Investigation on mechanical properties of Ti-6al-4 V & SS-304L frictional welding process

Article *in* Materials Today: Proceedings · February 2021

DOI: 10.1016/j.matpr.2021.01.053

R. Ramesh Kumar
Vel Tech - Technical University

Babu J M
Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology

V. K. Bupesh Raja
Sathyabama Institute of Science and Technology

Kayaroganam Palanikumar
Sri Sai Ram Institute of Technology

Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Investigation on mechanical properties of Ti-6al-4 V & SS-304L frictional welding process

R. Ramesh Kumar [a,*], J.M. Babu [a], V.K. Bupesh Raja [b], K. Palanikumar [c], Ghantasala Pranav Bhargav [d], Mathew Alphonse [d]

[a] Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai 600062, India
[b] School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai 600119, India
[c] Sri Sai Ram Institute of Technology, Chennai 600044, India
[d] National Cheng Kung University Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai 600062, India

ARTICLE INFO

Article history:
Received 8 December 2020
Received in revised form 31 December 2020
Accepted 2 January 2021
Available online xxxx

Keywords:
Heat absorption
Frictional parameter
Friction welding
Parameters
Friction time

ABSTRACT

Basic frictional contact joints and mechanical properties list of corrosion resistance, hardness, and mechanical behaviours are investigated from this research work. Different rotational speed based on residual stresses is calculated in the main purpose of this research work process. Varied rotational speeds are used in this process like 500, 700 and 800 rpm respectively. While increasing rotational speed at the same time axial load also increased gradually. Residual stress evaluation results also made in the center of joints. X-ray diffraction method carried out the process of different joint samples and residual stresses. The experimental results are identified the D-spacing, Residual stresses and electron microscope. The graphical representation results were analyzed in the process of friction pressure controlled by forging time. Hence these experimental work results can be used in different aerospace applications and automobile industries where the subject to be maintained in the temperatures.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Materials, Manufacturing and Mechanical Engineering for Sustainable Developments-2020.

1. Introduction

Frictional joint progress main concept is to be reduced the formation of porosity, no cracking solidifications. The shielding gas and crack materials are completely reduced by process and frictions [1–3]. The metallurgical process is mostly connected to industries samples of different dissimilar or similar materials. This process helps to connect the dissimilar materials with the heat losses parameters for different rotation speed controls. Basic titanium mechanical properties and chemical arrangements are identified before the experiments. Mathematical representation models were generated by the frictional welding process. The basic arrangements of frictional setup calculations are used in ultrasonic test and X-Ray Diffractions. Various structural components are tested by nondestructive techniques for avoiding damages of welded joint samples [4,5]. Semiconducting methods have identified the properties of mechanical strengths and characteristics [6–8]. Many of the researchers done the finite element models and numerical investigation results were compared on residual stresses. The experimental residual stress and mathematical residual stress results are compared and identified the error also. Many researchers have identified the maximum residual stress evaluation by the tensile method.

Stainless steel interference to conduct the neutron diffraction with high passages of residual stresses. In this process to identify the effect of residual stresses and different temperatures [8]. Rotating speed derived the transverse and longitudinal stresses of different structures. RSM techniques and strategies are defined by the different speed of rpm. Grain size and micro whole levels are changing from the different speed of rpm. Fusion welding and frictional joint progress have changed the deviations from the initial setups. The concept of the research work to analyses the temperature levels from different locations [9]. Tensile and compressive different locations were calculated and identified the better performance results. Different locations and stages are gathered from varying temperature levels and joints.

Aluminium is the most usable product to use in automobile industries by design engineers and researchers. D-spacing progress has created atomic structures and shapes. This recrystallized struc-

* Corresponding author.
E-mail address: ramesh.mech37@gmail.com (R. Ramesh Kumar).

https://doi.org/10.1016/j.matpr.2021.01.053
2214-7853/
Selection and peer-review under responsibility of the scientific committee of the International Conference on Materials, Manufacturing and Mechanical Engineering for Sustainable Developments-2020.

