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A Comparative Study of Micro-structural and Mechanical properties of Aluminium Alloy AA6062 on FSW and TIGW Processes

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Abstract: FSW (Friction Stir Welding) and TIGW (Tungsten Inert Gas Welding) are broadly known welding processes, FSW and TIGW both are acknowledged throughout the industries globally in current age. The aluminum alloys are used widely in Aviation, Shipbuilding and also in general engineering because it is having many applications in these sectors. In this paper a comparative study of Aluminum Alloy AA6062 properties on TIGW (Tungsten Inert Gas Welding) and FSW (friction stir welding) are obtained. Mostly in all the welding processes the purpose is to get welded joint by having its desired weld bead parameters, higher mechanical properties with the low distortion. The quality of the weld is determined through mechanical properties, bead geometry, and distortion. In this paper AA6062 (Aluminum Alloy) similar metal is joined, appraised and compared in TIGW and FSW welding processes for studying the welding process parameters and there different configurations.

Keywords: Friction Stir Welding, Tungsten Inert Gas Welding, Mechanical properties, Aluminum Alloy, Microstructure.

I. INTRODUCTION

Welding is a fabrication process where the application of heat is used for joining two material pieces together. In current scenario there are different-different welding processes which are adopted by the industries in current age for joining the metal work piece with a superior weld quality having high strength. Nowadays aluminum and its alloy are very highly demanding in many of the industries because if there is a comparison in different metal then the aluminumstood next to steel. Welding process generally depends upon the various factors like physical and chemical properties of the metal on which welding process is to be performed, through aluminum various components are easily produced because it is very compatible and various manufacturing processes like Casting, Forging, Extrusion and Machining etc. can be easily performed and by doing all these process easily a components are manufactured but for building a complete structured product a vital role is playedby welding process through which the components are joined together which makes a complete structures product assembly. Welding is a process which is mainly used for creating a complete product by joining different components of that product together with a very high strength joint.

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Welding process is widely adopted throughout the industries in current scenario and through this process components are manufactured and are widely used in many sectors like Automotive, Aviation etc.

II. LITERATURE REVIEW

Tungsten Inert Gas Welding (TIGW) also known as Gas Tungsten Arc Welding (GTAW) is a process where the heat is generated through the high temperature are produced using the electrical energy during the welding process. TIGW (Tungsten Inert Gas Welding) process can be can be done by using the filler material and also it can be easily done without using filler material. In TIGW process a Non-Consumable electrode is used through which the weld is produced. In this welding process Inert Gas is used for safeguarding the weld region from atmospheric contamination because Inert gas acts as a shield in TIGW welding process. TIGW process requires a Non-Fluctuating continuous current so that the required arc is generated [1,2]. Mostly this TIGW process of welding is used for Non-Ferrous thin plates of Magnesium, Aluminium, Stainless Steel and Copper [3]. TIGW process is complex as compared to other welding process like GMAW (Gas Metal Arc Welding), SMAW (Shielded Metal Arc Welding) etc. The figure of TIGW (Tungsten Inert Gas Welding) is shown below in figure 1.

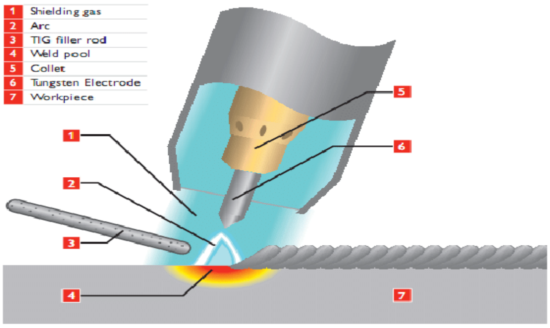

Fig.1 Tungsten Inert Gas Welding Process

FSW (Friction Stir Welding) is a process of joining two metal work piecesby the heat generated through the stirring of the non-consumable tool. In FSW the tool stir and due to stirring of the tool friction is generated and heat at very high temperature is obtained which brings the metal to its plastic stage it forms a strong bond with each other and the high

