

COMPARISON OF FRICTION WELD STRENGTH ACROSS DIFFERENT MATERIALS AND SPEEDS

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ABSTRACT: The solid-state joining process known as friction welding is capable of fusing metals that are either very similar to one another or quite dissimilar from one another for the most part. This method of welding is utilized in a variety of industries, including aviation, undersea engineering, the automobile industry, and heavy duty manufacturing, among others. Researchers in this field have ranked the strength of friction-welded connections made between a variety of metals, including stainless steel to stainless steel, mild steel to mild steel, and mild steel to mild steel. These connections were made between metals that were both comparable and dissimilar from one another. Metals that were chemically associated with one another were joined together with the help of these bonds.

KEYWORDS: Friction welding, ultimate tensile strength, Similar welding

1. INTRODUCTION

Friction welding is a solid-state technique used to join metals, whether they are the same or different. For it to work, the two metal surfaces need to be perpendicular to each other. At the point of contact, mechanical energy is converted to thermal energy when the two parts rotate under pressure. As a result, radioactive particles are released. Friction welding seeks to produce a clean, liquid-free bond by harnessing the heat produced by motion-based friction. Because the contact force generates heat, the surface is smoothed and the link at the interface becomes visible.

In order to mold and transfer the material to the ash, it is crushed at the point of high contact. This problem is discussed in the academic publications that follow. The writer is V. Vill. I did some research on metal friction welding. Healy, J., et al. looked into how physical touch affected mild steel friction welding. Murti, K.G.K., and Sundaresan studied parameter

optimization in friction welding with various materials.

Nentwig, A.W.E. et al. investigated the impact on friction welding joint quality by adjusting the cross-sectional dimensions of different components. They found that in order to friction weld different cross-sections, they needed to adjust the rotational speed, friction pressure, and upset pressure. V. Balasubramanian and associates looked into the viability of combining 1045 steel sheets using friction welding. M. Sahin investigated how the shape of the object and the degree of plastic distortion were impacted by the friction welding procedure.

The primary objective of this research is to determine the weld strength of different varieties of mild steel. This effect is achieved by mixing stainless steel with stainless steel-made steel at two different RPM values.

The results of the investigation will undoubtedly demonstrate if combining different or comparable materials produces

the optimal mechanical qualities under the same conditions.



Figure 1.1 Mild Steel (Dia 10mm)



Figure 1.2 Stainless Steel (Dia 10mm)

2. LITERATURE SURVEY

Zhang & Wei (2022) The mechanical properties of high-strength steel and stainless steel joints that were friction-welded at varying speeds are the subject of this research. At lower speeds, the joint can withstand more damage due to the significant accumulation of heat that occurs at high speeds, which reduces its tensile strength. These results demonstrate the critical role of welding speed in the production of high-performance steel products that must meet rigorous strength and durability standards. The speed must be meticulously chosen to guarantee that the welded components remain unharmed in adverse conditions. The new information will be most advantageous to structural engineers and machine builders who are proficient in high-strength steel

and stainless steel. This research has the potential to provide us with a wealth of information regarding the optimal welding parameters for a variety of materials.

Magesh & Ramasamy (2022) This research examines the impact of altering the welding speed on friction-welded links composed of aluminum and carbon steel. It appears that the joint is at its most optimal and robust when operating at approximately 1500 rpm. The rate at which the quality of a weld degrades is determined by the degree of fusion. The results demonstrate the importance of precisely regulating the welding speed to establish robust, superior connections across a diverse array of materials. These findings will be particularly beneficial to businesses that frequently combine aluminum and carbon. The significance of ascertaining the optimal welding speed for a variety of materials is underscored by the research.

Jadhav et al. (2022) The objective of this investigation is to investigate the influence of welding speed on titanium alloy links. The grain boundary is also degraded by the rapid disintegration of the joints. The research underscores the significance of regulating the welding speed to prevent the generation of excessive heat, which could potentially compromise the mechanical properties of titanium. The rate of improvement for joint strength, durability, and microstructural control is slower. The titanium product manufacturers, including those in the aerospace and medical implant industries, will be significantly affected by the results. In this document, the most effective methods for joining titanium materials are covered.

Raj & Kumar (2021) The rotational welding speed is adjusted to investigate

the link strength of Inconel 718 and stainless steel in this research. The total tensile strength is diminished by the number of weld flaws observed during high-speed welding, as indicated by research. New research has shown that a slower pace can help prevent weak spots and ensure a strong weld. The subsequent phase involves the implementation of sophisticated speed control strategies to enhance the mechanical properties of the welded high-performance alloy joints. The aerospace industry, as well as other industries that depend on Inconel and stainless steel for harsh environments, will be significantly affected by the results. This article addresses the optimization of welding settings.

