Post Welded Offsw Joints On Acrolein Coating

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ABSTRACT: Friction stir welding is a trending area in welding distribution as it has great demand in the automotive and aviation industries. This paper deals with the relative study of the influence of deviations on transverse speed to tensile behavior of AA6061 - AZ61 butt welded joints for both the Coated Friction Stir Welding (CFSW) and Normal Friction Stir Welding (NFSW). AA6061 - AZ61 alloy plates are butt welded with transverse speed which are ranging from 60 mm/min. to 120 mm/min, whereas the axial and rotational speed are maintained as constant. The welded plates are then coated with acrolein of about 25μm thick by using pressure die casting machine. Tensile behavior of the CFSW joints and NFSW joints are evaluated with respect to microhardness, tensile strength and elongation. Micro structures of Nugget Stir Zone (NSZ) are examined to study the reasons for variations in the tensile strength. Electrochemical corrosion behavior of CFSW and NFSW joints are assessed by potentio-dynamic polarization. The advantages of integrated bonding in Aluminum and Magnesium alloy weldments are better in terms of corrosion resistance, tensile strength and elasticity.

KEYWORDS: *FSW; AZ 61; AA 6061; Tensile Behaviour; Corrosion resistance*

1. INTRODUCTION

Friction Stir Welding (FSW) is a process of joining the metals that is represented by the heat generated due to friction and immersed flow of material because of the weld probe rotation and characteristically develops a nugget stir zone in a plane that is perpendicular to the direction of transverse welding [1-4].

Boundary management of the weld process is particularly important in areas that focus on stress during rigid behavior [5]. The effect of weld parameters on joint performance was assessed by specific techniques such as punch shear testing, tool strength, applied torque, temperature, microstructure [6] [7] [8].

Changes in the geometry of the tools influence the distribution of stiffness of the members of the FSW weld and their strength. Different geometric tools have been selected depending on the acceptable test outcomes as per collaborative work. Some better amalgamations of tool shapes depending on text studies, brass sheets - refined shoulder [9], Al 6082- Tri-flute tool [10], AA 6061 with AA 5086 - integrated cylindrical pin [11], AA 5754 - H22 - unread circular pin tools [12], AA 5083-H 111: continuous tool [13].

The strength of the weld is influenced by the variability of the tool rotating speed. In the case of Fe - Ni-C metal, the decrement values in the rotation speed of the tools, increases the refinement of the grains and where by the collected austenite removal at the Nugget Stir Zone (NSZ) confirms an increment in weld strength [14]. The impact of the rotation speed of the tools and the shortening speed were investigated with Al2195-T8, the detection of errors will be detected when there is insufficient time to move the goods in the moving speed zone [15]. Aluminum alloy 6061 and Magnesium alloy AZ31 are a highly volatile composite with various tool geometry, shortcut speed and rotation speed. With low welding speeds and cutting speeds, co-operation is good [16]

Magnesium alloy weld defects AZ 91 friction stir welded plates are analyzed by microscopy of different weld parameters. According to comparisons the internal voids are shown in the straight cylindrical pin profile, and the welded joints are made at low rotation speed and low cross-cutting speed were found to have minimal deformities [17]. Aluminum alloys 7020-T651 and 6060-T6 are turbulent due to the speed and rotation speed that exposes the impact of welding variables on mechanical behavior. High welding speeds improve grain refining and the cracking area remains at low hardness properties regardless of where the metal is found [18].

Many authors have investigated the application of coating on Friction Stir Welding (FSW) tool [19 - 21] but only few authors have tried the coating in FSW weldments [22, 23]. This paper focuses on the effect of applying the coating material Acoryln on FSW weldments and its effects on tensile behavior.

The practice in welding research fields is to recognize joint performance and corrosion-resistant materials and weight strength ratios. In addition to many welding processes, Friction Stir Welding (FSW) has been found to work well on both the same and different alloys. Aluminum is one of the most common stainless steel in FSW.

