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Friction Stir Welding Alloys for Different Applications

V. Jaiganesh[1*], R.Rajavel[2]

V.Jaiganesh [1*], Professor, Department of Mechanical Engineering, Academy of Maritime Education and Training (AMET), Deemed to be University, Kanathur, Chennai, Tamilnadu, INDIA.
.Email: jaiganeshresearch@ametuniv.ac.in.

***R.Rajavel**, Prof & Head, Department of Mechanical Engineering, Academy of Maritime Education and Training (AMET), Deemed to be University, Kanathur, Chennai, Tamilnadu, INDIA.*
Email: rajavelmech@ametuniv.ac.in

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Abstract

The Friction Stir Welds mainly depends on the three factors Tool pin which is the joining material will properly mixed during joining. FSW machine primarily used to control the critical parameters used in the specific range. The tooling fixture needs to be perfectly positioned and locate the work piece accurately as well as to dissipate the heat that imparted during welding. Most of the significant parameters are affected and controlled by input parameters like tool tilt angel, axial load, spindle speed and transverse speed of the work table. The physics behind the FSW process includes various stages such as the tool pin rotates and plunges into the parent material with larger amount heat generation and reaches the plasticized formation. Then the tool approaches the predefined tool path and makes the joining by stirring action by the shoulder of the tool. In recent days this process can also performed joints underwater submerging with dissimilar alloys. Joints are made by using ultrasonic vibrations for pipes under quality monitoring systems were also employed. The real challenges are still depends upon the reliability and durability of the weldments.

Keywords: *Tool pin, Axial Load, Spindle Speed, Travel Speed, Aluminium Alloys, Copper Alloys, Steels, Magnesium Alloys.*

I. INTRODUCTION

Most of the industrial applications on fabricating the parts requires stir welding and stir processing processes. Hence these FSW welding process requires many attention by the industries due to its eco friendly joining characteristics. In addition, the usages of a non consumable rotating tool for joining the alloys which can join the alloys with below the melting temperature of base alloy. In general the heat will takes place by the frictional force or the rotating force which is obtained along the tool rotation and base work material which can make the work alloy get soften by the rotating tool used. Therefore it is used for joining of light weight alloy materials which is suitable for different industries like aerospace, ship building and railways [1]. This review paper discusses the various modern stir processes and applications by various forms it gets welded and also discusses about possibility of welding similar and dissimilar alloys for various applications.

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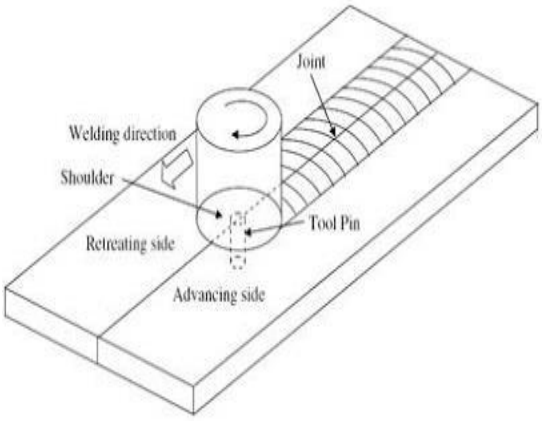

Figure 1: Scheme of weld rotating position on stir welding [1]

Fig. (1) represented the arrangements of base alloys along with a rotating tool for welding on the FSW process. The reasonable amount of heat source is produced between the shoulder and the base alloy which is fixed on the table rigidly by the fixture element. The significant process parameters for making a 100% strength similar to parent material is obtained by selection of input values such as Tool rotational speed, Feed of the table and axial load applied on the tool against the work piece base material.

