Al-Rafidain Journal of Engineering Sciences
Journal homepage https://rjes.iq/index.php/rjes
ISSN: 3005-3153 (Online)

Mechanical properties of frictional welded joints: a review

Saif Hameed Muslim *

Department of Mechanical Engineering, Al Mustansiriyah University, Baghdad, Iraq

ARTICLE INFO

Article history:
Received 21 May 2024
Revised 22 May 2024
Accepted 26 May 2024
Available online 31 May 2024

Keywords:
Friction welding
Similar joints
Dissimilar joints

ABSTRACT

Friction welding is an effective process for joining similar and dissimilar materials. It is widely used in industrial applications for automobiles and aircraft. It can be used to produce high-quality joints, so it is considered an alternative to traditional joining methods. As a result of friction between the two workpieces, sufficient heat is generated to soften the interface without reaching the melting point, which allows materials with different physical properties to be bonded. Process parameters such as speed, friction pressure, friction time, forging pressure and forging time have a major influence on the mechanical properties of the joint. One of these important properties is tensile strength. In this review, published research papers by various researchers were studied and the influence of parameters on the mechanical properties of welded joints was discussed.

* Corresponding author: E-mail address: ehm4025@uomustansiriyah.edu.iq
https://doi.org/10.61268/j8bcz974

1. Introduction

Friction welding (FW) is a solid state joining technique that can create strong welds in between two components of different or similar composition. In friction welding, heat is produced at the interface when the two components are pushed up against one another. In order to start a weld. as a result, the material at the rubbing interface becomes softer on both sides. The softer material then begins to blend together , Using relative movement between the work pieces, a device intended to generate heat at the welding joint by converting mechanical energy is used in the friction welding process [1]. that it is innovative, it is used in the section Friction welding (FW) offers an alternative for joining parts that are similar and dissimilar in situations where latches, self-piercing bolts, or glues are not economically feasible. The main test is based on the structure, chemical makeup, and different properties (mechanical and physical) that result in undesirable weld characteristics. Among the best welding techniques for fusing together materials that are similar and dissimilar, flux-welding (FW) does not involve melting the components in bulk. FW has stoked public interest in the automotive endeavors and fabrications. by citing the many advantageous circumstances, enhanced cycle power, reduced health and environmental concerns, reduced working costs, and enhanced mechanical qualities like fatigue and tensile [2]. A type of pressure welding called friction welding creates connections without liquefying the metal. Joint plastic distortion is involved of the component to be welded using heat from friction [3] .Here, we generate a noteworthy quantity of localized, powerful production of heat, and deformation, which uses fewer energy and produces a very strong weld [4]. Since the process of solid state welding does not result in the formation of a molten pool, solidification errors are eliminated. With friction welding, two distinct materials with dissimilar mechanical and thermal characteristics can be joined without the weld's strength being compromised. Because friction welding is inexpensive, repeatable, reliable, and produces very precise results, it is favored over traditional methods [5]. When welding, an force in axial direction is applied to bring the two pieces together., where one part rotates quickly while the other stays stationary[6], [7]. Both solid and tubular sections can be joined together with it. A flash is produced at the interface region when heat and pressure combine. Friction welding is generally possible with any forgeable metal. The engineers now have more flexibility because they can design bimetallic structures. Typical bimetallic friction joints include the following: 1) Steel to aluminum 2) Aluminum to Copper 3) Copper to Titanium 4) Steel and alloy of nickel although it is generally believed that copper to aluminum joints cannot be welded, friction welding makes it feasible. Since friction welding doesn't require any external heat or flux, it's a simpler and less messy process[8], [9]. Furthermore, in contrast to fusion welding, it has few or no flaws. Achieving speeds that are up to 100 or even double that of standard FW, friction welding is regarded as one of the fastest welding techniques. A literature review is conducted to determine the different process variables that are involved in welding different substrate materials. on friction welding has been conducted for the current study. In general, friction welding comes in three types: orbital, linear, and rotary (Fig. 1). The earliest and most widely used type of friction welding involves rotating one component around its axis while the other stays stationary. Next, under the force of friction, the two parts are brought together. There are two major types of rotary friction welding processes: inertia drive (stored energy) and direct drive (continuous drive), which vary in the way that frictional heat is produced from rotational energy [10].

2. Literature review

Paventhan et al.[15] The tensile strength of friction-welded AISI 304 austenitic stainless steel and AISI 1040 grade medium carbon steel was attempted to be empirically predicted by taking into account process variables like forging pressure, friction period, friction pressure, and forging period, which have a significant impact on the joint power.

