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ADHESION BETWEEN METAL/POLYMER-COMPOSITES IRRADIATED BY ELECTRON BEAM PRIOR TO HOT-PRESS

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Summary: Aluminum (Al) with its high electrical conductivity, shiny silver color, light specific weight and high corrosion resistance due to passivation are valuable light structural materials utilized for aerospace technology with high specific strength. In addition, Austenite stainless steels (18-8) have been also utilized for Shin-kansen vehicles, automobiles, ships and airplanes. To reduce the fuel cost reduction with the lightweight, the adhesion between the metal (18-8 or Al)/CFRP should be one of useful tools. Techniques to strengthen the metal/composite joints are important. It is always important to develop a joint with maximum safety enhancement adding minimal weight to the structure for low energy consumption with concern for the environment. On the other hand, carbon fiber reinforced epoxy polymers (CFRP) have been utilized for structural materials of airplanes and sports cars. However, methods of joining two different materials such as fasteners including bolts and rivets; and adhesive bonding articles such as welding and soldering, has always been some of the serious problems to decay the materials. A metal/CFRP joint was developed without the use of fasteners, chemical treatment, or external adhesive by a new adhesion method, a double-step treatment consisting of applying low dose of homogeneous low energy electron beam irradiation (HLEBI) to the CFRP and metal prior to lamination assembly and hot-press.

To aim for high reproducibility of tensile shear strength of adhesion results, the connecting surfaces of the metal and CFRP sheets were homogeneously irradiated by an electron-curtain processor (Type CB175/15/180L, Energy Science Inc., Woburn, MA, Iwasaki Electric Group Co., Ltd., Tokyo). The samples were homogeneously irradiated with an electron beam through a titanium window attached to a 24 cm-diameter vacuum chamber. A tungsten filament in a vacuum was used to generate the electron beam with an electric voltage of 0.17 MeV and an irradiating current of 2.0 mA. To prevent oxidation, the samples were kept in a nitrogen atmosphere of 0.10 MPa with a residual oxygen concentration of less than 0.040 %. The flow rate of the nitrogen gas was 1.5 L/s.

Composite sheets were constructed with metal (10 mm x 40 mm x 2.0 mm, Taiho trading Co., LTD.); and CFRP (10 mm x 40 mm x 0.25 mm) (1 ply 0.25 mm in thickness). Volume of carbon fiber cross textile reinforced epoxy polymer composite (CFRP; TR3110-331MP epoxy/CF, Mitsubishi Rayon Ltd., Tokyo) was 0.25 x 40 x 10 = 100 mm3 with adhesive area (10 x 10 = 100 mm2) for tensile shear test. In the CFRP sheet, Vf of carbon fiber was 60 %. The preparation steps of the metal/CFRP joint samples.

Spontaneous adhesion was detected for both CFRP-Epoxy/Al and CFRP-Epoxy/18-8 stainless steel lamination sheets, although it was not observed for PU/Al lamination sheet. Furthermore, HLEBI improved the adhesion for all composites lamination sheets.