DEVELOPMENT OF ALUMINUM AUTOMOTIVE BODY PARTS APPLIED REFILL FSSW TECHNOLOGY

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Abstract - In this paper, we investigated the aluminum welding process of less than thickness of 1mm using Refill FSSW (Refill Friction Stir Spot Welding) technology.Anvil, a cooling channel designed to improve the performance of the tool, is developed. In addition, the optimal welding conditions were derived from the parameters of tool rotation speed, insertion depth, and stirring time.Based on the results, we developed Heat Protector.

Keywords - Refill Friction Stir Spot Welding, Friction Spot Joining, Friction Stir Welding

I. INTRODUCTION

Aluminum is a representative nonferrous metal that can replace steel in automobiles, but due to limited welding, it is being applied to advanced cars. Conventional joining methods of aluminum materials include mechanical fastening such as self-piercing riveting, clinching, and RSW (Resistance Spot Welding) and FSSW (Friction Stir Spot Welding) using local plastic flow phenomenon. Self-piercing riveting has the disadvantage that material cost is extra, and large and complicated special joining equipment is required. And clinching is used with adhesives mainly because it has very low bond strength. It has strength in fatigue and corrosion problem, but it requires additional curing process, which increases manufacturing cost.

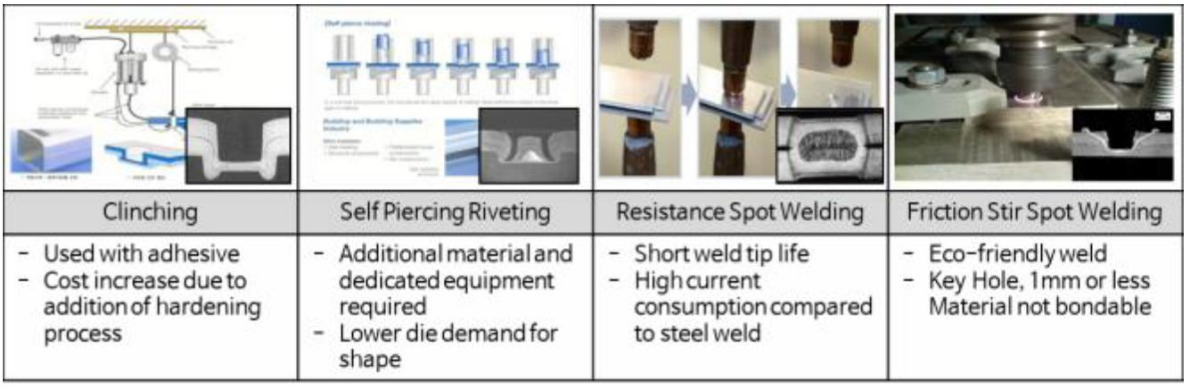
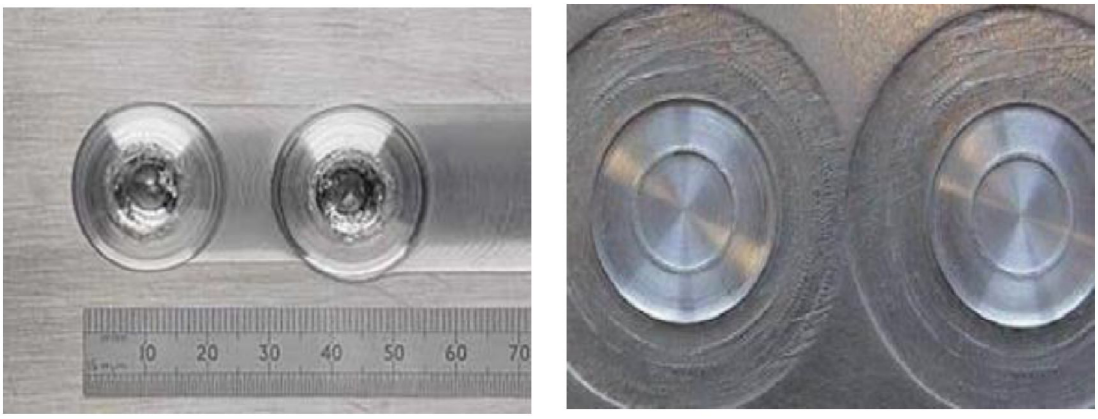


Fig.1. Conventional joining method for aluminum

Resistance spot welding for aluminum is highly contaminated due to the alloying of copper and aluminum, and electrode life is very short and frequent dressing is required.



