Comparative study of adhesive bonding and resistance element welding of Carbon Fiber-Reinforced Polymer and Steel

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Objectives / Description / Main outcomes

The aim of this STSM research is to compare mechanical and macrostructure characteristics of adhesive joint and novel jointing technology called Resistance element welding (REW). Also, the aim of this research is to show the possibilities of applying the adhesive and REW joint together (hybrid joint) in order to improve the mechanical properties of the joint. As representatives of multi-material structure, for this research were used 1,0 mm thick Carbon Fiber-Reinforced Polymer and 1.5 mm thick DP500 steel. S355JR steel rivet was used as the auxiliary element. For the purpose of later comparison, three types of joining technology of DP500 steel and CFRP were used for this research: (1) Resistance element welding-REW; (2) adhesive joining; (3) hybrid joining (adhesive and REW). The specimens were 30 × 100 mm for all types of joining technology. The specimens were assembled with an overlap distance of 35 mm. The REW joining procedure began by drilling a hole in the CFRP and inserting a 4 mm diameter steel element (S355JR) in the CFRP, after that classic Resistance spot welding - RSW was done. Welding was carried out using electrode type F1 with parameters: (1) welding current I=5 kA; (2) electrode force F=3,68 kN; (3) welding time T=80 ms. The adhesive that was used to bond the CFRP and DP500 steel in this study is LOCTITE® EA 9466. The bonding surface was previously prepared by sanding with P320 paper and then cleaned with nitro thinner. Curing lasted 24 hours at a temperature of 45 ºC with additional plastic clamps. The hybrid joint was obtained by combining the previous two joining technologies, but during curing wasn't used additional plastic clamps. The tensile-shear tests were done on a Beta 50-7 / 6×14 testing machine at a cross-head speed of 2 mm/min. Macrostructural analysis was done by using Keyence VHX-6000 microscope. Figure 1 shows a comparison of force-displacement curve for these listed three joints. Steel DP 500 and CFRP can be joined by Resistance element welding but the failure load of the joint is significantly lower compared to the adhesive and hybrid joint. The hybrid joint has about 30% higher failure load compared to the adhesive joint and also about 20% more absorbed energy. The results obtained in this way confirm that the mechanical properties of the joint can be improved by the hybrid joining using Resistance element welding and adhesive. The analysis of the macrostructure of the hybrid joint (Figure 2) showed that during REW welding, air inclusions and metal splash occur, so the focus of further research should be on finding the optimal geometry of elements and welding parameters to remedy these shortcomings.

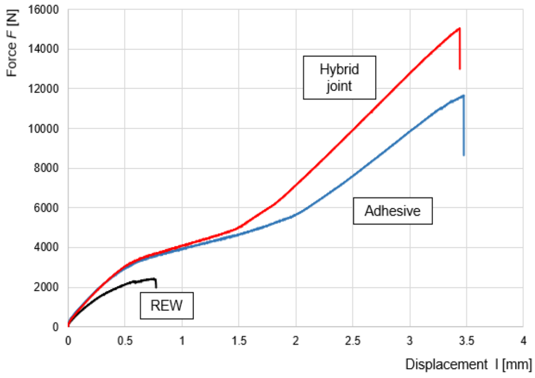

Figure 1: *Force-displacement curve for three different types of joints*

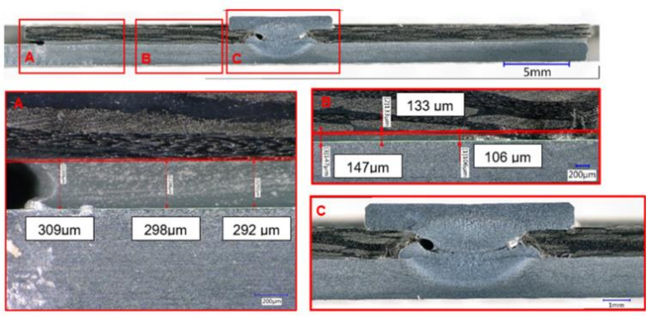

Figure 2: *The macrostructure of the hybrid joint*

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