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strength welded joint is formed[3].The heat is generated in FSW process due to the mechanical pressure which is applied on a mating between tool and work piece the blending of both the metal take places which forms a very strong joint between both the metal pieces. FSW process is having many process parameters and different combination of these process parameters of welding few of them which are very vital and plays a key role in FSW are Feed rate, Spindle speed etc.[5,6]. Tool geometry also plays a important role in FSW process so while designing a tool few of the essential parameters while designing a tool should be taken into consideration like Tool Pin diameter, Shoulder diameter etc. accordingly to the work piece dimensions because through proper dimensions of tool the required heat generated can be easily utilized so that the process of FSW can be smoothly done. The figure of FSW process is given below in Fig 2.

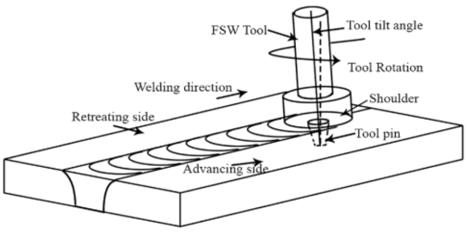

Fig.2 Friction stir welding process

The machine used for FSW is Vertical Milling Machine as shown below in Fig.3.

Fig. 3 Vertical Milling Machine Used for FSW

III. ALUMINUM ALLOY AA6062

Aluminium Alloy AA6062 is worldwide used medium strength Aluminium alloy. Aluminium alloy AA6062 is widely accepted in industries for light weighted structures. It is having approximately one third the density of the steel. Aluminium alloy AA6062 can also be strengthened by doing the heat treatment also it can easily weld, formed and machined. In this research work AA6062 10mm thick plate is used for experimentation as given below in the Fig.4.

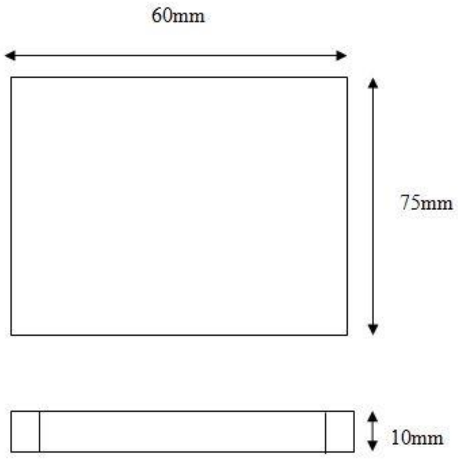

Fig.4 Model of Aluminium work piece used for experimentation.

The Dog Bone shapestructures are prepared from this work piece by the End Milling Process. The figure of samples prepared through End Milling Process is given below in fig.5.

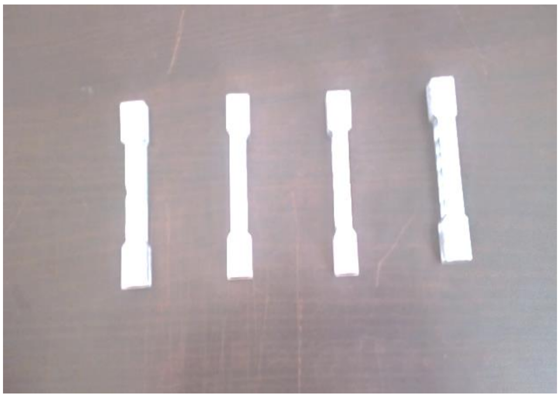

Fig.5 Samples prepared through End Milling Process for various testing.

The Mechanical, Physical and Chemical properties of Aluminium Alloy AA6062 are shown below in Table.1, 2 and 3.

