Mitigating delamination in CFRP bonded joints: A comparative study of high-performance thermoplastic and thermoset adhesives

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INTRODUCTION

In recent years, adhesive bonding has been preferred for joining Carbon Fiber Reinforced Polymer (CFRP) parts because of many advantages over mechanical fastening (such as better strength-to-weight ratios and a more even distribution of loads throughout the entire joint). Unfortunately, even with these benefits, bonded joints are still subject to premature failure due to delamination and/or localized stress at the ends of something called "the overlap". In this research project, we examine how film-based thermoplastic adhesives can be used as high-performing alternatives to traditional thermoset type adhesives, specifically to mitigate delamination through improved resistance to crack initiation and propagation.

The goal of this study is a comparative evaluation of thermoplastic films against thermoset benchmarks through a variety of service temperature and strain rate ranges. Results from the testing indicated that thermoplastic adhesives had greater damage tolerance and energy absorption levels than thermoset adhesives. By providing information about how these materials behave under different conditions, this research will help create a pathway for the use of thermoplastic adhesive bonding to enhance advanced composites in a variety of high-performance industrial applications.

EXPERIMENTAL DETAILS

Three different adhesives were compared (see Figure 1).

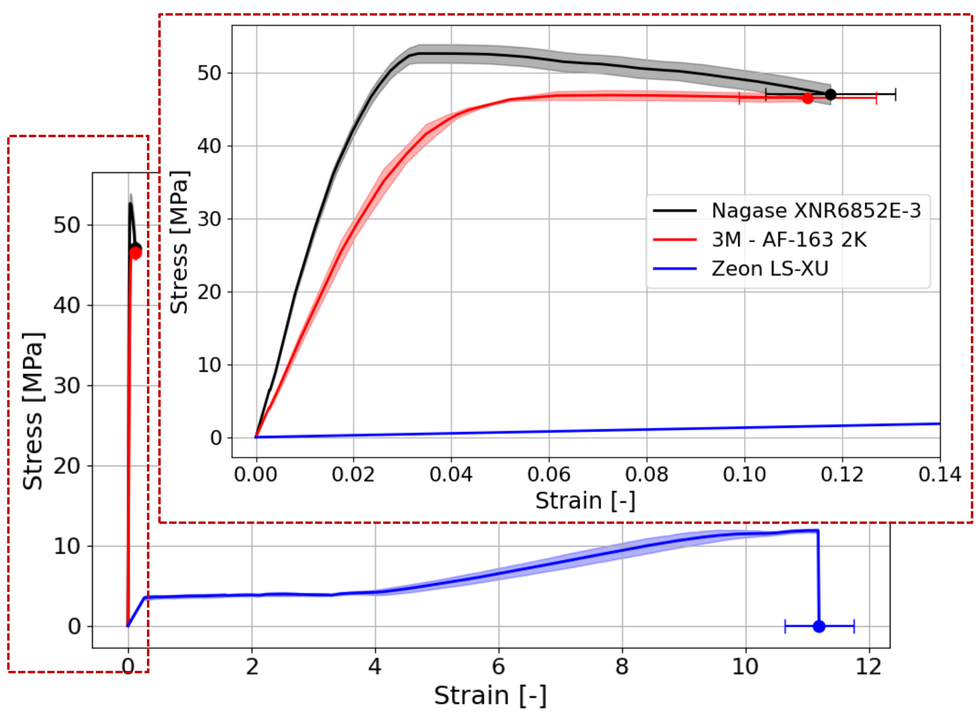

FIGURE 1. Stress-strain curve of three adhesives used.

The geometry of the single lap joint is illustrated in Figure 2.

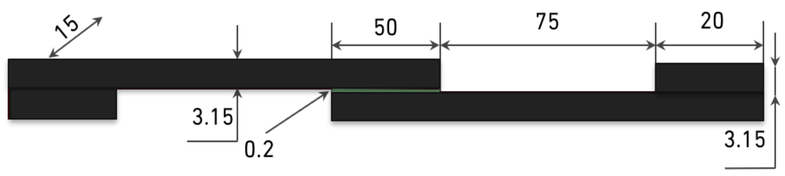

FIGURE 2. SLJ specimen geometry.

Quasi-static and impact tests, were evaluated using an Instron 3360 universal testing machine and a custom-built drop-weight machine.

RESULTS

The joints were manufactured and subjected to quasi-static (1 mm/min) and impact (3 m/s) test conditions, as well as different test temperatures (-30, 23 and 80 °C). Figure 3 shows the failure load as a function of temperature for the different conditions tested.