(a) FSSW **(b) Refill FSSW**

Fig.2. Comparison between FSSW & Refill FSSW

The FSSW is bonded through the stirring of the base material using the rotational force of the tool, and the performance is excellent[1]. However, since the shape of the tool remains, the aesthetic appearance is poor[2]. Refill FSSW consists of pin, sleeve and plunger as a method of joining method to compensate the key hole which is a disadvantage of FSSW.And it is excellent in strength characteristics compared to the conventional process by supplementing the existing process disadvantages. However, in the conventional system, it is used only for an aluminum material having a thickness of 1 mm or more due to the phenomenon of adhesion. In this paper, we developed 0.5 mm Al welding method by developing anvil with improved cooling performance and precise control of tool.

II. DETAILS EXPERIMENTAL

2.1. Principle of Refill FSSW

Fig.3. is an image representing the Refill FSSW process of welding. (1) Pin and sleeve idle in the same direction, (2) pre-heating while pressing down material, (3) pin is reversely raised when the sleeve is rotating, (4) sleeve is lowered The pin is lowered to fill the stirred material. (5) The process is completed while the tool returns to the home position[3].

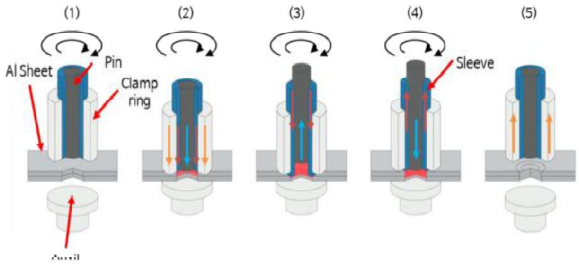


Fig.3. Refill FSSW Principle

2.2. Design of Anvil (Tool die)

Anvil was developed as shown in Fig.4.to improve the adhesion. In order to improve the cooling performance, the cooling channel was designed inside and the upper part was made of carbide.

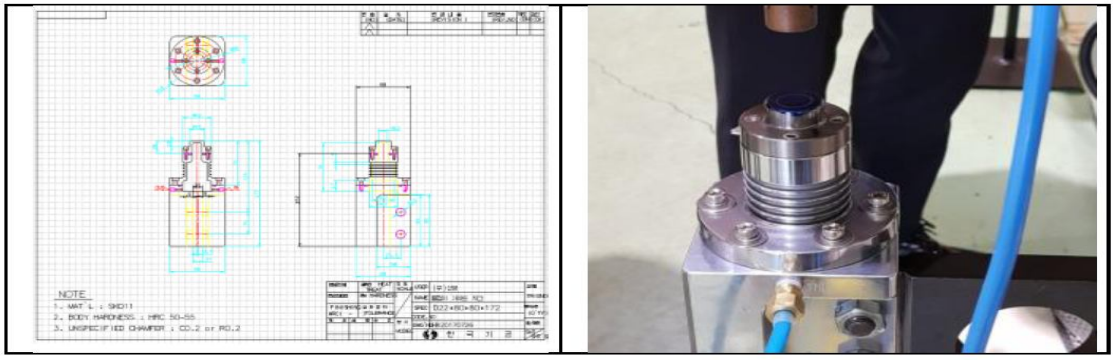


Fig.4. Design of anvil (tool die)

2.3. Establishment of weld conditions

In order to obtain optimum welding conditions, bonding tests were carried out with the tool rotation speed, insertion depth, and stirring time as variables as shown in Table 1.Specimens were prepared using Al 0.5 mm with embossed.

No.	RPM	Insertion Depth	Stirring time
1	1,000	0.2 mm	1.0 s
2	2,000	0.2 mm	1.0 s
3	3,000	0.2 mm	1.0 s
4	3,000	0.4 mm	1.0 s
5	3,000	0.6 mm	1.0 s
6	3,000	0.6 mm	0.5 s
7	3,000	0.6 mm	1.5 s

Table1: Welding condition table

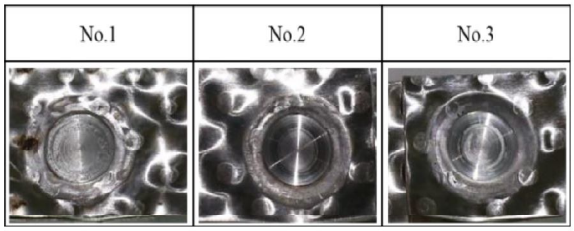


Fig.5. Comparison of surface roughness with tool rotation speed

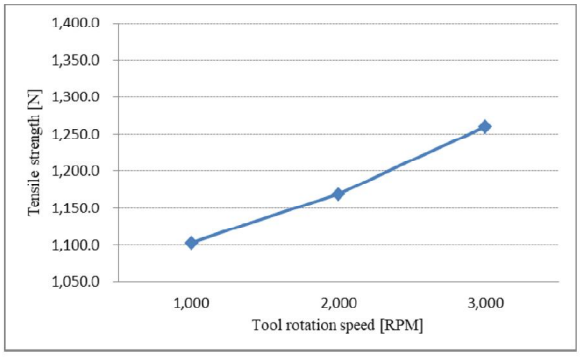


Fig.6. Change in tensile strength with tool rotation

III. RESULTS AND DISCUSSION

3.1. Change in tensile strength with tool rotation

As shown in Fig.5., the surface roughness varies depending on the rotational speed of the tool.

