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Analysis of Material Flow in Friction Stir Welding using Digital Image Processing

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Abstract- Friction Stir Welding is a novel material joining process which involves a tool probe which stirs the materials to be joined at the joining interfaces creating friction which in turn generates temperature resulting in material flow from one side to another due to which the joining of the materials takes place. The various parameters which influences the material joining process are the tool tilt angle, rotational speed, translational speed of the tool, tool geometry, axial force etc.. these process parameters influence the generation of heat and friction and influence the material flow pattern. In this present student the material flow due to change in the tool geometry is analysed using the principles of digital image analysis. This analysis is compared with mechanical and microstructural properties and results of the both the methods have shown good correlation.

Keywords – Friction stir welding.Digital Image Processing,tool geometry,material flow

I. INTRODUCTION

Friction Stir welding process is a significant metal joining process since its invention by The Welding Institute(TWI) in 1991[1].Friction Stir welding process is a joining process which employs a tool which rotates and travels along the joining surfaces which are clamped together. The tool is non-consumable and many types of tool profiles are employed for the welding purpose. Tool geometry is defined by the shoulder diameter, pin diameter, profile of pin and the pin length. The pin length is usually shorter than then the thickness of the plates. The pin is penetrated into the work pieces and the tool rotates and transverses along the centreline. The interaction that takes place between the tool & work piece gives rise to friction generating heat which in turn creates plastic deformation and the flow takes place in plasticized state as the tool traverses forward [2].the process is illustrated in the Fig The material flow in friction stir welding is complex in nature and mainly depends on the tool geometry& other process parameters viz. tool rotation speed, traverse speed of welding, tilt angle of the tool, axial force applied and properties of the material to be welded. The weld formation depends on the material flow behavior of the materials to be welded. As friction stir welding is a fusion welding process the welding takes place due to the intermixing of the materials for which material flow is the primary criteria.

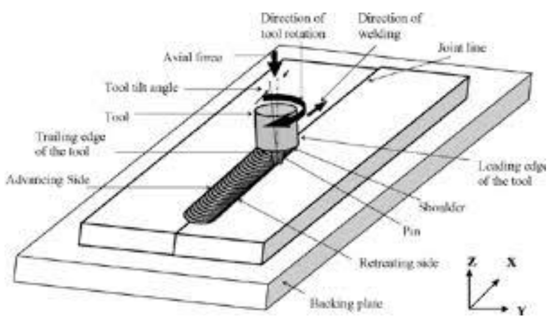


Fig. 1 Friction Stir Welding Process

Understanding of the material flow pattern and flow characteristics during the friction stir is very much essential for proper selection of the process parameters and the tool geometry [3].Few attempts are made by the researchers to describe the material flow characteristics. Material flow during the friction stir welding process is illustrated experimentally by employing marker insert technique which partially described the material flow in the weld zone [4].some attempts are made to describe the material flow using two-dimensional flow modelling around the tool pin [5-6].CFD was used by some researchers to describe the 3D model flow [7].Tool geometry plays an important role and influences material flow in friction stir welding process [8].The advantage of the friction stir welding process is that it reduces various metallurgical problems like porosity, spatter etc., and also it is an environmental friendly process. As friction stir welding is a hybrid thermo mechanical process the weld zone is near the joint and is divided into different zones Base Metal zone(BMZ),Heat affected ZONE(HAZ) and thermo mechanically affected zone(TMAZ).BMZ has no microstructural changes, no plastic deformation occurs in the HAZ but due to the heat generated microstructural changes occur in HAZ..Drastic microstructural changes are observed in TMAZ [9-12]. The properties of the welded joint are mostly influenced by the temperatures due to the heat generated due to the friction between the tool and the work piece.

II. Experimental work

In this study 8mm sheets of AA 6061 are welded to 8mm The chemical of the material composition and tool description are tabulated in the Table 1 and Table 2.

