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Analysis Of Friction Stir Welding Tools With Various Threaded Pin Profiles

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ABSTRACT:

The welding tool, its pin profile, shape and dimensions plays a vital role in making the weld joint. In Friction Stir Welding, the stress distribution of tool pin is affected by the thermo mechanical characteristics of the work piece. In this paper, three tools with different pin shapes such as Conical, Cylindrical and Frustum were designed with threads in their profiles .Initially the tools dimensions are based on the base material plate thickness taken in to consideration, the induced structural stresses were checked with in the permissible stress limits. The tools were modeled in CATIA and analysis is performed in ANSYS software for exploring stress distributions and displacement vector sum in the pin, at different speeds and temperatures. The frictional force between the tool shoulder and work piece is considered for simulating the stress and displacement vector in the pin profiles. The tool pin profiles considered for structural and thermal analysis are used in this study are cylindrical, conical, and frustum. The vonmises stress distributions in pin profiles, displacement vector sum of the pin profiles, are obtained from ANSYS software and the pin with optimum strength is determined.

I. INTRODUCTION

Friction Stir Welding (FSW) process is a solid state welding process, that uses a non consumable tool for joining the plates. The production of components of aluminium alloys is not very complex, joining of these materials can sometimes cause serious problems. Lack of structural transformations in solid state and excellent thermal and electrical conductivity cause problems in fusion and resistance welding of aluminium alloys. That led to the development of Friction Stir Welding a solid state joining technique in which the joined material is plasticized by heat generated by friction between the surface of the plates and the contact surface of a special tool, composed of two main parts: shoulder and pin. Shoulder is responsible for the generation of heat and for containing the plasticized material in the weld zone, while pin mixes the material of the components to be welded, thus creating a joint. This allows for producing defect-free welds characterized by good mechanical properties. A good number of publications are available on this topic, which indicates the importance and necessity of the analysis of the friction stir welding tools.

K. Elangovan,et.al [1] worked on the "Influences of tool pin profile and tool shoulder diameter on the formation of friction stir processing zone in AA6061 aluminum alloy" states that Compared to the fusion welding processes that are routinely used for joining structural aluminum alloys, friction stir welding (FSW) process is an emerging solid state joining process in which the material that is being welded does not melt and recast. The welding parameters such as tool rotational speed, welding speed, axial force, etc., and tool pin profile play a major role in deciding the weld quality. The effect of tool pin profile and tool shoulder diameter on FSP zone formation in AA6061 aluminum alloy is studied. Five different tool pin profiles (straight cylindrical, frustum cylindrical, threaded cylindrical, conical and square) with three different shoulder diameters have been used to fabricate the joints. The formation of FSP zone has been analyzed macroscopically. Tensile properties of the joints have been evaluated and correlated with the FSP zone formation.

Jeong-Luh Lin, et.al[2] Worked on "Stress analysis of FSW Tools Under Torsional and Bending loads". In this study One of the tool is made from the same one-piece material with a probe of round pin attached to a scrolled shoulder, while the other is a two-pieces tool with a pin inserted into a separate ring which acts like a shoulder and form similar pin on shoulder configuration like the first one. A comprehensive way of judging the strength of these tools have been established by comparing the stresses in these two tools when they all subjected to the same loading conditions. Physical tool models subjected to loading conditions as happened in actual FSW process are analyzed using FEM tool of structural analysis.

H.S. Patil, et.al [3] worked on "Experimental study on The Effect of Welding speed and tool pin profiles on AA602-o aluminium Friction Stir welded butt joints". The aim of this research study is to investigate the effects of different tool pin profiles on the weld quality of AA6082-o aluminum . Triflutes and taper screw threaded pin are used as tool pin profiles in this research. The appeared results explain the variation of stress as a function of strain and the effect of different pin profiles on yield strength, ultimate, tensile strength and elongation.

