Journal of Mines, Metals and Fuels, *71(12): 2610-2615; 2023. DOI: 10.18311/jmmf/2023/41771*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Investigation on Influence of Surface Structuring on Brazed Joint between Tungsten Carbide and Steel

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Abstract

The aim of this project is to investigate the effects of surface structuring on brazed joints made of steel and tungsten carbide as well as how these effects affect the joints' mechanical characteristics. The industry uses brazing as a common connecting method, although brazing is known to produce considerable residual strains because of cooling thermal gradients. The strength, longevity, and fatigue resistance of the brazed joint can be impacted by the existence of residual stress, which might be crucial for applications in aerospace and automotive. The impact of several brazing parameters on the development of residual stress will be examined in this study, including temperature, heating rate, cooling rate, and material choice. To describe the residual stress state and assess the mechanical characteristics of the joint, experimental methods such X-ray diffraction and Shear Strength test will be used. The results of this project can be applied to numerous sectors to optimize the brazing procedure and enhance the performance and dependability of brazed components.

Keywords: *Brazing, Micro Patterning, Single Shear Strength*

1.0 Introduction

Shear strength is a crucial factor to consider while brazing since it establishes if the joint can sustain forces acting perpendicular to its plane. A brazed joint's shear strength is influenced by several variables, such as the filler material selected, the joint's design, how clean the base metals are, and the brazing process parameters[1]. An improvement in the brazed joint's resistance to pressures operating perpendicular to its plane is often shown by an increase in the joint's shear strength. The joint is less likely to fail or deform when subjected to shear loads if it has a higher shear strength[2]. Few potential benefits of increased shear strength in brazing:

- **Enhanced structural integrity:** The joint may tolerate bigger loads and pressures without failing if its shear strength is higher.
- **Increased reliability:** Assembled parts or components are more reliable and durable because a stronger brazed joint decreases the possibility of joint failure in use.
- **Better load distribution:** A joint can more efficiently distribute applied loads through out the joint area when it has enhanced shear strength.

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To investigate the effect of micro patterning on Tungsten Carbide Surface on strength of induction brazed Carbide and Steel joint. To measure the strength of the joints using shear tests and compare the strength of the joints with different surface patterns.

2.0 Objectives of the Study

- To investigate the effect of micro patterning on Tungsten Carbide Surface on strength of induction brazed Carbide and steel joint.
- To measure the strength of the joints using shear tests and compare the strength of the joints with different surface patterns.

3.0 Review of Literature

Bo Mao, Arpith Siddaiah, Yiliang Liao, Pradeep L. Menezes - This work reviews Laser Surface Texturing (LST) techniques for enhancing tribological properties of engineering materials[3]. It explores how laser parameters affect the features of surface texture through discussions of process designs like laser ablation, interference, and shock processing[4]. The paper emphasizes increased friction and wear qualities gained through LST, encompassing numerous materials and applications in mechanical parts, bio-implants, and electronics. With an emphasis on scalability, efficiency, and optimization, LST's drawbacks and potential applications are discussed. The conclusion underlines the significance of LST in boosting tribological performance, giving significant insights for practitioners and scholars in building LST techniques for varied engineering applications.

Peixin Li, Yaotian Yan, Jin Ba, Pengcheng Wang, Haohan Wang, Xingxing Wang, J inghuang Lin, Jian Cao, Junlei Qi - Metals and ceramics are frequently bonded together via brazing, however the residual strains caused by the different characteristics are significant[5]. Particle reinforcement, interlayer control, and surface structure design are three techniques that can efficiently relieve stress, enhance joint plasticity, and lessen differences between ceramics and metals. These techniques may improve the functionality of ceramic to metal connections in a variety of applications. Discussion of the difficulties and potential solutions for controlling residual stress also sheds light on how to create ceramic to metal connections with better reliability and characteristics[6-10]. For businesses that depend on ceramic to metal connections, like electronics, communication, and chemical processing, this overview provides useful information.