Table I composition of AA 6061

Element	Al	Mg	Si	Cu	Cr
Amount (wt %)	Bal.	1.0	0.6	0.3	0.2

Table 2 Description of the tools used in the FSW process

Tool number	tool profile	Length of the Pin(mm)	diameter of the pin(mm)		diameter of the shoulder
1	Taper	7.8	4	2	12
2	Cylindrical	7.8	4		12
3	Hexagonal	7.8	4		12

Fig. 2 Friction stir welding experimental setup with provision to measure temperatures using thermocouples

The friction stir welding process is carried on a modified vertical milling machine on which a specially designed fixture is mounted to hold the 100mmX200mmX8mm plates and clamed firmly. Experiments are conducted using tools of varying tool pin profiles to estimate the impact of the tool pin profile on the weld strength. Taper, hexagonal and cylindrical tool profiles are used for the welding purpose and comparison of the mechanical and macrostructures properties is done. The process parameters for tool profiles are kept constant as follows the tool rotational speed of 1400rpm and welding speed of 60mm/min. Temperatures are measured using K-type thermocouples during the welding process to estimate the heat generated during the friction stir welding process using different profiles

image processin parameters are shown in Table 3

Table 3. First order Statistical parameter from Histrogram

Tool Name	Specimen No	Standard Deviation	Mean	Entropy

	Defect region	17.314	168.42	5.9531
Taper	Good region	16.322	175.7	5.7773
	Defect region	15.722	145.87	5.7525
Cylindrical	Good region	8.2481	160.63	4.9479
	Defect region	13.966	160.65	5.4461
Hexagonal	Good region	12.443	162.32	5.1442

Table 4. Second order Statistical parameter from Histrogram

Tool Name	Specimen No	Contrast	Energy	Homogeneity
Taper	Defect region	0.10463	0.36756	0.94786
	Good region	0.050599	0.42797	0.9745
Cylindrical	Good region	0.1275	0.42537	0.93838
	Defect region			
Hexagonal	Good region	0.021635	0.91967	0.98918
	Defect region	0.078104	0.46213	0.96095
		0.059062	0.57582	0.97047

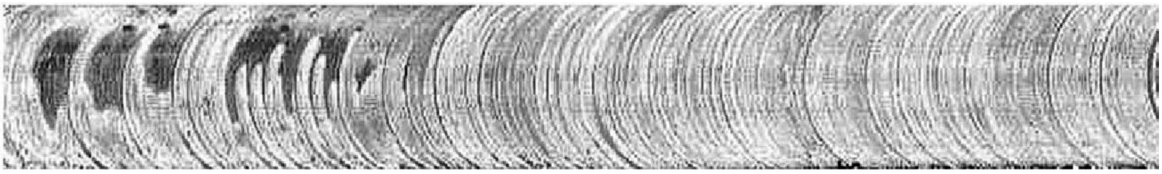
2.1 Colour images of Friction Stir Welded AA 6082-T6 Specimens

Following are the images of Friction Stir Welded specimens, welding are done by using different tools mentioned in Tool geometry details

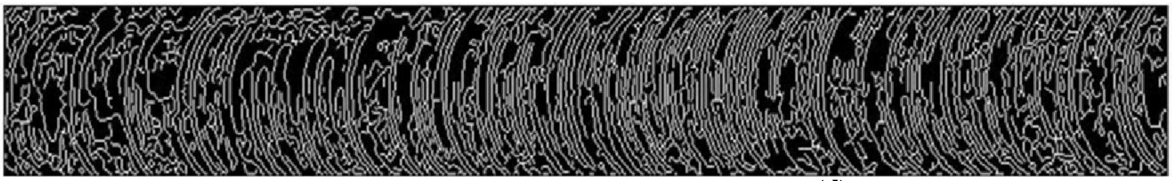
Fig. 3 A, B, C are Friction stir welded specimens by using Tool-1 (Taper,Cylidrical and Hexagonal tools

(a)

