A Review on Impact of Tool pin Geometry on Friction Stir Welding of Aluminum alloys

M.Shiva Chander\textsuperscript{1,2}, M.Ramakrishna\textsuperscript{3}, B.Durga prasad\textsuperscript{4} and Adla Rajesh\textsuperscript{5}

\textsuperscript{1}Center for Materials and Manufacturing, Department of Mechanical Engineering, SR Engineering College, Warangal, Telangana. \textsuperscript{2}Research Scholar, Department of Mechanical Engineering, JNTU Ananthapuramu, A.P. \textsuperscript{3}Department of Mechanical Engineering, NOVA College of Engineering, A.P. \textsuperscript{4}Department of Mechanical Engineering, JNTU Ananthapuramu, A.P. \textsuperscript{5}Sumathi Reddy Institute of Technology for Women, Warangal, India.

Abstract. FSW is a solid-state welding skill. In 1991 TWI welding institute invented this welding method. This method is utilized in fabricating of diverse structural additives, automobiles components, ship building and automotives. By many studies the higher mechanical properties using this method were acquired. This method turned into Aluminium alloys like AA5083, AA2024 and AA7075 and so forth. The procedure parameters which includes device pin geometry, tool shoulder diameter, D/d ratio, rotational velocity and welding speeds. In this observe, friction stir welding of aluminium alloys literature became performed using various tool pin profile inclusive of SQ, HEX, TR, CY, TTH profiles.

Keywords: FSW, Tool pin profile, process variables, mechanical properties.

1. Introduction

A (FSW) tool is glaringly a chief constituent to the achievement of the system. A rotating circular shoulder thetool consists of pin that raises the temperature inside the plates, in most cases through friction, and to shape the joint, moves the softened alloy round it. Due to less mass and cast potential, the Al alloys utilization in cars and aerospace packages are ever growing. Because of attendance of porous nature, the excellent of the welded joint is deteriorated, distortion and hot cracking, these alloys aren't without difficulty weldable via predictable fusion welding technique. The fabric going to be fabricated does now not soften and recast of a technique of FSW is an rising strong kingdom becoming a member of manner wherein. With properly mechanical properties, defect-loose welds selected asaluminum alloys.
2. Principle of FSW

A solid-state joining process called FSW which utilizes a solid and round shape non-consumable carried apparatus pivots on the outside of the plates to be fabricated. In the apparatus of FSW machine, the plates are which solidly cinched. On the welding surface the axial force is applied. Device is encouraged to join plates with no softening it for the period of the welding procedure and the plates are deformed because of the age of warmth and contact. Warmth is produced by erosion between the pivoting instrument and the workpiece material, which prompts a relaxed locale close to the FSW device.

