Universal Joints of Ti/Polymers Connected by Activated Carbon Fibers

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Introduction

Both titanium (Ti) and carbon fiber reinforced thermoplastic polymers (CFRTP) are typical light structural materials not only to save energy for the environment, but also to enhance the mobility of aircraft. They have been already utilized for dream worthy mover machines, as well as airplanes and automobiles. Although the four joint methods of welding, blazing, rivet connecting and glue are useful, they often reduce the materials strength. Popular carbon fiber reinforced epoxy polymers (CFRP) has been recently applied to not only wing, but also fan blades of turbo fan engines. To prevent impact fracture, leading edge of titanium is often wrapped in and mounted on the CFRP fan blades, as shown in Fig.1. In order to enhance the joining strength, a new joining method with extremely large friction force by broad interface of carbon fiber (CF: 6μm-diameter) used as the joint junction has been suggested, prepared and evaluated (Fig.2). Since the CF reinforced universal joint (CFR-UJ) can be developed and applied instead of conventional joints, it should tremendously enhance the joint fracture strength of metals / Epoxy joints [1].

Fig. 1: *Application of carbon fiber reinforced polymer (CFRP) with Ti sheath recently utilized for fan blades of turbo fan engines of airplane.*

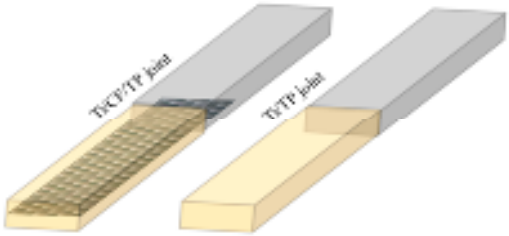


Fig. 2: *Schematic diagram of joining samples with and without carbon fiber.*

On the other hand, to reduce the cost, the inexpensive and rapidly solidified materials are often utilized for airplanes and automobiles. Since both materials costs and solidification times of thermoplastic polymers (TPs) are apparently smaller than those of thermos-hardened epoxy polymer, the TPs have recently watched with interest. However, the low adhesive strength of TP has been a serious problem because of typical low wetting of TP to CF.

To improve the CFR-UJ strength with extremely large friction force taking advantage of the high interface area of CF, CF-surface activation has been suggested and treated by electron beam irradiation (EBI) on the half-length prior to dipping in polymers. The purpose of the present work is to introduce the recent development of universal joints of Ti / polymers [2].

Experimental procedure

To improve the CFR-UJ strength with extremely large friction force taking advantage of the high interface area of carbon fiber (CF: 6 μm-diameter) cross weave cloth, surface activated by low voltage electron beam irradiation (EBI) by an electron-curtain processor (Type CB175/15/180L, Energy Science Inc., Woburn, MA, Iwasaki Electric Group Co., Ltd., Tokyo) on the TP half-length prior to dipping in ABS or Polycarbonate resin to enhance the adhering ability of thermoplastic with CF has been suggested for a joint (Ti/EBCF/TP) of titanium (Ti) and EB-irradiated carbon fiber (EBCF) reinforced thermoplastic polymer (TP).

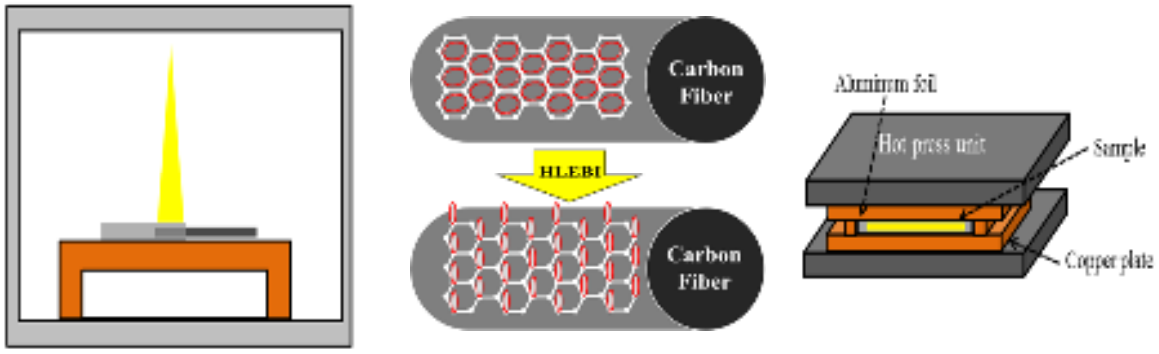
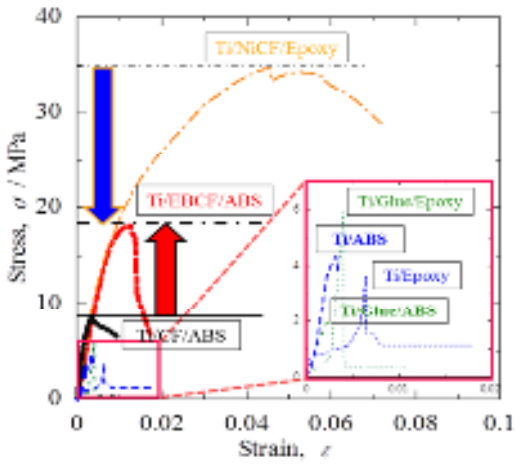


Fig. 3: *Schematic drawing of joining process for carbon fibers wrapped by molten Ti (a), carbon fibers treated by HLEBI (b) and carbon fibers wrapped by melted polymer (c).*

Results and Discussion

As shown in Fig. 4, experimental results shows tensile strength (σ_b) of the (Ti/EBCF/ABS) is higher than that without HLEBI (Ti/CF/ABS), and is much higher than that with glue (Ti/Glue/ABS) and without glue (Ti/ABS), respectively. The Ti/ABS joint is strengthened by CFR-UJ treated by HLEBI. Based on the results of X-ray diffraction (XRD) and wavelength dispersive X-ray spectroscopy (WDS) analysis, the titanium carbide (TiC) cannot be detected. Consequently, we conclude that the activated CFR-UJ enhances the joint strength of Ti/ABS.



σ_b (Ti/EBCF/ABS ; 18 MPa)

> σ_b (Ti/CF/ABS; 8 MPa)

> σ_b (Ti/ABS ; 5 MPa)

> σ_b (Ti/Glue/ABS: 2 MPa).

Fig. 4: *Tensile stress-strain curves of Ti/EBCF/ABS and Ti/CF/ABS, together with Ti/ABS joints with and without glue.*

Conclusions

The tensile strength of the (Metal/Polymer) joints treated by HLEBI (Ti/EBCF/ABS) were higher than that without treatments (Ti/Polymers). Thus, the activated CFR-UJ strengthened by the EBI-activated CF in metal side enhances the safety level of lightweight materials with high resistance to fracture for airplanes and automobiles over that without the treatments.

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References

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