2. FSW Process For Different Alloying Element

A. Magnesium [Mg]

Magnesium is one of the light weight alloys that can be used for structural applications which is also an alternative for copper and steel alloys in different applications including automotive and aerospace and marine applications [2]. In general the hexagonal lattice structure of magnesium alloys are difficult to deform into plastic stage when compared with other alloys like copper, steel and aluminium alloys [3]. In most of the cases these alloys which are as cast in nature are used in most of the applications most specifically the used in the manufacture of auto component industries [4]. Magnesium alloys are difficult to joint due to its nature of fire catching capabilities and other problems like solidification during not cracking on joining [5]. These Mg alloys needs more suitable joint for fabricating parts so that defects caused with solidification can be avoided [6]. In most of the cases the high strength can be obtained with less cost; and ability to perform the joint on different weld metals & non metals for choosing FSW process for different series of Mg alloy welding [7]. The recent series of magnesium alloy which includes AZ90 and AZ80 alloys have also received more attention by the researchers due to its weight ratio, good stiffness and easy workability. Sound joints of these alloys are tested using micro and macro analysis and other advanced testing such as fracture analysis and SEM, TEM and EDAX for surface morphologies. The fine equi-axed grains are present, which increases higher joint efficiency of 97%. The speed optimal to the experimentation could be of 1500 rpm has been achieved in the joint formation [8].

B. Alluminium [Al]

Aluminium alloys can be joined appropriately and successfully through plates having the accurate measurement of advancing and retrieving capabilities on joining welded region [9]. There investigations deals about the welded capacities on alloys which suitable for the analysis on nugget zones with respect to characterization and mechanical properties with defects related to the microstructure analysis of the welded joint. Defects which can be occurred on AA2219 aluminium alloy for their investigations on underwater are carried out by Zhang and Liu [10]. During the results the weld defect formation occurs with high rotational speeds on both the retrieving and advancing sides where the material stirring was unstable. Liu etal. [11], studied on optimum input variables on the underwater FSW process wherein the similarity of joint strength ratio is of 80% were recorded. In his past studies the work investigates by Zang and Liu [12], there are reduction in hardness on the stirred zone depends upon the grain

size and traditional hardness measurement on hardness and tensile strength of AA2219 alloying element with underwater FSW were studied. Sree Sabari et al. [13], studied on minimizing and further reduction on HAZ and TMAZ on underwater FSW studies could find the fine grain structures of grains observation on the friction stir welding of AA2519-T87 were investigated.

Heirani et al. [14], suggested cooling medium such as air and water as a source for cooling the base alloys heat on investigating the AA5083 alluminium alloy for improving the hardness and fine grain refinement studies for the joints were analyzed. Based on the studies the underwater FSW will produce an effective way for obtaining the fracture hardness was studied on the stirred zone. Tensile strength was also improved on welded region on joint structure.

Liang etal. [15] Studied AA7055 aluminium alloy under water cooling conditions for analyzing the tensile strength on friction stir welding process. The joint strength of 150% were achieved by this process due to less heat absorption on the inner surface of the welded plates using under water conditions with a temperature of 60°C. Wang etal. [16] Studied the analyzed the metal fluidity is greatly affected by the tool rotational speed during underwater treatment of friction stir welding process for AA7055 aluminium alloy. Material fluidity has weakened the sharpened tool and changes in tensile properties with tool rotational speed is also increased.

Papahn etal. [17] studied the FSW process underwater welding of AA7075- T6 aluminium alloy plates on FSW treatment by air. The cooling rates are affected and produced high brittleness on processing of FSW treatments.

Further analysis on cooling rates will affect high brittleness on underwater welded joints. Recent research investigations carried out by Tan etal. [18] analyzed aluminium-manganese alloy that can be joined using underwater FSW joining of AA3003 using critically analyzing the size of the weld nugget on reducing the temperature during submerged joint conditions on welded plates on AA3003 alloy.

Bijanrostami etal. [19] FSW joints on AA6061 and AA7075 dissimilar aluminium series were analyzed. Zhao et al. [20, 21] studied the analysis of AA6013 aluminium alloy series with dissimilar material with AZ31 magnesium alloy were the input parameter plays a significant role on fine grains size arrangements. The results also suggested that the FSW process could be more effective during the air ambient joining on producing of dissimilar weldments with higher tensile strength.

