FACTORS AFFECTING THE WEAR AND DAMAGE OF DRAWING TOOLS IN RING ROLLING MACHINES

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Abstract: The wear and damage of drawing tools in ring rolling machines are critical factors that influence the performance, efficiency, and operational lifespan of the machinery. This paper investigates the primary causes of tool wear and damage during the drawing process, emphasizing factors such as material properties, operational conditions, and environmental influences. An in-depth analysis of tool degradation mechanisms, including abrasive wear, adhesive wear, thermal degradation, and fatigue, is presented. Experimental results based on controlled tests are also discussed to understand the extent of wear under different operational parameters. The findings provide recommendations for improving tool life and the efficiency of ring rolling processes.
Keywords: Tool wear, damage, drawing tools, ring rolling machines, wear mechanisms, material degradation, operational parameters

Introduction

Ring rolling machines are widely used in the production of rings and cylindrical parts in industries such as aerospace, automotive, and energy. The drawing tools in these machines play a significant role in shaping metal, and their wear and damage directly affect the productivity, quality of products, and maintenance costs. Over time, the continuous mechanical stress and thermal exposure lead to various types of wear and damage, which can compromise the machine's performance.

Understanding the factors that contribute to tool wear is essential for improving the life of these tools and optimizing the operational processes. This study aims to explore the primary causes of tool degradation in ring rolling machines and identify key parameters that influence tool lifespan.

Materials and Methods

Materials

The drawing tools in this study are made from high-performance alloys, commonly used in the ring rolling industry, such as tool steel and tungsten carbide. These materials are selected for their resistance to wear, thermal conductivity, and toughness.

Experimental Setup

An experimental ring rolling setup was used to simulate the operational conditions. The machine parameters were controlled, including rotational speed, force applied, and temperature, to examine their impact on tool wear. The tests were conducted under varying lubrication conditions to observe the effect of lubrication on wear patterns.

Data Collection and Analysis

Wear and damage of the tools were measured using microscopic imaging techniques, surface roughness analysis, and hardness testing. These measurements allowed for the identification and classification of wear patterns and the quantification of material loss. A series of tests were carried out, and the results were compared to assess the effects of operational parameters on wear rates.

Results

Wear Mechanisms

The primary wear mechanisms observed during the tests included:

- **Abrasive Wear**: Caused by hard particles or debris between the tool and the workpiece, leading to surface roughness and material loss.
- **Adhesive Wear**: Occurred when the metal being rolled adhered to the surface of the tool, causing material transfer and subsequent tool surface damage.
- **Thermal Degradation**: High temperatures generated during the rolling process led to thermal fatigue, cracking, and softening of the tool material.
- **Fatigue Wear**: Repeated cyclic loading of the tools resulted in the formation of microcracks, which led to material failure over time.

Wear/Impact Factors	Description	Operating Conditions	Effects and Notes
Abrasive Wear	Occurs when hard particles or debris are present between the tool and material, causing surface damage.	High speed, high force, hard materials	Common at high operational speeds, degrades tool surface.
Adhesive Wear	Occurs when the material being rolled adheres to the tool's surface, causing material transfer.	Low-quality lubrication, sticky materials	Material transfer to the tool surface, can be minimized with proper lubrication.
Thermal Degradation	High temperatures cause softening, cracking, and weakening of the tool material.	High temperatures, prolonged use	Rapid heating and cooling can weaken the material; cooling systems are critical.
Fatigue Wear	Repeated loading cycles result in the formation of microcracks in the tool material.	Repetitive loads and stresses	Leads to cracks and eventual failure of the tool after continuous use.
Corrosion	Occurs due to chemical or electrochemical reactions on the tool surface.	Exposure to moisture, chemicals	Accelerates under high humidity and chemical exposure, reducing tool life.

High-Speed Wear	The tool wears out quickly at high surface speeds due to friction and heat.	High speed, high pressure	Causes surface roughness and increased material loss at high speeds.

Impact of Operational Parameters

The results showed that higher rolling speeds and increased force applied during the drawing process significantly accelerated wear. Increased temperatures were found to exacerbate thermal degradation, especially in high-load conditions. The use of lubrication reduced abrasive wear, but adhesive wear remained a significant issue in the absence of sufficient lubrication.

Tool Material Performance

The tools made from tungsten carbide demonstrated better resistance to wear compared to tool steel, particularly under high-temperature and high-stress conditions. However, even tungsten carbide tools showed signs of fatigue wear after extended use.

Discussion

The results of the study reveal that tool wear in ring rolling machines is a multifactorial phenomenon influenced by both material properties and operational conditions. Abrasive and adhesive wear were found to be the most common types of degradation under typical operational conditions. The presence of lubrication proved to be beneficial in mitigating abrasive wear but was less effective in preventing adhesive wear, which requires more attention in tool design and process optimization.

Thermal degradation was identified as a significant factor in high-speed rolling processes, suggesting that temperature control could be a key strategy for prolonging tool life. Additionally, the material selection plays a critical role in tool longevity, with advanced materials like tungsten carbide offering superior performance in harsh conditions.

Conclusion

The wear and damage of drawing tools in ring rolling machines are influenced by a combination of operational parameters and material properties. High speeds, increased forces, and elevated temperatures accelerate wear, while the use of appropriate lubrication can help mitigate abrasive wear. The choice of tool material is crucial for optimizing tool life, with advanced materials providing improved resistance to wear and thermal degradation. Future research should focus on improving lubrication techniques, temperature control, and material properties to enhance the efficiency and longevity of tools used in ring rolling machines.

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