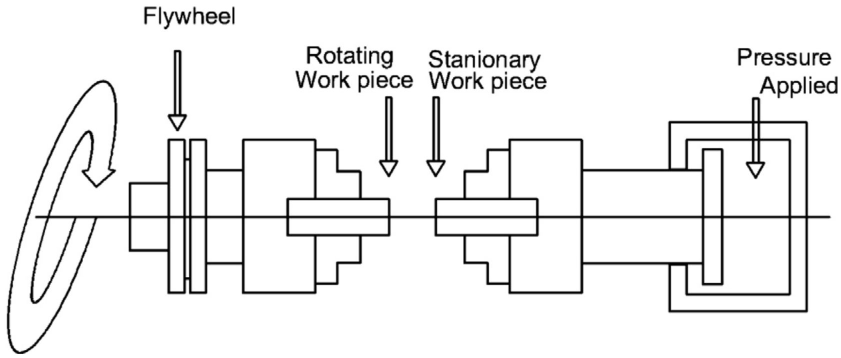

Fig 1. Experimental setup 2d model.

Fig 2. Fire point process of frictional welding.

ture was measured by residual stresses. Elastic regions and performances were calculated from different location structures. Comparison results and residual stress results are equally common for all locating stages. Cryogenic controls and different stages are determined with 500, 700, 900 rpm speeds were taken. Various rotational speed results are compiled, and performances are identified in different structures. Many researchers have created the process parameters and setup conditions is commonly [10].

2. Experimental details

Titanium and solidified steel delivered, approximation circumstance is 16 mm and 50 mm long. All the samples are almost in the same length and circumstances. These two materials are controlled by CNC machining progress. Atmospheric room temperatures and air levels are verified, before the start of the experiments. Degeneration welding fundamental limits are considered the maximum temperature of materials. Titanium and tempered steel welding parameters are needed high attentiveness and required extra time when diverged from various materials.

Rotational movements gathered the heat rate from the different rpm speeds and transferred the heat rate process by less timing controls and showed in Fig. 1. From the outset conditions, bonded joint strength was identified among standard materials with varying temperatures around 500–600 °C. welded samples fire point ranges are showed, very high in heat rate and very less in material hardness. The bonded aluminium end, materials are sharper and measured estimations lengths are 2 mm. joint 2 was related among aluminium and hardened steel with the high-temperature gradient of 800–900 °C. next strategy as same to be followed the implanted cold liquid process for all contents.

Presently determined the temperature changing stages are identified among the titanium and aluminium side. Materials temperature are gradually increased as different structures. The basic titanium and aluminium integration temperatures are 1500–1600 °C and appeared in Fig. 2. This high temperature acquired materials are getting more energy from different welding cycles. In any case, continuously processed by less temperature range between 500 and 600 °C. So this experimental arrangement decreased the cooling levels and expanded the heat energy of the materials from environmental conditions.

3. Results and discussion

Experimental results are located and identified with the help of joint one and joint two. More energy disaster to avoided the continues rotating process. These cyclic perimeters are avoided with the help of disintegration heat losses and sufficient contact frictions. Fig. 3 results are displayed, better strength of bonded structures to relate Titanium and SS304L materials performances. After added aluminium interlayer between raw Ti-6Al-4 V and stainless steel. Aluminium material gathered the heat transferred rates from contact frictional support easily.

The low rotating cycle is not allowing energy disaster to frictional contact surfaces. It could help sufficiently weld two special materials of the coated welding results are shown in Fig. 3.

This energy incident is not affected in gathering weight and processed time limit results are shown in Table 1 with the tested pattern of welded exceptional cycles.

The friction made energy is to be transferred from the kinetic form into mechanical form in upsetting stages. In these cyclic process, setup was calculated and shown in Fig. 4. Heat transferred

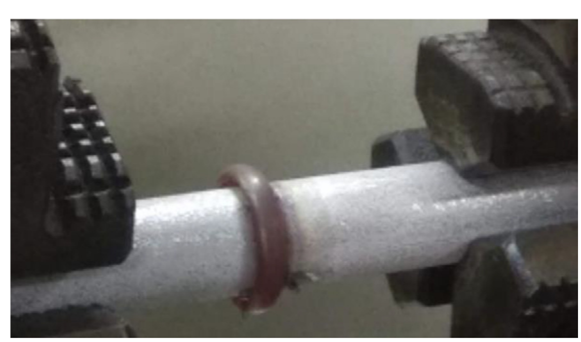

Fig 3. Friction Welded Samples.

Table 1
Setup parameters of different trials.