OlivierLorrain, et.al [4] worked on "Understanding the material flow path of friction stir welding process using unthreaded tools". According to them most of studies in literature used threaded pins since most industrial applications currently use threaded pins. However, initially threaded tools may become unthreaded because of the tool wear when used for high melting point alloys or reinforced aluminum alloys. In this study, FSW experiments were performed using two different pin profiles. Both pins are unthreaded but have or do not have flat faces. The primary goal is to analyze the flow when unthreaded pins are used to weld thin plates. Cross-sections and longitudinal sections of welds were observed with and without the use of material marker (MM) to investigate the material flow. Material flow with unthreaded pin was found to have the same features as material flow using classical threaded pins: material is deposited in the advancing side (AS) in the upper part of the weld and in the retreating side (RS) in the lower part of the weld; a rotating layer appears around the tool. However, the analysis revealed a too low vertical motion towards the bottom of the weld, attributed to the lack of threads. The product of the plunge force and the rotational speed was found to affect the size of the shoulder dominated zone. This effect is reduced using the cylindrical frustum pin with flats.

II. PROBLEM MODELLING

III. GEOMETRY:

The dimensions of the finite element model for different pins are taken as follows.

- Cylindrical: pin diameter (r_i) = 6mm, pin height (h) = 5.4mm
- Frustum: r_{i1} = 3mm, r_{i2} = 1.5mm, h = 5.4mm.
- Conical: r_{i1} = 3mm, r_{i2} = 0, h = 5.4mm

ELEMENT TYPE:

The element used for the present analysis is solid 45 of ANSYS which is developed based on three dimensional elastic theory and is having three degrees of freedom at each node.

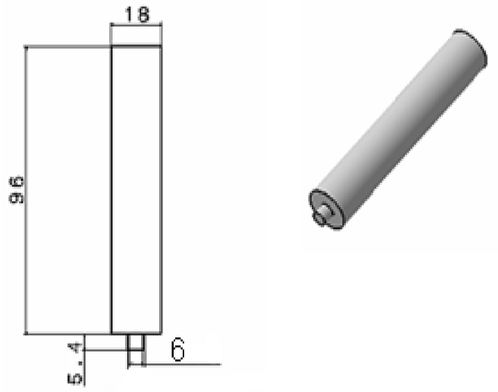

Fig 1: 2D and 3D models of FSW tool with threaded cylindrical pin

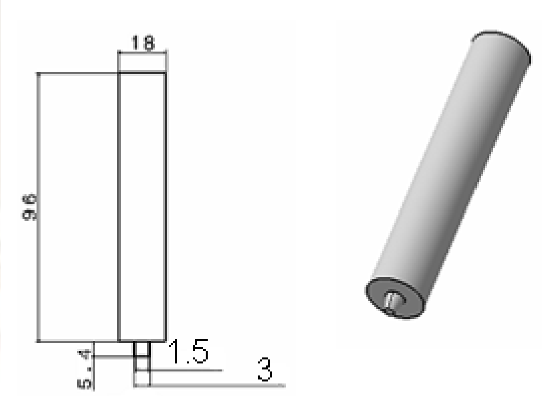

Fig 2: 2D and 3D models of FSW tool with threaded frustum pin

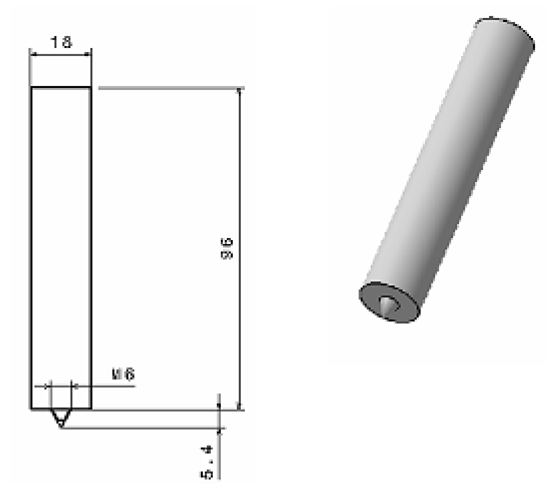

Fig 3: 2D and 3D models of FSW tool with threaded conical pin

LOADING

- An axial load of 7000N
- Tangential load of 2100N on tool pin
- Tool is rotated at a speed of 1200 to 1600rpm
- Temperature of 650 to 850^{0}C.

BOUNDARY CONDITIONS

On the shoulder of the tool for few nodes all DOF are fixed except rotation in z direction (R_Z).

