# Review Paper on Hardness Improvement Studies on Friction Stir Welded Alloys

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**Abstract-** Magnesium amalgam one of the significant crude material utilized in these businesses because of its light weight, great warm conductivity and so on. Additionally, Friction Stirs welding is the joining process that is being utilized in these businesses as it is a strong state joining process. A friction stir welding is widely used in automobile and aerospace sectors for smooth finishing and strength of materials, there is still scoped to take up further research in this area. In this paper, it is discussed the improvement method of friction stir welded magnesium alloy plates.

**Keywords:** Hardness; Welded alloys; Microstructure test; Cryogenic heat treatment.

## 1. Introduction

Friction stir welding is one of the new entrants to the solid-state joining technique which have made a remarkable process in welding technology. Wayne Thomas invented friction stir welding in 1991 has become field of interest of many research [1] due to high demand of joining process in welding. Friction Stir Welding is a process in which a rotating cylindrical tool with a pro fined pin and a shoulder is plunged into a butting plate to be joined. The plates are tightly clamped to a vertical milling machine and a cylindrical tool rotating at high speed slowly plunged between two plates, until the shoulder of the tool touches the top surfaces of plates. During the process friction heat is generated between tool and material. This helps to weld the metals.

## 2. Literature Review

The [1] impact of ultrasonic vibrations on microstructure and mechanical properties of the AZ91−C magnesium amalgam after ultrasonic helped rubbing blends welding in examination with traditional grinding mix welding (FSW) was researched. The FSW was applied at the rotational speed of 1400 r/min and welding pace of 40 mm/min. The microstructure of the examples was seen with optical and checking electron microscopy. The rigidity and hardness are expanded from 195 MPa and HV 79 in ordinary FSW to 225 MPa and HV 87 in ultrasonic helped erosion blends welding.

In [2] Improving quality of the disparate material. The distinction in microstructural and mechanical attributes of rubbing mix welded and half breed welded Al6061-T6/AZ31 joint was thought about. Half and half buttwelding of aluminium amalgam plate to a magnesium combination plate was effectively accomplished with Ni foil as filler material, The rigidity was 66% of the magnesium base metal malleable for cross breed welding (case 3), 45% for different FSW with Ni foil (case 2), 38% for disparate FSW without Ni foil (case 1), while imperfection free laser-grating mix welding (FSW) mixture welding was accomplished by utilizing a laser intensity of 2 kW.

The [3] Microstructures, pliable properties and work solidifying conduct of twofold sided circular segment welded and rubbing mix welded AZ31B-H24 magnesium combination sheet was learned at various strain rates. Kocks–Mecking type plots were utilized to show strain-solidifying stages. The strain-rate affectability assessed through Lindholm's methodology was seen to be higher in the base metal than in the welded tests.

In [4] Investigations of the impacts of different post-weld heat treatment methodology on tractable properties of grating mix welded AA6061 aluminium composite joints. Moved plates of 6-mm thick AA6061 aluminum composite was utilized to manufacture the joints. Tractable properties, for example, yield quality, elasticity, prolongation and joint proficiency were assessed. Microstructures of the welded joints were examined utilizing optical microscopy and transmission electron microscopy. As-welded joints ofAA6061 combination yielded a joint productivity of 66%. This was expanded to a joint productivity of 77% by the fake maturing treatment.

The [5] This examination was completed to grow a comprehension of the microstructural improvement of

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contact mix welding on an AZ91D magnesium compound and to assess the mechanical properties of the welds. AZ91D plates with the thickness of 4mm were utilized, and the microstructural advancement of the weld zone was explored utilizing optical and checking electron magnifying instruments. The microstructure of each zone demonstrated altogether different highlights relying upon the warm and mechanical conditions. The hardness tests indicated uniform appropriated and somewhat expanded saddle in the mix zone. Rigidity of the mix zone was surprisingly improved because of the fine recrystallized grain structure.

