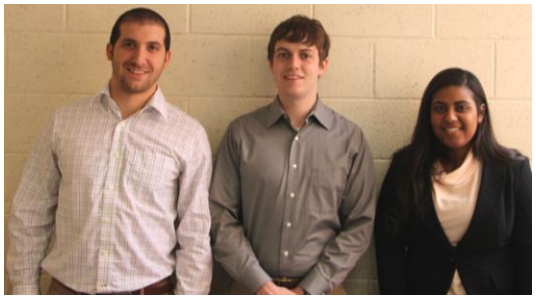
Team #16: Reliable Repair of Composites using Additive Manufacturing

Sponsored by: Sikorsky Aircraft Corporation
Sponsor Advisor: Tim Fekete



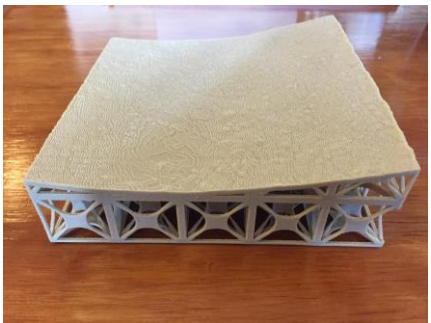
From left to right: Jeremy Higgins, Michael McGeever, and Amy Hernandez

MATERIALS SCIENCE & ENGINEERING

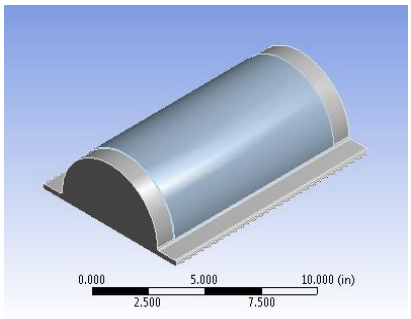
As composite materials begin to replace metals in many structural components in rotorcraft, a reliable and adaptable method must be developed to repair damaged composite parts. Traditional methods typically used for the repair of metal parts such as welding are not viable repair options for composites. Instead, the damaged area will be scanned and translated into a 3D computer model. A customized mold could then be 3D printed which would be used to lay up and cure the composite patch. Then, the cured patch could then be used to repair the damaged composite.

High dimensional fidelity of composite patches is required since they must fit precisely into the damaged area. Thus, the mold must be thermally stable and keep its shape constantly during the patch curing process at an elevated temperature. The glass transition temperature of polymer mold needs to be higher than 350^{o}F to avoid softening of mold. Also, the thermal expansion coefficient needs to be minimal. Furthermore, since resources will be limited during field repair scenarios, the mold material must be recyclable so that it can be ground up and used to create a new mold. Thus, thermo-plastic would be a good candidate.

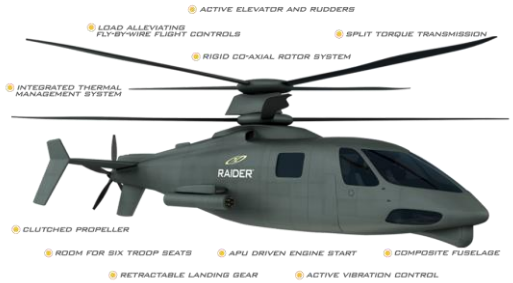
The mold material that was chosen was a polyetherimide based polymer, ULTEM 1010. It was chosen because it meets the requirements listed above. An additively manufactured mold was produced in the shape of a cylinder. This shape was chosen as it has only one direction of curvature and will be easy to visually inspect for dimensional inaccuracies. The composite was laid up using this mold between 6 and 18 layers thick. This was done as this is an industry standard for the composites used in rotorcraft. Residual stresses within the composite patches were analyzed to determine the effectiveness of the 3D printed molds for composite patch production. Visual inspection was also done to study any changes in dimension of the mold itself due to thermal expansion during the curing process as this could affect the dimensions of the final patch.



(1) 3D Printed Mold



(2) CAD model of composite laid up on 3D printed mold



(3) Sikorsky S-97 Raider Helicopter, relies heavily on composite parts