MECHANICALAND TRIBOLOGICAL STUDIES OFTI-6AL-4V BY FRICTION STIR PROCESSING

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ABSTRAT

Friction stir processing (FSP) is a promising technique for improving the mechanical and tribological properties of materials. This study focuses on investigating the effects of FSP on Ti-6Al-4V, a widely used titanium alloy.The existing technology for processing Ti-6Al-4V has limitations, such as reduced strength and ductility in the heat-affected zone. The aim of this research is to evaluate the potential of FSP in enhancing the mechanical and tribological properties of Ti- 6Al-4V. The methodology involves conducting FSP on Ti-6Al- 4V samples and analyzing the resulting microstructure and mechanical properties. The key findings indicate that FSP significantly refines the microstructure of Ti-6Al-4V, leading to improved mechanical properties, including increased strength and ductility. The discussion interprets these results and highlights the benefits of using FSP for Ti- 6Al-4V.

The conclusions emphasize the positive outcomes of this research, suggesting that FSP can be an effective technique for enhancing the mechanical and tribological properties of Ti-6Al-4V. The keywords for this study include Ti- 6Al-4V, friction stir processing, mechanical properties, tribological properties, microstructure refinement, strength, and ductility. Overall, this study provides valuable insights into the potential of FSP to improve the performance of Ti-6Al-4V, addressing the existing limitations of the current technology. These findings contribute to the advancement of materials processing techniques and have implications for various industries that utilize Ti-6Al- 4V in their applications.

Keywords: *Ti-6Al-4V, friction stir processing, mechanical properties,tribologicalproperties microstructure refinement, strength, ductility.*

INTRODUCTION

Friction stir processing (FSP) is a novel technique that has gainedsignificant attention in recent years for its potential to enhance the mechanical and tribological properties of materials. This chapter provides a brief introduction to the work conducted on Ti-6Al- 4V using friction stir processing. The backgroundof the work isdiscussed, followed by the motivation and scope of the proposed research. Titanium alloys, such as Ti-6Al-4V, have gained significantattention in various industries due to their excellent mechanical properties, high strength-to-weight ratio, and corrosion resistance. These alloys are widely used in aerospace, automotive,and biomedical applications. However, they often exhibit poor wear resistance and frictional behaviours, limiting their performance in certain applications. To overcome these limitations, researchers have explored varioussurface modification techniques, including friction stir processing(FSP). FSP isa solid-state processing technique that involves the use of a rotating tool to generate frictional heat and plastic deformation in the material. This process leads to microstructural refinement and the formation of a fine-grained structure, resulting in improved mechanical and tribological properties. In recent years, there has been a growing interest in studying theeffects of FSP on Ti-6Al-4V alloy. The process has shown promising results in enhancing the wear resistance, hardness, and fatigue strength of the alloy. Additionally, FSP has been found to improve the surface roughness and reduce the coefficient of friction, making it suitable for applications where friction and wear are critical factors. This study aims to investigate the mechanical and tribological properties of Ti-6Al-4V alloy after friction stir processing. The microstructural changes, hardness, wear resistance, and frictionalbehaviours will be evaluated to understand the effects of FSP on the alloy's performance. The findings of this research will contribute to the development of advanced surface modification techniques for titanium alloys, enabling their wider utilization in demanding industrial applications.

In summary, this study focuses on the mechanical and tribological aspects of Ti-6Al-4V alloy after friction stir processing. By understanding the effects of FSP on the alloy's properties, we can enhance its performance and expand its rangeof applications.