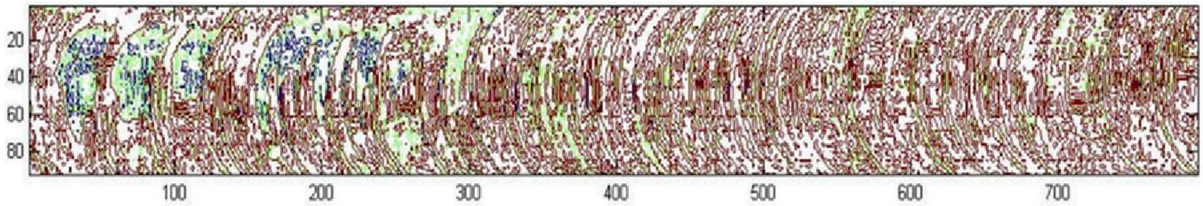
(b)



(c)

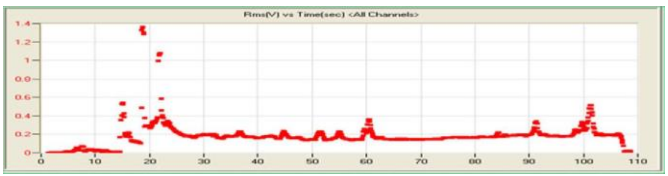


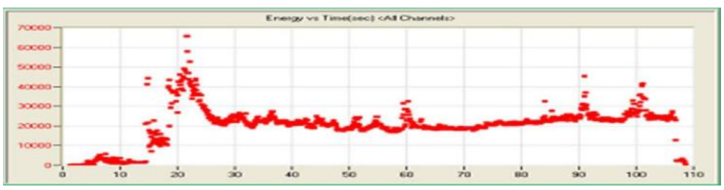
(d)



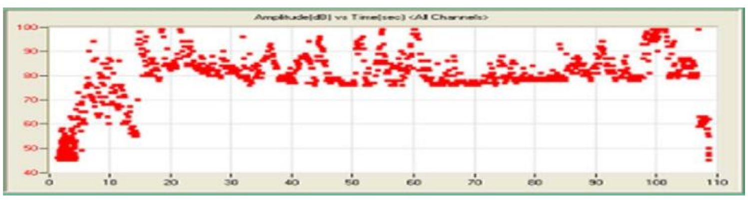
(e)

Fig. 4 a)Force graph ,b) Radiography image of specimen, c) Processed Gray level image of weld bead, d) Edge plot, e)Contour image, f)Line profile.





(a)



(b)

Fig. 5 AE Parameters (a) RMS v/s Time, (b) Energy v/s Time, (c) Amplitude v/s Time, (d)Counts v/s Time are generated during welding of Specimen-1 by using Tool-01

III. Observations

During plunging, wherein tool tip from work surface pierces into work till required depth, RMS, energy, amplitude signal strength and z-axis load were found to increase continuously at faster rate. The time taken for complete plunge and dwell time in this case is about 30 seconds, then the tool traverses with the set speed resulting in welding till the present length of weld obtained. Radiography test showed defect in the weld at a few places by comparing the variation in values of AE parameters and force data, it was observed that

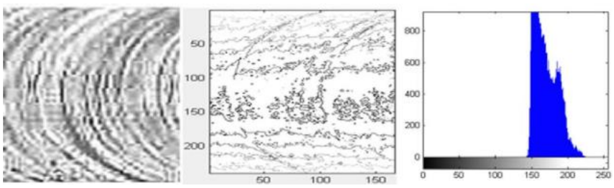
The RMS value is found to vary from 30 to 110 seconds of welding as welding is progressed The RMS value is found to vary from 0.15 to 0.25v except at places where the defect was identified. At the location where the defect was observed, the sudden increase in RMS was from 0.15 to 0.39v at 60th second and from 0.2 to 0.35v at 110th second of welding.

The Energy is found to increase marginally from 30 to 110 seconds welding is progressed The energy value is found to increase from 19000 to 30000 units except at places where the defect was identified. At the location where the defect was observed, the sudden increase in energy was from 19000 to 33000 units at 60th second and from 2300 to 40000 units at 90th second of welding.