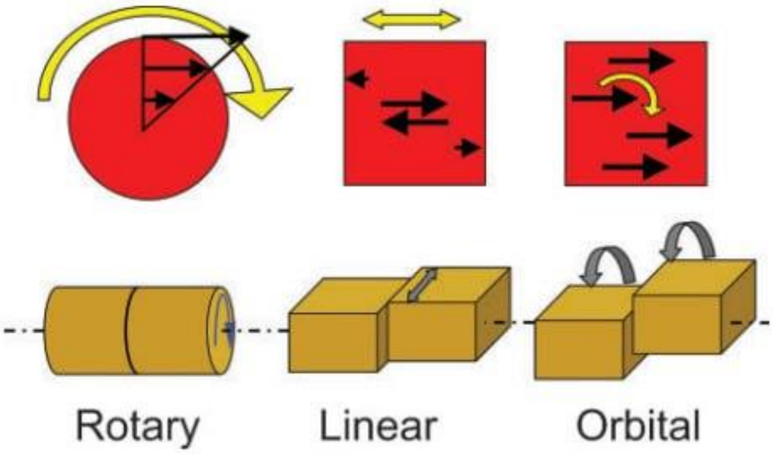

Figure 1. Three types of friction welding techniques [1]

To get maximum of the joint's strength of tensile, the friction welding process parameters were optimized using the response surface methodology. The highest possible strength of tensile of 542 MPa might be attained for articulations made when joining together is taking place, 90 MPa of friction pressure, 90 MPa of forging pressure, and 6 s of forging and friction period.

Winizenko and Kaczorowski [16] The friction-welded ductile iron and the stainless steel's mechanical properties and microstructure were examined by the writers. Utilizing scanning electron microscopy (SEM), the fracture morphology and phase transitions were examined. Throughout the friction welding procedure. During friction welding, atoms are moved in each way throughout the interface between ductile iron and stainless steel. As a result, carbon is added to stainless steel and atoms of nickel and chromium are added to ductile iron. Chromium carbides are formed as a result of carbon enrichment in stainless steel and are primarily found at the grains. Iron enhancement in Cr and Ni led to the production of ferrite alloy. There was also Cr in a carbide eutectic. The diffusion assortment in iron of Cr and Ni.

Selvamani and Palanikumar [17]. In this work, friction welding is used to create 12mm diameter AISI1035 grade steel rods in order to maximize the parameters of the operation. To create the joints, various combinations of process parameters—including ANOVA techniques—are employed. Examined for tensile power. The highest possible strength of tensile of 548.44 MPa can be reached by friction-welded AISI 1035 level moderate carbon steel strings when they are subjected to 28.8 MPa/s of friction pressure per time, 29.4 MPa/s of forging pressure per time, and 24.41 rpm of rotating velocity. It was discovered that rotational speed had a greater impact on the joints' tensile strength than either forging or friction pressure

Prasanthi et al [18] The researches goal was to use rotation FW to create a flawlessly bonded interface between titanium (Ti) and mild steel (MS). After multiple trials, to maximize the circumstances, the friction welding parameters (rotational speed, burn-off length, upset force, and frictional force) were adjusted. Using maximized values of frictional power, disturbed force, burn-off length, and velocity of rotational (0.8 tons, 1.6 tons, 3 mm, and 1000 rpm, correspondingly), friction welds of mild steel and level-2 Ti have been effectively made up.

Kimura et al.[19] The friction welded joint's tensile strength and joining phenomenon between low carbon steel (LCS) and titanium alloy (Ti–6Al–4V) were discovered by the authors. Temperature variations at the weld interface, joining behavior, and friction torque were all evaluated during the friction process. In addition, the metallurgical properties of joints were examined and the impacts of friction time, friction and forging pressure on joint power were examined.

Reddy [20] This work was done to evaluate AA1100 and Zr705 alloy friction welding. The FW operation was analyzed using finite element method. Frictional time, rotational velocity, and frictional and forging pressure were the process parameters. The strength, bulk deformation, penetration, and flange formation of the joints were assessed. The forging pressure for Zr705 and AA1100 alloy friction welding must be 1.25 times that of the frictional pressure. According to the research, under the following operating conditions, friction welding of AA1100 and Zr705 alloy is acceptable: 25 MPa of frictional pressure, 4 seconds of frictional time, 2000 rpm of rotation, and 31.25 MPa of forging pressure.