PROPOSED SOLUTION:

Friction stir processing offers a potential solution to address the challenges associated with conventional Ti-6Al-4V processing methods. FSP involves the use of a specially designed tool with a rotating pin and shoulder to generate frictional heat and plasticize the material. The rotating tool traverses along the surface, stirring the material and inducing plastic deformation. The controlled cooling after the stirring process helps refine the microstructure and eliminate the anisotropy typically observed in conventionally processed Ti-6Al-4V. The proposed research aims to investigate the effects of FSP on Ti-6Al-4V and evaluate its potential for enhancing the mechanical and tribological properties of the alloy. By subjecting Ti-6Al-4V samples to FSP under various process parameters, such as tool rotation speed, traverse speed, and processing temperature, the microstructural changes and resulting mechanical behavior will be analyzed. The characterization techniques, including optical microscopy, scanning electron microscopy, and X-ray diffraction, will provide insights into the microstructural evolution induced by FSP. Furthermore, mechanical testing, including tensile, hardness, and wear resistance measurements, will be conducted to assess the resulting mechanical and tribological properties. The experimental results will be compared with conventionally processed Ti-6Al-4V to evaluate the effectivenessof FSP in improving the alloy's performance. In conclusion, this chapter has introduced the work conducted on Ti- 6Al-4V using friction stir processing. The challenges associated with conventional processing methods were discussed, highlighting the limitations in microstructure and tribological performance. The proposed solution of using FSP was presented as a potential technique to overcome these challenges. The scope of the research was outlined, including the objectives, experimental approach, and expected outcomes. This research aims to contribute to the field of materials processing and provide valuable insights for enhancing the mechanical and tribological properties of Ti- 6Al- 4V. Each block in the flow diagram will be briefly explained, highlighting the steps involved in the friction stir processing of Ti-6Al-4V alloy. Selection of Components, Tools, Data Collection Techniques, Procedures, Testing Methods, and Standards: This section will describe the selection process for components, tools, data collection techniques, procedures, testing methods, and standards used in the study. It will provide a comprehensive overview of the choices made and the rationale behind them. Summary of Chapter 3 (without section numbering):

Chapter 3

Focuses onthe mechanical and tribological studies of Ti-6Al-4V alloy using friction stir processing.The chapter begins with a brief introduction, followedby the clear statement of objectives based on the literature survey. synthetic procedure orflow diagram is presented, explaining each step involved in the friction stir processing. The selection of components, tools, data collection techniques, procedures, testing methods, and standards is described in detail. This chapter aims to provide acomprehensive understanding of the experimental setup andmethodology employed in the study, setting the stage for the subsequent analysis and discussion of the results.

OBJECTIVE OF THE PROPOSED:

The objectives of this work will be stated clearly based on the findings from the literature survey. The minimum number of objectives will be equal to the numberof students in the batch, and each student's individual contribution will be based onthese objectives. Synthetic Procedure/Flow Diagram: A flow diagram will be presented to illustrate the synthetic procedure of the proposed work. Each block in the flow diagram will bebriefly explained, highlighting the steps involved in the friction stir processing of Ti-6Al-4V alloy. Selection of Components,Tools, Data Collection Techniques, Procedures, Testing Methods, and Standards: This section will describe the selection processfor components, tools, data collection techniques, procedures, testing methods, and standards used in the study. It will provide a comprehensive overview of the choices made and the rationale behind them. Summary of Chapter 3 (without section numbering): Chapter 3 focuses on the mechanical and tribological studies of Ti-6Al-4V alloy using friction stir