S. No	Friction pressure	Friction time	Forging pressure	Forging time	Speed (RPM)
1	40	5	45	5	1800
2	45	4	40	4	1600
3	50	5	55	5	2100
4	55	4	70	5	2300
5	60	4	80	4	2500
6	70	5	60	5	2100

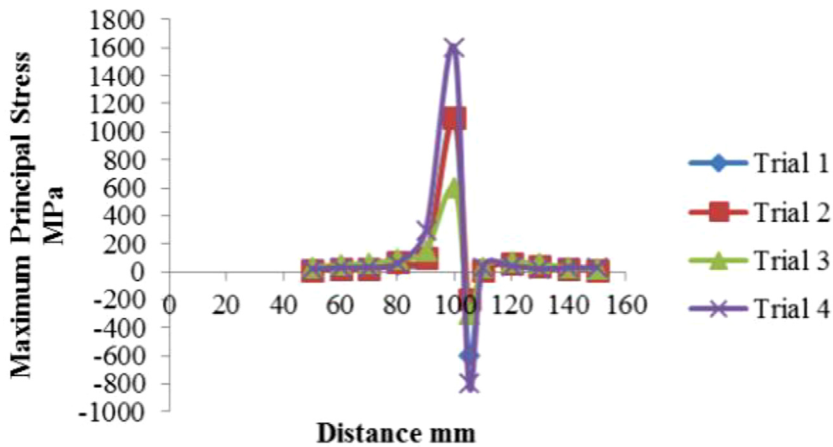

Fig 4. tensile sample results in bonded ends.

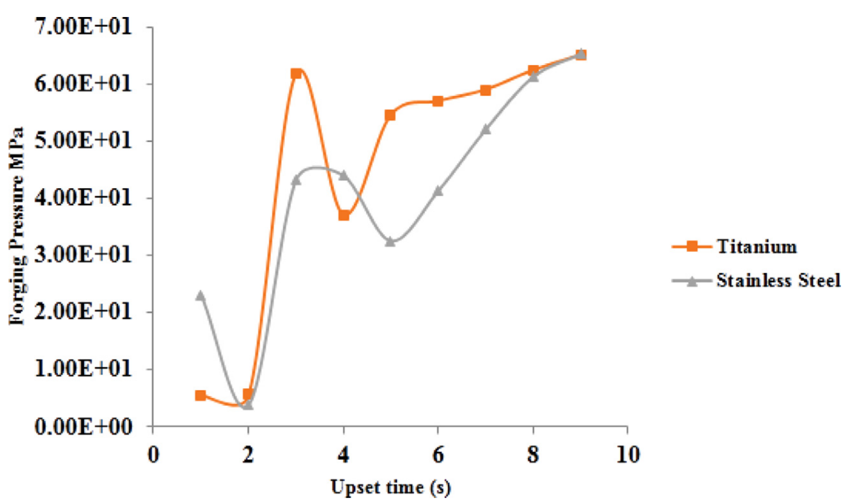

Fig 5. Time deviation progress results.

structures and flows are mentioned in graph formations. Calculated test results are shown in Fig. 5.

Initial speed needs more rpm and fewer velocity controls by the frictional welding conditions. Many of the lathe speeds are gradually increased from one location to another location. These samples transferred levels are shown in Fig. 6. Two particular different materials are acting in the field of frictional and heat diffusion conditions from solid to liquid formations. In this rotation occurs four classes of melting states. The transferring pressure variations are 1.50, 1.75, 2.0 and 2.25 MPa. In this diffractions are followed by upsetting time.

Frictional contact of energy changing in environmental temperatures is moving in liquid to solid-state. Upset limits for depends upon in time-varying strategies. This time progressive development results are shown in Fig. 6. Hardened steel and titanium weld sample results are shown, satisfactory strengths and good frameworks. Less contact time and incredible creating pressure results are shown in Fig. 7.

3.1. Forging pressure and Friction time

Mechanical and material temperatures are resolved in the initiating of cracking surfaces and reduced times. The surrounding energy was decided in the preliminary flow extrusions and strength of titanium with stainless steel. The room temperature has maintained in natural conditions and controlled inflow motions. Transferred temperature results are shown in between 1500 and 2300 °C.

