EVALUATION OF SURFACE TREATMENT METHODS FOR PA6 FRP BONDING WITH ADHESIVES

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ABSTRACT

In this research, to find the appropriate methods for surface treatment, the strength of adhesively bonded joints consisting of fiber reinforced thermoplastics has experimentally been investigated. After several surface treatments for increasing the surface energy of the material, the strength of joint specimens was tested. Specimens, whose adherends comprised of glass fiber reinforced plastics having PA6 matrix resin, were prepared for single lap joint tests, and the quasi-static tests were carried out. The surfaces of the adherends were treated by atmospheric plasma. The adherends were bonded with several types of adhesive. Enough strength for structural bonding was obtained by any treatment methods in those experiments. Adhesive bonding, therefore, must be promising even for thermoplastic composites.

1 INTRODUCTION

Fiber reinforced thermoplastics (FRTPs) are promising for the automotive industry because their application can drastically reduce the weight of car structures and processing time. The materials are usually joined each other by welding, which cannot be applied to fiber reinforced thermoset plastics. In contrast, to join the thermoplastics to other materials such as metals, adhesive bonding is still applicable due to the versatility for dissimilar materials joining. Thermoplastic composites are often poorer in adhesion strength than thermoset ones because of the low surface energy, although it is up to the type of matrix resin. Surface treatments before bonding is one of the methods to compensate the disadvantage of thermoplastic composites. Several types of surface treatment methods such as flame, plasma, etc., have been proposed for usual thermoplastics. It is, however, still not clear which method is the most appropriate for fiber reinforced thermoplastics that have higher strength. In this research, the improvement of adhesion strength for FRTPs by several types of surface treatments has experimentally been investigated.

As shown in Fig. 1, the data previously presented by the authors in Ref. 1 indicated that almost all the treatments are effective to improve the joint strength of the specimens and the adhesion strengths were higher than 10 MPa. However, the improvements by the treatments were not significant because cohesive fractures in the adhesive layers dominantly occurred. In the other words, the interfacial strengths between the adhesive and the adherends were higher than the intrinsic strength of the adhesive.

For this research, we selected plasma treatment from all the methods and changed adhesive in order to conduct further experiments. A specially made atmospheric plasma system was utilized and the type of gas and irradiation condition was carefully selected. An acrylate adhesive, which has higher intrinsic strength was selected and applied to make the SLJ specimens. In these experiments, the distance between the plasma nozzle and the adherend surface, the feeding speed of the plasma nozzle, and the number of processing were changed.

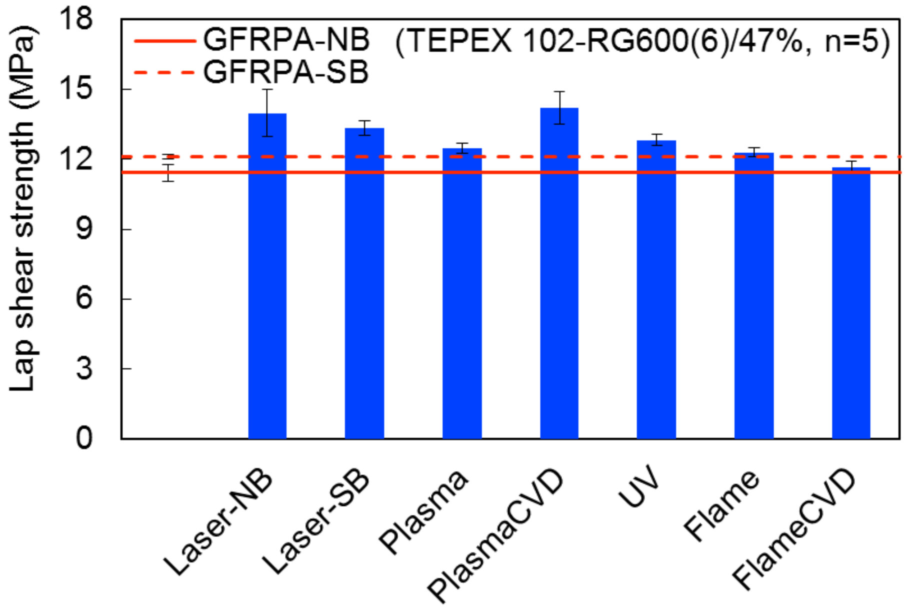
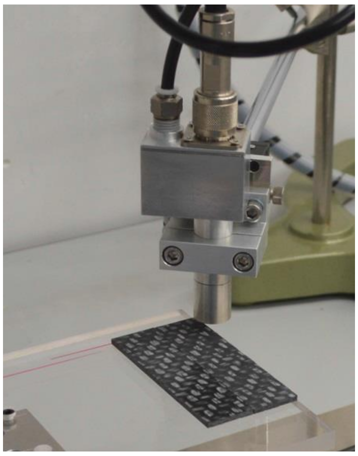
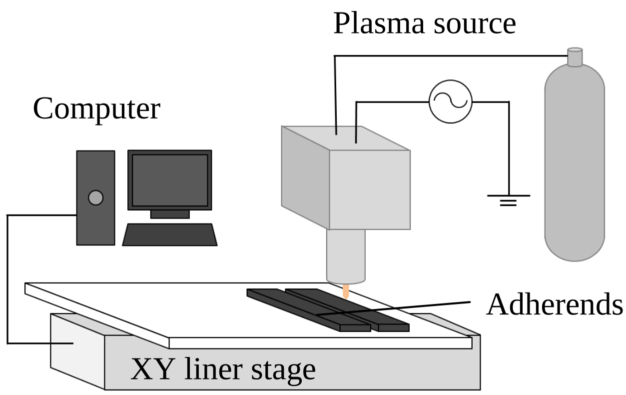


