Development of Laser-arc Hybrid Welding

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*Laser-arc hybrid welding combines the laser and arc welding processes to provide advantages not found in either. This process can weld lapped steel sheets that have a larger gap than is possible with laser welding. Blowholes form when lap-welding zinc-coated steel sheets because of the zinc that is vaporized. The laser-arc hybrid welding proc*ess can lap-weld zinc-coated steel sheets without causing blowholes. The welding speed of laser-arc hybrid welding *is nearly equivalent to that of laser welding. Laser-arc hybrid welding produces high-quality lap joints and is ideal for assembly welding of automotive parts.*

1. Introduction

In recent years, laser welding has begun to be used for assembly welding of automotive bodies and parts, although it has not yet to be used widely. One restraint is that in laser lap welding, the gap between the lapped sheets must be controlled very tightly. If the gap is wide, burn-through occurs, and, if the gap is excessive, the two sheets cannot be welded together. For this reason, the gap is generally restricted to 0.1 mm or less for laser welding. Laser lap welding of zinc-coated sheets poses additional problems. Laser lap welding of zinc-coated sheets is performed without any gap, so the zinc that is evaporated between the sheets tends to blow off weld metal, or the zinc vapor tends to remain in the weld metal and form blowholes.

Laser-arc hybrid welding was developed to solve these problems. This method combines YAG laser welding and arc welding, allows a larger gap between lapped sheets than in laser welding, and produces fewer blowholes, even in lap welding of zinc-coated sheets. Therefore, stringent gap control is not necessary for lap welds, and the industrial application of this method is easy. In addition, the welding speed can be equivalent to that of laser welding, so the high efficiency of laser welding can be utilized.

2. Configuration of laser-arc hybrid welding

Fig.1 shows the system configuration for laser-arc hybrid welding. A YAG laser is used for laser welding, and an arc-welding electrode is positioned behind the YAG laser radiation point. The aim position of the arc is about 1

to 3 mm behind the laser radiation point. A YAG laser is used because the plasma does not absorb much of the laser energy. Most of the energy reaches the sheets, so that the YAG laser energy is efficiently utilized for welding. In contrast, energy from a carbon-dioxide laser is strongly absorbed by the arc plasma, so that a sufficient distance must separate the arc and the laser radiation point. Therefore, the combined effect of the laser and arc is not possible with a carbon-dioxide laser.

3. Experiment

3.1- **Experimental method**

A YAG welding laser manufactured by Luminics with a rated output of 4.5 kW was experimentally combined with metal active gas welding (MAG welding). An 0.8 mm diameter, solid, mild steel wire was used for the welding wire. Cold-rolled steel sheets and hot-dip galvannealed (GA) steel sheets with thicknesses of 0.8 to 1.6 mm were used as specimens. All joints were lap welds. The welding conditions are given in **Table 1**.

Table 1 Welding conditions of laser-arc hybrid welding

3.2- **Analysis of hybrid welding phenomena**

Time variations of the arc voltage were recorded to investigate arc welding phenomena during hybrid welding. **3.3**- **Evaluation of welded joint performance**

The external appearance of the welded joints was visually inspected and evaluated for the presence of welding defects such as blowholes and pits. Further, macrosections were prepared and examined for the formation of the weld beads and existence of blowholes. The strength of the welded joints was determined by tension shear tests.

4. Experimental results

4.1- **Welding phenomena**

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Fig.2 shows the time variation of arc voltage between

Photo 1 compares a macrosection of a hybrid weld bead with those of laser and arc weld beads. The penetration geometry of the hybrid weld bead is a combination of that of the laser and arc weld beads. Near the surface, the arc heat melts the base metal, and the weld bead forms a bulge because weld metal is supplied from the wire. The penetration depth in hybrid welding is approximately equal to that in laser welding. This indicates that laser welding determines the penetration depth, and that, even when the heat input is increased by combining arc welding with laser welding, the arc heat merely melts the surface of the base metal and does not deepen the penetration. However, the fact that the hybrid weld bead contains a larger amount of weld metal than the laser weld bead is advantageous in terms of the gap tolerance and bead width in lap welding.

Photo 1 Cross sections of hybrid, laser and arc weld beads

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