International Journal of Information Movement Vol.5 Issue XI (March 2021)
Website: www.ijim.in ISSN: 2456-0553 (online) Pages 1-6

THE EFFECT OF TOOL ROTATION ON MECHANICAL PROPERTIES OF FRICTION STIR WELDING OF ALUMINUM ALLOY

Sanjay
Rajkumar Duhan
Pradeep Gahlot
Research scholar UIET,
Department of Mechanical Engineering MDU, Rohtak, India
Email: sanjay.er000123@gmail.com

Abstract: Manufacturing sector is rapidly increased after the 2nd world war across the worldwide. In today's world it is essential to compete with the world to improve the manufacturing sector. Present era is known as the fourth industrial revolution across the globe where modern technologies like; Artificial Intelligence is used in manufacturing sector this technology maximize the output with minimum error. Various type of operation are operated with the help of Artificial Intelligence. These technologies also define which type of material is suitable for tool manufacturing. Due to this specific material is used for tool manufacturing. This factor is increase the life of the tool which is used in FSW process.

The pattern of variation of percent elongation of the material, which is to be welded. Initially the Tool Rotation Speed (TRS) is constant at Welding Speeds (WS), at the certain limits when WS is increased the percentage of elongation of material is also increases for all TRS values. Further when the welding speed(WS) of material is increased beyond a certain limit the percentage of elongation of the material which is to be welded is decreased. This elongation is define by various factors like microstructure of grain, size of grain, tensile strength of the material etc. The increased welding speed causes heating of the tool due to this factor tool life is also reduced. If proper heat is not provided during the operation resulting in poor flow of plastic and clustering of precipitates. This reduces percentage of elongation material, which is welded.

Keywords: FSW process, Rotation of Tool, Tool Speed, various properties of tool, Aluminum alloy.

