2004년도 춘계 학술발표대회 발표논문, 2004년 5월, 제주

Fe-Al 레이저 용접시 접합강도 향상에 관한 연구

Joining strength improvement studies on Fe-Al laser weldment

주성민*, 김영표*, 오종인*, Rajesh S.R*, 방한서**
* 조선대학교 대학원 선박해양공학과
** 조선대학교 항공·조선공학부

1. Introduction

Welding or joining of dissimilar material is difficult and have limitations because physical properties of each material like melting temperature, heat expansion coefficient, conductivity, yielding point, etc. are different. Despite difficulty in joining dissimilar material, more efforts and researches are concentrated on the field of dissimilar joining in near future due to many technical and economical advantages.

Present paper include the experimental results of dissimilar material welding using continuous YAG laser beam on lap welded joint of steel and aluminum.

In this study, cold rolled steel and aluminum alloys were used in welding experiment with no filler metal. Every welding parameter was fixed same except welding speed and it was varied from 50 mm/sec to 90 mm/sec.

Welded specimens were cut by micro cutting machine and then grinded and polished and Scanning Electron Microscopy(SEM) and Energy Dispersive X ray Spectrometer(EDX) analysis are carried out on the polished surfaces (no etching) to view the weld geometry(penetration) and checked the presence of welding defect like crack and view the mixed degree of intermetallic compounds.

Tensile test is also carried out to search the welding condition (speed) that can get the highest lap joint strength. Finally the welded specimens with this welding condition are prepared by welding 2 or 3 seams of laser beam. The distance between the laser welding beads are varied from 1mm to 8mm. After welding the SEM, EDX analysis and tensile test are performed to determine the relationship between the structural properties (tensile strength) and the change of bead distance.

2. Experimental Procedure

Commercially available cold rolled steel SPCC of 1mm thick and aluminum alloys are used in present welding experiments. Aluminum alloys used are A1100 and A5052(2.52% Mg) of both 1mm and 2mm thick.

The experiment described in this present paper can be classified in to 2 part, namely, one part is the experiment with single seam of laser beam under various welding speed to choose best welding condition(speed) that can get maximum tensile strength among various welding speed and another part is about the experiment with multi seamed(2 and 3 bead respectively) specimen to investigate the relation between joint strength and variation of bead distance.

The welding conditions in the second part of experiment is fixed as per the value that is chosen at first part of experiment and only the bead distance is changed.

Laser beam welding was performed using a continous wave Nd:YAG laser of maximum 3kW power, which operated with axial sheilding gas of 100% pure Ar.

After welding, the specimens are sectioned and polished for checking the extent of penetration and to confirm the absence of defects like crack, using optical microscope

and SEM. At next stage, tensile test is carried out to find out the welding condition(speed) which indicate highest joint strength at each given workpiece combination.

With the welding condition obtained above, laser lap welding with multi bead specimen is perfomed to see the relations between bead distance varation and joint strength . The bead to bead distance (L) is changed .

Fig. 2 Laser welding bead with various bead distance

3. Results and discussion

Cross sections of weld beads were observed with optical microscope and SEM after polishing. Figure 3 is the sample EDX mapping results of Fe and Al. Upper side of Figure 3 is SPCC and lower part is A5052. As shown in Figure 3 there exist a certain layer produced by reaction between Fe and Al.

This intermetallic layer is formed as Al_xFe_y type like AlFe, Al_5Fe_2, Al_2Fe, etc. in fusion zone and seen clearly along interface of Fe and Al. Besides interface of Al and SPCC, there is aluminum in most lower part of weld bead and from this we can suppose molten pool is stirred strongly.

In most specimen, there was no crack in fusion zone including intermetallic compound layer and sound results are achievable. But as the welding speed become lower, the heat input is large and consequently the intermeatllic compounds layer become bigger.

Thus in some case of lower welding speed crack is occurred in intermetallic compound layer.

Prior to perform multi bead welding, the welding condition that indicates maximun

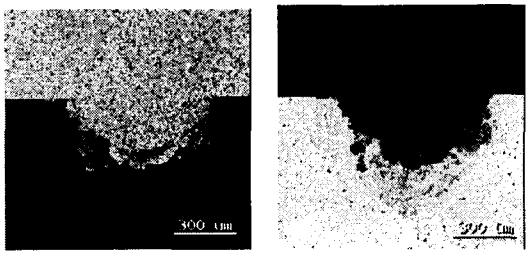

Fig. 3 EDX mapping result of Fe and Al

tensile strength is searched with single bead specimens from the total 4 combinations. Figure 4 is a sample of tensile test results .

The tensile strength vary with the change of welding speed(heat input). At certain welding speed, the strength has maximum value in each given combination and with this welding condition the next experiment, namely, multi bead experiment is performed. The aim of additional multi bead experiment is to check out the relation between tensile strength and bead number with various bead distance.

When proper penetration occurs, welded fusion zone of SPCC side act like a spike against aluminum body so the joint strength become large enough. But if the penetration is excessive or short the strength is decreased.

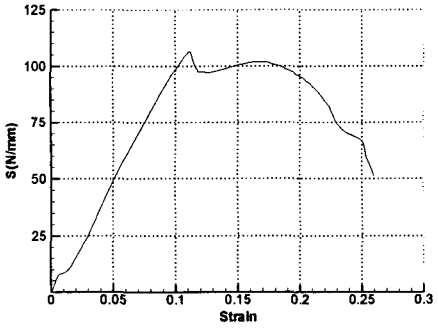

Fig. 4 Tensile test example of SPCC-A1100

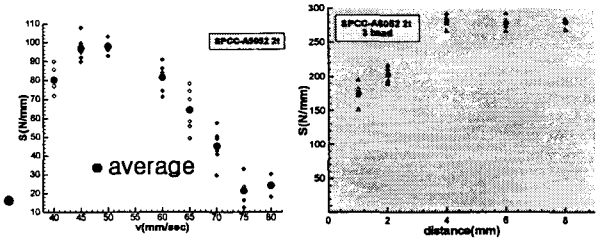

Fig. 5 Tensile test results with various welding speed

Figure 5 show the sample of tensile test results of single and 3 weld beads specimens with various weld bead distances. Compare with the single bead results, the strength is increased remarkably and fracture ocurr even in SPCC base metal .

4. Conclusions

The welding of dissimilar meterial with aluminum alloys and SPCC are carried out successfully by using Nd:YAG laser.

1. Sound results prove that laser welded lap joints are crack proof.
2. By varying the welding speed heat input was controlled and indirectly intermetallic compound layer affecting the joint strength was also controlled.
3. It is confirmed that there exist a certain condition of penetration to make a tensile strength maximum.
4. The joint strength is increased by welding 2 or 3 beads in specimens and the fracture occurred on the base metal.

Acknowledgements

This work was supported by grant No.(R05 -2003-000-10796-0) from korea Science & Engineering Foundation.

References

1. Seiji KATAYAMA, Masami MIZUTANI and Akira MATUNAWA : Laser Welding of Aluminum and Steel, IIW Doc.IV-814-02, June, 2002
2. E.Schubert, et al.: Proc.ICALEO '98, Vo;.85, section G (1988), pp.111-120