



LESSON Final Review

25/11/2022

Engineering
 Design Engineering
 Parametric models
 CAD Modelling
Thermal Analysis
 Thermal simulation
 Heater sizing
 Steady state
Engineering Services
 FEM NASTRAN
 Random Vibration
 Thermo-elastic
 Optimisation
 Modal Analysis
 Fatigue
Structure Analysis
 Shock
 Global spacecraft modelling
 Dimensional stability
Finite Element Method
 Vibro Acoustic
 Sine Vibration
 Automation
SpaceBolt™
Bolt Analysis Software
 Productivity
 Standoffs
 Harness
 Electrical conductivity
CFRP Brackets
 VDI 2230
Lightweight
 Electronic equipment housings
 Payload structures
Build-to-Spec structure assemblies
 Launcher structures
 Satellite structures
 Manned applications
Structures for Space Applications
 Dimensional stability
 Ultra-lightweight
 High stiffness
 Custom solution
SpaceStrut™
 Hybrid
 Off-the-shelf
 Space qualified
 Full CFRP
 Honeycomb core
 Optical bench
 Facesheets
Sandwich panels
 Inserts
Spacecraft primary structure
 Functional integration
 FFF
 High vibration damping
Additive manufactured parts
 SLS
 EBM
 SLA
 Topology optimisation
Metal and polymer parts
EN ISO 9100:2018 certified
 Quality Management
 First time right

Agenda

1. Introduction to GSTP de-risk LESSON project
2. Discussions on key achievements/Lessons learnt
3. Potential follow-on

4. De-risk project administration for close-out

Introduction



Existing **SpaceStrut™** family:

- **Full CFRP.** including the interfaces, with continuous carbon fibres
- **Maximum ultra-lightweight.** 50 - 80 % mass saving depending on length
- **Dimensionally stable.** No thermal expansion, insensitive to thermal cycling. Special DoubleZero™ variant with zero CTE and CME. CTE can also be customised.
- **Reduction of number of parts.**

Introduction

Goals:

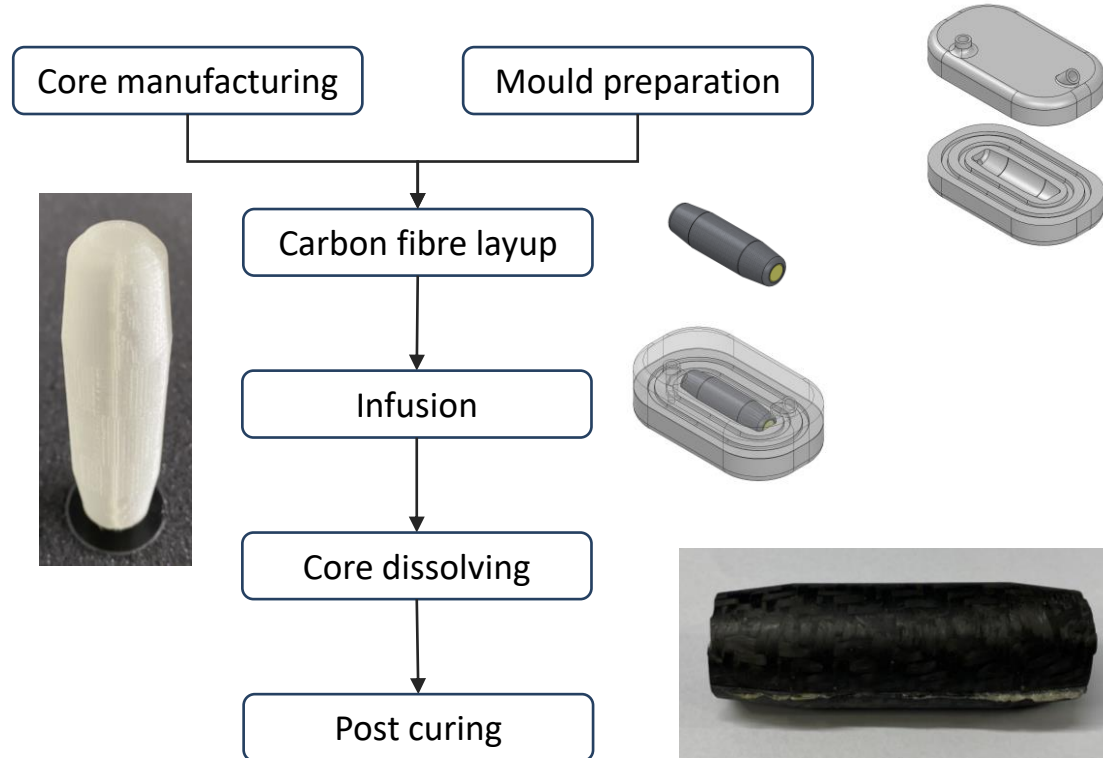
- Cheaper infusion cores
- No autoclave
- Increased Flexibility
- Increased worker safety

Capabilities developed:

1. Design and manufacturing of temporary, water-soluble tools suitable for liquid resin injection, i.e. impermeable to liquid resin.
2. Room temperature, out-of-autoclave, liquid resin injection
3. Dissolving process for temporary tools from 1. that need to be extracted via small openings in the part.