The [6] Electron backscatter diffraction (EBSD) and computerized picture connection were utilized to consider tractable conduct of grinding mix welded magnesium amalgam AZ31. The disappointment was demonstrated to be started at the weld root and to begin from twofold {1011} − {1012} twinning. The initiation of the twinning system was credited to the < 0001 >/ND surface created by the test tip during FSW. Split proliferation was affected by the "onion-ring structure" of the mix zone.

In [7] AZ 61A magnesium amalgam plates were welded by erosion mix welding and Pulsed current gas tungsten bend welding (P-GTAW). The impact of welding forms on mechanical properties of AZ 61A welded joints was dissected utilizing on optical microscopy, filtering electron microscopy, pliable testing and Vickers microhardness estimations. The outcomes show that the mechanical properties of FSW welded joint are far superior to those of P-GTAW welded joint; the quality coefficient of FSW joint is 84%. Progressively finished, rigidity and yield quality of FSW joint are 12% and 18% higher than those of P-GTAW joint, individually. Because of the low welding temperature during FSW process and the phenomenal warm solidness of Al 12Mg17 particles, the virus worked microstructures were all around safeguarded.

The [8] Aluminium amalgam 6061 and Magnesium combination AZ31 plates of 6 mm thickness are welded in round butt joint geometry by erosion mix welding (FSW) process, utilizing CNC vertical processing machine. Erosion mix welding has been done at welding speed changing from 10 to 40 mm/min and instrument rotational speed from 800 to 2000 rpm. Impacts of procedure parameters on butt welded roundabout joint were researched for weld quality. Right now, it is discovered that welded joint between divergent metals composites Al 6061 and Mg AZ31 can be framed utilizing contact mix welding by choosing appropriate apparatus pin profile and welding parameters. It is proposed that grating mix welding of Aluminium compound and Magnesium composite with roundabout butt joint geometry would be valuable later for car applications by getting the advantages from every material in a useful manner.

The work [9] high quality aluminium compounds commonly present low weldability in view of the poor cementing microstructure, porosity in the combination zone and misfortune in mechanical properties when welded by combination welding forms which in any case can be welded effectively by relatively recently created procedure called erosion mix welding (FSW). The abatement in yield quality of welds is more genuine than decline in extreme rigidity. As welded joint has most elevated joint productivity (92.1%). Post weld heat treatment brings down yield quality, extreme elasticity however improves rate extension.

In [10] Grating Stir Welding is viewed as the most critical advancement in metal participating in most recent two decades. FSW has numerous preferences when welding magnesium or lightweight amalgams. FSW adjusted the microstructure of the base metal and brought about the development of weld mix zone (SZ), thermo-precisely influenced zone (TMAZ) and warmth influenced zone (HAZ). Each zone displays distinctive microstructural attributes, including grain size, separation thickness, and remaining worry just as encourage size and dispersion. The mechanical properties are exceptionally affected by the FSW parameters and conditions. The expansion in hardness in the piece/mix zone is subject to the grain refinement just as the nearness of Mg 17 Al 12 particles alongside strong arrangement fortifying.

The [11] Grating mix Welded Mg AZ31B composite have been inspected. Contact blend welding (FSW) is finished at different rotational paces of 900 rpm, 1120 rpm, 1400 rpm and 1800 rpm and with change of equipment materials, for instance, Fast steel (HSS) and Tempered steel (SS) at a relentless welding speed of 40 mm/min, tilt purpose of 2.50 and centre point intensity of 5 KN. It is seen Right currently, effect of equipment material and rotational speed on microstructure and mechanical properties of that the joint fabricated using SS instrument material at a rotational speed of 1120 rpm obtained higher mechanical properties when diverged from those of 900 rpm, 1400 rpm and 1800 rpm and besides to those of HSS material.

