International Conference on Recent Research Development in Environment, Social Sciences and Humanities
University of Delhi (DU), Conference Centre, New Delhi (India) (ICRRDESH-15)
27 September 2015, www.conferenceworld.in ISBN: 978-81-931039-8-2

FRICTION STIR WELDING SCOPE AND BENEFITS

Harkamal Preet Singh

Assistant Professor, Panjab University SSG Regional Centre Hoshiarpur, Punjab (India)

ABSTRACT

Now a day Friction Stir Welding (FSW) has become field of interest of many researchers due to increase in the demand in joining process in the aerospace, railway and ship building industries especially in the fabrication of aluminium alloys. Light metals considerably add value by improving fuel economy and performance of vehicle. The cost of new material is always compared with presently employed product. The most important variable for selection of material is cost of material. In the automotive industry, the requirements of both environmental regulation and customer demands for greater performance and safer vehicle are currently accommodated by developing a lightweight, and therefore essentially energy efficient vehicle.

Keywords: Friction Stir Welding, Dissimilar, Joint, Intermetallic Compound.

I. INTRODUCTION

Now a day new materials are considered for incorporation into vehicle designs as they provide benefits at a reasonable cost. Light metals add considerable value by improving drivability, fuel economy, and performance of vehicle. However, before an engineer suggest a new material; many issues require resolution, including the effects on vehicle dynamics, durability, damageability, repair, and crash worthiness. The cost of a new material is always com-pared to that presently employed in a product. The most important variable that determines whether any new material has an opportunity to be selected for a vehicle component is cost. Cost includes actual cost of raw materials, manufacturing value added, and the cost to design and test the product [1]. In the automotive industry, the requirements of both environmental regulation and customer demands for greater performance and safer vehicle are currently accommodated by developing a lightweight, and therefore essentially energy-efficient vehicle. Electric resistance spot welding has been used for many years in the automotive industry for joining body sheet components, and it is particularly well suited for uncoated low carbon steel. Difficulties arise when applying such spot welding to low resistance metals, such as aluminum. It is known that resistance spot welding between dissimilar metals, such as

between a steel and aluminum, often creates an intermetallic compound (IMC) as a result of alloying between the dissimilar metals. In addition, the formation of the IMC results in deteriorated mechanical properties because the IMC is known to be brittle. In particular, for a combination of steel and an aluminum alloy, an IMC is likely to be formed and the electrical and thermal properties impose large restrictions on current conditions, making it very difficult to obtain sound welding. In recent years, many demands have been generated for a joining between dissimilar metals [2].

II. LITERATURE REVIEW

P. Heurtier et al. [3] highlights the thermo mechanical history of the various material elements of the weld using the semi-analytical simulation of the FSW process. This original modeling provides the trajectory of each material element of the weld, the strain rates, strain, and estimations of the temperatures and micro-hardness in the various weld zones. With the thermal history the micro-hardness profile is calculated and derived from the model and calibration with heat treated samples. Evolution of the micro-hardness profile points to the welding parameters which reduce the inhomogeneties of the weld zone properties, increasing the tool velocity smoothes out the hardness profile close to the nugget zone. This improvement is caused by a decrease of the average temperature of the weld zone. Another advantage of the model is to indicate the presence of a weakened zone in the weld with the prediction of the oxide distribution after welding to.

Takehiko Watanabe et al. [4] applied the friction stir welding (FSW) to join steel to aluminum alloy containing magnesium. In this study, the effects of pin offset and pin rotation speed on the structure of a joint and the tensile strength were investigated. Author concluded that (1) to activate the faying surface of steel, on adjust the rotating pin position enabled us to easily make a joint between aluminum alloy and steel. (2) To make a sound joint there was an optimum rotation speed for a pin. Insufficient increase in temperature at the weld is observed at lower rotation speed, so that a pin was worn out in a short time. An unsound joint was observed due to burning of magnesium result from the higher rotation speed. (3) At the pin offset of 0.2mm the maximum tensile strength of a joint was obtained toward steel, steel pieces were scattered in aluminum alloy matrix. The joint tensile strength decreases when these pieces became larger in size and some voids were formed. (4) At the interface between the steel and aluminum alloy no intermetallic compounds were formed. However, at the upper region of the weld where the temperature was highest due to the heat generated by the rotating tool shoulder, a little intermetallic compound was observed. As a result, these intermetallic compounds, formed at the upper region of the Fe/Al interface, lead to a decrease in the joint strength. (5) It was proved that the rubbing motion of a rotating pin could remove the oxide film from the steel faying surface and the removed oxide was carried away with steel fragments into the aluminum matrix. In addition, it is impossible to weld aluminum alloy to steel by the counterclockwise rotation of a pin.