McAndrew et al [21] investigated Ti-6Al-4v friction welding in relation to the production of bladed disks for aero engines. This study illuminated the limitations and significant features of linear friction welding. Finally, the researcher's conclusions for the manufacturing sector are illustrated in their study, which also included contributions from this article to the analytical and numerical modelling.

Wang et al. [22] A comprehensive study was conducted to examine the impact of welding parameters for linear friction on the mechanical properties, microstructure, and distribution of texture of titanium alloy joints composed of Ti-6.5Al-3.5Mo-1.5Zr-0.3Si.The authors discovered that in order to achieve a sound joint, a critical shear velocity must be attained. Friction pressure or-and shear speed decreased the width of the thermo mechanically-affected area (TMAZ), but the weld center area (WCZ) width stayed steadiness.

Cheepu and Che [23] They investigated how the burn-off length affected the frictional properties. Burn-off length is one of the important joining together conditions that controls the production of heat and friction coefficient during welding of welded dissimilar steel bars. In order to examine the impact of burn-off length on mechanical properties and weld interface characteristics, a range of 1 mm to 6 mm was chosen. To analyze the interface of welding properties, an optical scanning electron microscope and electron backscattered dispersion in action analyses were employed. Tensile, fatigue, and hardness tests were used to assess the joints' mechanical characteristics. It has been noted that as burn-off length increases, joint strength increases up to an optimal value of 4 mm and then begins to declines with further burn-off length increases.

Kimura et al. [24] The authors looked into how tensile strength affected the properties of the weld failing top surface and the friction welding condition of joints made of austenitic stainless steel (AISI 304) and pure copper. Investigations were done on the phenomenon of joining and the joint tensile strength under different friction welding circumstances. When the friction pressure was 90 MPa, the joint's maximum temperature was lower than when it was 30 MPa. Additionally, there was a partial join in the middle of the high friction pressure joint's weld interface. Thus, it was demonstrated that a low friction pressure should be used when creating the joint. In conclusion, a low pressure of friction, like 30 MPa, should be used to create the excellent joint with the break in the OFC side.

Kumar and Palani [25] They carried out investigations on the weld strength of austenitic stainless steel tubing that are rotary friction welded. By using rotary friction welding (RFW), austenitic stainless steel (SS304) tubes with an external diameter of 19 mm and a thickness of 2 mm are connected. The characterization experiments are carried out with a steady spindle speed of 1100 rpm while adjusting the load heating, disturbed load, duration of heating, and upset time. Tensile and micro hardness tests were performed on each of the manufactured joints in order to assess the mechanical characteristics of the welded samples. As the heating and disturbance loads increased, so did the joint strength. For a welding factor of upset load of 143 MPa and upset time of 4 seconds, the maximum joint strength of 780 MPa and hardness of 210HV were attained. The comprehensive fracture analysis indicates that a ductile mode was experienced by the weld sample joints.

Anandaraj et al.[26] They researched the metallurgical and mechanical characteristics of rotary friction welding dissimilar materials, In718/SS410. The ideal welding parameters include rotational speed of 1300 rpm, forging pressure of 220 MPa, forging time of 8 sec, friction pressure of 220 MPa, and friction time of 10 sec. With the use of all-purpose testing apparatus, the transverse tensile test was evaluated at room temperature, yielding the highest possible fracture strength of 652 MPa. The micro scale survey of hardness alongside the weld cross section documents the reduced hardness in the TMAZ area. At lower magnification, the macro composition was utilized to investigate the way rotary friction welding (RFW) flows.

Xie et al.[27] They looked into the impact of welding period on joint morphology, the axial shortening, and RFW tests on Mo in an atmospheric setting without upset forging. Tensile strength, microstructures, microhardness, and tensile fracture morphology. It was discovered that spiral flashes were seen after welding, and that there was excessive and sudden burning as well as a lot of smoke generated around the weld region through welding. When the duration of the welding process is between 2 and 5 s, the minimum average grain size and maximum tensile strength can be achieved in 4 s at a welding pressure of 80 MPa and spindle speed of 2000 r/min. The results of the scanning electron microscope (SEM) reveal that the fracture has a high amount of intergranular breakages and a low amount of transgranular breakages.

Balasubramanian et al. [28] researchers Using copper in the form of a pipe for technique 1 and copper coins for technique 2, the authors successfully conducted an experiment on the dissimilar joining of Ti and SS. In the joining of Ti and Stainless Steel, the oxygen-free copper did prove to be an excellent interlayer material, producing a faultless joint with exceptional strength. 303 MPa and 270 MPa maximum tensile strengths MPa was attained by employing techniques 1 and 2, respectively.