The Amplitude remained almost constant from 30 to 110 seconds during welding The amplitude value is found to vary from 58dB to 68dB except at place where the defect was identified. At the location where the defects was observed, the sudden increase in amplitude was from 60 to 75 dB at 60th second and from 65 to 75 dB at 90th second of welding.

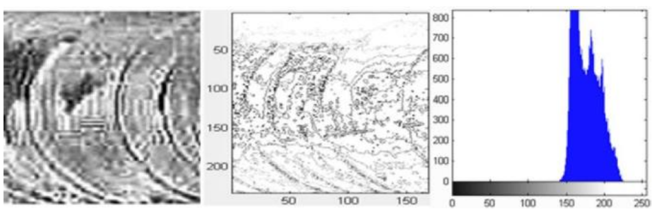
The Counts are found to increase marginally from 30 to 110 seconds as welding is progressed The counts are found to increase from 18000 to 25000 units except at places where the defect was identified. At the location where the defect was observed, the sudden decrease in counts was from 20000 to 23000 units at 60th, from 23000 to 26000 units at 90th second.

The contour plot, Edge plot, and Line profile of weld bead shows variation in there appearance along good region and defective region as identified from X-Ray radiography, force graph and AE parameters of this specimen. The variation in first order and second order statistical parameter of specimen along good and defective region are shown in the bar chart



(a) **(b)** **(c)**

Figure 6 a) Processed Good region image of weld bead, b)contuor plot, c)Histogram



(a) **(b)** **(c)**

Figure 7 a) Processed Defective region image of weld bead, b)contuor plot, c)Histogram

The variations of first order statistical parameter of weld specimens along good and defective region are shown in the bar chart Figure are due to the following reasons:

The value of the preceding measures for the two types of textures (good and defective) gives us: The standard deviation is much more informative: the numbers clearly shows that the good weld texture has significantly less variability in gray level (it is smooth) than the defective weld texture. The mean just tells us the average gray level of each region and is useful only as a rough idea of intensity, not really in accessing the texture. Looking at the measure of entropy, we again conclude that the good weld smoother (more uniform than the defective weld) and that the most random (highest entropy) corresponds to the defective weld texture.

The variations in second order statistical parameter of weld specimens along good and defective region are shown in the bar chart due to the following reasons: variation in the value of the preceding measures for the two types of textures (good and defective) gives us: Energy provides the sum of squared elements in the GLCM also known as uniformity or the angular second moment. Looking at the measure energy, we again conclude that the good weld smoother (more energy than the defective weld) and that the most random (lowest energy) corresponds to the defective weld texture. Contrast measures the local variations in the gray-level co-occurrence matrix, the number clearly shows that the good weld texture has significantly less variability in gray level (it is smooth) than the defective weld texture. Homogeneity measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. The good weld region has closeness than the defective weld region

Processed image show minimum variations in the pixels intensities along a selected line segment and consistency in the contouring data. The contour lines are continuous and uniform in good region of the weld zone

Also generated histogram does not have any pixels below the gray level number of 150 (This is indicative of the defect free first mode and the soundness of the weld.

In the defect welded regiion, similar image processing techniques are adopted and the results shows that the contours are broken and discontinuous The intensity profile taken along the transverse section reveals abrupt fluctuate between the grayscale ranges of 145-220 This indicates the discontinuity in that zone and inconsistency in first mode. Also the statistical analysis of the generated histogram plot reveals that a number of pixels are having grayscale numbers less than This is indicative of the presence of defects and imperfections in the weld quality.

The image parameters quantified as statistical parameters of weld bead surface texture shows distinct variations along good and defect weld regions, thus the quality of weld can be accessed from the image parameters. Steps followed in processing and analyzing the image remains same for other three specimens welded with tool of different configuration.