Dinesh Thakur, B. Ramamoorthy, L. Vijaya Raghavan - Through various post-treatments, this study attempted to improve the mechanical properties of cemented tungsten carbide cutting tools. We investigated three methods: oil bath quenching, forced air cooling, and cryogenic treatment. The results showed that all three post-treatments greatly enhanced the tools' mechanical characteristics, as shown by an increase in microhardness and modifications to the grain size and structure. Significant microstructural changes were seen in SEM scans and shifts in the Co metal phase were seen in XRD studies. These findings show the potential for improving tungsten carbide cutting tools through post-treatment techniques, promoting the creation of cutting-edge methods to increase tool efficiency and durability.

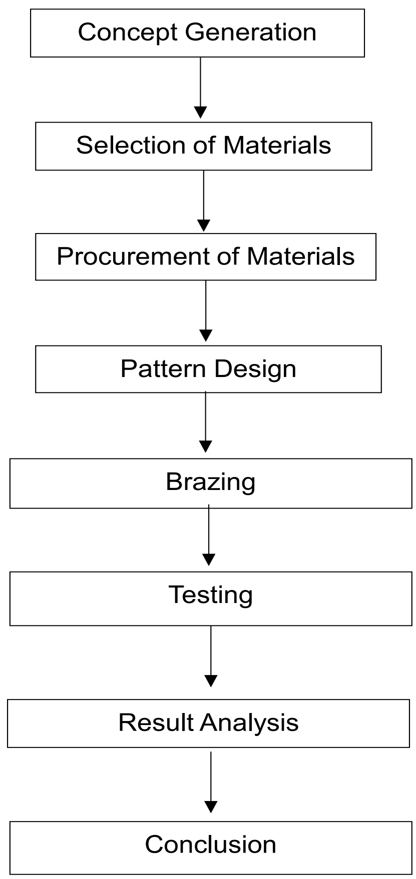

Figure 1. Methodology Flow chat.

Ahmed AD Sarhan - This study seeks to braze tungsten carbide (WC-Co) with cold work steel to produce a strong and impact-resistant joint. Due to its low melting point and capacity to entirely solidify within a constrained range, a new filler alloy called silver-copper near-eutectic alloy (BAg-8T) will be employed. The softness and ductility of the alloy will allow it to absorb motion and enhance wetting on the carbide. The study will look at how the brazing temperature and tungsten carbide's cobalt content affect the joint's microstructure and mechanical characteristics. The appropriate settings for getting the best joint performance will be decided by the results.

4.0 Research Methodology

The details of the experiments carried out on the studies on Investigation on Influence of Surface Structuring on Brazed Joint between Tungsten Carbide and Steel is presented under the following headings. These details are explained in Figure 1.

5.0 Results and Discussion

In order to investigate the shear strength of the samples the following UTM machine is used A UTM machine (Figure 2), also known as a universal testing machine, is a tool used to evaluate the strength and performance of materials by applying tension, compression, or bending forces.

Figure 2. Machine Figure (UTM).

Machine Specification - Model - TUE - CN – 600 Universal Testing Machines (Model: TUE- CN) Features:

- The Win UTM Software can run a variety of mechanical tests, recall data from previous test & prepare test report
- Display of load elongation (stress & strain are optional) at any instant throughout the test.
- Online display of load Vs elongation or Stress Vs Strain characteristics during conduction of test. The plot is auto scaled & displayed.
- Selectable units (kN, kgf, lbf, mm, inch)
- Variable sample break detection. Elongation is indicated with a resolution of 0.1 mm

5.1 Single Shear Test Report

5.1.1 Single Shear Test Report Sample Number S1

The work piece was fixed in UTM with a 5mm overhang. Load was applied onto tungsten carbide Sample Number S1 and the graph was drawn between load vs elongation. From the given output data and by observing the graph, Figure 3 we can conclude that the brazed joint withheld a load of up to 3.5KN until breakage with a maximum elongation of 1.1mm. Later the shear strength was calculated by using the formula,

Shear Strength = Max Load / Surface area,

The calculated shear strength for the sample S1 is 23N/mm^2. It is shown in Figure 3.