Figure 1: Adhesion strength of GFRPA treated by several methods [1]

2 SURFACE TREATMENT AND SPECIMENS

A type of glass fiber reinforced plastics (TEPEX® Dynalite 102-RG600(6)/47%, Bond-Laminates GmbH, Brilon, Germany), which have a polyamide 6 matrix resin, was used as the adherends of specimens for the research. The adherend material were treated by grid-blasting to remove the release agent residue on the surface. After that, the surface was wiped with acetone and treated by an atmospheric plasma equipment, was shown in Fig. 2. The equipment was composed of plasma source and XY linear stage and computer. The plasma source was specially designed and made for chemically unstable materials and can generate very low temperature plasma for several types of gas. After the treatments, a primer coating was applied to the surface and the adherends were bonded with an acrylate adhesives to single lap joint (SLJ) specimens shown in Fig. 3. The adhesive is 2 component type and provided by a cartridge of two syringes. Using an adhesive gun and a static mixer, the adhesive was applied on the surface of the adherends. The adherends were overlapped using a jig and joined, as shown in Fig. 4, kept at ambient temperature for 6 h, and cured at a temperature of 60 °C for 2h.





(a) Close-up of surface treatment (b) Schematic views of the surface treatment equipment

Figure 2: Testing setup for tensile tests of specimens

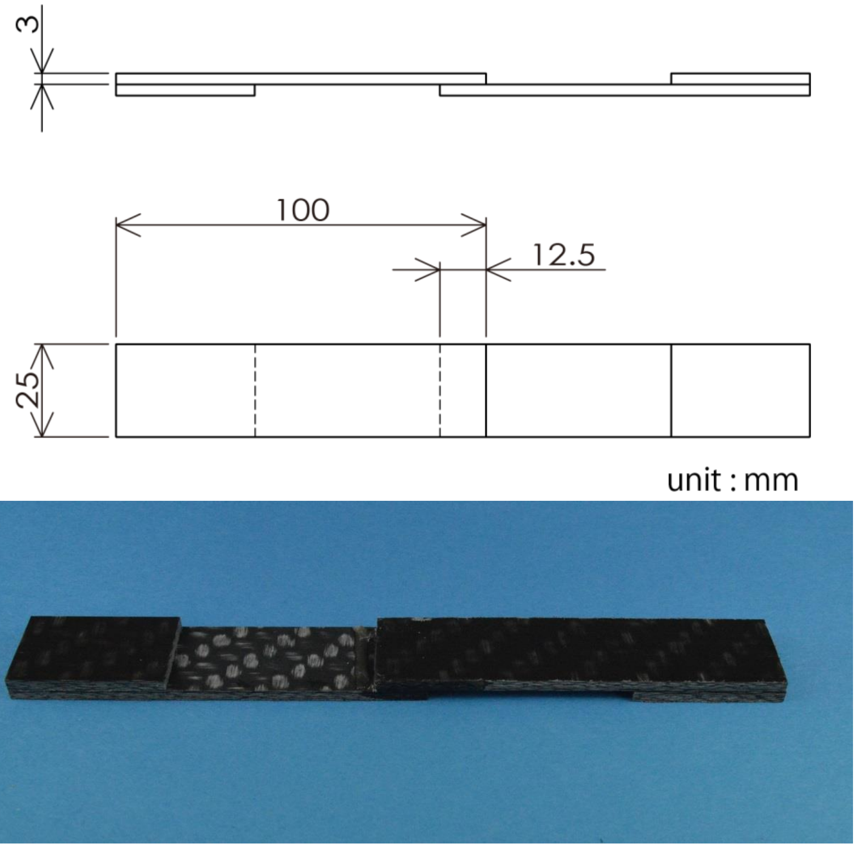


