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A Technology of Hot Stamping and Welding of Carbon Reinforced Plastic Sheets Using High Electric Resistance

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Abstract : In recent years, environmental problems and energy problems typified by global warming are intensifying, and transportation devices are required to reduce the weight of structural materials from the viewpoint of strengthening fuel efficiency regulations and energy saving. Carbon fiber reinforced plastic (CFRP) used in this research is attracting attention as a structural material to replace metallic materials. Among them, thermoplastic CFRP is expected to expand its application range in terms of recyclability and cost. High formability and weldability of the unidirectional CFRP sheets conducted by a proposed hot stamping process were proposed, in which the carbon fiber reinforced plastic sheets are heated by a designed technique. In this case, the CFRP sheets are heated by the high electric voltage applied through carbon fibers. In addition, the electric voltage was controlled by the area ratio of exposed carbon fiber on the sample surfaces. The lower exposed carbon fiber on the sample surface makes high electric resistance leading to the high sample temperature. In this case, the CFRP sheets can be heated to more than 150 °C. With the sample heating, the stamping and welding technologies can be carried out. By changing the sample temperature, the suitable stamping condition can be detected. Moreover, the proper welding connection of the CFRP sheets was proposed. In this study, we propose a fusion bonding technique using thermoplasticity, high current flow, and heating caused by electrical resistance. This technology uses the principle of resistance spot welding. In particular, the relationship between the carbon fiber exposure rate and the electrical resistance value that affect the bonding strength is investigated. In this approach, the mechanical connection using rivet is also conducted to make a comparison of the severity of welding. The change of connecting strength is reflected by the fracture mechanism. The low and high connecting strength are obtained for the separation of two CFRP sheets and fractured inside the CFRP sheet, respectively. In addition to the two fracture modes, micro-cracks in CFRP are also detected. This approach also includes mechanical connections using rivets to compare the severity of the welds. The change in bond strength is reflected by the destruction mechanism. Low and high bond strengths were obtained to separate the two CFRP sheets, each broken inside the CFRP sheets. In addition to the two failure modes, micro cracks in CFRP are also detected. In this research, from the relationship between the surface carbon fiber ratio and the electrical resistance value, it was found that different carbon fiber ratios had similar electrical resistance values. Therefore, we investigated which of carbon fiber and resin is more influential to bonding strength. As a result, the lower the carbon fiber ratio, the higher the bonding strength. And this is 50% better than the conventional average strength. This can be evaluated by observing whether the fracture mode is interface fracture or internal fracture.

Keywords : CFRP, hot stamping, weliding, deforamtion, mechanical property
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