Mg	Si	Fe	Cu	Cr	Mn	Zn	Ti	Al
0.65	0.45	0.42	0.12	0.19	0.05	0.08	0.02	98.02

Table.1 Chemical composition of AA6062

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Density (g/cm^3)	2.7
Melting point (^{0}C)	595
Modulus of Elasticity(GPa)	72-85
Poison Ratio	0.34

Table.2 Physical composition of AA6062

Yield Strength (MPa)	275
Ultimate Strength (MPa)	360
Elongation (%)	25
Reduction in cross sectional area (%)	65
Hardness (HRB)	70

Table.3 Mechanical composition of AA6062

IV. EXPERIMENTAL PROCEDURE

The material on which the experimentation and investigation is done is Aluminium alloy AA6062 having a wide use in industries as well as for light weighted structure fabrication.

Tool used in FSW process is made of steel and having certain specified dimensions so that the friction stir welding process can be done firmly as per requirement. Tool in FSW process plays a very vital role so while designing of tool all the parameters mainly Tool Pin Diameter, Shoulder diameter should be perfectly considered. In the below given figure the tool used for performing FSW process is shown in Fig.6.

Fig.6 FSW tool used in Experimental Work

TOOL DIMENSIONS	Values
Pin Diameter, d (mm)	6
Shoulder Diameter, D(mm)	24
Pin Length, L(mm)	8.5
Tilt Angle	2^0

Table.4 Tool dimensions (Tool used in FSW)

The investigation of impact testing (IZOD) has been done on Impact testing Machine. The values obtained from the investigation of impact tests on FSW and TIGW samples are given below in the Table.5.

Type of Welds	Energy Absorbed(Joule)	Effect
Base Metal	26	Break
FSW 1	73	Break
FSW 2	71	Break
FSW 3	69	Break
FSW 4	68	Break
TIGW 1	8	Break
TIGW 2	7	Break
TIGW 3	8	Break
TIGW4	6	Break

Table.5 Summary of Impact Test

The investigation of hardness testing has been done on Rockwell hardness testing machine at B grade (HRB) as shown below in Fig.7.

Fig.7 Hardness testing Machine

The obtained values of hardness testing of FSW and TIGW samples are given below in the Table.6

(HRB)

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Type of welding	hardness of weld region
FSW 1	71
FSW 2	73
FSW 3	74
FSW 4	72
TIGW 1	41
TIGW 2	37
TIGW 3	39
TIGW 4	40

Table.6 Hardness of the Weld Region

The Investigation of Tensile testing has been done on UTM (Universal testing Machine). The tensile properties of FSW and TIGW samples are given below in the Table.7.

Table7. Tensile Properties of Welded Joints

Type of Joint	Yield Strength (MPa)	Ultimate Tensile Strength	Elongation (%)
FSW 1	221	295	7.69
FSW 2	229	283	8.1
FSW 3	234	292	8
FSW 4	232	290	7.8
TIGW 1	192	286	4
TIGW 2	179	233	3
TIGW 3	180	276	3.8
TIGW4	185	248	3.2

V. MICROSTRUCTURE

Microstructure study of each sample of FSW and TIGW weld regions as well the base metal Aluminium Alloy AA6062 is inspected through the microstructural microscopic setup with software version Micron 4.0 and also it is examined that the joint mainly break from the weld fusion zone. All the microstructures of the weld fusion zones are examined through the microscopic setup in the laboratory are shown below in the figures.

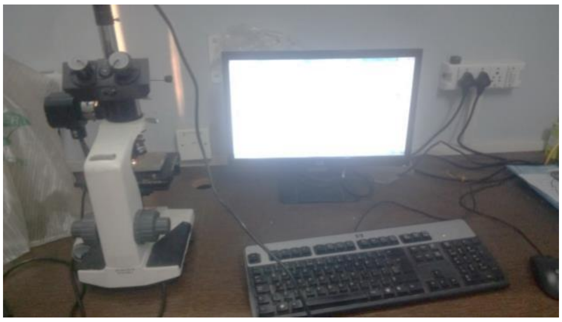

Fig.7 Microscopic setup for Microstructure investigation.