Banerjee et al. [29] they studied the Using of inertia friction welding (IFW) at different friction and forge pressures, flawless welds between A-516 ferritic and 316L austenitic stainless steel were produced. Characterization of the microstructural evolution and related mechanical properties was done for various weld regimes. The welds showed improved properties; they were free of microcracks and had greater superior to the parent metal in terms of strength and hardness. The absence of carbide precipitates at the weld interfacing suggests that the stainless steel did not become sensitized. Grain orientation spread (GOS) values that were low and refined in combination indicated continuous dynamic recrystallization (CDRX) through IFW.

Sundaraselvan et al. [30] . They assessed the advancement of joints made of solid state composed of mild steel and Al6082 aluminum, two distinct materials. The joints were made by rotary friction welding (RFW). Methodology for response surface was used to optimize the FW machine's procedure parameters in order to maximize the joint's strength of tensile. The effects of parameters are influenced by friction pressure, forging pressure, friction time, and forging time. Among them, forging time has a stronger effect on tensile strength due to the intermetallic that form. The sample arranged by friction (6 MPa) and forging (7 MPa) pressures for 4 s yielded a maximum tensile strength of 613 MPa.

Raj and Biswas [31] According to the authors, enhancing material flow and lowering axial load throughout friction stir welding (FSW) of materials with high melting point is a promising strategy for extending tool life. The welding was done at welding speeds of 300 rpm, rotating at a constant speed. In the assisted FSW, preheating temperatures of 300 °C and 70 and 140 mm/min were used. The findings demonstrate that the use of friction stir welding (FSW) produced extremely refined grains in the stir zone of both materials along with deformed carbide particles, which improved the mechanical qualities. The weld strength was enhanced where the interface was of the SS316L and Inconel 718 joint due to a slight rise in particle size and high atomic diffusion of Cr and Mo elements caused by a temperature increase during the FSW process.

3. Friction welding parameters

There are three factors responsible for controlling weld quality: the relative speed between the two work pieces, the axial pressure, and the welding time. The welding process consists of two stages. Welding factors have different effects depending on the welding stage. In the friction stage, the speed must be sufficient to plasticise the interface material. The rotation speed depends on the type of materials to be welded and the dimensions of the piece at the interface zone. Mechanical properties may be affected by the speed applied for welding [11]. Therefore, an appropriate rotational speed must be used to prevent damage to the interface material during welding. At this stage, pressure is also important for heating. The temperature gradient is controlled through frictional pressure in the welding area. When pressure is applied, axial shortening occurs at the joint [12]. The pressure value depends on the metals to be welded and the geometry of the joints. It is important to maintain contact between surfaces and to prevent oxidation; a sufficiently high friction pressure is applied. High friction pressure results in a high heating rate and rapid axial shortening. The friction time is chosen during preparation or through previous experiments. When the time increases at this stage, excessive heating occurs, causing material waste. In some soft materials, such as aluminum, the loss of the material to be plasticise at the interface increases when the friction time increases [13]. Insufficient time in the friction stage may lead to uneven plasticise and unbounded areas. In the second phase, which is the forging stage, rotation is stopped after sufficient plastic deformation has occurred for the weld, and the forging pressure is maintained at the same value as the friction pressure or increased. Forging pressure has a direct effect on the joint strength. When pressure values increase, the joint strength increases to a maximum and then decreases again, due to increased plastic deformation when excessive forging pressure is applied [14].

4. Conclusions

The effect of process parameters on weld quality is discussed. Incorrect selection of process parameters leads to defects and failure of the joint.

It is possible to weld similar and different materials with different cross-sectional areas, including circular and non-circular.

Tensile strength increases when the forging pressure and friction time increase until it reaches its limit, and any other increase leads to a decrease in tensile strength.

High speeds have a negative effect on the interface material. It is preferable to use sufficient speed to achieve sufficient plastic deformation for the weld.

References

[1] M. Maalekian, “Friction welding – critical assessment of literature,” Sci. Technol. Weld. Join., vol. 12, pp. 738–759, 2007, [Online].

