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A review on Friction Stir Welding

Dr. Jayabalakrishnan1, Mr. D.B.Naga Muruga2
1 Associate Professor,2 UG Student (second year)
Dept of Mechanical Engineering, Sriram Engineering College
Perumalpattu, Tiruvallur Dist – 602024
djayabal2000@yahoo.com, nagamuruga403@gmail.com

Abstract

Friction Stir Welding, a type of welding which was discovered in the year of 1991 with a few countable methods and processes. But today it is one of the necessary and important type of welding techniques. To develop it, several researchers showed their interests in this technique. Today, it acts as the heart of welding of automobiles. Thousands of inventions has been made in field of Friction Stir Welding and also successfully being implemented. If a researcher tries to make some research in this field, he has to go through thousands of journals where hours of time is being consumed. To solve that problem several Re-view journals are being published and also successfully solved this issue of time consumption. In this paper, similarly a re-view of several important and different types of papers are discussed with their results, outcomes, the parameters being performed for analysis.

This paper also discusses about various methods and various metals as tools and job materials. It will be much easier and lenient to understand from this paper to research. The authors of the papers also clearly explained about the usages and applications of their methods and provided several statistical data for clear observation of their methods.

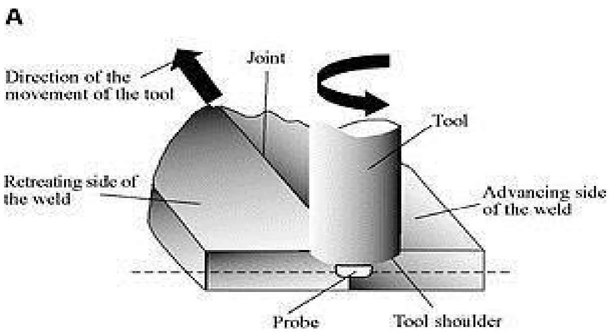
Introduction

Friction stir welding is a solid state joining technique that is used on metals where the original characteristics of the metal must remain as unchanged as possible. The technique of friction stir welding is most commonly used on aluminium and larger pieces that cannot be heat treated after welding in order to retain the temper characteristics of the metal. The Friction Stir Welding process is performed using a cylindrical tool which has a profiled threaded probe. During welding, this tool is rotated and maintained at constant speed, then it is led to rotate up on two pieces of metal, where they are needed to be join.

Working Principle

The metals that are going to be joined must be clamped onto a backing bar so that their joint faces cannot be forced apart by the process. Initially the rotation creates less heat, after reaching a constant speed, this produces more heat required enough to weld the two pieces. This method has several advantages than any other welding techniques. Also in other welding techniques problems relating cooling of liquid phase arrives, but in Friction Stir Welding it will not occur. Similarly, other welding problems like hot cracking, porous defects, solute redistribution will not occur in this Friction Stir Welding. The problems identified in Friction Stir Welding are commonly very less when compared to other welding techniques. Even though some problems came at beginning but it is being eradicated step by step. Some defects like inadequate welding temperatures, lack of continuity in the bond, tunnel forming defects between materials and formation of a kissing bond which can be very difficult to notice without the use of an x-ray or ultrasonic testing of the welded area.

This type of joining process includes the absence of toxic fumes or splatter. No other consumables are needed to perform this weld, and it is very well perfect for industrial applications. It can be performed in all positions and will not create a weld pool.



Tool Parametres

1. **Tool design**
   The design of the tool could be an essential issue, as a good tool will improve each the standard of the weld and also increase the rate of welding. It's fascinating that the tool material be sufficiently hard, tough, and arduous carrying at the temperature of welding. Further, the tool should have the properties of good oxidation resistance and less thermal conductivity to decrease loss of heat and prevent thermal damage to the machines. Hot-worked alloy steel like AISI H13 has verified absolutely acceptable for welding metallic element alloys at intervals thickness ranges of 05–50 mm. However a lot of advanced tool

materials necessary for a lot of foremost applications like extremely abrasive metal matrix composites or higher-melting-point materials like steel.

Improvements in tool style are shown to cause substantial enhancements in productivity and quality. TWI has developed tools specifically designed to extend the piercing depth and so increasing the plate thicknesses which will be with successfully welded. The Triflute style contains a complicated system of 3 tapering, rib re-entrant flutes that seem to extend material movement round the tool. The Trivex tools use a less complicated, non-cylindrical, pin and are found to scale back the forces engaged on the tool throughout welding.

2. Tool rotation and traverse speeds

Depending on speed as a parameter, to make a productive and efficient weld, the rotation of tool speed and welding speed along the interface are to be measured and analyzed. These teo variables have great effect and to be chosen with care to check an efficient and outstanding welding cycle. The relationship between these two parametres during the process of welding is very complicated, but commonly it is observed that minimizing the traverse speed or maximizing the rotation speed will provide a hot weld.