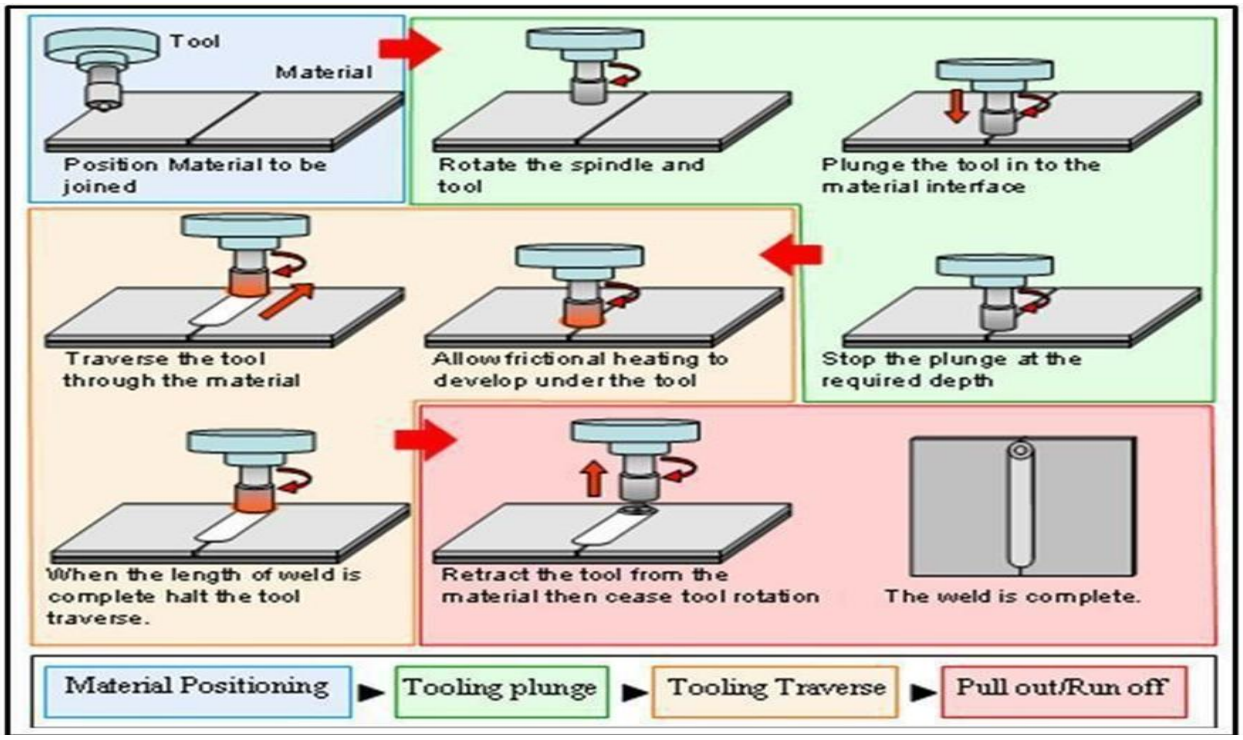
Introduction

In today's world where every sector emerging rapidly in last three decade. Science and Technology rapidly change the world. Manufacturing sector is one of the field which is rapidly grow and fulfill the requirements. Now world is reaches in the fourth Industrial Revolution where Artificial Intelligence play important role to run the Industry. It is very easy to operate various operating system with the help of programming which are programmed in a computer system. FSW process is also a advance mechanism to weld the two metals whose properties maybe same or not. Tool Rotation and its speed an important factor in FSW process. TRS shows its relation with the WS of the material. The elongation of welded joint is depends on the WS as well as TRS. Initially when WS is increases at certain limits TRS is constant and elongation of welded joint takes place which is depends on heat generated when metal and tool are in contact during the welding process but, when further WS is increases to the certain limits the percent of elongation of weld joint due to TRS is increases it means WS is directly proportional to the TRS at that point. But when WS is further increases beyond that certain limit. The percent of elongation of weld joint decreases, this define when WS is beyond that certain point is inversely proportional to the TRS.

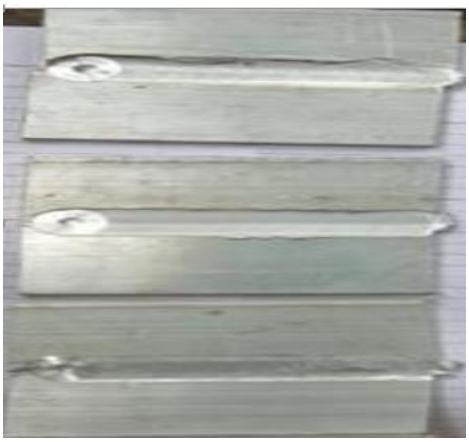
This phenomenon define that welding speed shows the various characteristics of TRS and it either increases or decreases the elongation of weld joints as per the requirement. Tool rotation speed is used for weld the joints. The material which is used for tool making have ductility, high stiffness, high melting point, etc. as compare to those materials where welding process takes place. If tool is made by low quality of material, it may be break during operation it means its life is small as compare to the standard tool.
Friction Stir Welding (FSW) Process is the phenomena where two metals are contact with each other, due to that heat is produced between the material because of friction which is occurs due to their contact. In present scenario welding process is depends on various factor which may be the microstructural characteristics of material which is to be welded, material of the tool, TRS, WS also in which method to weld the materials like manually or by using

Artificial Intelligence. Artificial Intelligence brings boom in the various sectors like; in manufacturing sector where various operations are takes place with the help of programming. This phenomenon increases the quality and productivity of the products in manufacturing sector with minimum error.

Artificial Intelligence also play vital role in adjusting the tool rotation speed as per the requirement during the FSW process of Aluminum alloy. We know that TRS is depends on the WS, so with the help of AI it is very easy to regulate the tool rotation speed.



Process chart of FSW process



(FSW PROCESS)

1.0 Literature Review

We study the effects of tool rotation during FSW process. Where we study that which type of material is used for making tool and it also noted that tool must be heat resistant because during friction metal, which is welded, is heated due to this heat metal is melted and it is easily welded by FSW process. The TRS varies with the WS, as we study earlier. We have worked in different parameter of FSW process and their effect in the weld properties. The

analysis of heat transfer during welding process helps to analyze the efficiency of joint of the weld. As we know that there are residual stresses is produced during welding processes which is unwanted stresses in the weld material because of uneven heating of the part during welding process can be analyzed by heat transfer analysis. In this chapter, we concerned to analyze the butt joint of two similar material as well as also referred the processes involved for dissimilar material to join. Many researchers performed their work to analyze the different properties like tensile strength, hardness as well as microstructure of heat-affected zone but very few one tried to analyze various properties of weld zones because of intense heating of the weld material. But it is quite clear that the friction stir welding processes used to join the different variety of material but it is more suitable to join the aluminum alloys which is found by many researcher during their work.