H.B. Schmidt and J.H. Hattel [5] in the past decade the FSW community has been presented many models aimed to describe different aspects of FSW. The complexity of these models has increased. The present model is a step back but it is an improvement over thermal models, in the sense that it captures the first-order effect arising from the self-controlling mechanism due to thermal softening. We need simple and fast models to use as effective alternatives to more comprehensive models. Together they constitute the basis for further understanding of FSW based on modeling. There is a critical need for additional knowledge regarding the material response for different alloys, which should be an alternative to investigation of frictional behavior. In his work the basic elements of the thermal modeling of FSW are briefly outlined, and it is pinpointed that for any thermal model of FSW the modeling of the heat generation between the work piece and the tool is crucial. As a natural consequence of this, a new thermal pseudomechanical model in which the temperature yield stress of the weld material is the driver for the heat generation is proposed. The model shows very encouraging results as compared to existing more classical thermal models of FSW as well as compared to experimental measurement of temperatures. Thus the reliability and thereby the applicability of pure thermal models (which the proposed model in essence also belongs to) has been extended to a new level.

T. Saeida et al. [6] concluded from the attempt made to use FSW with tool rotational speed of 1180rpm and different welding speeds in lap joining of commercially pure copper and 1060 aluminum alloy: The maximum tensile shear strength has been achieved at welding speed of 95 mm/min of lap joint between aluminum and copper through FSW. Due to formation of high amount of microcracks in the dark area at welding speeds of 30 and 60 mm/min, the tolerable tensile shear was lower than that of 95 mm/min. On the other end, the cavity defects are produced at higher welding speeds of 118 and 190 mm/min and again tensile shear strength is decreased in compare with 95 mm/min. Furthermore, higher welding speed caused less vertical transport on the retreating side, while a lower welding speed caused more vertical transport.

S. Bozzia et al.[7] produce a joint of 2mm thickness IF-steel to a 1.2mm thick Al 6016 has been performed by friction stir spot welding (FSSW). At the interface Al 6016/IF-steel the intermetallic compounds have been identified and quantified as a function of tool penetration and the rotational speed. TEM observations indicated the presence of tangles of elliptical intermetallic compounds. FeAl3, Fe2Al5 and FeAl2 were identified depending on welding conditions. The influence of IMC on tensile shear strength has been established. An IMC layer seems necessary to improve the weld strength, but if the layer is too thick, cracks initiate and propagate easily through the hard IMC tangles. Author investigated the interface Al 6016/IF-steel in FSSW spots. It aimed at characterizing the intermetallic compounds (IMC) formed during spot welding. The dependence of weld tensile shear failure load on IMC has been established. Also IMC layer thickness increases with the penetration depth and the rotational speed. IMC structure and hardness depends upon conditions of welding. An IMC layer seems to be necessary to improve the weld strength, but if the IMC layer is too thick cracks initiate and propagate easily through the brittle IMC tangles. For a rotational speed of 3000rpm and a tool penetration depth of 2.9mm an optimal IMC layer thickness of 8_mhas been measured.

P. Xue et al. [8] by friction stir welding produced a butt joint of pure copper and 1060 aluminium alloy and investigated the effect of this on the surface morphology, mechanical properties and interface. The experimental study revealed that under larger pin offsets sound defect free joints could be produced when on advancing side the hard Cu plate was fixed. At higher rotation rates good tensile properties were achieved and proper pin offsets of 2 and 2.5mm; further, the joint produced at 600rpm with a pin offset of 2mm could be bended to 180◦ without fracture. The mechanical properties of the FSW Al–Cu joints were related closely to the interface microstructure between the Al matrix and Cu bulk. To achieve sound FSW Al–Cu joints a thin, uniform and continuous intermetallic compound (IMC) layer at the Al–Cu butted interface was necessary. Under higher rotation rates stacking layered structure developed at the Al–Cu interface, and crack initiated easily in this case, resulting in the poor mechanical properties.