These results are accepted by the mechanical strength and consequences process. Metallurgical yield strength calculations are shown in Fig. 8. The test procedures are done by comprehensive machining as per the standard testing techniques. Force concern

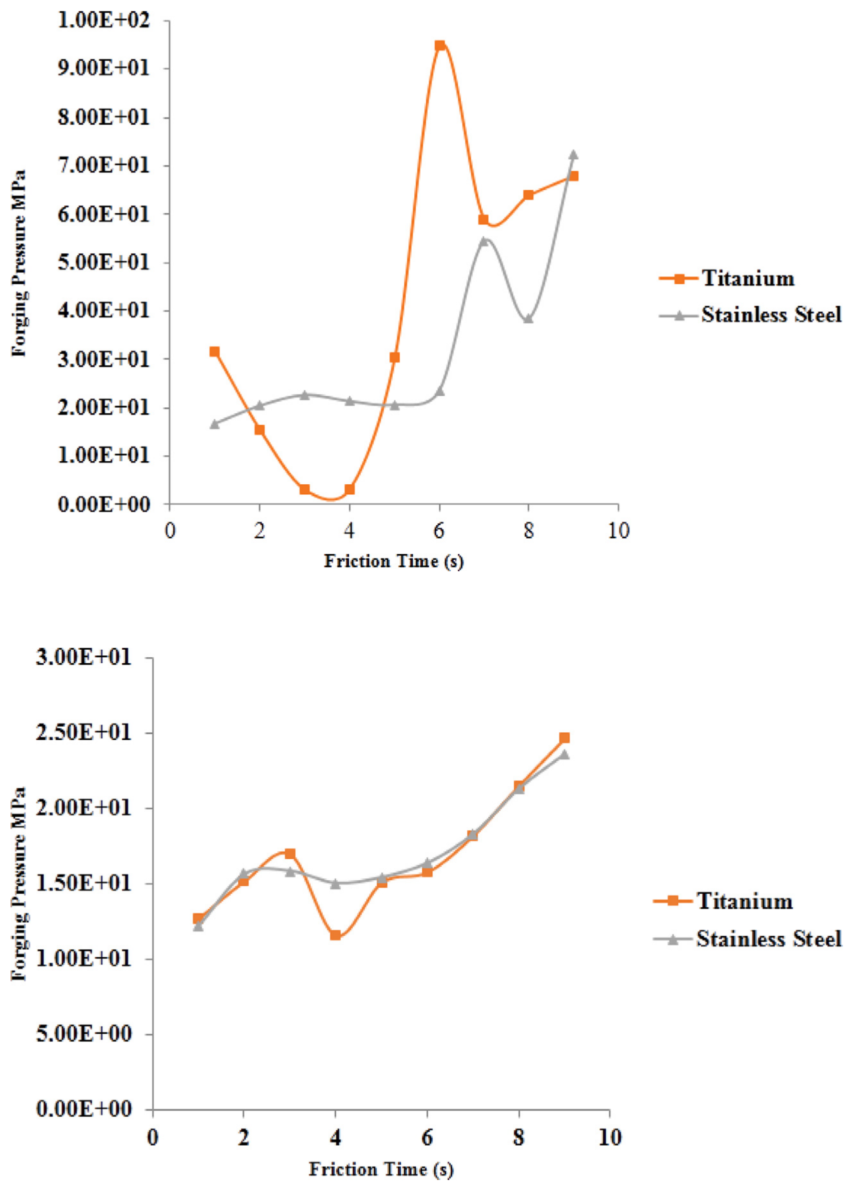

Fig 7. increased pressure techniques of different joints.

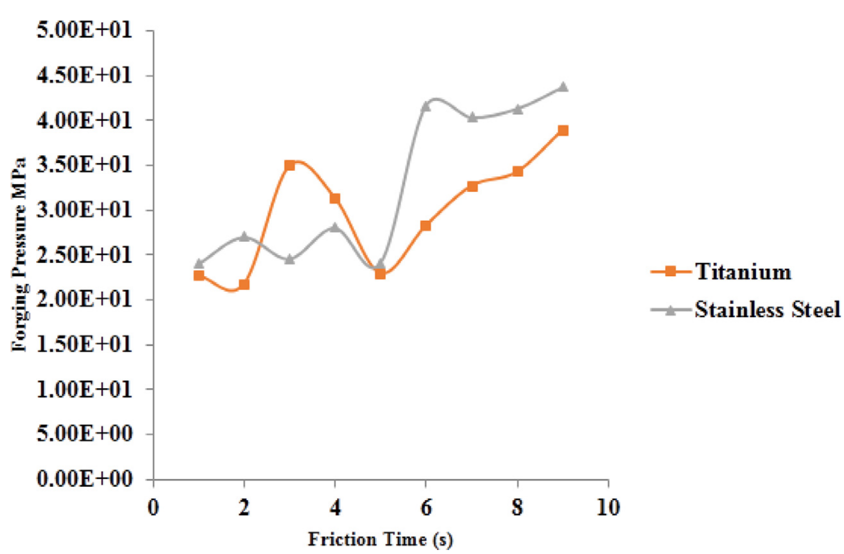

Fig 8. increased velocity techniques of different joints.

is maintained by upsetting pressure and developments. This analytical investigation could be observed the strength of the material cycles and shown in Fig. 8. The heat transferred rate gradually developed by frictional support. Temperature results are given by additional support energy adding in two unique materials in with aluminium covered.