Available:https://api.semanticscholar.org/CorpusID:136934570
[2] M. Haghshenas and A. P. Gerlich, "Joining of automotive sheet materials by friction-based welding methods: A review," Eng. Sci. Technol. an Int. J., vol. 21, pp. 130–148, 2018, [Online]. Available: https://api.semanticscholar.org/CorpusID:139539316.
[3] V. Ajay, N. K. Babu, M. Ashfaq, T. M. Kumar, and K. V. Krishna, "A Review on Rotary and Linear Friction Welding of Inconel Alloys," Trans. Indian Inst. Met., vol. 74, no. 11, pp. 2583–2598, 2021, doi: 10.1007/s12666-021-02345-z.
[4] H. D. Vyas, K. P. Mehta, V. Badheka, and B. Doshi, "Friction welding of dissimilar joints copper-stainless steel pipe consist of 0.06 wall thickness to pipe diameter ratio," J. Manuf. Process., vol. 68, pp. 1176–1190, 2021, doi: https://doi.org/10.1016/j.jmapro.2021.06.050.
[5] M. Sahin, "Evaluation of the joint-interface properties of austenitic-stainless steels (AISI 304) joined by friction welding," Mater. \& Des., vol. 28, pp. 2244–2250, 2007, [Online]. Available:https://api.semanticscholar.org/CorpusID:137326809.
[6] M.-N. Avettand-Fènoël, G. Racineux, L. Debeugny, and R. Taillard, "Microstructural characterization and mechanical performance of an AA2024 aluminium alloy - Pure copper joint obtained by linear friction welding," Mater. \& Des., vol. 98, pp. 305–318, 2016, [Online]. Available:https://api.semanticscholar.org/CorpusID:138926967
[7] K. Ozel, M. Sahin, and A. Akdogan, "Mechanical and Metallurgical Properties of Aluminium and Copper Sheets Joined by Cold Pressure Welding," Strojni{\vs}ki Vestn., vol. 54, pp. 796–806, 2008, [Online]. Available: https://api.semanticscholar.org/CorpusID:138816790
[8] H. Nami, H. Adgi, M. Sharifitabar, and H. E. Shamabadi, "Microstructure and mechanical properties of friction stir welded Al/Mg 2Si metal matrix cast composite," Mater. \& Des., 2011, [Online]. Available: https://api.semanticscholar.org/CorpusID:135769431
[9] D. Wang, Q. Z. Wang, B. L. Xiao, and Z. Y. Ma, "Achieving friction stir welded SiCp/Al-Cu-Mg composite joint of nearly equal strength to base material at high welding speed," Mater. Sci. Eng. A-structural Mater. Prop. Microstruct. Process., vol. 589, pp. 271–274, 2014, [Online]. Available:https://api.semanticscholar.org/CorpusID:137526037
[10] D. L. Olson and J. R. Davis, "Welding, brazing, and soldering," 1993. [Online]. Available: https://api.semanticscholar.org/CorpusID:85504603
[11] M. B. Uday, M. N. A. Fauzi, H. Zuhailawati, and A. B. Ismail, "Advances in friction welding process: A review," Sci. Technol. Weld. Join., vol. 15, pp. 534–558, 2010, [Online]. Available: https://api.semanticscholar.org/CorpusID:137289085
[12] E. P. Alves, F. P. Neto, and C. Y. An, "Welding of AA1050 aluminum with AISI 304 stainless steel by rotary friction welding process," J. Aerosp. Technol. Manag., vol. 2, pp. 301–306, 2010, [Online]. Available: https://api.semanticscholar.org/CorpusID:59128302
[13] "Rotary Friction Welding of Dissimilar Materials," Int. J. Recent Technol. Eng., 2019, [Online]. Available: https://api.semanticscholar.org/CorpusID:242539777
[14] R. Winiczenko, A. Skibicki, and P. Skoczylas, "Optimization of Friction Welding Parameters to Maximize the Tensile Strength of Magnesium Alloy with Aluminum Alloy Dissimilar Joints Using Genetic Algorithm," Processes, 2021, [Online]. Available: https://api.semanticscholar.org/CorpusID:239675241
[15] R. Paventhan, P. R. Lakshminarayanan, and V. Balasubramanian, "Optimization of Friction Welding Process Parameters for Joining Carbon Steel and Stainless Steel," J. Iron Steel Res. Int., vol. 19, no. 1, pp. 66–71, 2012, doi: 10.1016/S1006-706X(12)60049-1.
[16] R. Winiczenko and M. Kaczorowski, "Friction welding of ductile iron with stainless steel," J. Mater. Process. Technol., vol. 213, pp. 453–462, 2013, [Online]. Available: https://api.semanticscholar.org/CorpusID:137216854
[17] S. T. Selvamani and K. Palanikumar, "Optimizing the friction welding parameters to attain maximum tensile strength in AISI 1035 grade carbon steel rods," Measurement, vol. 53, pp. 10–21, 2014, [Online]. Available: https://api.semanticscholar.org/CorpusID:110518503
[18] T. N. Prasanthi, C. Sudha, Ravikirana, S. Saroja, N. Kumar, and G. D. Janakiram, "Friction welding of mild steel and titanium: Optimization of process parameters and evolution of interface microstructure," Mater. \& Des., vol. 88, pp. 58–68, 2015, [Online]. Available: https://api.semanticscholar.org/CorpusID:136960040
[19] M. Kimura, T. Iijima, M. Kusaka, K. Kaizu, and A. Fuji, "Joining phenomena and tensile strength of friction welded joint between Ti–6Al–4V titanium alloy and low carbon steel," J. Manuf. Process., vol. 24, pp. 203–211, 2016, [Online]. Available: https://api.semanticscholar.org/CorpusID:138559111

