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論　文　内　容　要　旨

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学位論文題目	Investigation of the two-steps clinching process for joining aluminum alloy sheets （２段クリンチ加工によるアルミニウム合金板の接合に関する研究）		

内容要旨

In order to reduce the protrusion height and increase the strength of clinched joints, a two-steps clinching method using a rivet to reshape the clinched joint was put forward in the study. The first step is mechanical clinching process, and the second step is reshaping process. The reshaping method in the second step can be a helpful supplement of conventional mechanical clinching.

Deform-2D was used to simulate the two-steps clinching process. The numerical results and experimental results of the two-steps clinching process are in good agreement, and the error in the evaluation of the cross-tensile strength is less than 1%. The best combination of the reshaping rivet geometrical parameters was gotten in terms of the cross-tensile strength by orthogonal design. Factor A and factor B have significant effects on cross-tensile strength and the order of the factors' importance is A (d_1), B (α_1), F (l_2), C (l_1), E (α_2), and D (d_2). In the experiment, when the protrusion height of the joint was reduced to 1.0 mm, the average cross-tensile strength was increased from 957.9 to 1154.9 N, and the average tension-shearing strength was increased from 1229.4 to 2757.3 N.

Forming force is an important factor in the forming process. The neck thickness and interlock of the two-steps clinched joint are all larger than those of the clinched joint. The material flow in the reshaping process contributes to increase the strength and reduce the protrusion height of the clinched joint. The protrusion height of the two-steps clinched joint decreases with the increase of the reshaping force. The cross-tensile and tension-shearing strengths of the two-steps clinched joints with different reshaping forces are all higher than those of the conventional clinched joint. The cross-tensile and tension-shearing strengths of the two-steps clinched joint with a forming force of 35kN are the highest of all. Neck fracture mode is the main failure mode. Neck thickness has an important influence on the strength of the joint. The failure process of the two-steps clinched joint involves much higher energy absorption than the conventional clinched joint.

The two-steps clinching process is suitable for joining different aluminum alloy sheets. The joint with an upper sheet of AL6061 and a lower sheet of AL5052 has higher strength than the joint with an upper sheet of AL5052 and a lower sheet of AL6061. The rivet can help the joint to increase the strength in the two-steps clinching process. The two-steps clinching process is suitable for joining aluminum alloy sheets with different thicknesses. The COJ2.5-2.0 joint has the highest strength, while the CLJ2.0-2.5 joint has the lowest strength. For joining aluminum alloy sheets with different thicknesses, it is better to take the thicker sheet as the upper sheet to get a higher strength. The two-steps clinched joint with a bottom thickness of 1.6 mm has the highest cross-tensile strength and tension-shearing strength among the two-steps clinched joints in case of the joints with bottom thicknesses of 1.4, 1.5, and 1.6 mm.

The maximum reshaping force of the reshaped joint with no auxiliary is the lowest, while the maximum reshaping force of the reshaped joint with a rivet is the highest. The additional parts used in the reshaping process can increase the reshaping force. The cross-tensile strength of the clinched joint is the lowest, while the cross-tensile strength of the reshaped joint with a rivet is the highest. All the reshaping methods can increase the cross-tensile strength of the clinched joint. The energy absorption of the joint in the cross-tensile test also can be increased by the three reshaping methods. All the reshaping methods can increase the tension-shearing strength of the clinched joint. The reshaping method with a rivet has the best performance for increasing the tension-shearing strength of the clinched joint. The energy absorption of the joint in the tensile-shearing test also can be increased by the three reshaping methods. Neck fracture mode is the main failure mode of the different joints. The failure mode of the clinched joint was not changed by the three reshaping methods. The clinched joint has the smallest neck thickness, while the reshaped joint with a rivet has the largest neck thickness. The strength of the joint was mainly influenced by the neck thickness. The three reshaping methods can increase the static strength and energy absorption of the joint by increasing the neck thickness.