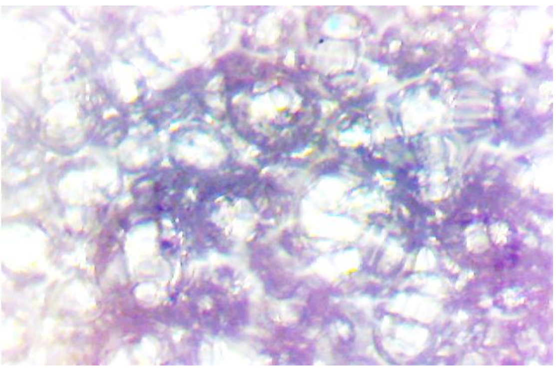

Fig.8 Microstructure of Aluminium Alloy AA6062 base metal.

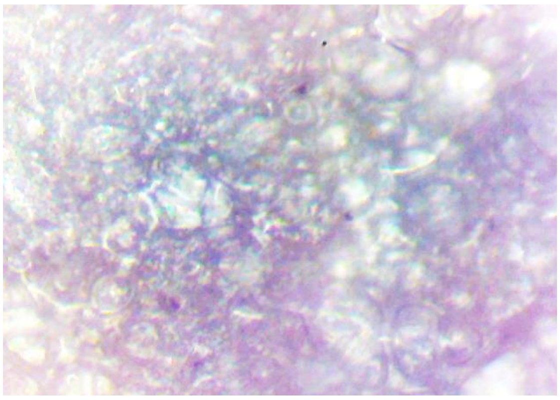

Fig.9 Microstructure of FSW sample 1.

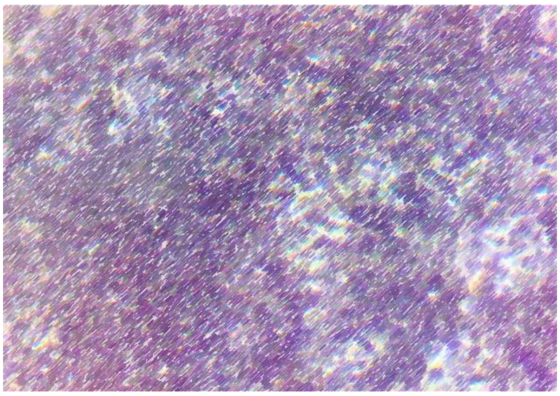

Fig.10 Microstructure of FSW sample 2

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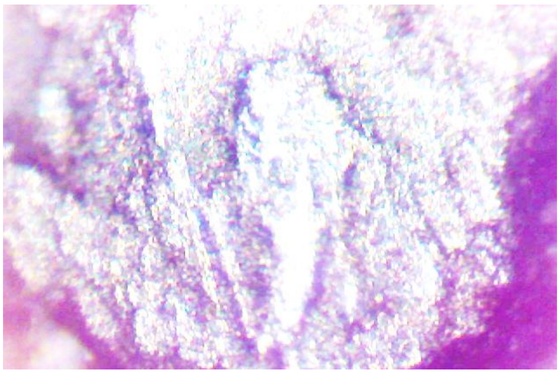