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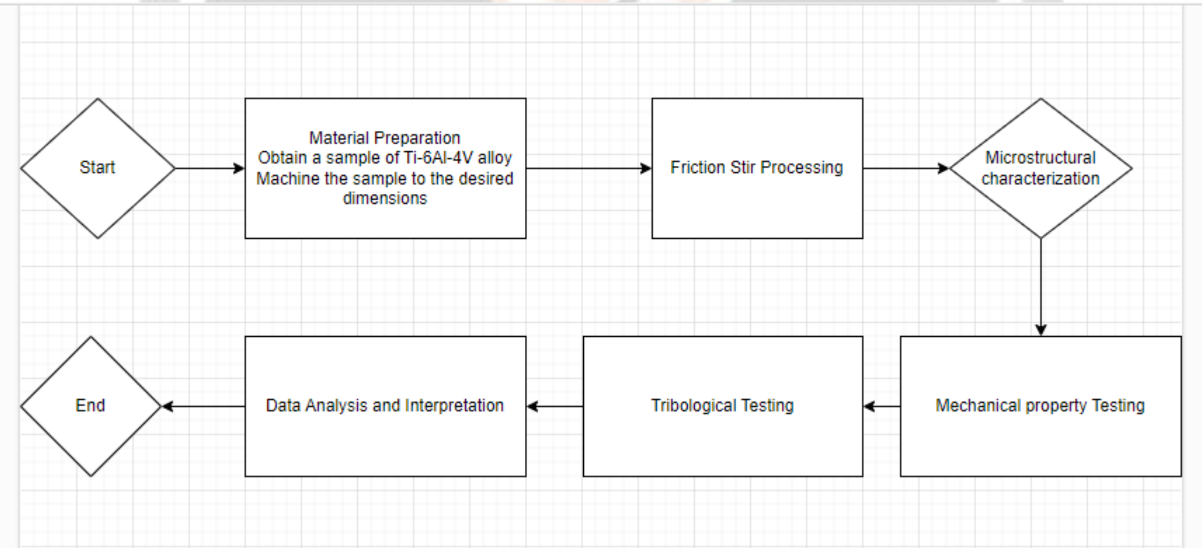
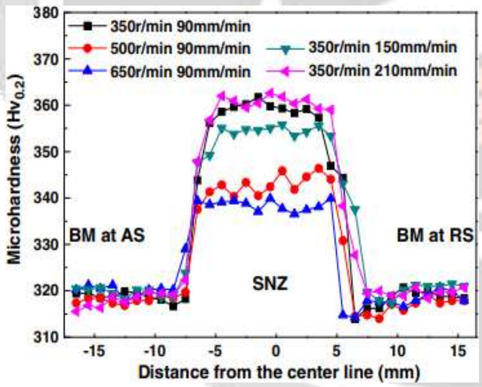


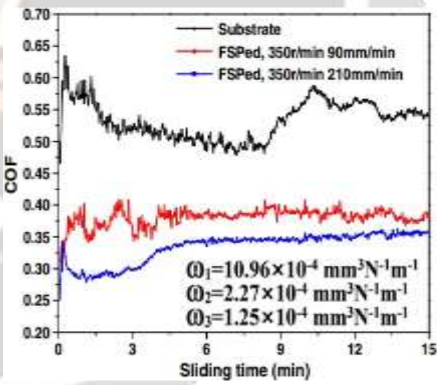
METHODOLOGY AND PROPOSED WORK:

The methodology of the proposed work on mechanical and tribological studies of Ti-6Al-4V by friction stir processing can be divided into the following steps:

1. Material preparation: Ti-6Al-4V plates with a thickness of 10 mm will be used as the base material. The plates will be cut into the desired dimensions and cleaned to remove any surfacecontaminants.

