



NASA Langley's Composite Manufacturing using Double-Vacuum Bags

Improved out-of-autoclave processing with better volatile management and resin content control

NASA Langley Research Center has developed composite manufacturing techniques to improve traditional single-vacuum-bag (SVB) processes. Although using an SVB technique in an oven is a cost-effective non-autoclave method for producing high-performance composites, it is often ineffective when a reactive resin matrix, or solvent-containing matrix or prepreg is used. NASA Langley has developed a double-vacuum-bag (DVB) process to overcome SVB deficiencies by improving volatile management and eliminating excessive resin bleed situations.

Benefits

- Superior volatile (residual solvent, reaction by-products, and entrapped air) management versus standard SVB process
- Produces void-free quality laminate parts
- Cost-effective relative to press/autoclave molding
- Applicable to both pure resin in molten polymer form (e.g., NASA's PETI and Air Force's AFR-PE) and monomers in concentrated solutions (e.g., NASA's RPX and Air Force's J1)
- Adaptable to molding processes such as resin film infusion (RFI), and vacuum-assisted resin transfer molding (VARTM)

partnership opportunity

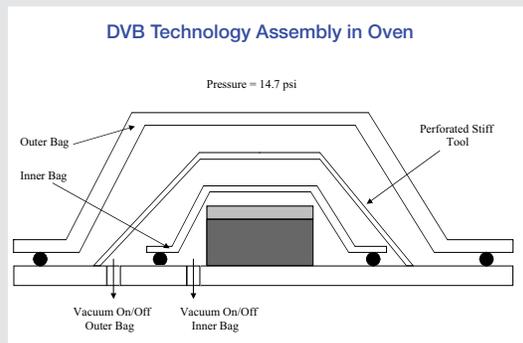


The Technology

To produce a void-free quality laminate from resin-impregnated prepregs, it is imperative to deplete volatiles and solvents before commencing forced consolidation. The traditional SVB assembly inherently hinders and/or retards the volatiles depletion mechanisms during composite fabrication because a vacuum-generated compaction force is applied to the laminate during volatile depletion period (i.e., B-stage). NASA designed their DVB technique to overcome such a deficiency. Specifically, NASA's DVB process eliminates the compaction force generated by vacuum suction while in the meantime maintaining the vacuum effectiveness for the volatile depletion. The technique has been proven and validated to be effective for volatile management and resin content control in composites with reactive resin matrices such as solvent-containing phenolic and polyimide resin matrix prepregs.

The NASA DVB process can also combine the infusion of resin and consolidation of composite in one processing step. The molding assembly's double-vacuum environment enables the improved void management and laminate net shape control. By using two vacuum environments during the curing process, a vacuum can be drawn during a B-stage of a two-step cycle without placing the composite under significant compressive pressure. During the final cure stage, a significant pressure can be applied by releasing the vacuum in one of the two environments. Inner and outer bags are useful for creating the two vacuum environments, with a perforated tool between the two. The composite is placed on a tool, with the inner bag and tool plate defining the first environment. The second environment is characterized by the outer bag, which is placed over the inner bag and the tool plate—see graphic on left.

The technology portfolio includes U.S. patent 7,186,367 granted March 7, 2007.



Applications

Non-autoclave production of complex composite parts with improved volatile management capability in a cost-effective process

Mechanical Properties

Mechanical Property	Test Temp.	Im7/LARC™ PETI-8 by DVB	Im7/LARC™ PETI-8 by SVB	7781 E-glass/Cyccom 6070 (from supplier*)	7781 E-glass/Cyccom 6070 (fabricated by SVB)	7781 E-glass/Cyccom 6070 (fabricated by DVB)
SBS strength (Ksi)	RT	17.7 ± 0.7	14.7 ± 0.8	2.1 – 2.2	4.5 ± 0.1	6.5 ± 0.2
	180°F	—	—	1.6 – 1.8	—	6.1 ± 0.2
	177°C	5.4 ± 0.1	—	—	4.1 ± 0.1	—
Flex strength (Ksi)	RT	236 ± 18.3	204.2 ± 11.0	67 – 74	65.2 ± 3.0	88.3 ± 1.4
	180°F	—	—	61–68	57.5 ± 2.55.4	75.4 ± 2.0
	177°C	150.8 ± 6.2	144.9 ± 12.4	—	—	—
Flex Modulus (Msi)	RT	20.8 ± 1.8	18.9 ± 0.6	3.5 – 3.8	5.1 ± 0.2	4.9 ± 0.1
	180°F	—	—	3.5 – 3.9	4.5 ± 1.0	4.5 ± 0.2
	177°C	18.2 ± 1.2	19.0 ± 0.2	—	—	—
Tensile Strength (Ksi)	RT	—	—	59 – 61	52.6 ± 2.2	57.1 ± 2.2
	180°F	—	—	50 – 52	50.3 ± 1.6	55.6 ± 3.4

*cycom 6070 Phenolic Resin Technical Datasheet, January 29, 2002, Cytec Engineered Materials, Anaheim, CA

For More Information

If your company is interested in licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact:

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LAR-16877