3. Mechanical properties of FSW joints

Mostafa M et.al.,[1] at unique circumstances, friction stir welding of 6 mm with plates AA5083-O were done; the equipment used was tapered smooth and cylindrical threaded pin geometries, and under various welding speeds, tool rotational speeds. At all welding speeds, values of tensile power by a threaded tool pin profile obtained are higher as compared with conical tool probe profile. Indira rani et.al., [2] square profiled device facilitates the rotating motion from tip to the collar causes in prevention of the turbulence. With the square profiled tool, the defect-free welds had been feasible. K. Kumar et.al., [3] in this paper, the impact of geometry of tool was studied onal alloys using FSW. Chamfered shoulder with frustum shaped rounded end pin produced a higher first-rate weld. P. Satish Kumar et al [4] tested the motive of Tool Rotational pace on FSW 5083-Aluminum composite. By threaded profile carried approximately remarkable mechanical properties found at revolution velocity of 710/40 traverse velocity. R. Palanivel et.al. [5] Unlike joints of AA5083-H111 alloy to AA6351-T6 alloy on the behavior of tensile making consciousness were produced by FSW. Five exceptional tool pin probes, consisting of (SS), (TS), (SH), (SO) and (TO) were used in this process. Welding speeds mm/min (63,50, and 75) for joints was considered. The joints produced on this research, at a welding pace of 63 mm/min using SS pin probe tool confirmed the pleasant tensile properties. V. PatelChandresh et.al., [6] Outcome investigation generally lies on traits of FSW tool pin profile on FSW joint. In this work, the usage of numerous tool pin profile like TCY, SQ, THEX, and THCY were studied. From acquire consequences and numerous exams, testing specimen’s has been prepared (bending and tensile and) could be finished to show its best joints. On the foundation of these outcomes and parameters used all over experiments, the effect of tool pin profile can be understood. M. Ilangovan et.al. [7] 5086 and 6061-aluminium alloys made to combine using FSW tried in this research. SC, TC and THC pin profiles was used here. Using grooved pin probe of device contributes to advanced flow of substances between two alloys and the era of defect loose stir zone, become founded from this investigation. J. C. Verduzco Juárez et.al., [8] bolt-head pin profile in this work impacted on the performance of 6061-T6 alloy using FSW process. This performance can be checked with conventional pin probes. FSW parameters consisting of the tool revolving velocity and
the welding velocity have been examined collectively. The bolt-head pin probe achieved more mechanical properties. SS, SH, TC, and It became observed the “bolt-head” (SHBH) pin profiles used on this work. The final pin probe develops the plastic deformation uniformly and on the nugget zone major defects decreased. To conclude the tensile power on welded specimens, mechanical tensile exams were conducted. With the SHBH pin profile topmost mechanical properties were achieved.D.Raghavendra et.al., [9] Aluminium alloys 6061 and was efficaciously welded. Thru FSW research the effect of D/d ratio and revolving speed on mechanical residences of Aluminum alloy 6061-T6 joining and the subsequent conclusions are received. At rotational speed 900 rpm, welding velocity 60mm/min and D/d ratio 3, the weld joint presents utmost tensile properties, as differed to other joints.

Elangovan et al. [10] pin and shoulder diameter of tools on FSW of AA6061 aluminum alloys were studied in this paper. With shoulder diameters and special probes of tools are availed. Based on tool shoulder and pin profile, micro structure and mechanical houses are rather enhanced.Lakshminarayanan et al. [11] FSW of RDE-40 aluminium alloy tensile power caused by locating the factors. ContemplatedTaguchi method and affects of tensile strength of the weld is based totally on geometry of tool was observed. Tensile power was stepped forward for FSW welded aluminium alloys. Mohanty et al. [12] tool velocities and different pin probes of AA1100 al alloys were included to investigate the parameters in this work. And for optimization ANOVA used. By methods of heightening spinning and welding speeds these are applied to locate the mechanical properties and elasticity is exceptionally duplicated. Murugan N et.al., [13] rectangular, hexagon, octagon and concentric circular grooved shoulder tool pin profiles together investigated the effects of FSW on stir cast Al-10 wt-% TiB2 steel matrix composite welds. Shahabuddin et.al., [14] in addition to scrutinize the causes of welding parameters like welding speed, pin diameter and shoulder diameter for FSW, a research was made on mechanical properties. AA7075-T6 material was selected in this work. If both shoulder diameter and rotational pin diameter increases, the float pace of the material will also boom. The flow velocity of material close to the weldment floor at the same time as a boom of the pin tip diameter, an enlargement in the shoulder dia can enhance be appropriate for the material in the weldment.

L.Trueba et al. [15] six unique tool shoulder diameters developed on 6061-T6 Aluminium alloy to pick up the metal flow. By raising spiral shoulder geometry even under non-perfect condition, exceptional weld with top floor high-quality and mechanical properties was obtained. V. Anand Kumar et.al., [16] tensile properties of the disparate FSW of aluminium alloys AA6082 and A319 were studied in this paper. In reading the joint properties of the weldsquare, hexagonal and cylindrical dissimilar device profiles with three welding speeds (25, 30, 35 mm/min) and 3 revolving speeds (800, a thousand and 1300 rpm) had been used. Higher tensile strength acquired by square tool profile for the parameters of 30 mm/min and 1300 rpm. The result of device pin profile in determining the tensile electricity can be seen from the high distinction between square pin and round pin profile.
Ravinda S. Thube et al., [17] by understanding the impact of welding parameters and tool pin profile a research with effort has been made in AA5083 aluminium alloy on development of friction stir processing sector and tensile properties. With a thickness of 2.5 mm FSW along with 5083 aluminium alloy plates became completed. Five sole tool pin profiles (TC, TR, CY, SQ and CO) had been used in this process. The joints with 3 outstanding rotational speeds i.e. 900, 1400 and 1800 rpm below a consistent traverse pace of sixteen mm/min was done. Mechanically sound disorder unfastened welds produced as compared to cylindrical pin profiled tool to different device pin profiles. (a) Taper (b) Triangular (c) Cylindrical (d) Square (e) Cone

