ISSN 2063-5346

MICROSTRUCTURE AND MECHANICALPROPERTIES OF DISSIMILAR FRICTIONSTIRWELDEDUSING ALUMINIUMBRASSALLOY

Mohan.K[(a)], Shanmuga Prasanth.S [(b)], Rithik Roshan.S[(b)],Nirmal Raj.N[(b)]

Article History: Received: 01.02.2023 Revised: 07.03.2023 Accepted: 10.04.2023

Abstract

The goal of the current paper is to Aluminium (1100) to brass (c2700) alloyjoints were used in this work to explore the microstructure and mechanical aspects of dissimilar friction stir welding. The tool's(FSW) mechanical characteristics are tungsten. Additionally,micro hardness assessments and tensile tests to evaluate mechanical qualities were established. The spinning speed,welding speed, and traverse speed of the tungs ten tool were the three keyfactors in this study.The joint's maximum tensile strength was not done for the aluminium to brass base material at the time it was fastened.Results demonstrate that the factors will greatly influence the material flow and microstructure qualities at the interface between(FSW) a joint in a defect-free joint. The tensile strength of the weld is reduced with increasing rotationspeed and traverse speed increases, which is followed by the disappearance ofthe intermetallic layer at the interface, high weld defect values, and rotationthickeningthislayer.

KEYWORDS: dissimilar alloy joining, friction stir welding.

(a) Professor, (b)UG student, Mechanical Engineering[(a,b)], K.S. Rangasamy College of Technology, Tiruchengode-637215 , Namakkal, Tamil Nadu.

DOI:10.31838/ecb/2023.12.s1-B.325

1. INTRODUCTION

The Welding Institute (TWI) developed friction stir welding (FSW), a solid-state welding process, in 1991 [1]. It has been used to connect steel, Mg [5,6], Ti [7], and Cu [8], some of which had been deemed virtually unwieldable by conventional welding techniques. Traditionally, the FSW has been used to create butt joints. Recent Friction Stir Lap Welding (FSLW) feasibility studies have increased the number of applications that potentially profit from the technique.Because the heat generated by the shoulder is transported to the interface of the sheets through the top sheet in FSLW, it is more difficult to construct high-quality connections using this method than with butt welds. Additionally, the material flow's tangential velocity needs to be high enough for it to cover the gap in the weld zone. Additionally, compared to friction stir butt welding (FSBW), the mobility of the materials within the weld is more significant in FSLW [9].In many new applications, the creation of strong couplings between materials that are different is crucial. Al-Br, which is nearly unwedable by fusion welding procedures because brittle intermetallic compounds (IMC) develop, is one of the most difficult FSLW of dissimilar alloys. Getting high-quality welding of Al-Br is essential since aluminum to brass junctions are so important in the electric sector. As a result, various investigations on FSW of aluminum to brass were made. The location of the materials on the heat generation during friction stir lap welding of Al to Cu was examined by Akbari et al.They performed micro-structural investigations to discover several microcracks and intermetallic compounds. Their findings show that Al put on top of Cu produces the joint's maximal fracture load. The microstructural and mechanical characteristics of friction stir welding the 1060 aluminum alloy to commercially pure copper was examined by Abdool-lay-Zadeh et al. [10]. According to their findings, the predominant intermetallic compounds generated in the interfacial area arethere hasn't been a large study on the material flow of dissimilar FSW, where the simultaneous existenceof dissimilar material flows alters the situation from that of comparable FSW.

2.MATERIAL AND METHODS

. To produce defect free welds between dissimilar aluminium alloys AA1100 and BRc2700 using the friction stir welding process.

. Evaluation of the joint mechanical properties (tensile and hardness).

. Optimization of friction stir welding parameters (rotational speed, welding speed, ratio of shoulder to pin diameter and pin profiles) with reference to joint tensile properties shown in the table 2.1

. Metallurgical characterization of welds to obtain structure property correlations.

. Evaluation of pitting and the general corrosion behaviour of welds

Level	Rotational speed (rpm)	Tool tilt angle (h)	Traverse speed (mm/min)
Level 1	1200	1.5	25
Level 2	1500	2.5	20
Level 3	1600	4.5	15

Table 2.1 Process Parameters values and their level

MATERIALS

Aluminium alloy

Brass alloy

Tungsten tool

ALUMINIUM ALLOY

Aluminium is a soft, durable, light weight, malleable metal with an appearance ranging from silvery to dull grey, show in Fig 1 depending on the surface roughness. Aluminium is non-magnetic and non-sparking. It is also insoluble in alcohol, though it can be soluble in water in certain forms. Aluminium has about one-third the density and stiffness of steel. It is ductile and easily machined, cast, drawn and extruded. Corrosion resistance can be excellent due to a thin surface layer of aluminium oxide that forms when the metal is exposed to air, effectively preventing further oxidation. The strongest aluminium alloys are less corrosion resistant due to galvanic reactions with the alloyed copper.