The ability to balance weight is the preliminary concern in automobile and aerospace applications. Therefore, the achievement of improved weldability, lower grade materials such as 'Mg' alloy is compulsory in research exploration. Numerous researches have been performed on weldability of 'Mg' alloy. According to the studies of small structure and the strength of the strength of the strength by various process variables, the best processes and possibilities can be determined.

In the present investigation, a pin with straight thread is used as a standard tool for various welding transverse speeds for the two cases of weld samples Coated Friction Stir Welding (CFSW) and Normal Friction Stir Welding (NFSW). The respective characterizations of tensile properties as well as micro structures are examined.

2. EXPERIMENTAL WORK

The FSW of AA 6061–AZ 61 plates were performed with straight threaded pin profile of M2 material. The welding process is carried out with a rotation speed of 60 mm / min., 80 mm / min., 100 mm / min. and 120 mm / min., while the axial and rotational speeds were maintained as equal to 1 kN and 1200 rpm, respectively. The plate welded by this process is refereed as Normal Friction Stir Welding (NFSW) plates. These normally welded plates is squeezed with the Acrolein material as a coating material in a cold pressure die casting of make HMT machine tool with model DC 120. These coated plates are Coated Friction Stir Welding (CFSW) plates. Fig.1 shows the sample specimens of NFSW and CFSW plates.

(a) (b)

Figure **1**.(a) Normal FSW specimen . (b)Acrolyn CFSW specimen.

Figure 2**.** (a) Mould (b) pressure die casting

Table 1. Chemical Composition of AA 6061 and AZ 61

Element (%)	Al	Mg	Si	Fe	Cu	Mn	Ni	Cr	Others
AA6061	96.1	1.0	0.5	0.5	0.3	0.1	0.05	0.3	0.95
AZ61	6.1	92.18	0.1	0.005	0.05	0.14	0.005	-	1.2

As per the percentage of weight, chemical constituents of alloy AA6061 and AZ 61 for the experimentation are identified and shown in Table 1. The tool for FSW has been prepared of M2 contains of pin (6mm dia, 5.8 mm length and 18mm shoulder dia). A square butt joint of size 90 X 90 mm was fabricated with aforementioned process parameters. Friction stir welding for dissimilar metals AA6061 and Mg AZ61 was performed with a dimension of size 90 mm X 45 mm X 6 mm thick as a plate. The NFSW plates were clamped inner side of the die and then Acrolein is applied above the welded area for actual use of coating on the weldment surface using fixture assembly as illustrated in Fig.2.
The selection of rate of feed, speed of rotation and transverse are vibrant for the generation of heat. For the improvement of good material flow around the tool and work interface, the forces on the tool should be minimum. The force developed must be minimum for better flow of material around tool and work interface.

Figure 3. Acrolyn **c**oated Friction Stir Welded sample specimen

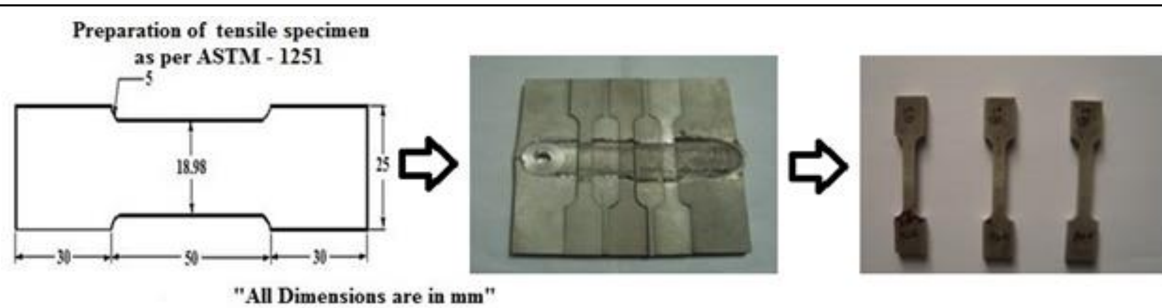

Figure 4. FSW plates are cut in to tensile test specimen as per ASTM-1251 norms using wire cut EDM

In the Coated Friction Stir Welding (CFSW), the complete weld specimen inclusive of fixture is coated with Acrolein material as shown in Fig.3. Tensile tests are carried out for all the NFSW and CFSW specimens for the identification and comparison of tensile strength and elongation using Universal Testing Machine of LS 1 series. The tensile test is carried out as per ASTM E1251 as shown in Fig.4. The specimens are cut using wire cut Electrical Discharge Machining (EDM).