[20] A. C. Reddy, "Evaluation of Parametric Significance in Friction Welding Process of AA1100 and Zr705 Alloy using Finite Element Analysis," Mater. Today Proc., vol. 4, pp. 2624–2631, 2017, [Online]. Available: https://api.semanticscholar.org/CorpusID:136158742
[21] A. R. McAndrew, P. A. Colegrove, C. Bühr, B. C. D. Flipo, and A. Vairis, "A literature review of Ti-6Al-4V linear friction welding," Prog. Mater. Sci., vol. 92, pp. 225–257, 2018.
[22] X. Wang, W. Li, T. Ma, X. Yang, and A. Vairis, "Effect of welding parameters on the microstructure and mechanical properties of linear friction welded Ti-6.5Al-3.5Mo-1.5Zr-0.3Si joints," J. Manuf. Process., 2019, [Online]. Available: https://api.semanticscholar.org/CorpusID:202944872
[23] M. Cheepu and W. S. Che, "Effect of Burn-off Length on the Properties of Friction Welded Dissimilar Steel Bars," J. Weld. Join., 2019, [Online]. Available: https://api.semanticscholar.org/CorpusID:139492039
[24] M. Kimura, K. Ohara, M. Kusaka, K. Kaizu, and K. Hayashida, "Effects of tensile strength on friction welding condition and weld faying surface properties of friction welded joints between pure copper and austenitic stainless steel," 2020. [Online]. Available: https://api.semanticscholar.org/CorpusID:225607666
[25] M. D. Kumar and P. K. Palani, "Characterization studies on weld strength of rotary friction welded austenitic stainless steel tubes," Mater. Today Proc., 2020, [Online]. Available: https://api.semanticscholar.org/CorpusID:225467534
[26] J. A. Anandaraj, S. Rajakumar, V. Balasubramanian, and V. Petley, "Investigation on mechanical and metallurgical properties of rotary friction welded In718/SS410 dissimilar materials," Mater. Today Proc., 2020, [Online]. Available: https://api.semanticscholar.org/CorpusID:216401471
[27] M. Xie, X. Shang, Y. Li, Z. Zhang, M. Zhu, and J. Xiong, "Rotary Friction Welding of Molybdenum without Upset Forging.," Mater. (Basel, Switzerland), vol. 13, no. 8, Apr. 2020, doi: 10.3390/ma13081957.
[28] M. Balasubramanian, S. Murali, C. Hemadri, and R. Kumar, "A new method of dissimilar friction welding of titanium to stainless steel," Mater. Today Proc., 2021, [Online]. Available: https://api.semanticscholar.org/CorpusID:233973816
[29] A. Banerjee, M. Ntovas, L. da Silva, and S. Rahimi, "Microstructure and mechanical properties of dissimilar inertia friction welded 316L stainless steel to A516 ferritic steel for potential applications in nuclear reactors," Manuf. Lett., 2022, [Online]. Available: https://api.semanticscholar.org/CorpusID:250516592
[30] S. Sundaraselvan, N. Senthilkumar, T. Balamurugan, C. Kaviarasu, G. B. Sathishkumar, and M. N. Rajesh, "Optimization of friction welding process parameters for Joining Al6082 and mild steel using RSM," Mater. Today Proc., 2022, [Online]. Available: https://api.semanticscholar.org/CorpusID:254670170
[31] S. Raj and P. Biswas, "Effect of Induction Preheating on Microstructure and Mechanical Properties of Friction Stir Welded Dissimilar Material Joints of Inconel 718 and Ss316l," SSRN Electron. J., 2023, [Online]. Available: https://api.semanticscholar.org/CorpusID:251111945