R. Ashokkumar et al., [18] A356 and AA6061 alloys in this research, have been fabricated by FSW. The last parameters equal and AA6061 alloys have been friction stir welded by using various TR, SQ, HEX pin profiles of tool preserving. Without converting other parameters this was happened with the aid of changeable tool shoulder diameter as 12mm, 15mm, 18mm. It is found that when as compared to other pins, hexagonal pin profiled tool and 15mm shoulder diameter device exhibited superior tensile strengths. Tensile strength of AA6061 aluminium alloy with 60% was given by tool with SQ pin profile. And also AA6061 aluminium alloy with 66% tensile electricity of was given by HEX pin geometry tool. HEX pin profiled tool got good joint and higher percentage elongation and tensile strength of the two joints TR and SQ profiled tools. H. M. Anil Kumar et al., [19] by FSW technique aluminium alloys AA 7075 T651 and AA 6061 T6 were tried to join in this study. Exceptional process parameters under which include device welding speed (ninety mm/min to one hundred ten min) and rotation speed (750 rpm to 1250 rpm) were taken. With 5 tools with pin profiles—threaded cylindrical (TC), triangular profile (TP), conical profile (CP), square profile (SP) and hexagonal profile (HP) were made. The outcome of the experimentation indicated that square tool pin profile and hexagonal device pin profile on the tool revolvingspeed of 1250 rpm and the welding velocity of a hundred and ten mm/min respectively yielded good nice welds in comparison to other device pin profiles. The proper choice of tool pin profile, rotational speed, feed and different necessary parameters will give the better consequences.

Koilraj et al [20] Investigated the highest quality values of unlike FSW process parameters along with device rotational velocity, tool geometry, transverse velocity, ratio between device pin diameter and shoulder diameter for aluminium AA2219-T87 and AA5083-H321 alloy. The results indicated that most appropriate ranges of the revolving pace, D/d ratio and cross-wise velocity are seven
hundred rpm, 3 and 15 mm/min correspondingly. A fine in assessment to different profiles becomes determined from the cylindrical threaded pin tool profile.

R Palanivel et al [21] results studied was of pin profile and tool revolving velocity on tensile strength and microstructure. Via the usage of FSW aluminum alloys AA5083-H111 were welded. Under a variety of practice parameters with special tool pin profiles this process was done. The effects showed that the joint made by way of Straight Square at the tool revolving velocity of 950 rpm yielded highest tensile energy of 273 MPa. Hariharan et al [22] with the help of Computerized Numerical Control Machine Al 6061 & 7075 alloys mechanical properties were examined by using FSW technique. The cylindrical & taper pin profiles are selected and welding is completed between 1600 to 1250 rpm at the charge of one hundred twenty mm/min with the tool tilt attitude of 2°. At 1250 rpm, 120mm/min and a pair of tilt perspective a 485 MPa high tensile strength is produced. The most hardness of 131 BHN is received at 1600 rpm. The taper tool at 1250 rpm has proven very exceptional grain shape 100μm because of the dynamic recrystallisation method. N Srujana et al., [23] pin profiles CY, TC, THC, SQ and TR made an impact on the mechanical and microstructure characterization of FS welded aluminium AA6351 alloy. The triangular tool produced robotically sound and metallurgically free, disorder weld joints in the outcomes when compared to unlike pin geometries.