Nacl Solution with pH values of 4, 7 and 9 with non-deaerated conditions have been engaged to perform the polarization analysis. The electrolyte which is used in this experimentation were prepared by double sprayed water and chemicals for the analar range. The test specimens have been prepared as per the metallographic standards (20mm widthX40mm lenth) for ensuring the 10mm diameter of welded portion to be immersed inner side of electrolyte. The schematic of computerized setup used for polarization is represented in Figure 5.
The corrosion resistances have identified for all specimens anodic/cathode polarization. The intersection of Tafel zones and the curves of polarization offers the current density for corrosion (i_{corr}) and the potential. With an aid of computerized setup, the desired current and potential have been attained for each plots.

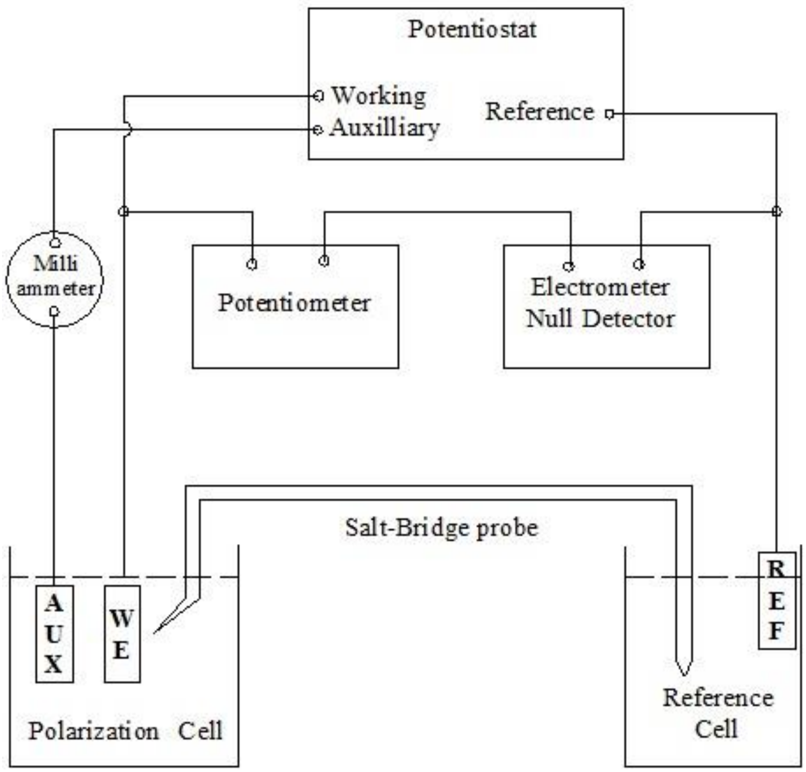

Figure 5. Schematic representation of the polarization set-up

3.RESULT AND DISCUSSION

The probability of better joint efficiency by Friction Stir Welding process can be assessed with help of tensile strength, elongations and micro-structural analysis of fracture zones. In this present work, it is appraised for the four different transverse speeds with a constant rotational speed as mentioned earlier combinations of parameters. The properties are estimated for two different processes as one is Normal Friction Stir Welding (NFSW) and the other one as Coated Friction Stir Welding (CFSW).
The probability of attaining better efficiency for making joints by FSW process has been evaluated with an aid of tensile properties, elongations and microscopic analysis of the fractured regions. In this present work, four various transverse speeds with a constant speed of rotation as declared earlier combinations of parameters are appraised. The characteristics were estimated for two various process such as NFSW and CFSW processes.

