Return to Menu

Improving Interlaminar Shear Strength

Project Manager(s)/Lead(s)

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Sponsoring Program(s)

Marshall Space Flight Center/Center Management and Operations
Dual-Use Technology Cooperative Agreement Notice

Project Description

To achieve NASA's mission of space exploration, innovative manufacturing processes are being applied to the fabrication of complex propulsion elements.[1] Use of fiber-reinforced, polymeric composite tanks are known to reduce weight while increasing performance of propulsion vehicles. Maximizing the performance of these materials is needed to reduce the hardware weight to result in increased performance in support of NASA's missions. NASA has partnered with the Mississippi State University (MSU) to utilize a unique scalable approach of locally improving the critical properties needed for composite structures. MSU is responsible for the primary development of the concept with material and engineering support provided by NASA.

The all-composite tank shown in figure 1 is fabricated using a prepreg system of IM7 carbon fiber/CYCOM 5320-1 epoxy resin. This is a resin system developed for out-of-autoclave applications. This new technology is needed to support the fabrication of large, all composite structures and is currently being evaluated on a joint project with Boeing for the Space Launch System (SLS) program. In initial efforts to form an all-composite pressure vessel using this prepreg system, a 60% decrease in properties was observed in scarf joint regions. Inspection of these areas identified interlaminar failure in the adjacent laminated structure as the main failure mechanism. This project seeks to improve the interlaminar shear strength (ILSS) within the prepreg layup by locally modifying the interply region shown in figure 2.[2]

Figure 1: 18-ft- (5.5-m-) diameter, all composite tank at MSFC.

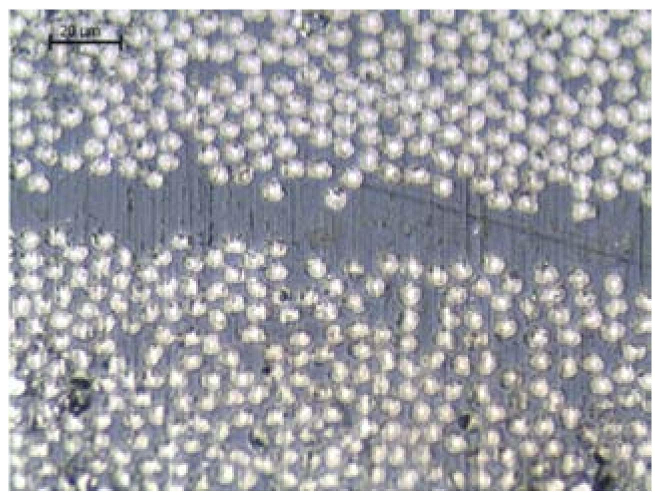

Figure 2: Resin-rich area between plies.

Anticipated Benefits

The prepreg system uses a continuous carbon fiber to realize the overall global strength of the part. This approach can also be applied locally by use of reinforcing additives, such as carbon nanotubes (CNTs) within the epoxy resin. In studies on neat resins using various

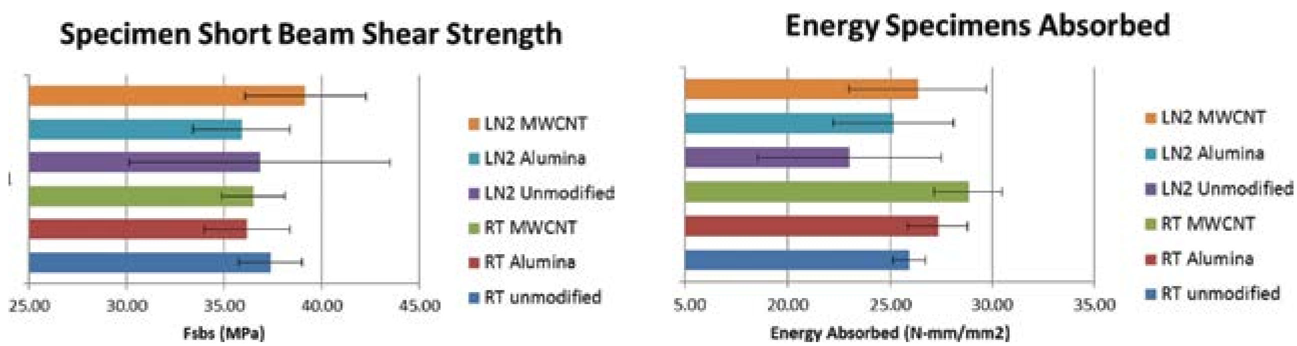

Figure 3: Improved shear strength and energy absorbed has been demonstrated using a local modification of nanoparticles.

additives, an increase has been shown both in strength and toughness.[3] As ILSS is reported to be matrix driven, methods to improve the strength and toughness of the resin are of interest. However, these types of modifications cannot be applied to an existing prepreg system without extensive development costs.

MSU is exploring methods to embed reinforcing nanoparticles in the resin between plies to strengthen and toughen the matrix. Although preliminary research has shown this to show promise in improving shear strength as shown in figure 3, the studies are continuing to optimize both the selection of the dispersant as well as the additives. Once identified and proven, this concept can be readily implemented into current fabrication schemes.

Potential Applications

Methodology being developed in this project can immediately benefit current production of an out-of-autoclave fuel tank for the SLS program as well as have commercial interests in transportation usage of alternative cryogenic fuels.

Use of CNTs as piezoelectric sensors is also being pursued on other studies at NASA.[4] Proving that CNTs are effective in locally modifying joint properties may be possible to provide local monitoring for structural health.

Notable Accomplishments

Use of three-point bend tests on coupon specimens indicated that both the shear strength and energy absorption can be improved at both room and cryogenic temperature.

References

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