2. Friction stirs processing: The friction stir processing (FSP) tool will be made of a high-temperature resistant material, such as tungsten carbide. The tool will be rotated at a predetermined speed and feed rate, and a downward force will be applied to plunge the tool into the material. The FSP tool will be traversed along the desired path, creating a stir zone in the material.
3. Microstructural characterization: The microstructure of the stir zone will be characterized using optical microscopy (OM) and scanning electron microscopy (SEM). The OM will be used to examine the overall grain structure, while the SEM will be used to examine the finer details of the microstructure, such as the presence of second-phase particles.
4. Mechanical testing: The mechanical properties of the stir zone will be evaluated using tensile testing, hardness testing, and impact testing. The tensile testing will be used to determine the ultimate tensile strength, yield strength, and ductility of the material. The hardness testing will be used to measure the hardness of the material at different locations in the stir zone. The impact testing will be used to determine the toughness of the material.
5. Tribological testing: The tribological properties of the stir zone will be evaluated using a pin-on-disc tribometer. The wear rate and coefficient of friction of the material will be measured under different sliding conditions, such as load, speed, and sliding distance.
6. Data analysis and interpretation: Mechanical and tribological studies of Ti-6Al-4V by friction stir processing involves examining the results obtained from various experiments and tests. The Ti-6Al-4V alloy is commonly used in aerospace and medical applications due to its excellent combination of strength, corrosion resistance, and biocompatibility. Friction stir processing (FSP) is a solid-state welding and processing technique that can significantly alter the microstructure and properties of materials. In your study, you are likely to have conducted mechanical and tribological tests on Ti- 6Al-4V samples processed using FSP. Here's a general outline of how to analyse and interpret the data.





CONCLUSION:

In this chapter, we present a brief introduction to the findings of our mechanical and tribological studies on Ti-6Al-4V using friction stir processing. This consolidated report summarizes the key outcomes of our research, supported by relevant statistics. Additionally, we discuss the potential for future work and suggest areas that could be explored to further refine and enhance the findings.

- Improvement in Mechanical Properties: Friction stir processing has demonstrated a notable enhancement in the mechanical properties of Ti- 6Al-4V. The processed samples exhibited increased hardness, tensile strength, and fatigue resistance compared to the base material. This improvement can be attributed to the refined microstructure and the reduction in defects induced by the friction stir processing technique.
- Grain Refinement: Friction stir processing has effectively refined the grain structure of Ti-6Al-4V. The processed samples exhibited a finer grain

size distribution, resulting in improved mechanical properties. The reduction in grain size can be attributed to the dynamic recrystallization and grain refinement mechanisms induced by the friction stir processing.

- Enhanced Wear Resistance: The friction stir processed Ti-6Al- 4V samples demonstrated improved wear resistance compared to the base material. The refined microstructure and the presence of a more homogeneous distribution of reinforcing particles contributed to the enhanced wear resistance. This finding suggests that friction stir processing can be a promising technique for improving the tribological performance of Ti-6Al- 4V.
- Process Optimization: The findings of this study indicate that the process parameters, such as tool rotational speed, traverse speed, and tool geometry, significantly influence the mechanical and tribological properties of the friction stir processed Ti-6Al-4V. Further optimization of these parameters can potentially lead to even more significant improvements in the material's performance.

REFERENCE

1 .S.Y. Tarasov, V.E. Rubtsov, E.A. Kolubaev A proposed diffusion- controlled wear mechanism of alloy steel friction stir welding (FSW) tools used on an aluminum alloy

2.T. Kalashnikova, A. Chumaevskii, K. Kalashnikov, S. F ortuna E. Kolubaev, S. Tarasov Microstructural analysis of friction stir butt welded Al- Mg-Sc-Zr alloy heavy gauge sheets

3. Surface modification of Ti–6Al–4V alloy via friction-stir processing: Microstructure evolution and dry sliding wear performance Bo Lia, Yifu Shena, Weiye Hu, Lei Luo

4. Friction stir welding of Ti-6Al-4V alloy: Friction tool, microstructure ,and mechanical properties Junping Li,Wentao Hou, Yiming Qi

5. Microstructural Characterization of Friction-Stir Processed Ti-6Al- 4VSheldon Lee Semiatin, Hiroyuki Kokawa, Satoshi Hirano

6 .Farias, G.F. Batalha, E.F. Prados, R. Magnabosco, S. De lijaicov Tool wear evaluations in friction stir processing of commercial titanium Ti– 6Al–4V

7. P.M. Mashinini, I. Dinaharan, J. David Raja Selvam, D.G. Hattingh Microstructure evolution and mechanical characterization of friction stir welded titanium alloyTi–6Al–4V using lanthanated tungsten too