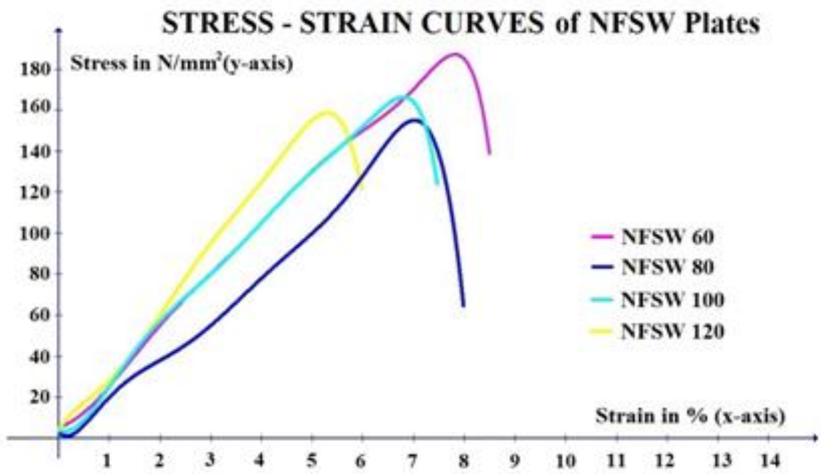

Figure 6. stress strain curve

Fig. 6 illustrates the tensile properties and elongations of samples welded by NFSW process. It is revealed from the illustration that the welded sample by NFSW executes better strength at 60mm/min while comparing with remaining transverse speeds. Also the tensile characteristics of the NFSW welded samples with more transverse speeds executes comparably reduced tensile properties at 80mm/min that needs to examine further by microhardness and microscopic methods.

The increased values of transverse welding speeds reduces the elongation and lesser transverse weld speed affirms the appropriate flow of materials. So the lesser transverse weld speed of 60mm/min obtained ultimate tensile strength and also better elongation percentage. Fig.7 represents tensile properties of CFSW welded plates and it is clear that the tensile properties and elongations of CFSW are considerably better while comparing with NFSW. The increase in transverse speed values have the similar influence on decreasing the elongation. Because of the coating, the tensile strength is observed as increasing trend from 180 N/mm^2 to 200 N/mm^2 and motives are essential for studying with the help of microscopic investigations.

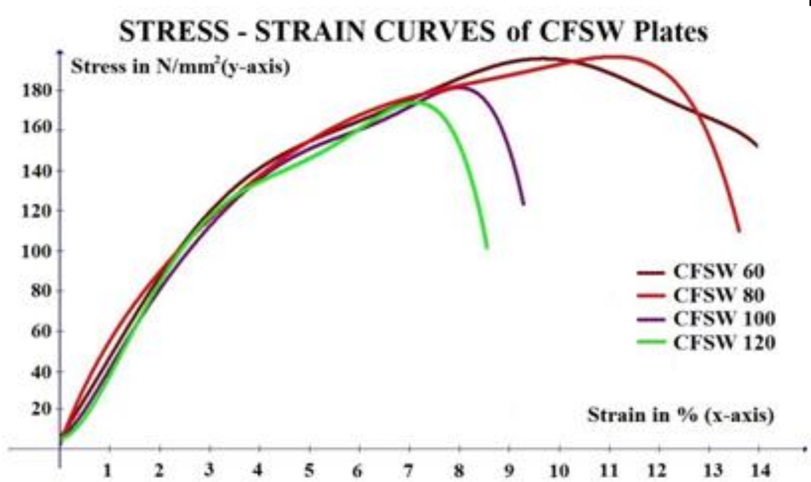

Figure 7. Stress Strain Curve for CFSW

Fig.8 represents the microhardness values of NFSW welded samples made with different speeds. At the nugget region, the values of micro hardness are increased for the lesser transverse speed at 60 mm/min. and also it is observed that the values of hardness of welded samples for remaining speed values are getting inversely proportional trend.
Similarly, Fig.9 illustrates the measured values of microhardness for CFSW welded samples with different speeds. At the nugget region, the measured values of hardness are observed as better for the lesser transverse speed of 60 mm/min. While comparing with the NFSW welded samples, the CFSW plates are having more hardness. The microhardness values measured at 800 mm/min, having higher fluctuations while comparing with the remaining welded samples, as this fulfils the needs to analyze furthermore with microscopic analysis.