Figure 3: Configuration and dimensions of single lap joint specimen

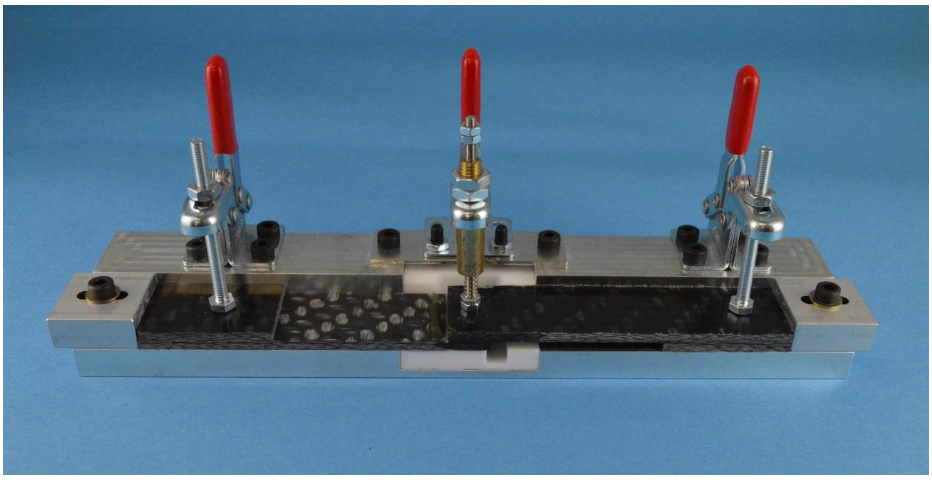
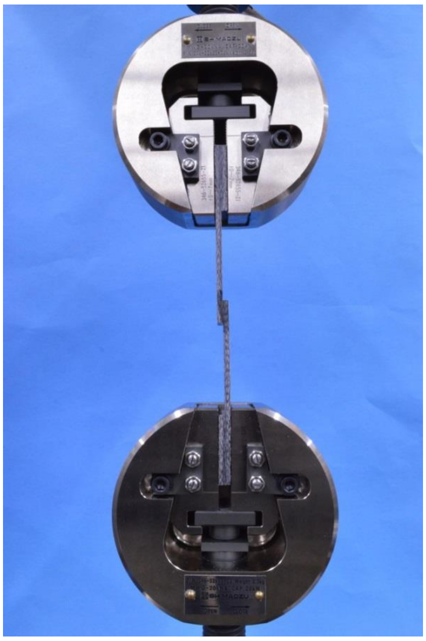


Figure 4: Jig for making single lap joint specimen

3 EXPERIMENTAL METHODS

The SLJ specimens were tested by a testing machine, as shown in Fig.4, and the lap-shear strength of the specimens were measured under a quasi-static condition. Tensile speed was selected as 10 mm/s and the lap-shear strengths were calculated from the maximum load and the area of adhesive joint in the specimens.



(a) Testing machine (b) Close-up of specimen

Figure 5: Testing setup for tensile tests of specimens

4 RESULT AND DISCUSSION

For these experiments, the feed rate and number of processing did not influence significantly the lap shear strength of the specimens. As a result, the average strength of 19.7 MPa was obtained for a condition, although the strength of a non-treated specimen was 13.8 MPa, as shown in Fig. 6. In other words, strength increases 42% by the surface treatment. The fracture surfaces are shown in Fig. 7. Only adhesive failure was observed in the fracture surface of untreated specimen, as shown in Fig. 7 (a). By contrast, in addition to adhesive failure, material failure also occurred in plasma treated specimen, as shown in Fig. 7 (b). The strength is not lower than a typical strength of joint strength for thermoset composites bonded adhesively. Therefore, it was confirmed that adhesive joining is a promising method even for thermoplastic composites.

