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Strength evaluation of multipoint clinch and adhesive bonded joints of high strength steel and aluminum alloys

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Decreasing the weight of automobiles contributes to reducing automotive greenhouse gas emissions. One lightweight strategy for automotive body manufacturing is to use the suitable material in the proper form for the correct application. This strategy has resulted in the mixed-use of high-strength and lightweight materials, for example, high-strength steel and aluminum alloy, which drive the development of reliable joining processes for dissimilar materials [(1)]. Mechanical clinching is a method of joining different metal parts (mainly sheets) by local deformation without using any additional joining elements with the application of a punch and a die. The amount of formed interlock determines the strength of the joint, but this strength is not high compared to other joining methods, e.g., self-piercing rivets. Combining clinching with adhesive joining can create a hybrid joining method with new potential applications in the manufacturing industry [(2)]. The authors' research has confirmed that the bond strength increased [(3)].

This research aims to experimentally analyze the strength of single-point and multi-point clinch-bonding joints of high-strength steel and aluminum alloy sheets in the forms of both Steel-on-top and Al-on-top. Based on the experimental results, constructed simulation models incorporating the natural clinch-bonding joint geometries and adhesive bonds were to quantify the interactions between the clinching process and adhesive bonding strength. It is expected that this research will contribute to the joining strength evaluation and simulation of the clinch-bonding process in manufacturing multi-material structures.

The base materials selected for this study were high-strength steel JSC780 with 1.2mm thickness and aluminum alloy A5052-H34 with 1.5mm thickness. A commercial CEMEDINE EP138 adhesive was used. Four samples were made to study the effect of stack orientation and the number of clinching points. The basic phenomena of clinch-boding joints with different stack orientations and the number of clinching points have been revealed from the experiments. Six numerical models were developed to identify the adhesive parameters for different clinch-bonding joints. Four of them had clinch-bonding. The others were the adhesive shear and the adhesive peel without clinching. Comparisons between the two types' clinch-bonding numerical models and experimental curves are given in Fig.1. The simulated force-stroke curves match well with the experiments.

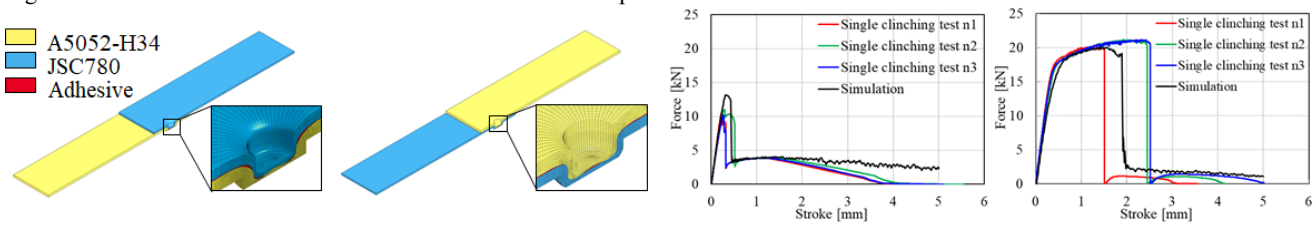

Fig.1 Numerical simulation model and validation

Conclusions:

This study analyzed the strength of adhesive and multi-point clinching joints of high-strength steel and aluminum alloy sheets through experiments. Constructed a numerical simulation model was to quantify the clinching process's effect on the adhesive layer's performance. For the Steel-on-top case, the clinching process makes the adhesive layer discontinuously distributed, which decreases the adhesive strength significantly. Whereas for the Al-on-top case, the adhesive layer was still continuously distributed after the clinching process and exhibited much higher strength than the Steel-on-top case. Increasing the clinching point from single to double can increase the adhesive strength of the Steel-on-top case but have little influence on the Al-on-top case.

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