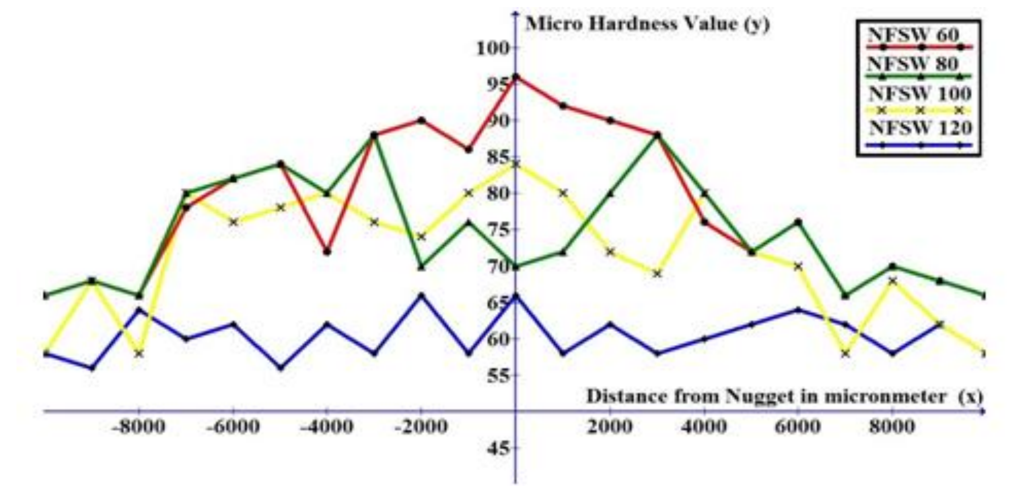

Figure 8. Micro hardness for NFSW

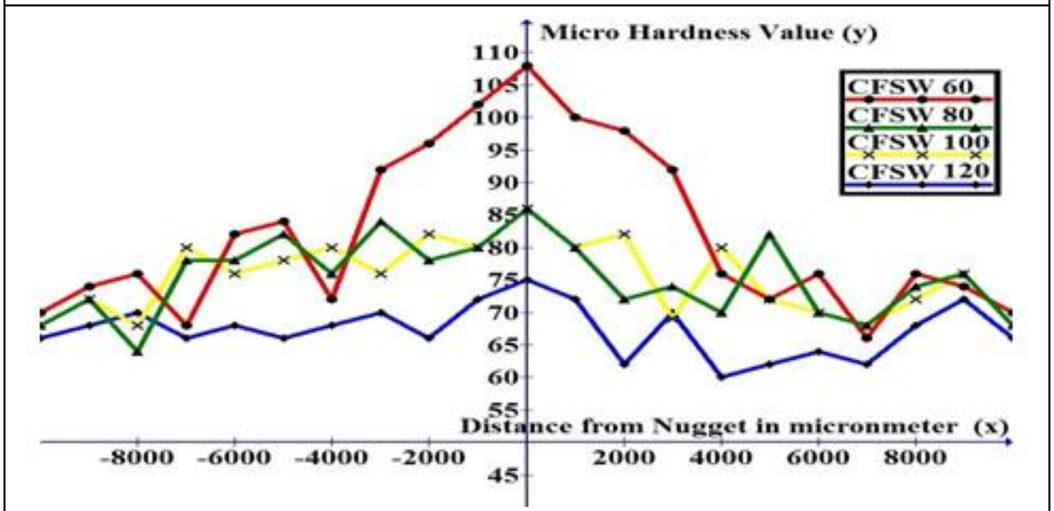

Figure 9. Micro hardness for CFSW

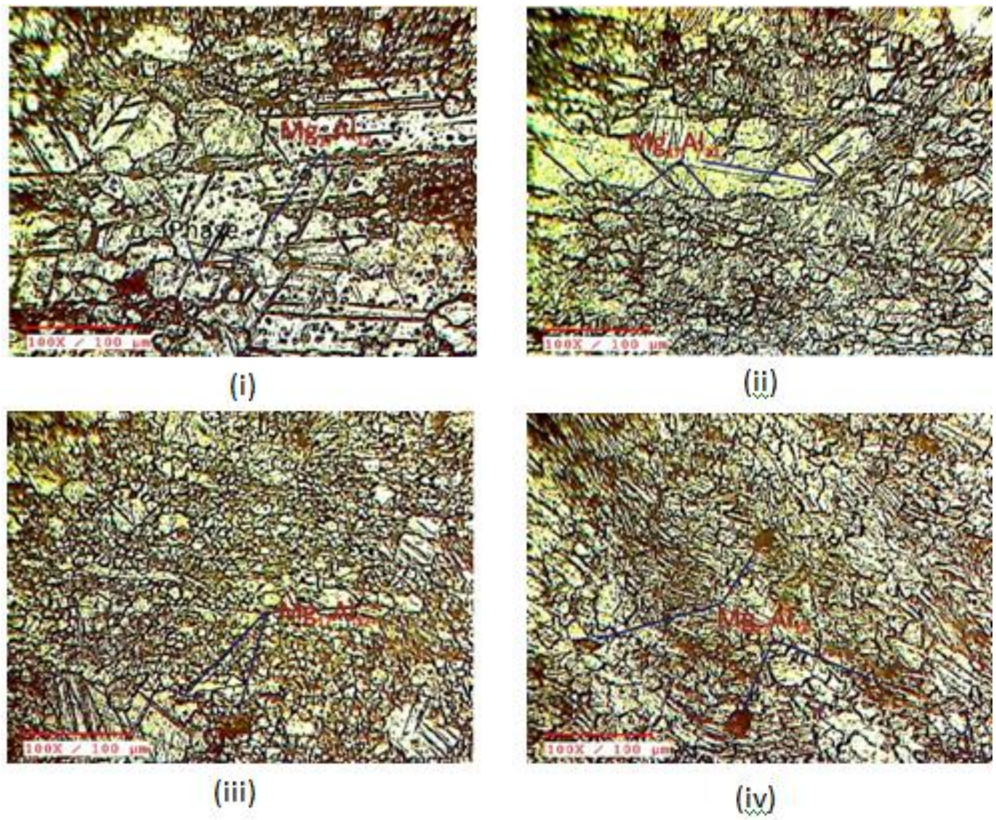

Figure 10. NFSW Microstructure specimens

The microscopic analysis of the tensile fracture zones for NFSW samples is illustrated in Fig. 10. The microscopic images of welded samples illustrate the extended grain particles with structure of needle shapes that is precipitated $Mg_{17}Al_{12}$ eutectic amalgamation on the preliminary 'Mg' alloy closer to the grain boundary. Since it is indulged for rolling and working, few twinned grains also noticed. Because of the fragmentation and also heat generated, finer grains also noticed. In the NFSW 80 welded samples, grains with coarser structure were formed and development of numerous dispersoids converted from a structure of needle shape that makes the increased strength of the welded components. NFSW 100 welded sample affirms the fragmented grain of preliminary 'Mg' solid solution. But the increasing values of the tensile strength of welded samples is due to the wider $Mg_{17}Al_{12}$ (γ phase). NFSW 120 welded samples represents the dark structure since the increased values of speed influenced the evenly distributed gamma phase in the nugget region.