Conclusions:

The values of RMS, energy and amplitude were found to be high, while the values of counts were found to be low at location where the defects occurred. The sudden decrease in counts at the occurrence of defect during FSW is due to low frequency of AE waves having very high amplitude, energy and RMS values. The contour and edge plot of weld bead which are formed by interaction of tool shoulder with a base metal while welding appears continuous evenly spread along good region compared to irregularly speared, fractured in the defect region .The first order and second order statistical parameter of weld bead texture shows less variation in gray level locally in good region compared to defect region. AE technique can be effectively used for online monitoring of FSW process. So that the occurrence of defect/flaws can be immediately sensed/identified for possible corrective action.

References:

[1] Preetish sinha, S.Muttukumaran, R.Sivakumar, S.K.Mukherjee, "Analysis of first mode metal transfer in friction stir welded plates by image processing technique", Journal of Materials processing Technology, June 2007.

[2] K.Venkat raman and B.Ramamoorthy, "Statistical methods to compare the texture features of machined surfaces", Journal of pattern Recognition, Volume 29, No.9, Pages 1447-1459, 1996.

[3] Preetish Sinha, S.Muthukumaran, R.Sivakumar and S.K.Mukherjee, "Condition monitoring of first mode of metal transfer in friction stir welding by image processing techniques", International Journal of Advanced Manufacturing Technology, volume 36(2008), Pages 484-489.

[4] K. Kumar and Satish V.Kailas, "The role of friction stir welding tool on material flow and weld formation", Materials Science and Engineering A, 485(2008), 367-374.

[5] K.Venkatramana and B.Ramamoorthy, "Statistical methods to compare the texture features of machined surfaces", Pattern Recognition, Volume l29, No.9, Pages 1447-1459, 1996.
[6] C.N.Suresha, B.M.Rajaprakash and Sarala Upadhya, "Applicability of acoustic emission in the analysis of friction stir welded joints", International Journal of Recent Trends in Engineering, Volume 1, No. 5, May 2009.
[7]R.S. Mishra and Z.Y. Ma, "friction stir welding and processing", Materials Science and Engineering: R: Reports, Volume 50, Issues 1–2, Pages 1–78, 31 August 2005. [1] W.M.Thomas,.D.Nicholas.J.C.needham,M.G.murch,P.Templesmith and C J ,Dawes,G.B.Patent Application 91259788,Uk Patent office,London 1991.
[8] R.S.Mishra,and Z.Y.Ma,"Friction stir welding and Processing"Mter Sci Eng R,50 pp 1-78,2005.
Seidel T U,reyonolds A P,"Visualisation of material flow in AA2195 friction stir welds using a marker technique,Matallurgical and Material Transactions A,2001:2879-2884
[9] Siedel T U ,Reynolds A P " Two dimensional .friction stir welding processmodel based on fluid mechanics.Science and Technology of Welding and Joining 2003,:175-183
[1010 Technology of Welding and joining ,2004:483-492
[11] Schmidt H,Hattel J " Modelling heat flow around the tool probe in friction Stir welding "Science and Technology of Welding and joining,2005:1176-186
[12] Colegrove p A,Shercloff h R .'3 D CFD modeling of flow round a threaded friction stir welding tool profile " journal of material Processing and Technology,2005,:320-327.
[13] Colegrove P A ,Shercloff H.R"CFD modeling of Friction stir Welding of thick plate 7449 alluminium alloy" Science and Technology of welding and joining 2006,;429-441
[14] G.lin,L E Murr,C S niou,J C ,mcclure,ER vega" Microstructural aspects of the friction Stir Welding of 6061-t6 aliminium ' Scripta materilica (1997)335-361.
[15] C.G.rhodes,M W.Mohany, W H Bignet,R.A.Spurling,C C Bampton'Effects of friction Stir Welding on Microstructure of 7075 aluminium" Scripta materilca (1997);69-75
[16] O.v.Flores ,c kennedy,l E Murr,D Brown,S Pappu,B M nowak,j C Mcclure"Microstructuralissues in a Friction stir Welded aluminum alloy "Scripta Mechanica (1998)703-708
[17] J Q Su.t W Nelson R,Mishra M,Mohoney"Microstructural investigation of friction stir welded 7050-1661Aluminum"Acta Meterilica(2003)713-729.