MATERIAL PROPERTIES

Modulus of Elasticity E = 210Gpa, Poisson's ratio υ = 0.3, heat capacity = 0.46 J/g-^{0}C, thermal conductivity = 24.3 W/m-k

IV. RESULTS AND DISCUSSIONS

From (Fig.4), It is observed that the value of displacement vector sum increases with rotational speed i.e from 1200 to 1600rpm and the values are high for cylindrical pin when compared to the other two pin profiles. The variation of stress distribution is progressively increasing with temperature from 650 to 850^{0}C and the stress value is also high for cylindrical pin (Fig.5). The displacement vector sum is same for the three pin profiles and the value is progressively increasing with temperature (Fig. 6). The stress distribution is same at all rotational speeds for the three treaded pin profiles (Fig. 7).

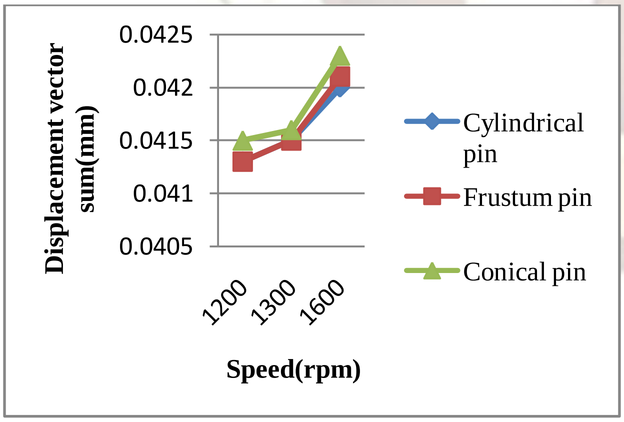

Figure 4: Variation of displacement vector sum with rotational speed in various threaded tool profiles

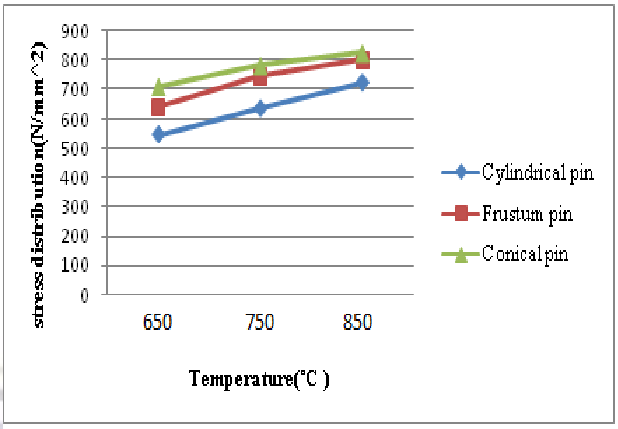

Figure 5: Variation of stress distribution with temperature in various treaded tool profiles

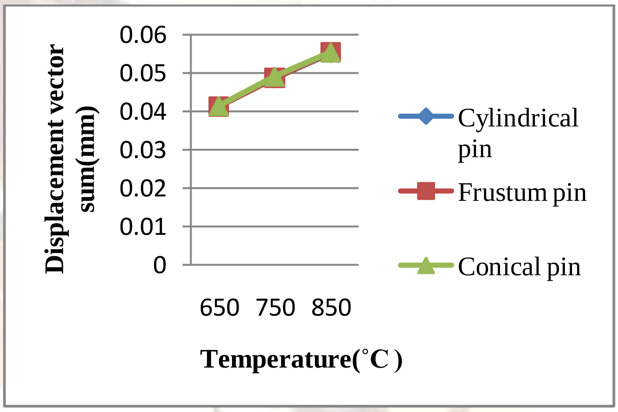

Figure 6: Variation of displacement vector sum with temperature in various threaded tool profiles

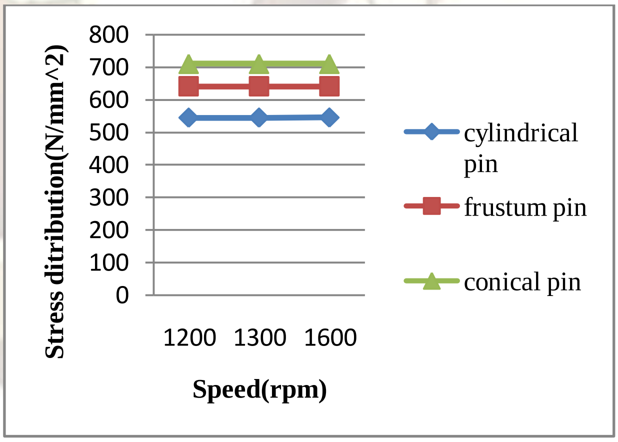

Figure 7: Variation of stress distribution with rotational speed in various threaded tool profiles

