A Novel Method For Joining Composites

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Introduction

In recent years, the use of composite structures has greatly increased. In many applications, composites have been taking the place of many isotropic materials. This is due to their lightweight design and their ability to withstand high amounts of stress. The performance of continuous composite structures are phenomenal, but there are very few structures that are continuous. Many structures must be assembled by utilizing joints. Although there are many benefits to using composites, it still remains an engineering challenge to produce a strong joint.

One of the main problems in joining composites is finding a method that will be accepted by industry generally. New methods must bring about substantial performance improvements with marginal labor increases. This project investigates several innovative ideas that increase joint strength while minimally deviating from the base design of a single-lap joint.

Procedure

The composite specimens in this project were made up of eight layers. Each layer was a unidirectional resin pre-impregnated fiber lamina (prepreg). The quasi-isotropic lay-up of $[0/45/-45/90]_s$ was chosen because it is used in industry readily. Prepreg laminas of IM7 carbon measuring 6.625”× 16.875” were pressed together to form the upper and lower laminates of the specimens. The laminas were pressed in a step fashion to give a joint end taper of 35°. The laminates were placed in a vacuum-sealed mold that allowed a common joint interface of 2 inches. After co-curing in an autoclave at the ASTM prescribed pressure and temperature profile, the specimen plates were machined to 1”×10” coupons. Fiberglass tabs were adhered (with epoxy based adhesive that cured at room temperature) to the ends of the specimens to prevent damage from the grips of the MTS testing machine and to minimize the inherent load eccentricity.

Currently, the industry standard in joining composites is the single-lap joint. This joint fails because of the high peel stresses that build up at the ends. The aim of this project is to increase the joint strength by placing various materials at the interface. Although the two composites will not be able to bond together as closely, we can create a scattered arrangement at the joint that would cause a crack to meander. As the crack path becomes more torturous, it requires more energy (in the form of a higher load) to achieve failure.

Four different materials were chose to be placed on the interface. They are: chopped pre-impregnated fibers, chopped dry fibers, silica sand and a woven fiberglass cloth. Except for the fiberglass cloth, these materials are placed on the interface at random until it looks about uniform to the human eye.

These specimens were then tested in quasi-static tension, where the load is slowly increased, to determine the ultimate load that each specimen could withstand.

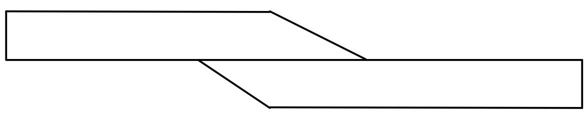
Results

None of the materials caused a relevant increase in tensile load strength. Other methods must be attempted.

Test results of the materials used on the interface:

Material	Mean Ultimate Strength (kN)	Standard Deviation (kN)
None	16.86	0.61
Pre-Impregnated Fibers 1	17.56946233	1.601623858
Pre-Impregnated Fibers 2	16.1249375	1.35526476
Dry Fibers 1	17.46841878	0.880043649
Dry Fibers 2	17.92703664	1.010301916
Silica	15.69034367	0.445584929
Fiberglass	17.11912067	0.398154595

Basic design of the composite lay-up:



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