Ericsson M. etal studied the FSW process parameters and their effect of variation on the strength of the weld and their microstructural behavior and also tried to analyze the difference with this welding to MIG welding as well as TIG welding. As we know that, the speed of weld is a very important parameter, which affect the properties of the weld.

Mahoney et al (1998b) studied the effect of FSW and subsequent thermal aging on the longitudinal and transverse properties of 7075T651 aluminum alloy. The HAZ was found to be the weakest zone with a decrease in ultimate tensile strength and yield strength in longitudinal tensile tests. [2].

Rhodes et al (1997) joined AA7075 plates using FSW process where speed of welding is 5 min/min and due to this speed, alloys change its microstructural properties during FSW process. [3].

Sutton et al (2004) study the microstructural features of FSW process of AA2024 Al alloy. Microstructural bands with regions rich and poor in hard particles were observed alternately and related to onion ring pattern. [5].

Krishnan (2002) study the making of rings of onion, their significance and effect on properties of FSW process. Due to rotation of tool, heat is generated because of friction heating due to this process and the movement of tool in forward direction forms the onion ring [6]. Krishnan, K. N. (2002).

Sato et al (2002) FSW aluminum alloy 6063 at temper condition of T4 and T5 at different rotation speeds. Increase in rotation speed causes maximize the temperature of welding process due to this fact exponential increases the size of grain. [8]. Sato, Y. S., Urata, M., & Kokawa, H. (2002).

Peel et al (2003) FSW process on AA5083 alloys of aluminum under varying conditions. The effect of WS on the microstructural strength, ductility, heat resistance and stiffness of the material was studied. [9].

Arora et al (2010) adapted milling machine is used for FSW weld Al alloy. Frictional heat and deformation resulted in microstructural change on thermos mechanically affected zone. Rotational speed and shoulder diameter affects the force in welding direction. Shoulder diameter and welding speed are major factors, which define the microstructural properties of the material [16].

2.0 Objective of the study

We study the Friction Stir welding process. This process is generally based on how to weld the material. In FSW process various factors are involve like; strength of material, stiffness, hardness, melting point of the material etc. Tool rotation speed (TRS) also play vital role in welding process. We studied that tool rotation speed (TRS) is depends on the Welding Speed (WS). In initially when Welding Speed in increased the Tool Rotation Speed (TRS) is constant, further when WS is increased to 40 mm/min the percentage of elongation of the material is increase to all TRS value, it means Welding Speed is directly proportional to TRS value. Further WS is increased to 60 mm/min elongation is decreased at all TRS values; in that case WS is inversely proportional to TRS value. Elongation of material during welding process can be regulated with the help of Tool Rotation Speed (TRS)

3.0 Methodology

As we studied the various literature, we found various properties of the material like; microstructural property, fine grain size, tensile strength, heat resistance of the aluminum alloys. With the help of its microstructural properties, we

improved strength and ductility of the material as per our requirement. We also studied that welding speed (WS) and tool rotation speed (TRS) are depends on each other. Welding speed is regulated by the TRS and vice-versa.

4.0 Experimental Work

In previous section, we study the available literature on friction welding of similar and various types of aluminum alloys, FSW is critical enabling the integration of the welding of aluminum material in a wide range of applications in various sectors like; aerodynamics, automobile, shipping sectors etc., the growth of the microstructure, structure and size of grain, the mechanical properties like; strength, ductility, stiffness etc. and the various parameters for using heat transfer as well as material flow and statistical modeling. In this chapter we find some ideas about the composition and properties of the base material, with the help of these factors material is modify as per the requirement in the FSW process, the dimension of parts and details of the tool used, various tests of welding process are performed, Design of thermocouple, tensile strength tests, characterization microstructure and measurement of micro hardness. To obtained percentage elongation of welded joints and tensile strength of the material used for developing regression models for welding process.