V. CONCLUSION

From the above results it can be concluded that, among all profiles in the tool with cylindrical profile with threads is preferable because the maximum stress distribution and displacement vector sum are very less. As the temperature in the welding zone increases in the profiles with threads the stress distribution and displacement vector sum are observed to be increased. It is also maximum in the tool with threaded conical profile. It is observed that by increasing the rotational speed there is not much change in the maximum stress distribution and displacement vector sum.

REFERENCES

1. Jeong-LuhLin, Wei-Ranlin, I-Horng yang, Jian-TingDai, "Stress analysis of friction stir welding tools under Torsional and Bending loads" WHAMPTON- An interdisciplinary Journal 52, PP-33-45(2007).
2. H.S.Patil, S.N.Soman,"Experimental study on the effect of welding speed and tool pin profiles on AA6082-0 Aluminium friction stir welded butt joints", International journal of Engineering sciences and technology, vol .2. No-5, PP-268-275(2010).
3. Hosein Atharifar, Dechaolin, "Numerical and experimental investigations on the loads carried by the tool during friction stir welding" JMEPEG18, PP- 339-350, (2009).
4. K.Kumar, Satish V.Kailas, "The role of friction stir welding tool on material flow and weld formation", Materials science and Engineering A 485 ,PP-367-374,(2008).
5. K.Elangovan, V.Balasubramanian, "Influences of tool pin profile and tool shoulder diameter on the formation of friction stir processing zone in AA6061 aluminium alloy", Materials and Design 29, PP-362–373, (2008).
6. K. Elangovan, V. Balasubramanian, "Influences of tool pin profile and welding speed on the formation of friction stir processing zone in AA2219 aluminium alloy", Journal of materials processing technology 200 ,PP-163–175(2008).
7. Olivier Lorrain, Véronique Favier, Hamid Zahrouni, Didier Lawrjaniec, "Understanding the material flow path of friction stir welding process using unthreaded tools", Journal of Materials Processing Technology 210 ,PP-603–609,(2010).
8. R.S. Mishra, Z.Y. Mab, "Friction stir welding and processing", Materials Science and Engineering , 50 1-78, (2005).
9. G.Roy, R.Nandan and T.DebRoy, "Dimensionless Correlation to estimate peak temperature during friction stir welding", Science and Technology of welding and Joining, vol. 11, No.5, PP-606-608 .
10. T.DebRoy, H.K.D.H.Bhadeshia, R.Nandan, "Recent advances in friction stir welding process weldment structure and properties" Progress in materials Science,(2008).
11. P. Cavalierea, A. Squillace, F. Panella, "Effect of welding parameters on mechanical and microstructural properties of AA6082 joints produced by friction stir welding", Journal of materials processing technology 200, PP-364–372.
12. Colligan.K, "Material flow behavior during friction stir welding of aluminium", Welding Journal, PP-229-237(1999).
13. G.H.Payganeh,N.B.Mostafa Arab, Y.Dadgar Asl, F.A.Ghasemi and M.Saeidi Boroujeni, "Effects of friction stir welding process parameters on appearance and strength of poly propylene composite welds",International journal of the physical sciences,Vol.6(19), pp. 4595-4601,(2011)
14. R.Palanivel,Dr.P.KoshyMathews,Dr.N.Murugan, "Influence of tool pin profile on the mechanical and metallurgical properties of friction stir welding of dissimilar aluminium alloy",International journal of Engineering science and technology,Vol.2(6),pp.2109-2115,2010
15. P.Bahemmat,A.Rahbari,M.Haghpanahi,M.K.Besharati, "Experimental study on the effect of rotational speed and tool pin profile on AA2024 Aluminium friction stir welded butt joints", ASME Early Career Technical Conference,2008