4. Conclusion

The immense completions of the assessments on Ti-6Al-4 V and SS304L welded discussions are under:

1. This assessment showed better joint relationship in-between titanium and hardened steel. The most outrageous boss weight started for granulating welding results is predictable of proper working conditions.

2. These results are surveyed external contact pressure of 70 MPa, fragmentation time 5 sec, forging pressure 60 MPa, Forging time 5 sec and 1200 speed (RPM). Heated welding of titanium and hardened steel was created pressure ranges of 1.5 trials of higher frictional weight.

3. Friction welded samples grain size as compared to normal welded process is better. The lattice and residual performances are varied from the normal welded process. There are no significant variants performs in d-spacing levels.

4. The high compressive force is acted in the field experimental process. The residual stress values have deviated from the microstructure performances. While decreasing grain size lattice structure increasing.

CRediT authorship contribution statement

R. Ramesh Kumar: Methodology, Investigation, Writing - review & editing. **J.M. Babu:** Conceptualization, Visualization. **V. K. Bupesh Raja:** Validation, Resources, Supervision. **K. Palanikumar:** Validation, Resources, Supervision. **Ghantasala Pranav Bhargav:** Formal analysis. **Mathew Alphonse:** Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] S. Suresh, N. Elango, K. Venkatesan, W.H. Lim, K. Palanikumar, S. Rajesh, Sustainable friction stir spot welding of 6061–T6 aluminium alloy using improved non-dominated sorting teaching learning algorithm, J. Mater. Res. Technol. 9 (5) (2020) 11650–11674, https://doi.org/10.1016/j.jmrt.2020.08.043.

[2] S. Suresh, K. Venkatesan, E. Natarajan, S. Rajesh, W.H. Lim, Evaluating weld properties of conventional and swept friction stir spot welded 6061–t6 aluminium alloy, Mater. Express 9 (8) (2019) 851–860, https://doi.org/10.1166/mex.2019.1584.

[3] R. Kumar, M. Balasubramanian, Experimental investigation of Ti–6Al–4V titanium alloy and 304L stainless steel friction welded with the copper interlayer, Defence Technol. 11 (1) (2015) 65–75, https://doi.org/10.1016/j.dt.2014.10.001.

[4] R. Ramesh Kumar, R. Varatharajan, V. Thiruvengadam, An investigation of friction welding heat dissipation in titanium alloy and stainless steel, Int. J. Ambient Energy 41 (14) (2020) 1639–1644, https://doi.org/10.1080/01430750.2018.1525580.

[5] S. Suresh, K. Venkatesan, E. Natarajan, S. Rajesh, Performance analysis of nano silicon carbide reinforced swept friction stir spot weld joint in AA6061-T6 alloy, Silicon (2020), https://doi.org/10.1007/s12633-020-00751-4.

[6] S. Suresh, K. Venkatesan, E. Natarajan, Influence of SiC nanoparticle reinforcement on FSS welded 6061–T6 aluminum alloy, J. Nanomater. 2018 (2018) 1–11, https://doi.org/10.1155/2018/7031867.

[7] J. Praneeth, Friction stir welding for Al-and its alloys, Int. J. Res. Appl. Sci. Eng. Technol. V (X) (2017) 1330–1332, https://doi.org/10.22214/ijraset.2017.10193.

[8] B. DU. Microstructure and mechanical properties of friction plug welding joints for dissimilar aluminum alloys. J. Mech. Eng., 53(04), 43. doi:10.3901/jme.2017.04.043.

[9] S. Suresh, K. Venkatesan, E. Natarajan, S. Rajesh, Influence of tool rotational speed on the properties of friction stir spot welded AA7075-T6/Al2O3 composite joint, Mater. Today Proc. 27 (2020) 62–67, https://doi.org/10.1016/j.matpr.2019.08.220.

[10] W. Ratanathavorn, A. Melander, Influence of zinc on intermetallic compounds formed in friction stir welding of AA5754 aluminium alloy to galvanised ultra-high strength steel, Sci. Technol. Weld. Joining 22 (8) (2017) 673–680, https://doi.org/10.1080/13621718.2017.1302553.