Figure 6. SC, TC, THC, Sq, Triangular pin geometries [23]

Md.Reza-E-Rabby et al., [24] the parametric end-results of pin features on FS weldability and material pour was examined on two al alloys (AA 7050 and AA6061) along with four thread pitches CY tool pin (1.02 mm, 1.41 mm, 2.12 mm & 3.18 mm). This was also Inclusive of unvarying single scrolled shoulder geometry attached to clean/unthreaded pin. Intermediate thread pitches tool pins having (1.41 mm and 2.12 mm) executed higher than whicheverfarthest over the variety of tried parameters. Deepti Jaiswal et al., [25] in this study FS welded AA6063 T5 joints were studeid. They discovered higher tensile and impact power for square tool profile with D/d ratio three: 1. Rotation in line with minute (rpm) discovered the maximum large parameter for welding accompanied with the aid of shoulder-diameter, welding speed, pin-diameter and geometry of tool. Strength of joint beyond 1000 rpm starts decreasing due to stresses and better warmness era. Different device pin profiles were utilized viz., (a) THC, (b) triangular, and (c) rectangular to look at the cause of pin profile at the fabricated joint. Best welds found with square device pin and a thousand rpm, a hundred m/min welding pace, 18 mm shoulder diameter and pin diameter of 6 mm. Square tool pin furnished greatest swirling of weld metal that is needed for sound weld.
P Biswas et.al.,[26] The industrial grade aluminium alloys can be efficaciously accomplished with a view to acquire favored residences with the help of FSW tools with trapezoidal and tapered cylindrical pin geometry on this present investigation by way of FSW welding. The consequences confirmed that equipment with tapered pins created advanced mechanical properties for the FSW joints. Sabari, S.S et.al., [27] to understand the have an effect on of tool pin profiles a relative observe is made mainly instantly (STC), (TAC), (STHC) and (TTC) in this examination. This take a look at has been made lying on swirl sector traits and the consequential tensile strength of all FSW and UWFSW joints. Superior tensile properties was observed for the joint with taper threaded pin profiled tool with underwater cooling medium showed from this research that of 345 MPa with joint effectiveness of seventy six %.

Ravindra S et.al., [28] Right here, to comprehend the effect of device pace (rpm) and pin probe on FSP area pattern, a challenge has been made in AA5083 aluminium alloy. Thickness with 2.5 mm, FSW 5083 al alloy plates turned into performed. At 3 definite revolving speeds i.e. 900, 1400 and 1800 rpm fabrication of the joints below a constant traverse speed of sixteen mm/min were done. Here 5 dissimilar tool pin probes were utilized. Compared to other pin geometries, SCY pin profiled tool produced automatically metallurgically defect loose and sound welds. Pankul Goel et.al.,[29] in this present observe on FSW of butt and headscafr joints of Al 6063-T6 investigation had been done. 5 different kind device pin profiles (CY, TCY, SQ, TR, and HEX) had been carried out for appearing welding. Best tensile strength (162 MPa) with TCY exhibited through FSW manner, whereas bottom tensile strength (115.6 MPa) confirmed by triangular. Nabeel Gharaibeh et.al.,[30] He discovered right here, FSW process values on the microstructure and mechanical houses of the 6061 aluminium alloy welded joints made by using FSW effected by using the device pin profile. A first-class grain microstructure obtained with the aid of hexagonal pin profile has been located here. A better strength welded joints produced with the helpof a square pin profile. Bayazid el al [31] than cylindrical or triangle profiles the square pin profile formed fine grain size on the welding area moderately.

