Composite Engineer's Viewpoint

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Mechanically Fastened Joints in Composite Structures
Part 1 – The Issues

In a several part series we will look at the engineering issues in joining composite structures with bolts, rivets, pins, etc. This issue we consider the issues in a broad sense and will discuss them in detail throughout the coming series of articles.

The joining of advanced composite structures is a challenging design issue, particularly with the use of mechanically fasteners. Bolted joints in composite structures have several issues to be addressed in the design process. These design issues include: bearing strength, fastener tipping and clamp-up, ply configuration effects, fastener hole preparation, corrosion and overall joint configuration limitations. There are 10 major issues engineers face when developing bolted joint designs in composite structures. These 10 major issues are:

1. Bearing strength – typically the bearing strength of composite materials is relatively lower than that in metals, and the bearing strength is a function of the ply orientation and distribution.

2. Fastener hole preparation – drilling and reaming the fastener hole requires care so as not to damage the exit side of the hole and thus reduce bearing strength.

3. Fastener installation – likewise to hole preparation, fastener installation requires careful consideration not to damage the composite laminate.

4. Corrosion – the attachment of composite and metal structures with metal bolts can be a source of corrosion damage of the metal if appropriate installations processes are not followed.

5. Fastener interaction (pull-through, bending) – there are significant factors to consider in the way a fastener interacts with a composite structure whilst under load.

6. Clamp-up – How much should you tighten a fastener that bears down on a composite structures? What is the crushing resistance of the composite through-the-thickness? Such questions can be answered with proper understanding of composite material properties and directional relationships.

7. Stress concentrations – whilst a bolt fills the open hole in a structure there is still a stress concentration effect in both tension and bearing failures modes.

Composite laminate configurations play a key role in the variations of the local stress concentration factors of bolted joints.

8. Multiple row limitations – unlike metallic structures that have a better multiple row load sharing capability (due to local ductility), composite structures are linear elastic to failure and thus require better understanding of multiple rows of fastener bearing/by-pass load interaction.

9. Ply configuration effects – both the percentage of fibres in any one direction and the through the thickness placement of the plies requires an understanding of the effects on structural performance of mechanically fastened joints in composite structures.

10. Off-axis loading – because composite laminate are general orthotropic any loading off the material axis results in general orthotropic behaviour. This has significant implications for the laminate design with fasteners that are loaded off-axis.

In the next article we will discuss the bearing strength of mechanical fastener design issues in composite structures. I also welcome questions, comments and your point of view. Feel free to contact me via r.heslehurst@adfa.edu.au. I may publish your questions and comments, and my response in future newsletters.