Fig.11 Microstructure of FSW sample 3

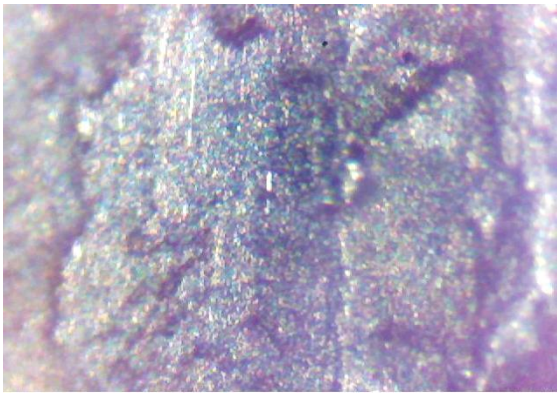

Fig.12 Microstructure of FSW sample 4

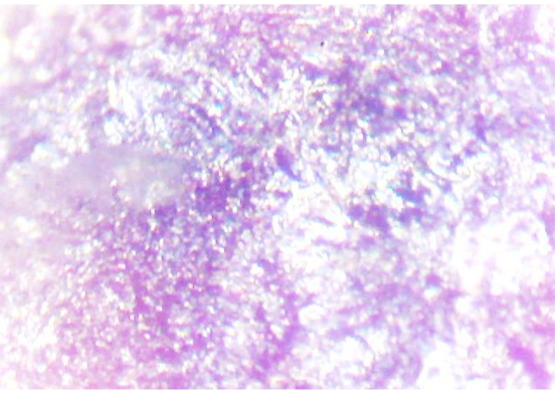

Fig.13 Microstructure of TIGW sample 1

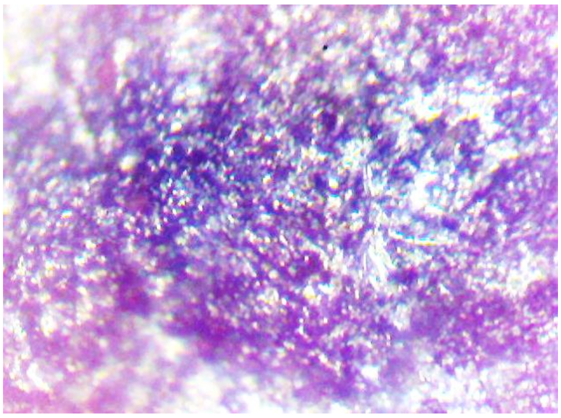

Fig.14 Microstructure of TIGW sample 2

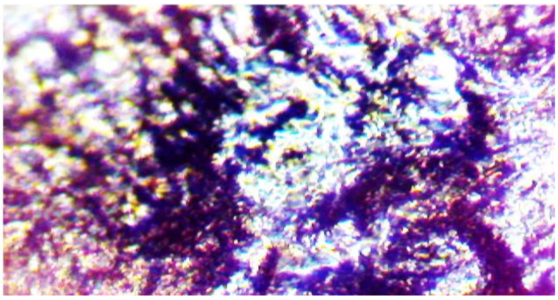

Fig.15 Microstructure of TIGW sample 3

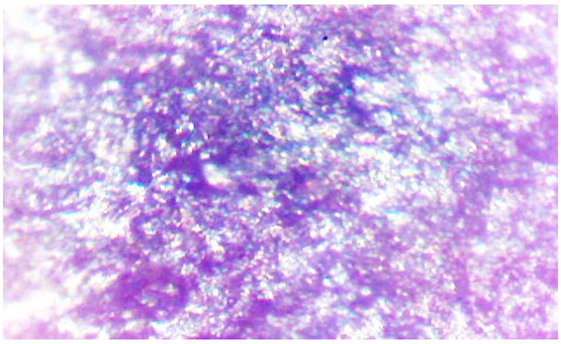

Fig.16Microstructure of TIGW sample 4

VI. CONCLUSION

This experimental comparative Investigation shows the comparison between the FSW process which is performed on different tool rotational speed and TIGW on different current and voltage After the experimental investigation of two of the different welding techniques TIGW (Tungsten Inert Gas Welding), FSW (Friction Stir Welding) the microstructures of different samples of both the process and mechanical properties of both the process following inferences are drawn:

1. TIGW is having very low tensile strength as compared to FSW which is having approx. 3 times more tensile strength then TIGW.
2. The tensile strength, microstructure and micro hardness properties of the weld zone remains the same in FSW because of the HAZ generated in this process is very low as compared to TIGW but changes in TIG due to the high HAZ.
3. The micro hardness of FSW is higher than TIG
4. Porosity and cracks are seen in HAZ of FSW but in TIGW not seen such defect.

VII. ACKNOWLEDGEMENT

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