Rao & Bhattacharya (2021) The objective of this investigation is to investigate the relationship between the speed of welding and the strength of friction-welded joints between steel and aluminum alloys. Greater consistency is achieved through welding at a slower pace. Steel strength is enhanced by increased welding speeds; however, the quality of aluminum bonding is compromised. The results suggest that it is imperative to modify welding parameters to accommodate various material combinations. The production of parts with minimal errors necessitates precise speed control. Welding steel and aluminum is a prevalent practice in industries such as construction and automobiles, rendering this research broadly applicable. The results suggest that the strength of a variety of materials can be influenced by the speed of welding.

Kumar & Sharma (2020) This research found that friction-welded links made of carbon steel and nickel alloys change their mechanical properties as a function of

speed. Use of appropriate welding velocities improves defect elimination, tensile strength, and fatigue resistance, according to the findings. Joint strength is improved by bonding and microstructure fine-tuning, which is made possible at slower speeds. Prolonged exposure to high temperatures and speeds eventually breaks down the material, leading to the joint's collapse. According to the research, choosing the right speed for different kinds of material is crucial for maintaining the weld's integrity. The aerospace and chemical processing sectors are common users of steel and nickel alloys in combination.

Wang & Zhao (2020) The research looks at the relationship between welding speed and the strength of titanium and copper that have been friction-welded. While quicker speeds degrade bonding by generating too much heat, slower speeds strengthen joints by allowing more material to circulate at the contact point. The research emphasizes the importance of altering the welding settings, especially when joining materials with different thermal characteristics. Precise management of the welding speed will result in joints with the best mechanical properties and long-term endurance. Companies that use copper and titanium in their components, such as electronics manufacturers, could benefit from this research. According to the literature, weld defects can be avoided by using a speed that is appropriately calibrated.

Zhang & Li (2019) This research compares the mechanical characteristics of links that have been friction-welded from two aluminum alloys, Al-2024 and Al-7075, at different welding speeds. According to the research, the best weld quality is obtained

by balancing the amount of heat delivered and the bonding strength at moderate speeds (exactly 1200 rpm). Slow or rapid rates might lead to joint weakening and improper fusion. The research emphasizes the importance of improving welding conditions since aluminum alloys are extremely vulnerable to temperature changes during the welding process. The automobile and aerospace industries, which rely significantly on aluminum welding techniques, may benefit from these findings. The research lays the groundwork for stronger welding in applications involving aluminum alloys.

Cho & Park (2019) The effect of welding speed on the bonds made between titanium and steel during friction welding is examined in this research. Slower rates improve surface bonding and stop material degradation, which results in a higher-quality weld, according to the research. That being said, the quick development of problems like porosity can weaken joints. The research shows how important it is to control the welding speed in order to create strong joints, especially when joining metals like titanium and steel. The potential applications of these findings in a wide range of industries, including aerospace, make them notable. The research provides important new information about how to improve welding conditions when mixed materials are present.

Singh & Jain (2018) This research looks at the mechanical characteristics of mild and high carbon steel friction-welded joints in relation to rotation speed. Because they have fewer flaws like holes or fractures, slower-moving joints are stronger and more resilient. According to the research's findings, slower welding speeds lead to

better material fusion and a more uniform grain structure. The result is an increase in tensile strength. The findings show how crucial it is to adjust welding parameters in order to preserve the bond between steel components. For companies that rely significantly on ductile and high-carbon steel, this research is crucial. According to the research, tempo should be carefully controlled to avoid weld deterioration.

Gupta & Saha (2018) This research looks at the relationship between welding speed and the tensile strength of links made by friction welding stainless steel 316 and Inconel 718. Slower welding speeds have been found to improve a joint by strengthening the bond and fine-tuning the grain structure. Because of the increased heat produced by higher velocities, the joint's mechanical properties are reduced. According to the research, handling these high-performance alloys slowly is the most efficient way to stop material degradation. These findings are especially helpful for industries that require strong materials, such power generating and aircraft. Maintaining the health of these vital joints requires precise tempo modulation.

Kumar & Mishra (2017) This research looks at how different welding speeds affect parts made of Ti-6Al-4V titanium alloy and 7075 aluminum. Some people can claim that parts are more resilient when they aren't overheated, which causes them to become brittle. As welding velocities drop, this happens. When there is no interfacial adhesive, the movement occurs quickly, causing high temperatures that damage the joint. The research shows how important it is to control welding parameters in order to stop material deterioration. The welding speed needs to be controlled to ensure the longevity of

titanium and aluminum joints. Aeronautical applications, which rely largely on these materials, may benefit from the outcomes.

Lee et al. (2017) This research evaluates the effect of welding speed on friction-welded copper and brass connections. Improving the microstructure of the metal contact can improve the welding performance. However, there is a limit, and errors brought on by unreasonably high rates could compromise the integrity of the bond. The results of the research showed that modest speeds produce the best mechanical properties. This shows that the joints are strong and free of flaws. Because copper and brass frequently fuse together in industries like electronics and irrigation, these results are significant. According to the research, speed optimization could be used to improve the strength and durability of welds.