To provide a effective joint, it is important that the ,aterial enclosed by the tool is more warm enough to permit the extensive plastic flow to be needed and decrease the forces acting on the tool. If the material is less in temperature, then voids may arrive in welded zone and in abnormal cases, it leads to breakage of tool. Surplus level of high heat input can greatly affect the results of weld. So, these two variables are considered to be important parametres in Friction Stir Welding.

3. Tool tilt and plunge depth

The plunge depth is outlined because the depth of least point of the shoulder below the surface of the welded plate and has been found to be a essential parameter for making certain weld quality. Plunging the shoulder below the plate surface will increase the pressure below the tool and helps guarantee adequate forging of the material behind the. Tilting the tool by 2–4 degrees, specified rear of the tool is not up to the front. It has been found to help this forging method. The plunge depth must be properly set, each to make sure the required downward pressure is achieved and to make sure that the tool absolutely pierces the weld. Given the high loads needed, the welding machine could deflect so scale back the plunge depth compared to the nominal setting, which can lead to flaws within the weld. On the opposite hand, AN excessive plunge depth could lead to the pin rubbing on the backing plate surface or a big underneath match of the weld thickness compared to the bottom material. Variable-load welders are developed automatically make amends for changes within the tool displacement, whereas TWI have established a roller system that maintains the tool position on top of the weld plate.

4. Flow of material

Early work on the mode of material flow round the tool used inserts of a unique alloy, that had a unique distinction to the conventional material once viewed through a microscope, in an effort to analyze where material was stirredbecause the tool passed. the info was understood as representing a kind of unchanged extrusion, wherever the tool, backing plate and cold base material type the "extrusion chamber", through which the hot, plasticised material is forced. during this model the rotation of the tool attracts very little or no material round the front of the probe; instead, the material elements ahead of the pin and passes down either side. when the material has passed the probe, the side pressure exerted by the "die" forces the material back along, and unification of the joints occurs, because the rear of the tool shoulder passes overhead and therefore the large down force forges the material.

More recently, another theory has been advanced thatadvocates noticeable material movement in bound locations. This theory holds that some material will rotate round the probe, for a minimum of one rotation, and it's this material movement that produces the "onion-ring" structure within the stir zone. The researchers used a mix of thin copper strip inserts and a "frozen pin" technique, wherever the tool is quickly stopped in place.

5. Generation and flow of heat

For any welding method, it is, in general to extend the travel speed and decrease the heat input, as this may increase productivity and definitely scale back the impact of welding on the mechanical properties of the weld. Similar, it's necessary to make sure that the temperature round the tool is sufficiently high to allow adequate material flow and avoid flaws or tool breakage.

6. Case Studies: Effect of Various Welding Parameters on FSW

S.No.	Author (year)	Substrate Material	Parameters selected for study	Conclusion
1.	Y.Tozaki, Y. Uematsu, K.Tokaji (2010)	6061-T4 Sheets aluminium alloy	Actual dimension of nugget and thickness of welded material	Maximum tensile strength of shear fracture obtained was 4.6 Kn. Provided good stirring of material
2.	A.Scialpi, M.De.Giorgi, L.A.C.De Fillips, R.Nobile, F.W.Panella (2007)	6082-T6 Sheets aluminium alloy, 2024-T3 Sheets aluminium alloy	Presence of defects and Elongation of failure in Weld	Wohler curves have limited scatter and fatigue limits upto range of 40-75 Mpa Deep input upon thickness of material;
3.	C.Blignault, D.G.Hattingh, G.H.Kruger, T.I.Van Niekerk, M.N.James (2006)	aluminium alloy plate	Tool geometry Temperature at weld zone Rake angle Welding Speed Weld feed	The real time measuring device called Multi-axial transducer which is designed in NMMU (Nelson Mandela Metropolitan University) was used and its results were explained indetail. Possibility
4.	Daeyong Kim, Wonoh Lee, Junehyung Kim, Chongmin Kim, Kwanson Chung (2010)	6114-T4 aluminium alloy	Material flow direction	Aluminium alloy 6114-T4 sheets with three different combinations RD||RD, TD||RD, TD||TD were obtained. Hollomon type FLD simulation showed better failure predictions than the voce type FLD results. (RD – Rolling Direction, TD - Transverse Direction)
5.	S.Rajakumar, C.Muralidharan, V.Balasubramanian (2010)	AA7075–T6 aluminium alloy	Tool rotational speed Welding speed Axial force Tool shoulder diameter Pin diameter Tool Hardness	The higher strength properties of 315 MPa yield strength, 373 MPa of tensile strength, 397 MPa of notch tensile strength, 203 HV of hardness and 77% of joint efficiency respectively was attained for the joint fabricated using using given tool parametres.
6.	L.Ceschini, J.Boromei, G.Minak, A.Morri, F.Tarterini (2007)	AA7005 aluminium matrix composite with 10% vol of Al_2O_3 (W7A10A)	Vertical force Tool rotation speed Welding speed	The abrasive effect of the pin gave significant reduction in the particles shape factor with 80% efficiency due to ultimate tensile strength. Different fracture morphologies in tensile and fatigue specimens from the upper to bottom zones were found.
7.	M.B.Silva, M.Skjoedt, P.Vilaca, N.Bay, P.A.F.Martins (2009)	AA1050-H111 aluminium alloy Tailor welded blank	Thickness of Heat Radius of forming tool	This journal demonstrates the usage of Single Point Incremental Forming to the production of sheet metal parts made from Tailor welded blanks manufactured by Friction Stir Welding is best and worked well in manufacturing complex sheet metal parts with high forming depths.
8.	Lars Cederquist, Tomas Oberg (2008)	Copper Canisters	Tool of rotation speed Welding speed Axial Force Shoulder depth Tool temperature	The reliability of a system for sealing copper canisters with spent nuclear canister has been developed and evaluated under production-like conditions. The methodology of statistical experimental design was implemented with good results .
9.	Dong-Yang Yan, Ai-Ping Wu, Juergen Silvanus, Qing-Yu Shi (2010)	6065-T6 aluminium alloy	Three co-ordinates of positions for welding Welding Speed Axial Force Shoulder depth Tool temperature	Initially a 3D thermo-mechanical model was developed. Later the assumption indicated that the structure had the same residual distortion trends as the sheet after Friction Stir