In [12] Rubbing mix welding of high-quality aluminium amalgams has been developed as an elective joining procedure to maintain a strategic distance from the issues during combination welding. As of late FSW is being utilized for Armor grade AA7075 aluminium compound in barrier, aviation, and marine applications where it needs to serve in non-uniform stacking and destructive situations. Even though contact mix welds of AA7075 composite have better mechanical properties however experience the ill effects of poor consumption obstruction. The impacts of pinnacle matured condition (T6), RRA and expansion of B4C nano particles on microstructure, hardness and pitting consumption of piece zone of the grating mix welds of AA7075 amalgam have been examined.

The [13] Expelled Mg–Al–Zn (AZ80) plates were exposed to grating mix welding at a welding velocity of 100 mm·min−1 and an instrument revolution paces of 800 rpm. The yield quality of the joint without the arrangement before welding expanded by 30% in the wake of maturing, with the extension being diminished. The break conduct of the matured joints was firmly identified with the united structure where the split spread all the more effectively along the course spasmodically hastened groups.


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In [14] Erosion mix welding system was used to weld cast AM50 magnesium compound plates. The microstructures in the base metal (BM) and the weld joint were seen by optical microscopy. The mechanical properties were examined by utilizing hardness estimation and malleable test, and the fractography were seen by filtering electron microscopy. The outcomes show that the microstructure of the base material was portrayed by mass essential α stage, α-grid and intermetallic compound β (or Mg17Al12), and the weld chunk displaying recrystallized microstructure comprises of α-network and β stage. A definitive rigidity and yield quality of the Friction Stir Welded AM50 are 86.2% and 94.0% of those of the base metal.

In [15] The warmth influenced zone (HAZ) is commonly the characteristic most fragile area of the typical grinding mix welded accelerate solidified aluminium amalgams. So as to improve the mechanical properties of the HAZ by controlling the temperature level, submerged rubbing mixes welding of an Al-Cu. Microstructural examination uncovers that the hardness improvement is credited to the bringing down of accelerate coarsening level and the narrowing of encourage free zone, which are basically prompted by the varieties of welding warm cycles under the cooling impact of water.

The [16] Right now, joining of aluminium to steel was led by ultrasound improved contact mix welding (USE-FSW). The force ultrasound was brought into one of the metal sheets by an ultrasonic move crease module synchronously to the FSW-process. The non-ruinous testing strategy for registered laminographic demonstrated the perceptions made by optic microscopy due to non-permeable joints for the two procedures. Erosion examinations demonstrated just low consumption current densities and no improved galvanic consumption.

## 3. Method and Discussion

### *3.1.Hardness*

A hardness test is a method employed to measure the hardness of a material. Hardness refers to a material's resistance to permanent indentation. There are numerous techniques to measure hardness and each of these tests can identify varying hardness values for a single material under testing

### *3.2.Microstructure Test*

Microstructural analysis testing is used widely throughout industry to evaluate products and materials. Metals have a preferred microstructure obtained by a specified processing or heat treatment to achieve desired material properties

### *3.3.Cryogenic Heat Treatment*

Cryogenics is the production and behaviour of materials at extremely low temperatures. It is not well defined at what point on the temperature scale refrigeration ends and cryogenics begins, but scientists assume a gas to be cryogenic if it can be liquefied at or below −180 °C (93 K; −310 °F).

## 4. Conclusion

In this study, the microstructural development and hardness test of the friction stir welded AZ31B 8mm thick plates have been determined. The mechanical properties, such as hardness was improved due to the refinement of the grain structure in the stir zone.

## Declaration of Competing Interest

The authors declare no conflict of interest.

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## References

[1] Woong-Seong Chang, S.R. Rajesh, Chang-Keun Chun and Heung-Ju Kim. “Microstructure and Mechanical Properties of Hybrid Laser-Friction Stir Welding between AA6061-T6 Al Alloy and AZ31 Mg Alloy”, J. Mater. Sci. Technol., 2011, 27(3), 199-204.

[2] M. Dadashpour, R. Yeşildal, A. Mostafapour and V. Rezazade, “Effect of heat treatment and number of passes on the microstructure and mechanical properties of friction stir processed AZ91C magnesium alloy”, Journal of Mechanical Science and Technology 30 (2) (2016) 667~672.