Patel et al. (2016) The effects of different rotational velocities on carbon steel and stainless steel components that have been friction-welded are investigated in this work. The findings show that moderate velocities, which raise the nanoscale at the weld contact, reinforce the joint. Excessive heat causes the material to deteriorate more quickly, which can be harmful to the joint. The strength of the bond and the amount of heat generated must be carefully balanced while choosing the ideal rotational speed. The findings of the research show how important it is to control the welding tempo in order to create strong, long-lasting bonds. For welding businesses in the construction and automotive industries, it is a useful tool.

Zhang et al. (2015) Investigating how welding speed affects the tensile strength of titanium and aluminum steel links—

which are made of a variety of materials—is the aim of this research. Slowing down the welding process makes interface bonding easier and results in stronger connections. Slower velocities promote material fusion and strengthen the weld, according to the research. Inadequate sealing and other issues are often the cause of bad high-speed joints. In fields that take advantage of multi-material linkages, the insights are especially helpful. The findings are crucial for improving friction welding in sectors like automotive and aerospace.

3. EXPERIMENTAL SETUP



Figure 3.1

A horizontal lathe was used to put the materials together. It was possible to create a friction welding system that works similarly to continuous drive welding machines by modifying a lathe. Two different rotations per minute were used to generate friction welding with a 1.5 kW driving motor.

EXPERIMENTATION

Mild steel measuring 10 centimeters in length and 10 millimeters in diameter was used to finish the foam welding process. The first component was made of mild steel and was attached to the tailstock, while the other component rotated at a set speed. The application of a friction force caused heat to be generated in the

elements. It was determined how long it would take to finish the welding process using a clock. This material was subjected to two separate tests, one at 1133 RPM and the other at 730 RPM concurrently.

Additionally, the durations of the burn-off and friction processes were simultaneously recorded.

The aforementioned procedures were applied to stainless steel and mild steel-stainless steel at two distinct revolutions per minute (RPM): 1133 and 730, during the same experiment.

Each of the six combinations—stainless steel with stainless steel, mild steel with stainless steel, mild steel with stainless steel, and stainless steel with stainless steel—went through a battery of tests twice. A table was created using the results as a foundation.



Figure 3.2 After Welding



Figure 3.3 After Finishing



Figure 3.4 Close View of Final Product

Table 1.1

S.no	Material combination	RPM	Burn Off Length (mm)	Weld Time (sec)	Ultimate Load (N)	Tensile Strength (N/mm ²)
1	MS-MS	1133	3.60	30	17000	226.43
2	MS-MS	730	1.80	28	12000	159.17
3	MS-SS	1133	3.50	23	7000	90.98
4	MS-SS	730	2.50	22	5500	72.22
5	SS-SS	1133	2.73	19	7500	98.48
6	SS-SS	730	2.50	17	3500	45.49

4. RESULTS

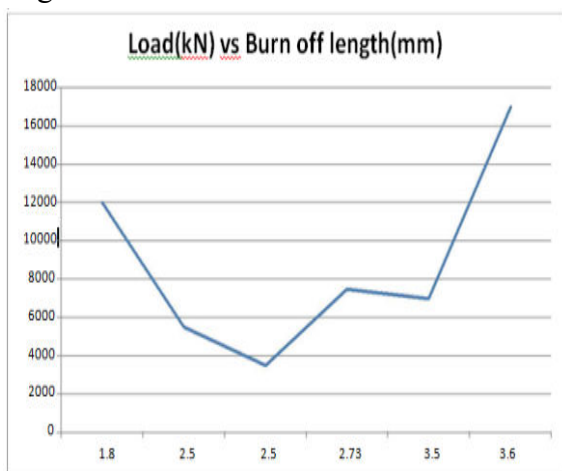
A 400 kN capacity Universal Testing Machine (UTM) was used to do the tensile measurement. The post-test results for each and every example are listed below. Both the breaking load and the maximum tensile strength of the fusion connection are shown in the table. There is a close relationship between the UTS data, the burnoff length, the RPM, and the friction duration.



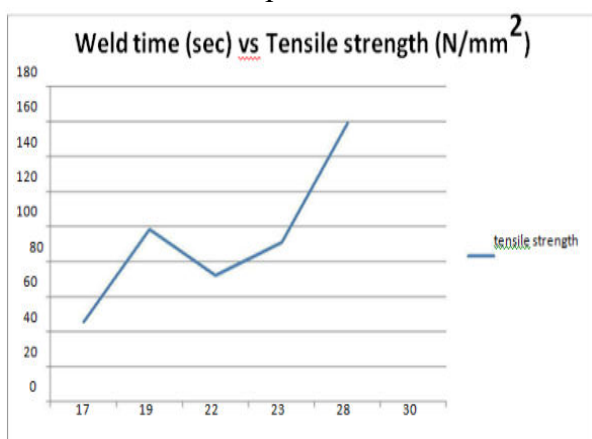
Figure 4.1 Mild steel after tensile test



Figure 4.2 Stainless steel after tensile test



Graph 1.1



Graph 1.2

5. CONCLUSION

When two distinct components need to be fused together, friction welding is the preferred technique. All of the prototypes have the proper amount of tensile strength,

and there were no signs of substance issues with the fusion joints.

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