The strength of the aluminium alloys exceeds the strength of mild steel. The Important factors in selecting aluminium and its alloys are their high strength-to-weight ratio, resistance to corrosion by many chemicals, high thermal and electrical conductivity, nontoxicity, reflectivity, appearance, ease of formability, machinability, and their nonmagnetic nature. The melting temperature of these alloy ranges from 482 – 660^{o} C.

The thermal conductivity is six times that of steel and the thermal expansion is twice that of steel. Corrosion resistance can be excellent due to a thin surface layer of aluminium oxide that forms when the metal is exposed to air, effectively preventing further oxidation. Also, it is non-toxic.

figure-1aluminium alloy

BARSS ALLOY

CuZn40 brass alloy with 38-42% zinc content has different applications regarding its formability and machinability properties. In this study, friction stir welding (FSW) of CuZn40 brass alloy was performed by selecting the specified welding parameters according to the design of experiment (DOE) table. Regarding to the response surface method (RSM) with central composite design (CCD), an optimization was done according to the results of the specimen tensile test and the final function related to it was extracted show in Fig.2

In order to achieve a predictive finite element model, an attempt was first made to consider all simulation cases regarding the experimental test. Then, by calibrating the model, while placing the optimal parameters in it, the temperature results were compared in practical mode and simulation. The relationship between welding parameters and ultimate tensile strength was not done with this brass alloys.

figure-2brass alloy

TUNGSTEN TOOL

Tungsten is a special metal alloy which is commonly used to make filaments ofbulbs because of its unique property to glow when current is passed through it. Since it isan alloy, it has a very high melting point and has a high resistivity so that it doesn't burneasilyunder roomtemperature show in Fig 3

Due to tungsten's high melting point (3400°C) and exceptional toughness, stickorMIGweldingdoesnotrequireaconsumableelectrodethatmeltsintothe weldbutratherusesatungstenelectrodetoheatandmeltthefillermaterialthatissuppliedintotheweldingregionby theoperator.

figure3tungsten tool

3.EXPERIMENTAL WORK

The materials chosen for the current investigation were rolled plates made of 1100 aluminium alloy and C2700 brass that were 3 mm thick. The aluminium alloy sheet was put on top of the brass alloy sheet, and a spinning tool was then inserted into the brass surface from the aluminium alloy surface. The sheets were joined in a line with the direction of rolling. The revolving tool was built of an alloy of tungsten steel, with a 20 mm shoulder, and a cylinder pin that was 6 mm in diameter and 2.9 mm long. The tools' specs are displayed. A series of tensile tests were carried out to describe the mechanical characteristics of the joint under various welding circumstances. The test specimen had a rectangular form, and the width of each sample measured 15 mm. Additionally, using a Vickers microhardness tester, the hardness of the welded samples was assessed at various locations throughout the welded zone and throughout the thickness. A 100 g load was applied for 15 g for this purpose.

3.1 EXPERIMENTAL SETUP

FSW criteria to flawlessly build joints made of different materials like brass and aluminium. Microstructural features and the mechanical behaviour of the welded connections were used to assess it. The cylindrical tool shoulder generated heat through friction between the tool shoulder and the base materials throughout this operation. Commercially sized plates measuring 100 mm x 50 mm x 6 mm in Al and Br were welded using a machine with characteristics of 1200 rpm rotating speed, 50 mm/min travel speed, and 8 kN of axial force applied straight down. Scanning electron microscopy (SEM) and optical microscopy (OM) were used to characterise the microstructures of the FSW specimens.

Vickers hardness tester measured microhardness. The measured stir zone region was flawlessly linked in different metals and increased the microhardness value.

It may be brazed or soldered without melting the aluminium or brass using a third metal alloy. Welding calls for melting part of the brass and aluminium, allowing them to combine, and then cooling and freezing them. When these two highly dissimilar alloys are combined, the resulting alloy has inferior characteristics.

Since aluminium alloys have a lower melting point than brass alloys by 300 degrees, if this were done in the open air, the aluminium would burn up before the brass ever melted. The liquid aluminium’s oxide coating would prevent the brass liquid from mixing with it. These two shouldn't be welded for a variety of reasons.

4.WORKING PRINCIPLE

The development of sound joints between dissimilar materials is of great importancein many emerging applications. One of the most challenging FSLW of dissimilar alloys isAl–Br which is virtually unsellable by fusion welding techniques due to the formation of brittle inter metallic compounds(IMC). Due to the highimportance of the joints of aluminum to brass in electricindustry, obtaining the high-quality welds of Al–Brisindispensable. Thus, some investigations were carried out on FSW of aluminum to brass.Akbarietal.investigated the effect of position of material son the heat generation on friction stir welding of AltoBr. They carried out micro structural analyses to gain inter metallic compounds and some microcracks. Their results reveal that the maximum fracture load of the joint is obtained when Al is placed on the top of Br. Abdollah-Zadeh et al. investigated the microstructural and mechanical properties of the friction stir welding of 1100 aluminumal loy to a commercially purecopper.They claimed increasing the rotational speed upto1600rpm of the tool decreased the shear load of joints almost1kN,because the higher rotational speeds increase show in fig the amount of intermetallic compound formed at the aluminum/copperinterface. Esmail et al. studied the intermetallic compounds formation during dissimilarfriction stir butt welding of brass to aluminum 1100.