Introduction

Coupon – Phase - VRTM



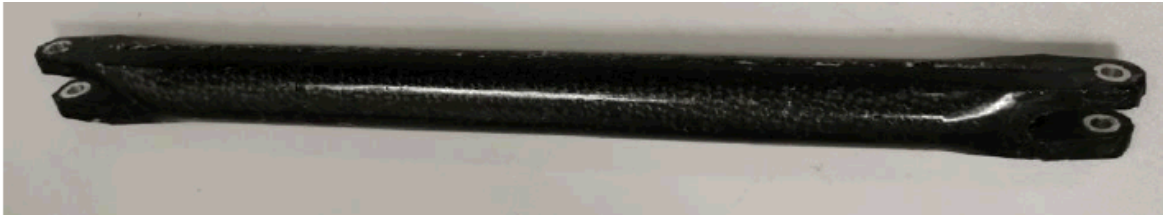
Introduction

Requirements, Design & Analysis

Application	I/F Distance [mm]	Weight [g]	Tube Outer Diameter [mm]	Design Load [kN]	Model
Secondary structure moon lander legs	348	93	28	14.33	
VEGA SSMS dispenser strut	875	733	60	22	

Introduction

Manufacturing - 5 Breadboards each



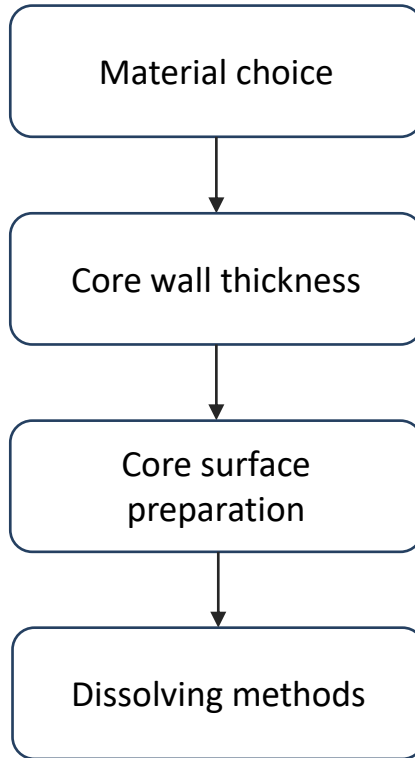
Introduction

Testing

- Visual Inspection and NDT
- Mass Measurements
- Dimensional measurements
- Electric conductivity measurements
- Concentric axial loading
- Material Tests



Achievements/Lessons learnt



- ◆ PVA
- ◆ AquaSys120
- ◆ AquaSys180
- ◆ Number of layers
- ◆ Mech. polishing
- ◆ Polishing with PVA solutions
- ◆ Surface coating
- ◆ Temperature
- ◆ Agitation
- ◆ Saturation

Achievements/Lessons learnt

Property	Qualitative Description	Target	Avg Test Result
Glass transition temperature	Glass transition temperature of resin near to or above datasheet value	$\geq 110^{\circ}\text{C}$	120°C
Fibre volume content	Fibre volume content as designed	55% \pm 5%	< 55%
Porosity	Low porosity – target <2%	<2%	1.2%
RML		<1%	0.319%
CVCM		<0.1%	0.051%

Achievements/Lessons learnt



Achievements/Lessons learnt



Achievements/Lessons learnt

S/N	Mass (92.9 ± 5%) [g]
BB-A-002	96.4
BB-A-004	92.5
BB-A-005	95.8
BB-A-006	97.1
BB-A-007	96.7

S/N	Mass [g] (max: 1000, nominal: 733)
BB-B-003	749
BB-B-005	735
BB-B-006	731
BB-B-007	721
BB-B-008	724

Sub ASSY	Component Name	Sub Assy Q.ty	Assy Q.ty	Main Assy Q.ty	Total Q.ty	Component Mass [kg]	Applied Margin [-]	Component Mass [kg] (with margins)	Components Mass in Sub Assy [kg]	Components Mass in Sub Assy with margins [kg]	Components Mass in Main Assy [kg]	Components Mass in Main Assy with margins [kg]
Sub Assy Mass									1.736	1.823	10.415	10.936
External Rod Assy	External Rod	1	6	1	6	0.957	5.0%	1.005	0.957	1.005	5.740	6.027
	External Rod End Fitting	2			12	0.065	5.0%	0.068	0.130	0.136	0.778	0.816
	External Rod FML Lug-Upp	1			6	0.234	5.0%	0.246	0.234	0.246	1.404	1.474
	External Rod FML Lug-Low	1			6	0.130	5.0%	0.136	0.130	0.136	0.779	0.818
	External Rod Pin	2			12	0.034	5.0%	0.035	0.067	0.071	0.403	0.423
	External Rod Terminal	2			12	0.063	5.0%	0.066	0.127	0.133	0.760	0.798
	Screw & Washers	1			6	0.092	5.0%	0.097	0.092	0.097	0.552	0.580

Achievements/Lessons learnt

S/N	Applied load [kN]		Stiffness – loading [kN/mm]		Failure
	Tension	Compression	Tension	Compression	
BB-A-002	21.5	21.5	17.4	19.0	No failure
BB-A-004	17.9	17.3	17.0	19.3	Failure in compression
BB-A-005	21.5	21.5	20.3	20.6	No failure
BB-A-006	21.5	21.5	19.5	20.1	No failure
BB-A-007	21.5	21.5	17.6	15.7	No failure
Average	-	-	18.4	19.0	-

Achievements/Lessons learnt

S/N	Applied load [kN]		Stiffness – loading [kN/mm]		Failure
	Tension	Compression	Tension (≥ 50)	Compression (≥ 50)	
BB-B-003	33	33	73	62	No failure
BB-B-005	33	33	71	58	No failure
BB-B-006	33	33	67	57	No failure
BB-B-007	33	33	66	57	No failure
BB-B-008	33	33	66	56	No failure
Average	-	-	69	58	-