The No.2 specimen was the most beautiful, and the No.1 specimen was stirred and the most rough. On the other hand, the No. 3 specimen was burned to the tool after welding.The tensile strength was highest at 1.2kN at 3,000 RPM and 1.1kN at 1,000 RPM.

3.2. Change of tensile strength according to insertion depth

As shown in Fig.7., the tensile strength was different according to the insertion depth of the tool. When inserted 0.6 mm, it was the highest at 1.3 kN and the lowest at 1.2 mm when inserted at 0.2 mm. However, the specimen was stuck to the anvil under the condition of insertion of 0.6mm.

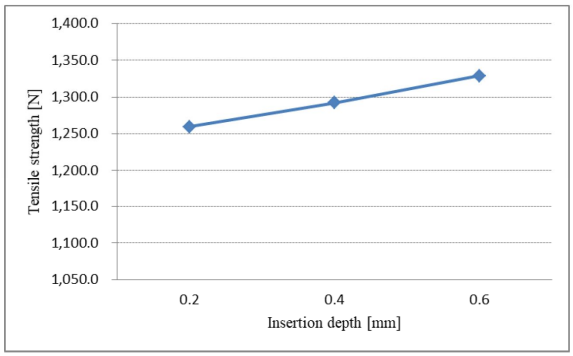


Fig.7. Change of tensile strength according to insertion depth

3.3. Change in tensile strength with stirring time

As shown in Fig.8., the effect of stirring time on tensile strength was negligible. Tensile strength of about 1.3 kN was observed under all conditions and all the anvilwas observed to be attached.

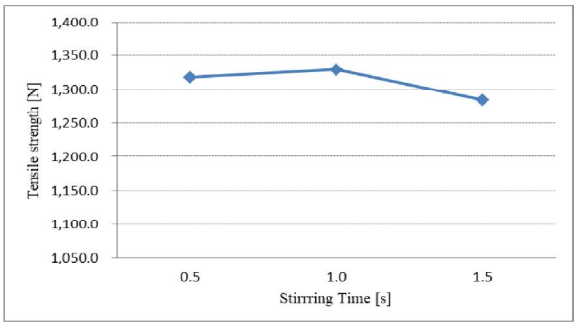


Fig.8. Change in tensile strength with stirringtime

3.4.Development of Al Heat Protector

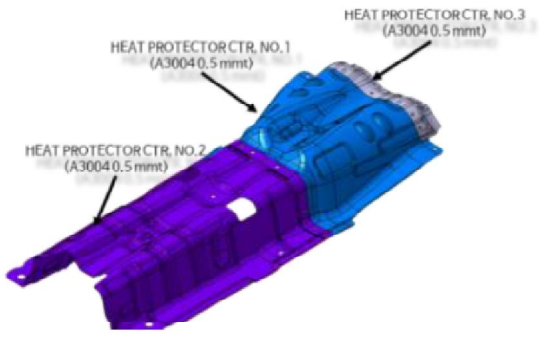


Fig.9. Design of Al Heat Protector

Fig.9. is a heat protector consisting of three parts, mounted on the top of the muffler to prevent heat from being transferred to the inside. In the past, RSW was applied and prototype was fabricated by applying Refill FSSW based on test results. Considering the surface roughness and the adhesion phenomenon, No.2 condition was applied.

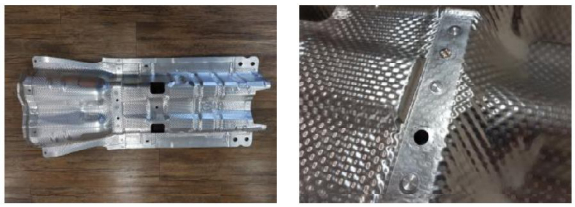


Fig.10. Developed Heat Protector applied to Refill FSSW

CONCLUSIONS

Through this study, the conditions for Refill FSSW were derived and the prototype of Heat Protector was developed by applying it.

1. Anvil with improved cooling performance improves the phenomenon that the agitated material sticks to the tool when the Al material is less than 0.5mm.
2. When applying Refill FSSW method, the tensile strength compared to the conventional RSW method is improved by about 20%.
3. Optimum bonding conditions were derived from the parameters of tool rotation speed, insertion depth, and agitation time.
4. Heat Protector applying Refill FSSW was developed by applying the derived bonding conditions and the dimensional accuracy was secured.

ACKNOWLEDGMENTS

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