				Welding, but its deformation value was much smaller.
10.	Takehiko Watanabe, Hirofumi Takayama, Atsushi Yanagisawa (2006)	SS400 Mild steel and A5083 aluminium magnesium alloy A5083	Pin rotation speed Pin offset Tensile strength of joint	In this journal aluminium alloy containing magnesium and steel were tried to join by Friction Stir Welding process. It is observed that, it is impossible to weld aluminium alloy and steel by counter clock wise rotation of a pin.
11.	Olivier Lorrain, Veronique Favier, Hamid Zahrouni, Didier Lawrjaniec (2010)	7020-T6 aluminium alloy	Welding speed Plunge force Tool rotational speed	Experimental outputs have been proposed for two different tool shapes with with unthreaded pin for several welding parametres combinations. The journal showed that the material flow with unthreaded tool has the same features as the material flow using classical threaded tools.
12.	C.M.Chen R.Kovacevic (2003)	6061-T6 aluminium alloy	Temperature of weld Traverse speed	The journal has a prediction of that explains high stress is located in the region extending down from the peak to the mid-thickness of the weld. A higher traverse speed exhibits a larger high longitudinal stress zone and a narrow lateral stress zone in the weld, which complies with the previously reported measurements with the synchrotron and neutron techniques.
13.	M.Geiger, F.Micari, M.Merklein, L.Fratini, D.Contorno, A.Giera, D.Stuad (2008)	AA5182 aluminium alloy, AA6016	Welding feed Rotational speed Tilt angle Tool hardness	A newly welding process called Friction Stir Knead Welding has been introduced in this journal. The researches on numerical simulations were executed in Abaques Implicit in order to define an enhanced profile of the steel sheet. The qualitative ratio between the forces, which are transferred by form clamping amounts about 70% and 30% because of chemical bonding.
14.	J.Adamowski, M.Szkodo (2007)	6082-T6 aluminium alloy	Welding Speed Tool rotation	Experiments were done on aluminium alloy 6082-T6 and it is observed that on initial stage a hardness drop was observed in weld region. A Tunnel defect was identified at the intersection of welded portion.
15.	Rajesh S.R, Han Sur Bang, Woong Seong Chang, Heung Ju Kim, Hee Seon Bang, Chong In Oh, Jae Seon Chu (2007)	A16061-T6	Rotational speed Welding speed Tool-to-work piece angle Plunge depth	The maximum predicted longitudinal residual stress component was approximately 24% of the yield strength of A16061-T6. Because of asymmetry in plasticized material value along the advancing and retreating side of the stir zone that generate heat,and an asymmetry in the residual stress distribution is obtained.

7. Conclusion

By the way of conclusion, our journal discussed about several journals of Friction Stir Welds, discussed about distinguished methods, aluminium alloys as jobs also other non-metals as jobs. We also discussed in brief with the help of several tool parametres and the evaluated outcomes and results of the authors. The novelty of the above journals are introduction of new sub type of Friction Stir Weld called Friction Stir Knead Welding of steel aluminium butt joints and another assumption journal present. This Friction Stir Welding is definitely a boon for several industries and sooner thousands of new methods will evolve and grow in this field.

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