Table: 1 FSW parameters and levels

S.N.	Parameter	Low (-1)	Medium (0)	High (+1)
1.	TRS (rpm)	900	1100	1300
2.	WS (mm/min)	22	38	72
3.	SD (mm)	16	18	20

Table: 2 Design Matrix and Experimental Procedure

Exp. No	TRS (RPM)	WS (mm/min)	SD (mm)
1	900	22	16
2	1100	37	16
3	1300	52	16
4	900	58	18
5	1100	38	18
6	1300	68	18
7	900	60	20
8	1100	68	20
9	1300	72	20
10	900	62	17.5

Figure shows friction stir welding joint

Table: 4 tensile test result

Expt.N.	TRS (RPM)	WS (mm/min)	SD (mm)	UTS (MPa)
1	900	22	16	154
2	1100	37	16	176
3	1300	52	16	198
4	900	26	18	143
5	1100	38	18	205
6	1300	68	18	223
7	900	60	20	179
8	1100	66	20	183
9	1300	72	20	187
10	900	62	17.5	159

5.0 Result

As we studied that Tool Rotation Speed (TRS) is play vital role in FSW process where material, which is to be welded, depends on its microstructural grain size, fatigue, tensile strength, ductility etc. during research we found that WS of the material is regulated by the TRS and vice versa.

6.0 References

1. Jha, A. K., & Sreekumar, K. (2008). Metallurgical studies on cracked Al–5.5 Zn–2.5 Mg– 1.5 Cu aluminum alloy injector disc of turbine rotor. Journal of Failure Analysis and Prevention, 8(4), 327-332.
2. Mahoney, M. W., Rhodes, C. G., Flintoff, J. G., Bingel, W. H., &Spurling, R. A. (1998). Properties of friction-stir-welded 7075 T651 aluminum. Metallurgical and materials transactions A, 29(7), 1955-1964.
3. Rhodes, C. G., Mahoney, M. W., Bingel, W. H., Spurling, R. A., &Bampton, C. C. (1997). Effects of friction stir welding on microstructure of 7075 aluminum. Scriptamaterialia, 36(1), 69-75.
4. Sutton, M. A., Yang, B., Reynolds, A. P., & Yan, J. (2004). Banded microstructure in 2024-T351 and 2524-T351 aluminum friction stir welds: Part II. Mechanical characterization. Materials Science and Engineering: A, 364(1), 66-74.
5. Krishnan, K. N. (2002). On the formation of onion, rings in friction stir welds. Materials science and engineering: A, 327(2), 246-251.
6. Lockwood, W. D., Tomaz, B., & Reynolds, A. P. (2002). Mechanical response of friction stir welded AA2024: experiment and modeling. Materials Science and Engineering: A, 323(1), 348-353.
7. Sato, Y. S., Urata, M., & Kokawa, H. (2002). Parameters controlling microstructure and hardness during friction-stir welding of precipitation-hardenable aluminum alloy 6063. Metallurgical and Materials Transactions A, 33(3), 625-635.
8. Peel, M., Steuwer, A., Preuss, M., & Withers, P. J. (2003). Microstructure, mechanical properties and residual stresses as a function of welding speed in aluminium AA5083 friction stir welds. Actamaterialia, 51(16), 4791-4801.
9. Liu, H. J., Fujii, H., Maeda, M., & Nogi, K. (2003). Tensile properties and fracture locations of friction-stir-welded joints of 2017-T351 aluminum alloy. Journal of Materials Processing Technology, 142(3), 692-696.
10. Squillace, A., De Fenzo, A., Giorleo, G., & Bellucci, F. (2004). A comparison between FSW and TIG welding techniques: modifications of microstructure and pitting corrosion resistance in AA 2024-T3 butt joints. Journal of Materials Processing Technology, 152(1), 97105.
11. Cavaliere, P., Campanile, G., Panella, F. and Squillace, A. "Effect of welding parameters on mechanical and microstructural properties of AA6056 joints produced by Friction Stir Welding", Journal of Materials Processing Technology", Vol. 180, No. 1-3, pp.263-270, 2006a.
12. Cabibbo, M., McQueen, H. J., Evangelista, E., Spigarelli, S., Di Paola, M., &Falchero, A. (2007). Microstructure and mechanical property studies of AA6056 friction stir welded plate. Materials Science and Engineering: A, 460, 86-94.

13. De Giorgi, M., Scialpi, A., Panella, F. and De Filippis, L. "Effect of shoulder geometry on residual stress and fatigue properties of AA6082 fsw joints", Journal of Mechanical Science and Technology", Vol. 23, No. 1, pp.26-35-35, 2009.

14. Fratini, L., Buffa, G., & Palmeri, D. (2009). Using a neural network for predicting the average grain size in friction stir welding processes. Computers & Structures, 87(17), 11661174.