Figure 4 FSW (al to cu)

5. RESULT AND DISCUSSION

VICKER HARDNESS TEST

The traversecross section of ther unno.2weldedjoint (optimumjoint) is subjected to a Vicker shardness test.from the interface on the sides made of brass and aluminium.The average hardness profile is shown in progress in Fig. 1. The hardness profile shows that onthe aluminium side, hardness varies depending on the welding zones, whereas base metaland the stirring zone (SZ) have almost the same hardness value. Due to exposure to rapidly increasing temperatures,the thermal mechanical affected zone (TMAZ) and the heat affected zone (HAZ) have reduced hardness numbers.Due to exposure to high temperatures,brass in the HAZ hasalower hardness number than base metal**.**

VICKER HARDNESS TEST RESULTS

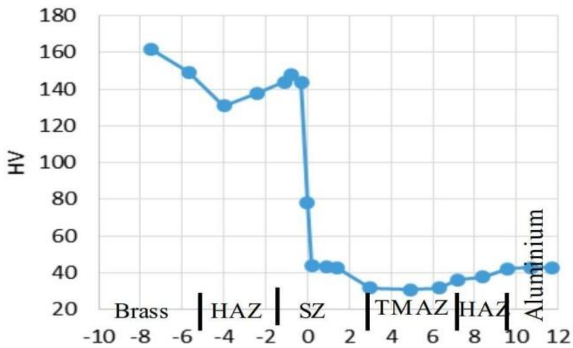

Fig 5 Distance from interface mm

Vickersmicrohardnesstestsmaybeperfor medbyElementatambienttemperatures as well as at increased temperatures ranging from 175 to 870°C (350 to1600°F); eachsamplecan beevaluated at up to8different temperatures**.**

Metalsandotherequallyhardmaterialscan havetheirhardnesstestedusingtheVickers technique. But its main objective was to concentrate on the capacity of softermaterials,likeplastic, towithstand deformationunder sustainedstress.

The Vickers number (HV) is calculated using the following formula:HV=1.854(F/D2),

With F being the applied load (measured in kilograms-force) and D2 the area of theindentation (measured in square millimeters). The applied load is usually specifiedwhenHVis cited.

6. CALCULATION

$HV = 2F\sin 136° \div 2/d^2$

$HV=1.854F/d^2$

$HV=0.00154kgf /mm^2$.

CONCLUSION

Frictionstirweldingcanproducedefectfreebuttwelds,betweenAA2219-T87andAA5083-H321plates,with a joint efficiency of around 95% (based on the yield strength of the softer material i.e. AA1100.

The weld joints were stronger than thes ofter base material, and the tensile failures occur in the heat-affected zone of the alloy1100.

The friction stir welding process parameters were optimized, with respect totensile strength of the joint and the optimum level of settings were found. The optimumlevels of the rotational speed, transverse speed, and the ratio of shoulder diameter to pindiameter(D/d)are 1600 rpm, 15 mm/min and2 respectively.

REFERENCE

1. Amancio-Filho, S.T., Sheikhi, S., Dos Santos, J.F., Bolfarini, C. “Preliminary studyon the microstructure and mechanical properties of dissimilar friction stir welds in aircraftaluminium alloys 2024-T351 and 6056-T4”, Journal of materials processing technology,Vol.206, pp. 132-142, 2008.

2.Atallah, M.M. and Hanadi G Salem. “Friction stir welding parameters: a tool forcontrolling abnormal grain growth during subsequent heat treatment”, Materials ScienceEngineering, Vol. 391, pp.51–59, 2004.

3.Bala Srinivasan, P., Dietzel, W., Zettler, R., dos Santos, J.F., Sivan, V. “Stresscorrosion cracking susceptibility of friction stir welded AA7075–AA6056 dissimilar joint”,MaterialsScienceand Engineering A, Vol. 392, pp. 292-300, 2005.

4.Watanabe, T.; Takayama, H.; Yanagisawa, A. Joining of aluminum to steel byfrictionstir welding. J. Mater. Process Technol. 2006, 178, 342–349

5.Colegrove, P.A.; Shercliff, H.R. 3-Dimensional CFD modelling of flow aroundthreadedfrictionstir weldingtoolprofile. J.Mater. ProcessTechnol.2005,169,320–327.

6.Chen,Y.C.;Nakata,K.Microstructurecharacterizationandmechanicalpropertiesinfrictionstirweldingofaluminumandtitaniumdissimilaralloys.Mater.Des.2009, 30,469–474.

7.Aissani, M.; Gachi, S.; Boubenider, F.; Benkedda, Y. Design and optimization offrictionstirweldingtool.Materialsand ManufacturingProcesses2010,25(11),1199–1205.

8.Nandan,R.;Debroy,T.;Bhadeshia,H.K. D.Recentadvancesinfriction-stirweldingprocess.J. Progress in Materials Science2008, 53, 980–1023.