P.Prasanna et.al., [32] In this paper, to examine the mechanical homes of AA 6061 al alloy an attempt has been made for four exclusive device pin profiles. Rotational pace 1200RPM, welding speed 14mm/min and by keeping regular procedure parameters of device and an axial pressure 7kN 4 one-of-a-kind profiles utilized to produce the square joints. The % of elongation and utmost tensile power of 20.9 and 210M Pacorrespondingly turned into discovered on Hexagonal pin probe tool with annealing manner from the 4 tool profiles. Rajbir Singh et.al., [33] to observe in FSW of al alloys as tool pin geometry and transverse speeds the route parameters were taken. The welding becomes finished with AA 6101 T6 strips of 6mm thickness with unique tool pin profile (CY, T CY, SQ and T SQ). With taper square tool pin profile strength is superior as compared with CY, T CY and SQ device
pin profile from this research. H. S. Patil et al., [34] to reveal the effects on AA6082-O aluminium, different welding speeds and tool pin profiles in this research were inspected. Taper screw thread and tri-flutes are used as device pin profiles in this research. The look of the weld is well and no apparent illness is discovered the usage of these equipment. It is observed that the joint fabricated the usage of taper screw thread pin well-known shows superior tensile residences as compared tri-flute pin profile, regardless of welding speed. S. Ravikumar et al., [35] With numerous manner parameters like tool rotational, device welding pace and device pin profiles diverse AA6061-T651 and AA7075-T651 alloy had been FS welded. Compared to all different conditions With TCT device, with the FSW plate made-up with 900 rpm device revolving pace, 100mm/min welding pace higher mechanical homes (Hv and UTS) had been acquired. A.A.M. da Silva et al [36] AA2024-T3 and AA7075 mechanical behaviour were examined by using FSW. It plays an important role within the combining pattern and material flow of multiple FSW of AA2024-T3 and AA7075-T6 Al alloys with the threaded profile of the pin tool was noticed. Nishit D Chaudhary et al., [37] Here inside the gift investigation the effect of pentagon tool pin profile is been studied on becoming a member of of diverse aluminium alloys AA6061 and AA7075. Tool transverse feed is kept as 31.5 mm/min; device rotational velocity is kept as 765 rpm and tool tilt angle as 2 ranges forward. Due to using the pentagon device pin profile the microstructure received inside the nugget quarter is finer as compared to the original microstructure. Satish Kumar. P et al., [38] The impact of grain size with the aid of the use of cooling medium by dry ice on AA6061 and AA5083 alloys additionally control the microstructure of FSW had been studied. With taper thread pin profile at a welding speed of 60mm/min and revolving pace of 900 rpm higher mechanical properties are gained. P. Satishkumar et al., [39] study was made on Al alloy 5083 to test various properties. To hold the revolving pace (rpm) 450 to 1400 a thought was generated and additionally by changing welding rpm (velocity), this FSW is utilized in nasa for becoming a member of of two totally distinct or identical varieties of substances and additionally, on this paper an insight into destiny evaluation for the duration of this procedure of look at the project of FSW. A. Deveraju et al., [40] weldments were fabricated with different tool rotational speeds in this study, by fixing welding speed as stable. The tool revolving speed at 900rpm showssuperior mechanical properties. M. Shiva chander et al., [41] on aluminum combination 5083 plates with 4mm-thick an investigation was made using FSW process. The tests arrangement was readied dependent on capacities of general processing machine. The apparatus rotational rates of 900r/min, 1120r/min, 1400r/min and 1800r/min, the welding pace of at 40mm/min were taken. It was seen that the better mechanical properties were accomplished at moderate device rotational speed and equi-cut out grains achieved at cone shaped shape device profile as contrasted and tighten strung apparatus. Nowadays, finite element analysis is becoming a popular tool for design and simulation [42-50]. Various author performed testing and characterization of the fabricated components includes tensile strength, hardness, joint quality such as surface roughness [51-54].

4. Conclusion
Similar and varied FSW welded al alloys have been applied for business packages as a result of its mechanical homes were observed in this paper. Tool pin probes in different forms the friction stir welding system efficaciously fabricated the joints of aluminium comparable and varied plates. It is to be discovered that the mechanical homes and joint energy sincerely effected by the tool pin geometries. In this have a look at Square, Cylindrical, Triangular, Tapered, Threaded and hexagonal tool pins have been succeeded in welding aluminium plates. Of the all tool pin profiles, it’s far to be determined that square and threaded device pin profiles exhibited advanced mechanical residences like tensile strength, % Elongation and hardness. AA2024, AA5083, AA7075 aluminium plates from the literature survey bring out above, had been fabricated with sound strengths by using FSW process.

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