Input Data

- Specimen Shape - Flat
- Specimen Width - 20mm
- Specimen Thickness - 7mm
- Specimen Cross Section Area -
- 150mm^2
- Overhang - 5mm

Output Data

- Load at Peak - 3.5kN
- Elongation at Peak - 1.1mm
- Shear Strength - 23N/mm^2

5.1.2 Single Shear Test Report Sample Number S8

The work piece was fixed in UTM with a 5mm overhang. Load was applied onto tungsten carbide Sample Number S8 and the graph was drawn between load vs elongation.

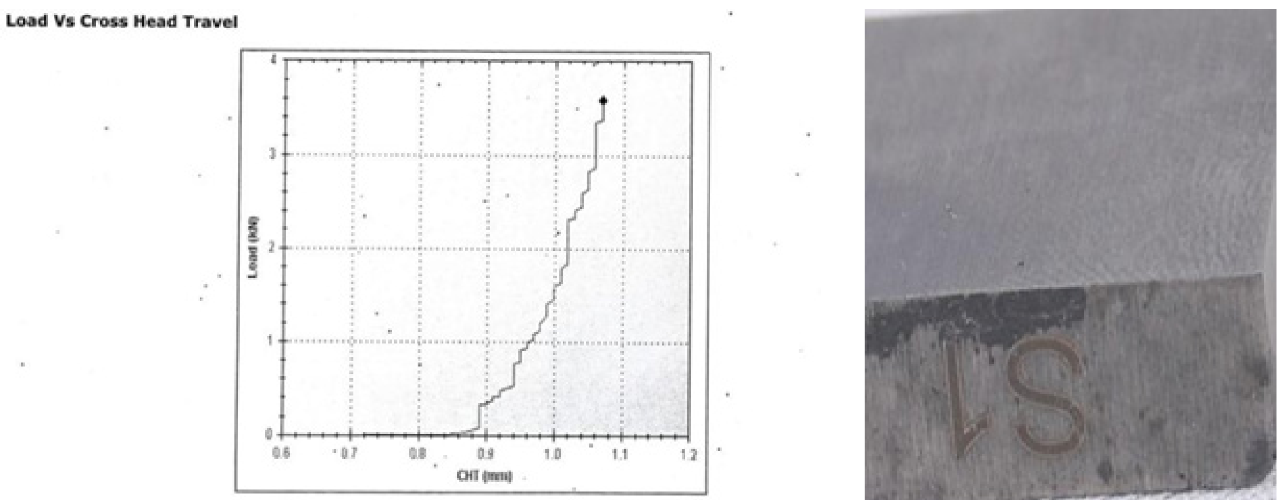

Figure 3. Single Shear Test Report Sample Number S1.