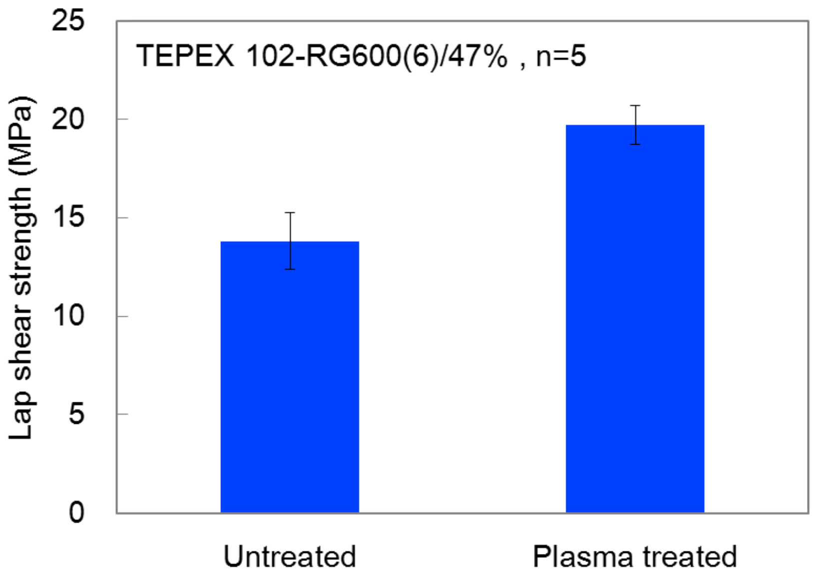
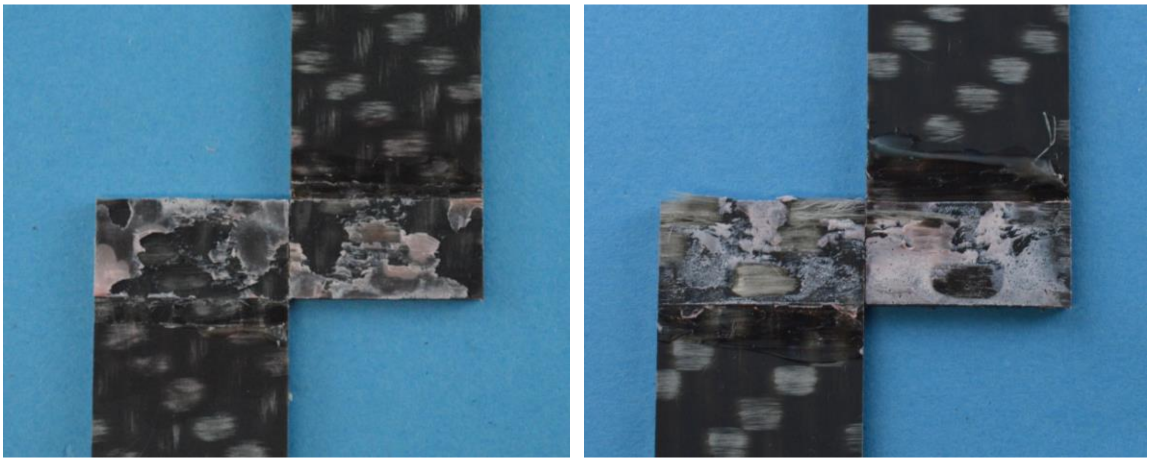


Figure 6: Result of tensile tests



(a) Untreated specimen (b) Plasma treated specimen

Figure 7: Fracture surface of lap shear specimens

5 CONCLUSION

GFRTP having a polyamide 6 matrix resin was able to be bonded with an acrylate adhesive. Combining atmospheric plasma treatment and a primer coating, the joint strength increased drastically. The average strength obtained in a series of the experiments was 19.7 MPa, which is strong enough for the structural use of composite materials.

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