[3] K. Elangovan, V. Balasubramanian, “Influences of post-weld heat treatment on tensile properties of friction stir-welded AA6061 aluminium alloy joints”, Material Characterization 59 (2008 )1168–1177.

[4] Won-Bae Lee, Jong-Woong Kim, Yun-Mo Yeon and Seung-Boo Jung1; “The Joint Characteristics of Friction Stir Welded AZ91D Magnesium Alloy”, Materials Transactions, Vol. 44, No. 5 (2003) pp. 917 to 923.

[5] R.K.R. Singh, Chaitanya Sharma, D.K. Dwivedi, N.K. Mehta, P. Kumar; “The microstructure and mechanical properties of friction stir welded Al–Zn–Mg alloy in as welded and heat-treated conditions”, Materials and Design 32 (2011) 682–687.

[6] S. Ugendera, A. Kumar b, A. Somi Reddy: “Microstructure and Mechanical Properties of AZ31B Magnesium alloy by Friction stir Welding”, Procedia Materials Science 6 (2014) 1600 – 1609.

[7] P. Vijayakumar, G. Madhusudhan Reddy, K. Srinivasa Rao; “Microstructure and pitting corrosion of Armor grade AA7075 aluminium alloy friction stir weld nugget zone e Effect of post weld heat treatment and addition of boron carbide”, Defence Technology xx (2015) 1e8.

[8] J. Yang, D.R. Ni, D. Wang, B.L. Xiao, Z.Y. Ma; “Friction stir welding of as-extruded Mg–Al–Zn alloy with higher Al content. Part II: Influence of precipitates”, Materials Characterization 96 (2014)135–141.

[9] Zeng Rong-Chang, W. Dietzel2, R. Zettler2, Chen Jun, K. U. Kainer2; “Microstructure evolution and tensile properties of friction-stir-welded AM50 magnesium alloy “, Trans. Nonferrous Met. Soc. China 18(2008) s76-s80.

[10] H.J. Zhang, H.J. Liu, and L. Yu; “Effect of Water Cooling on the Performances of Friction Stir Welding Heat-Affected Zone”, JMEPEG (2012) 21:1182–1187.

[11] Mehdi Zohoora, M.K. Besharati Givib, P. Salamia; “Effect of processing parameters on fabrication of Al–Mg/Cu composites via friction stir processing”, Materials and Design 39 (2012) 358–365.

[12] Faraz Baradarani, Amir Mostafapour, Maghsoud Shalvandi; “Effect of ultrasonic assisted friction stir welding on microstructure and mechanical properties of AZ91−C magnesium alloy “, Trans. Nonferrous Met. Soc. China 29(2019) 2514−2522



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[13] S.M. Chowdhury, D.L. Chena, S.D. Bholea, X. Caob, E. Powidajkoc, D.C. Weckmanc, Y. Zhouc; "Tensile properties and strain-hardening behaviour of double-sided arc welded and friction stir welded AZ31B magnesium alloy", Material science and Engineering A527 (2010) 2951-2961.

[14] S. Mironov, T. Onumaa, Y.S. Satao, S. Yoneyamab, H. Kokawaa; "Tensile behaviour of friction-stir welded AZ31 magnesium alloy", Materials Science & Engineering A 679 (2017) 272–281.

[15] S. Rajakumar, V. Balasubramanian a, A. Raza rose; "Friction stir and pulsed current gas metal arc welding of AZ61A magnesium alloy: A comparative study", Materials and Design 49 (2013) 267–278.

[16] Heena K Sharma, Kamlesh Bhatt, Krunal Shah, Unnati Joshed; "Experimental Analysis of Friction Stir Welding of Dissimilar Alloys AA6061 and Mg AZ31 Using Circular Butt Joint Geometry", Procedia Technology 23 (2016) 566 – 572.