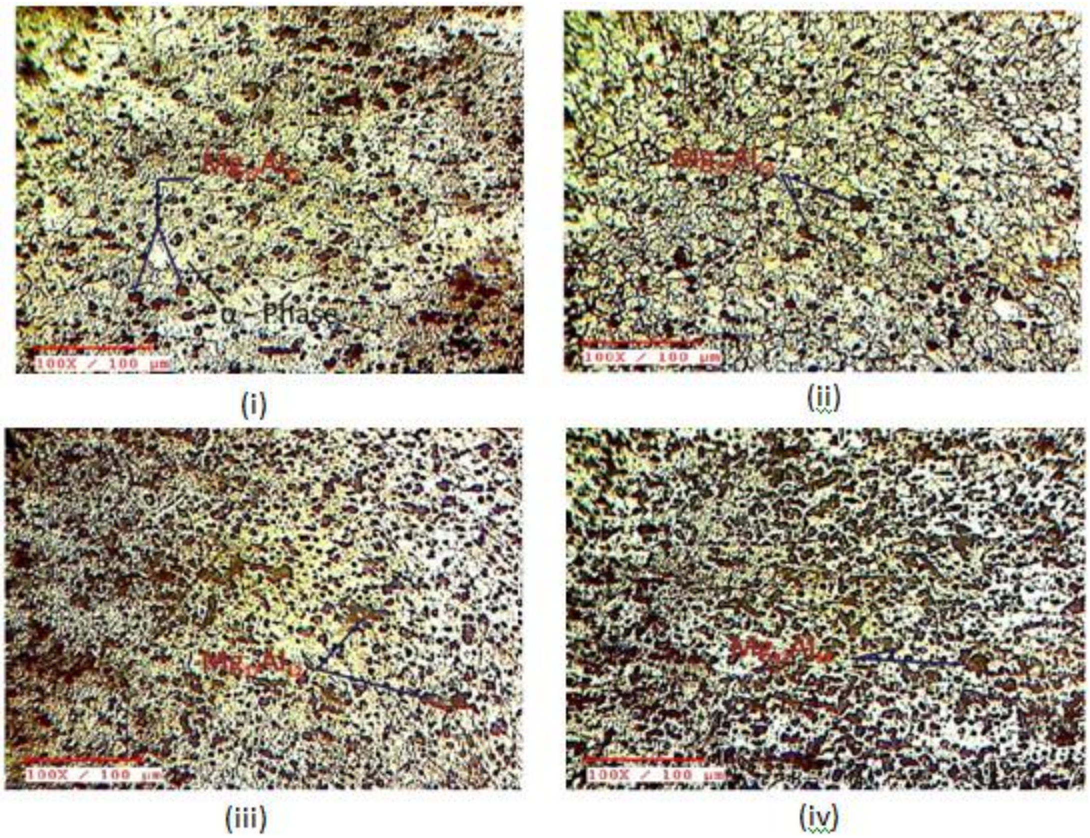

Figure 11. CFSW Microstructure specimens:

Fig. 11 illustrates the microscopic images on the tensile test fractured zone samples CFSW. The coating layer surpasses the dominion of Aluminium since a softer alpha stage particle as an alternative of ‘Mg’ that is in the normal FSW sample. The Acrolein has a reaction with ‘Al’ and ‘Mg’ and forms the softer matrix (alpha stage) as dominion of ‘Al’ and hardening of dispersal particles dispersal plays a dominant part on improving of the tensile strength. The microscopic analysis of the CFSW 60 sample shows the dominant behavior of ‘Al’ alloy at the Nugget region. The microscopic analysis represents the particles of precipitated eutectic of $Mg_{17}Al_{12}$ in preliminary alpha aluminium solid solution.

The grain orientation is along the direction of the rolling. In CFSW 80, the microstructure at the NZ zone where the eutectic particles have partially dissolved and the grains have re-crystallized without orientation. In CFSW 100, at the nugget zone where the eutectic particles have re-precipitated and the matrix also undergone dynamic re-crystallization. The grains are finer and the grain size is between 10 to 15 microns where as in CFSW 120 specimen, more uniform precipitates observed. However according to micro-structures, the CFSW plates yield very less defects.