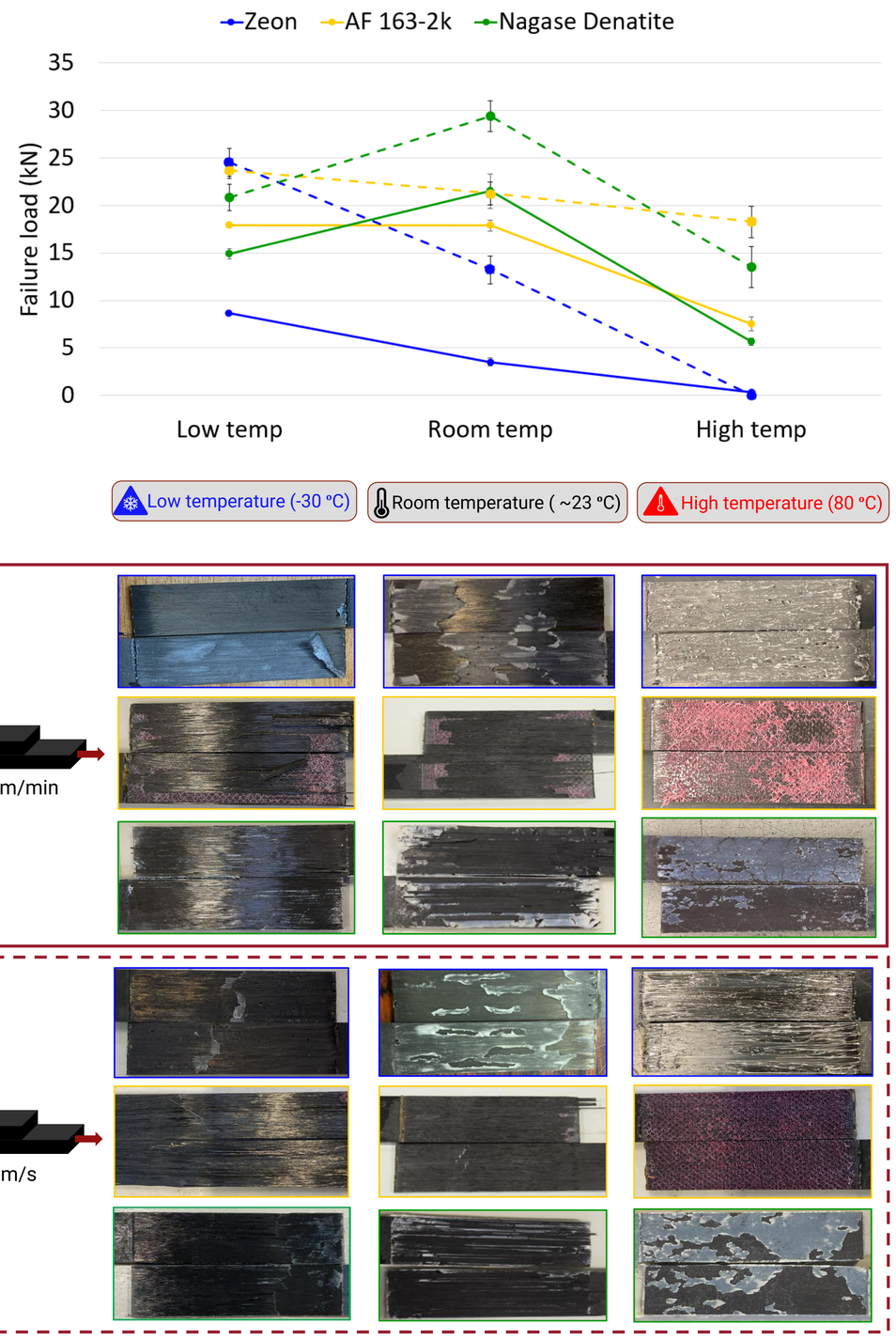

FIGURE 3. Failure load-of three adhesives under varying temperatures and testing rates.

CONCLUSION

- Performance of the LS-XU improved under impact, showing a very high strain-rate sensitivity;
- The LS-XU is excellent at low temperatures, acceptable at RT but totally unsuitable at 80 °C due to low T_g (85 °C);
- Energy absorption increased in both CFRP and wood joints, especially under dynamic loading;
- Overall, this adhesive is lightweight, recyclable and can be a viable repairable bonding strategy.
- Cyclic olefin-based thermoplastic adhesive offer a recyclable, and repairable alternative applications.

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