The metal sandwich plate has many good properties such as high specific stiffness, high specific strength, good impact absorption, effective thermal insulation and soundproofing. Several bonding methods such as brazing, adhesive bonding, projection welding and adhesive-assisted projection welding are tested for fabrication of the metal sandwich plate. Finally, a new bonding method, 3-layer roll projection welding, is introduced to fabricate the metal sandwich plate of large area for the plate width of 270 mm. The new method uses a pair of roll electrodes like in seam welding; however, the workpiece width is much wider than that of seam welding by more than ten times. Projection welding of large area is made at two internal interfaces of the 3-layer weldment, consisting of a structured inner sheet of projection-like shape and a pair of skin sheets, when it passes through the gap between the roll electrodes. The weld quality is inspected by peeling test for various welding conditions, in order to find the optimal welding parameters. The welding sequence is to be synchronized for the given welding speed and pattern type of structured inner sheet to provide the consistent welding condition.

IIW-Thesaurus keywords: Monitoring systems; Projection welding; Resistance welding; Sandwich constructions.

1 INTRODUCTION

In recent years, there have been growing demands for high performance metal plate in various industries including automotive and shipbuilding. On the one hand, much research has been conducted to achieve lighter and stronger properties of the plate through alloying and heat treatment. On the other hand, researchers have tried to obtain these properties using composite and/or structured materials [1, 2] and the metallic sandwich plate is a promising one.

Adhesive bonding is the most popular fabrication method for such a sandwich plate, but there are still problems to be resolved: the selection of the correct adhesive, the uniform spread of the adhesive, the curing time and prevention of pore. There are other joining methods: resistance welding, vacuum brazing, laser welding, soldering and transient liquid phase bonding. Unfortunately, there are hardly any results on these joining methods in relation to productivity. [2-5]

In this study, several bonding methods such as brazing, adhesive bonding, projection welding and adhesive-assisted projection welding are investigated for fabrication of the plate. Finally, a new bonding method, 3-layer roll projection welding, is introduced to fabricate the metal sandwich plate with large area and the newly
developed welding machine can produce the structured metal sandwich plate without any additives by roll projection welding.

2 PRELIMINARY STUDY FOR BONDING METHODS

2.1 Resistance and furnace brazing

For resistance brazing, brazing foil (BAg-1) is inserted between the woven metal inner structure and stainless steel skin sheets. The foil is molten and bonding is achieved at the contact point of inner and skin sheet by electric conduction. But most of the foil remains solid where contact is not made and the remaining part does not contribute to bonding as shown in Figure 1. Because the reflow of brazing filler metal is insufficient in short conduction time, relatively thick brazing foil is needed for good bonding strength. This waste of filler metal and increase in weight are the main reasons why resistance brazing is not selected.

Furnace brazing was also considered. Dual phase steel for automobiles was used as skin sheets. Thinner brazing foil was enough to give an acceptable bonding strength in furnace brazing, but it takes a relatively long time. In addition, the material property of skin sheet was varied considerably by lengthy exposure to a high temperature environment; the dual phase steel having lost its good properties.

2.2 Adhesive bonding and adhesive-assisted projection welding

Much research has been conducted on metal laminate bonded with adhesive, but the feature is simple in many cases; two flat metal sheets are bonded with adhesive and there is no inner structure. In our study, it was hard to fill the internal space of the structured plate completely with adhesive in a short time. The unfilled part was observed in the cross-section of the plate shown in Figure 2. The increase in weight by adhesive was not preferred, either.

In spite of the weight increase, further study based on adhesive bonding was carried out to improve the bonding strength. It was adhesive-assisted projection welding. There were two possible approaches in adhesive-assisted projection welding – welding first, then filling with adhesive later, and vice versa. In the former case, it takes a long time to fill with adhesive. In the latter case, the pre-filled adhesive was burnt due to the high temperature during the welding process.

2.3 Roll projection welding

This method is the final selection in this study. Before designing and making an actual welding machine, various kinds of preliminary welding experiments and performance tests were carried out. [6, 7]

Figure 3 shows the modified electrode shape to simulate the roll electrode. It was installed in a general-purpose spot welding machine. The measured welding current was about 6 kA for the plate with a width of 30 mm. This value was used as basic data to estimate the required current for a real roll projection welding machine.

Several performance tests were carried out to compare the result with other material; especially with automotive steel. For example, the comparative result of a 3-point impact bending test is shown in Figure 4.

The inner, structured sandwich plates are thicker and lighter than the SPFC780 solid plate because there is an empty space inside the sandwich plates. They have a larger value of second moment of area and show a high resistance to bending. Among the two sandwich plates, the brazed one shows a better stiffness; this is mainly because of the larger thickness of the brazed one. The maximum load and the total absorbed energy, however, are high in the welded plate.