C. Copper [Cu]

The most common alloys used specifically for industrial application with low melting temperature are obtained by using copper alloys. The copper alloys reaction in the fusion zone which produces oxides is very difficult to control due to high thermal conductivity and higher expansion coefficient.

Copper with the F.C.C. crystal structure, with more rust or technically the corrosion will be occurred on the base alloys joining for performing better and high thermal conductivity [22]. Defects and joining difficulties on Cu alloys are produced on the fusion welding which can be compared with conventional joining processes. Insufficient penetrations are occurred on the fusion zone. In the higher thermal input with heat requirement of Cu that produced better joints on decreasing the welding speeds with better rotational speeds. This Cu alloys with pure virginity alloys and observed low heat conductivity on Cu alloy [23].

Figure 2: Welding of Copper on rotating tool fitted with cooling settup

Welding of copper was carried out in figure 2 under friction stir welding with cooling setup. The required heat input on FSW of Cu-alloys on higher heat dissipation causes the work piece, particularly for pure Cu, this is not expected to make no changes on these FSW alloys.

This problems associated with Cu alloys has be addressed by [24], on conducting different speeds and feed variation for conduction of FSW joints with higher rotational rates. Welded plates was analyzed on the nugget region were fine grains microstructure were obtained on the dynamic re-crystallization region on the Stir zone (SZ) of friction stir welded plates [24].

D. STEELS

Steel carries a major role in the manufacturing of all industries such as automobile and marine applications. Major usage on steel rolling mills and steel fabrication industries requires more attention on steels than other metals. The study carried out for the investigation on low alloy steel plates of 3 mm thick in size which will get 0.2% of carbon with reasonable mechanical and metallurgical properties with different speeds and feeds [25]. In the case of high carbon steel with high strength alloys for welding has been carried out as an alternative of Ni alloys.

3. OTHER ALLOYS AND DISCUSSIONS

Jaiganesh et al [25] investigated welding of thermoplastics on polymer materials like nylon, ABS, LDPE and HDPE of different thermoplastics were the input parameters are more influencing the output of the joint. In most of the cases where the joint strength was achieved is very low due to material stirring action on different materials having temperatures were very low [25]. Polymers such as ABS plastics are now a day's used in automotive sectors increasingly. The joint produced on those base materials produces a reasonable weld joints with good mechanical properties.

4. CONCLUSION

Observations were made on different alloys on welding of Al, Mg, Steel and Copper alloys on friction stir welding were discussed in this paper and addressed several issues related to the industrial application problems. The FSW joints are produces sound nature in the joining of automobile parts and marine applications [28]. This paper discussed about the major alloying element that can be welded by FSW and challenges and difficulties in welding other special alloys by friction stir welding.

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AUTHORS PROFILE

Dr.V. Jaiganesh is currently working as a Professor in Mechanical Engineering Department at AMET, Chennai.

His previous employment is with G.S. Moze College of Engineering as HOD-Mech, Pune, Maharashtra. He was the Research and Development Head (R&D) of S A Engineering College, (Chennai, Tamilnadu) from 2011-2018 for 6.5 years and the Head of the Department of Mechanical Engineering at Sri Ram Engineering College from 2010-2011. He graduated Production Engineering from University of Madras (First Class), completed his ME(Ind.Engg) from NIT Tirchy (First Class) & PhD from Anna University Chennai, Tamilnadu, India, all in Mechanical Engineering.

Dr. Ganesh has done extensive research work in the area of Material Joining (Friction Stir Welding and Stir Processing. He has published over 30 research papers in International Journals and 45 Papers Published in Conferences. of repute, has successfully completed 1 research project under the RPS Scheme of Rs.13 Lakhs from AICTE, and 5 sponsored national seminar and conferences.

Dr.R.Rajavel, Professor and Head, Department of Mechanical Engineering, AMET university, Chennai- 603 112. Tamilnadu, India. He has authored more than 35 research papers in the international journal and conferences.