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Surface Preparation Study

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SENIOR DESIGN

MECE 471

HONORS PROJECT

MECE 497

By

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Abstract

Throughout the aeronautical and aerospace industry, materials that possess high strength while maintaining low weight are desirable due to the demand for energy-efficient vehicles. As a result, composite materials, such as carbon fiber reinforced polymer (CFRP), are being increasingly used due to their high strength-to-weight ratio that accommodates such desired characteristics. Even with the advancement of composite materials, non-traditional methods of joining materials are often required to integrate them efficiently into structures. The use of traditional joining methods using bolts and rivets creates high-stress concentrations, leading to localized damage and bearing failure. As such, the advancements in adhesive technology have allowed composite joints to become a staple in aerospace structures. Although adhesives offer substantial mechanical improvements for composite joining, some factors strongly affect the adhesive joint's performance and durability, such as the surface preparation of the adherend material and the environmental temperature.

This work explores a custom air atmospheric pressure plasma treatment (APPT) machine's effectiveness in cleaning and chemically activating a CFRP surface. It is explore by implementing water contact angle (WCA) measurements, water-break free (WBF) testing, and adhesive tubular lap-joint (TLJ) tensile testing. An 8x3 test matrix of different machine parameters is defined with the bounding conditions being the machine's capabilities and industry standard recommendations. Each configuration of the test matrix is explored after treatment at multiple time intervals up to 2 weeks afterwards to gain insight into the outlife of the treatments with the intention of adhesively bonding to the surfaces. Multiple data analysis processes such as one-way ANOVA studies, box and whisker plot interpretations, and visualizations of (24) different process parameters at once are performed to understand the custom plasma machine's effect on the surface of the CFRP components.

Results show that treatments that are closer to the tube are best for uniformly treating the surface which is supported with all of the tests performed. It is also shown that there is a statistical difference between the surface chemistry of different CFRP tows visible on the surface of the CFRP tube.

This work will be published in American Society for Composites 2023 later this year under a similar title.