into the distribution spring.
- We pulled up both vacuum bags, removed a section of the spring, and then infused the part. All this occurred at 220 F.



History education Research community Tradition pride **MISSISSIPPI STATE** 6/4/2025



Thick end			
Thickness (in)	FVF (%)		
0.43	54.3		
0.42*	55.6		
0.41	56.9		

Thin end			
Thickness (in)	FVF (%)		
0.33	55.4		
0.32*	57.2		
0.31	59		

History education Research community Tradition pride

MISSISSIPPI STATE



MISSISSIPPI STATE 6/4/2025

History education Research community Tradition pride

Kinked area looks great!



History education Research community Tradition prijde

MISSISSIPPI STATE

Infusion Trial #2



History education Research community Tradition pride **MISSISSIPPI STATE** 6/4/2025 UNIVERSITY

Infusion Trial #2

MISSISSIPPI STATE

6/4/2025

We had issues with the flow media causing wrinkling at the radius. We placed perforated plate that was "bent" to shape to try to help avoid wrinkles.



fistory education Research community Tradition pride

Infusion Trial #2



MISSISSIPPI STATE

History education Research community Tradition prize

7' wing box tooling



7' wing box tooling



History education Research community Tradition pride

MISSISSIPPI STATE

7' wing box tooling

UNIVERSITY

Ply Number	Orientation	
1	[0/90]	
2	[+45/-45]	F
3	[0/90]	1
4	[+45/-45]	2
5	[0/90]	3
6	[+45/-45]	4
7	[0/90]	5
8	[0/90]	6
9	[+45/-45]	7
10	[0/90]	8
11	[+45/-45]	9
12	[0/90]	1
13	[+45/-45]	1
14	[0/90]	1

Stringers:

Ply Number	Orientation
1	0
2	0
3	[0/90]
4	[+45/-45]
5	0
6	0
7	0
8	0
9	[+45/-45]
10	[0/90]
11	0
12	0

<u>Skin:</u> 29% [0] Plies 42% [+/-45] Plies 29% [90] Plies

Stringer:

tistory education Research community Tradition prizde

60% [0] Plies 27% [+/-45] Plies 13% [90] Plies

MISSISSIPPI STATE 6/4/2025

Skin Lay-up with Drop Plies



Skin:

Ply Number	Orientation
1	[0/90]
2	[+45/-45]
3	[0/90]
4	[+45/-45]
<mark>5</mark>	<mark>[0/90]</mark>
<mark>6</mark>	<mark>[+45/-45]</mark>
7	<mark>[0/90]</mark>
8	<mark>[0/90]</mark>
<mark>9</mark>	<mark>[+45/-45]</mark>
<mark>10</mark>	<mark>[0/90]</mark>
11	[+45/-45]
12	[0/90]
13	[+45/-45]
14	[0/90]

History education Research community Tradition pride

MISSISSIPPI STATE

Skin layup



MISSISSIPPI STATE



Stringer layup



History education Research community Tradition prize

MISSISSIPPI STATE

Spar layup



MISSISSIPPI STATE

History education Research community Tradition prijde

Wing box layup



MISSISSIPPI STATE UNIVERSITY





MISSISSIPPI STATE 6/4/2025

History education Research community Tradition pride





MISSISSIPPI STATE

UNIVERSITY



History education Research community Tradition pride 6/4/2025



MISSISSIPPI STATE

MISSISSIPPI STATE

UNIVERSITY



6/4/2025 History education Research community Tradition prizde



History education Research community Tradition pride

MISSISSIPPI STATE

Resin

Syensqo Cycom 823 RTM resin

Fabric

Teijin Tenax 0/90 (380 gsm, 39 yards), ±45 (286 gsm, 45 yards), and UD (300 gsm, 25 yards)

MISSISSIPPI STATE

UNIVERSITY









6/4/2025

Fiber wrinkling

MISSISSIPPI STATE

UNIVERSITY

Excess resin



History education Research community Tradition pride



OK compaction at radius Some wrinkling Z-caul poor fit caused porosity and resin pocket



MISSISSIPPI STATE 6/4/2025



NDI





Kink was difficult to scan



6/4/2025

History education Research community Tradition pride

MISSISSIPPI STATE



NDI



Large dry spot, no backwall reflection totally, 2*24 inches, can see dry fiber from other side.

Solid back wall reflection

UNIVERSITY_®

NDI



Large dry spot, no backwall reflection totally, 2*24 inches, can see dry fiber from other side.

History education Research community Tradition pride

MISSISSIPPI STATE

Control and Defect Areas for Photo micrographs

Spar Upper – Defect Area



Control Area – Spar Upper



MISSISSIPPI STATE



Photo micrographs

Upper Spar Control



Upper Spar Defect

istory education Research community Tradition pride

MISSISSIPPI STATE UNIVERSITY

Photomicrographs



Photomicrographs



MISSISSIPPI STATE UNIVERSITY. 6/4/2025 History education Research annually Tradition Plate

The next infusion

- High-temp resin: Syensqo EP2400
- Better spar tooling: welded aluminum plug and caul
- Stringers will a more gradual ply drop
- More debulk cycles



History education Research community Tradition pride

Questions?

History education Research community Tradition pride

Wayne Huberty, PhD Associate Director, ACI whuberty@aci.misstate.edu

MISSISSIPPI STATE

Resin Infusion Simulation



Modeled consistent with infusion plan

History education Research community Tradition pride

MISSISSIPPI STATE

6/4/2025

Confidential

Resin Infusion Simulation

6/4/2025

Confidential



MISSISSIPPI STATE

History education Research community Tradition pride

Resin Infusion Simulation



Modeled with racetracking at the edges and far end

History education Research community Tradition pride

6/4/2025

MISSISSIPPI STATE

UNIVERSITY

Confidential

Resin Infusion Simulation – NASA SAA



6/4/2025

Confidential



Provided race tracking location at the end of the preform, and corroborated issues identified during infusion.

MISSISSIPPI STATE UNIVERSITY



The top 10 lessons learned – 2024 Update



Vacuum integrity is especially important for infusion.



The resin viscosity and flow plays a huge role in a successful infusion.



There is little difference between vacuum bagging for an infusion and for a prepreg.



Dry fabric can be tricky to work with, mostly because it is slippery.



Global and local FVF are not always equal. Tooling plays a huge role in correct local FVF control.



A successful infusion with a specific material set does not all material sets will be successful.



Integration of the spar, stringers, and skin was easier than expected.



The simulation provided direction, but not quantitative information.



Resin reaching the vacuum outlet causes a vacuum loss, a killer for infusions.



The pot life of the resin should not be a concern.

MISSISSIPPI STATE



Spar Tool Inspection

Analysis: "Cloud_ProjectFilter_BestFit" Tol: MBD Max Dist: 1.0000 Total Points: 2840206 Good: 1610575 Bad: 1229627 Failed: 4 MinDev: -0.0600 MaxDev: 0.0598 Range: 0.1198 AveDev: -0.0060 StdDev: 0.0112 RMS: 0.0127 TP: 0.1200



8.9328 in Inch

0.0598

MISSISSIPPI STATE