Won-Bae Lee et al. [9] concluded that the reaction layers of friction stir welded joints made from Al alloy and austenitic stainless steel consisted of mixed layers of elongated and ultra-fine grains and the intermetallic compound layer. The intermetallic compound layer was identified as Al4Fe with a hexagonal close-packed structure and a thickness of approximately 250 nm. Because of their ferromagnetism and a body-centered cubic crystal structure, the elongated grains were shown to consist of a ferrite phase.

III. BENEFITS OF FSW

Friction sir welding (FSW) has many benefits over the conventional methods. FSW is a solid phase process and there is low distortion of work piece. In FSW there is good dimensional stability, repeatability, No loss of alloying elements, Fine microstructure and absence of cracks. In FSW no shielding gas and surface cleaning is required. It eliminate grinding wastes and saves consumable materials. Improved materials use as it can join materials of different thickness. Due to fabrication of joints by FSW fuel consumption in light weight aircraft automotive and ship applications[10].

IV. CONCLUSION

By using Friction Stir welding (FSW) is a major point of interest for industries. Hard materials such as steel and other important engineering alloys can now be welded efficiently using this process. With FSW dissimilar metals can be easily joined with sound results. With FSW materials even with different thickness can easily be joined and hence there is saving of material and otherwise reduction in wastage of materials. The understanding has been useful in reducing defects and improving uniformity of weld properties and, at the same time, expanding the applicability of FSW to new engineering alloys. FSW can weld aluminum and copper of > 75mm thickness with single pass.

REFERENCES

[1] G. S. Cole and A. M. Sherman. Presented at the International Metallographic Society Symposium on “Microstructural Characterization of Light- weight Materials for Transportation,” Montreal, July 24-25, 1994. SSDI 1044-5803(95)08063-5.

[2] C.Y. Choi, D.C. Kim, D.G. Nam, Y.D. Kim and Y.D. Park. A Hybrid Joining Technology for Aluminum/Zinc Coated Steels in Vehicles. J. Mater. Sci. Technol., 2010, 26(9), 858-864.

[3] P. Heurtier, M.J. Jones, C. Desrayaud, J.H. Driver, F. Montheillet, D. Allehaux. Mechanical and thermal modeling of friction stir welding. Journal of Material processing technology 171 (2006) 348-357.

[4] Takehiko Watanabe, Hirofumi Takayama, Atsushi Yanagisawa. Joining of aluminium alloy to steel by friction stir welding. Journal of Material processing technology 171 (2006) 342-349.

[5] H.B. Schmidt and J.H. Hattel. Thermal modeling of friction stir welding. Scripta Materialia 58 (2008) 332-337.

[6] T. Saeid, A. Abdollah Zadeh, B. Sazgari. Weldability and mechanical properties of dissimilar aluminium-copper lap joints made by friction stir welding. Journal of Alloys and Compounds 490 (2010) 652-655.

[7] S. Bozzi, A.L. Helbert Etter, T. Baudin, B.Criqui, J.G. Kerbiguet. Intermetallic compounds in Al 6016/IF steel friction stir spot welds. Materials Science and Engineering A 527 (2010) 4505 – 4509.

[8] P. Xue, D.R. Wang, B.L. Xiao, Z.Y.Ma. Effect of friction stir parameters on the microstructure and mechanical properties of the dissimilar Al-Cu joints. Materials Science and Engineering A 528 (2011) 4683 – 4689.

[9] Won-Bae Lee, Martin Schmuecker, Ulises Alfaro Mercardo, Gerhard Bialls and Seung-Bo Jung. Interfacial reaction in steel – aluminium joints made by friction stir welding. Scripta Materialia 55 (2006) 355-358.

[10] Mandeep Singh Sidhu and Sukhpal Singh Chatha. Friction Stir Welding – Process and its Variables: A Review. International Journal of Emerging Technology and Advanced Engineering. ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 2, Issue 12, December 2012