A process that improves repair of carbon fiber airplane components

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A team from A*STAR is helping Singapore companies that specialize in the maintenance, repair, and overhaul of airplanes to deepen their understanding of a technology for repairing high-tech carbon fiber

components.

Carbon fiber structures are strong enough to replace avionic parts typically made from steel. But when damaged, these lightweight materials require special repair techniques to ensure they can still bear mechanical loads. Technicians normally cut wedge-shaped chunks from the defective site, and glue in pre-made patches. Finally, components are placed in pressurized ovens called autoclaves to remove volatile gases and cure the adhesives.

Autoclave-based repair techniques, however, are impractical for maintenance of extra-large components, such as wings or fuselages, that cannot be removed from the aircraft. Stefanie Feih and co-workers from A*STAR's Singapore Institute of Manufacturing Technology (SIMTech) have now investigated a technique for patching carbon fiber structures while they are still in place on the aircraft.

The team studied a double vacuum debulking process that places a rigid box containing an inner flexible vacuum bag on top of a patch. By creating a second and different vacuum level within this chamber, volatile gases can be quickly removed from the repair material. The patch is then transferred to the aircraft to complete the curing step.

"Double vacuum debulking adds an additional step to an already very complex repair scenario," says Feih. "Repair processes require highly accurate surface temperature control over surfaces with generally complex internal features. Performing large scale repairs further complicates the process."

High porosity in the final patch is a significant issue during carbon fiber repair, because voids can lessen mechanical strength. The researchers found that the adhesive films used to bond repair patches can also trap volatile gases to create additional voids. The double vacuum debulking

process, however, was found to almost completely eliminate porosity in both the adhesive film and repair patch for all repair geometries.

"These findings highlight why you need a highly skilled workforce in an avionic hub city," says Feih. "It's crucial for attracting operators to Singapore, and we undertook this project to improve the understanding of repair processes for composite structures among local companies."

Feih and colleagues also examined the impact of patch geometry by mechanically testing configurations ranging from simple laminate films to more complex wedge shapes. Here, circular 3-D repairs proved inherently stronger than simplified 2-D shapes when under tension. Further study is needed to determine optimal improvements under complex conditions experienced by real components during flight.

More information: H.M. Chong et al. Out-of-autoclave scarf repair of interlayer toughened carbon fibre composites using double vacuum debulking of patch, *Composites Part A: Applied Science and Manufacturing* (2018). DOI: 10.1016/j.compositesa.2018.01.001

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