The orientation of grain is along the rolling direction. In CFSW 80, the microscopic analysis at the NZ region at which the particles of eutectic have incompletely dissolved and also with no orientation the grains were recrystallized. In CFSW 100 at the nugget region the eutectic particle were reprecipitated and the matrix suffered a active recrystallization. The grains were getting fine particles and the size of the grains are between 10 – 15 microns where as in CFSW 120 process welded specimen offers better uniform precipitates. Though, as per the microscopic analysis, the CFSW welded plates provides very lesser defects.

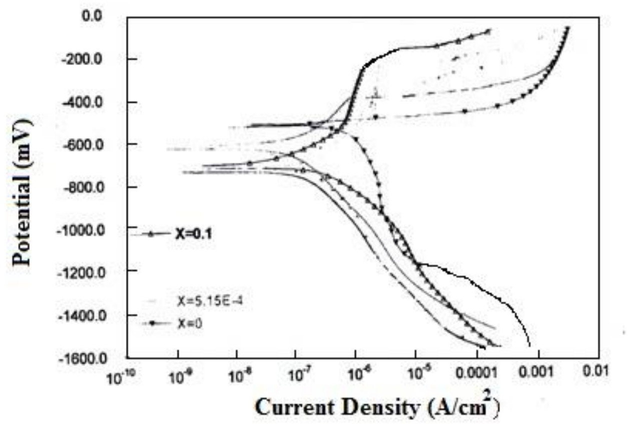

Figure 12. Polarization curve for uncoated plate

The polarization curves of uncoated and Acrolein coated FSW 'Mg' alloy in 4.5 wt.% NaCl solution and the fitting results have been represented in Fig. 12 and Fig. 13. While comparing the both curves, it illustrates that the resistance of corrosion for the FSW 'Mg' alloy with Acrolein layer coating has improved in an excellent manner. The corrosion ability of the Acrolein layer coated FSW sample is better than that of the uncoated specimen. In the meantime, the density of current in the coated weld joint is three or even four orders of magnitude lesser than uncoated FSW welded samples.

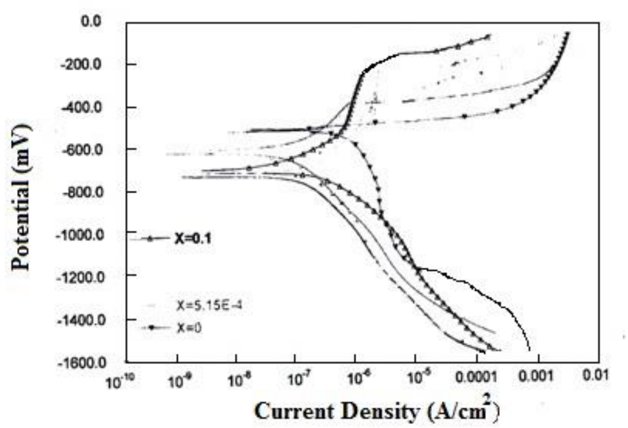

Figure 13. Polarization curve for coated plate

4. CONCLUSION

Experimental research has revealed the following conclusions, which may be useful for FSW for AA 6061 alloy and 'Mg' AZ 61. The preference can be given for welding with CFSW process while comparing with NFSW in accordance with the influence of tensile strength and the elasticity property. Various welding variables influences the tensile strength and the elastic property of welded joints. The tool rotation speed of 1200 per minute and a weld speed of 60 mm / min have been determined to be the strongest limits, influencing the butt weld mechanical characteristics integrated between the AA6061 and AZ61 when inserted with a cylindrical pin tool for M2 material. Experimental studies show that lesser welding values are better in FSW for different alloys considered when using the M2 tool. Coating of the FSW plates increases both the tensile strength and elongation. Acrolein-coated template has increased corrosion resistance and plate compaction capable of increasing the bonding strength.

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