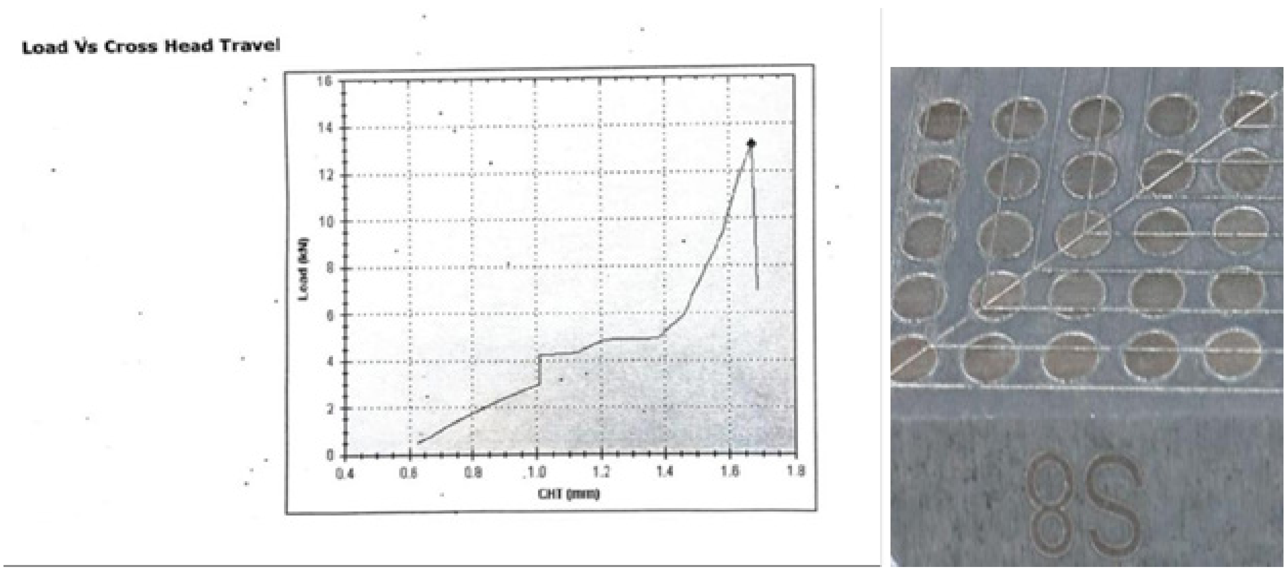

Figure 4. Single Shear Test Report Sample Number S8.

From the given output data and by observing the graph, Figure 4 we can conclude that the brazed joint withheld a load of up to 13KN until breakage with a maximum elongation of 1.6mm. Later the shear strength was calculated by using the formula,

Shear Strength = Max Load/Surface area,

The calculated shear strength for the sample S1 is 86N/mm^2.

Input Data

- Specimen Shape - Flat
- Specimen Width - 20mm
- Specimen Thickness - 7mm
- Specimen Cross Section Area -
- 150mm^2
- Overhang - 5mm

Output Data

- Load at Peak -13KN
- Elongation at Peak -1 .6mm
- Shear Strength - 86N/mm^2

The work piece was fixed in UTM with a 5mm overhang. Load was applied onto tungsten carbide

Sample Number S8 and the graph was drawn between load vs elongation. From the given output data and by observing the graph, Figure 4 we can conclude that the brazed joint withheld a load of up to 3KN until breakage with a maximum elongation of 1.5mm. Later the shear strength was calculated by using the formula,

Shear Strength = Max Load / Surface area,

The calculated shear strength for the sample S1 is 20N/mm^2.

It can be observed that the shear strength of various design pattern brazed joints has greatly improved when compared to a typical un-patterned brazed joint. It is further observed that among all the above design patterned brazed joints, the sample **S8** has the highest shear strength of the design patterns, whereas **S11** has the lowest shear strength. This suggests that the strength of the final joint can be significantly improved by the X mas tree design pattern for the brazing process. In design of sample number S8 X mas Tree like pattern is created with the help of lines and small circular holes are created randomly in between.

6.0 Conclusion

According to the brazing joints' shear test findings, the surface structured brazed junction has a much higher shear strength than the standard brazed joint. Except for one joint with a design pattern referred to as S11, the shear strength of the surface structured brazed joint is around twice that of the standard brazed joint.

This joint has a square block structure with a pattern of circular holes in the middle. Contrary to other surface structured joints, the S11 design pattern did not exhibit a comparable gain in shear strength. The maximum shear strength was demonstrated by another design pattern known as S8, which has an X-max tree-like structure with a circular hole pattern in the middle. Overall, the findings show that adding surface structuring to brazed joints can significantly increase shear strength, possibly doubling it over conventional brazed joints.

The joint strength, however, might be affected in different ways depending on the particular design pattern used. The S8 pattern, which has an X-max tree-like structure and a circular hole pattern, displayed the best shear strength among the examined designs, but the S11 pattern with a square block structure and circular hole pattern did not increase the shear strength as expected.

It would be advantageous to investigate different design patterns and carry out additional tests to comprehend the underlying mechanisms behind the observed variances in shear strength to further optimize the design and strengthening effects and also useful in applying in mining and its materials.

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