



DEVELOPMENT AND APPLICATION OF SECONDARY METAL AND POLYMER MATERIALS IN BEARING PRODUCTION

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Abstract. This study comprehensively examines the potential of using secondary metal and polymer materials in the production of bearings. Bearings are essential components in mechanical systems, and adopting sustainable production practices can significantly reduce environmental impact. The research evaluates the mechanical, tribological, and environmental properties of bearings made from recycled materials, comparing them with those made from primary raw materials. Findings indicate that secondary materials can provide cost-effective and environmentally friendly alternatives without sacrificing essential performance characteristics. The study also highlights the potential of innovative processing methods and advanced recycling technologies to enhance product quality.

Keywords: Bearings, secondary metals, recycled polymers, sustainable production, tribological properties, mechanical properties, eco-friendly materials, industrial application, waste management, circular economy, advanced recycling technologies.

1. Introduction. The global demand for bearings continues to rise due to their essential role in various industries, from automotive to aerospace. Traditionally, bearing production relies on high-grade metals and polymers, leading to significant environmental concerns related to resource depletion and waste generation. Utilizing secondary materials, including recycled metals and polymers, offers a promising solution to reduce environmental impact while maintaining production efficiency

[1]. This paper investigates the feasibility of using secondary materials in bearing production, focusing on their mechanical properties, durability, and industrial applicability. It also explores strategies for improving the quality and performance of bearings through enhanced recycling methods and technological innovations.

Research Questions:

- Can secondary metals and polymers be effectively used in bearing production without compromising quality and performance?
- What environmental and economic advantages arise from using recycled materials in bearing manufacturing?
- How can advanced technologies improve the integration of secondary materials into bearing production processes?

2. Methods. The study was conducted in three main stages: material preparation, performance testing, and advanced processing evaluation.

2.1. Material Preparation. Secondary metals, including recycled steel, aluminum alloys, and brass, were sourced from industrial scrap yards. Recycled polymers such as polyamide, polyethylene, and polypropylene were obtained from post-consumer waste. The materials were refined, processed, and prepared for bearing production using conventional casting, molding, and additive manufacturing techniques.

2.2. Performance Testing. The following tests were conducted to evaluate the mechanical, tribological, and chemical properties of the produced bearings:

- **Hardness Test (ASTM E18):** Evaluates surface hardness.
- **Wear Resistance Test (ASTM G99):** Assesses material wear under different loads.
- **Tensile Strength Test (ASTM E8):** Measures maximum tensile strength.
- **Friction Coefficient Test:** Determines friction behavior in dynamic conditions.
- **Corrosion Resistance Test:** Evaluates resistance to chemical degradation in various environments [2].

2.3. *Advanced Processing Evaluation.* Advanced techniques such as heat treatment, surface coating, and composite layering were applied to enhance the performance of recycled materials. These processes aimed to improve wear resistance, load capacity, and environmental stability.

3. Results. The experimental results demonstrated that bearings made from secondary metals and polymers exhibited comparable performance to those made from virgin materials. Key findings include:

- **Mechanical Properties:** Bearings made with secondary steel alloys had a tensile strength only 7% lower than those made from primary steel, still within acceptable industrial standards.
- **Wear Resistance:** Bearings containing recycled polymers demonstrated slightly higher wear rates but maintained operational reliability.
- **Friction Coefficient:** The frictional performance remained stable across all tested samples, with differences of less than 5%.
- **Corrosion Resistance:** Secondary metal bearings showed moderate resistance to corrosion, suitable for low-to-medium load applications [3].
- **Surface Quality:** Bearings treated with protective coatings displayed improved resistance to wear and environmental degradation.

4. Discussion. The findings suggest that using secondary materials in bearing production can reduce raw material costs while minimizing environmental impacts. Although slight reductions in mechanical properties were observed, the materials remained within industry specifications. Cost savings could be substantial due to reduced raw material expenses and lower waste management costs.

The successful application of recycled metals and polymers aligns with sustainability goals and supports the circular economy. However, optimizing production methods and material compositions is crucial to improving product performance further. Future research should explore innovative processing

techniques such as additive manufacturing, hybrid composites, and advanced recycling technologies [4].

Additionally, advanced quality control measures, including non-destructive testing and real-time monitoring, could enhance the reliability of recycled material applications. Investment in specialized recycling facilities may also boost efficiency and reduce contamination risks.

Environmental policies supporting recycling and sustainable manufacturing should be strengthened to encourage the adoption of eco-friendly materials in the bearing industry. International collaboration among manufacturers, research institutions, and policymakers can facilitate the development of a sustainable production ecosystem.

5. Conclusion. This research confirms that secondary metals and polymers can be effectively used in bearing production, offering viable alternatives to traditional materials. Their application can lead to economic and environmental benefits, making bearing production more sustainable. Additional studies focusing on long-term durability, scaling production methods, and integrating cutting-edge recycling technologies are recommended to advance the adoption of recycled materials in the bearing industry [5].

Overall, the implementation of secondary materials in bearing production not only addresses environmental challenges but also opens avenues for innovation in product design and material engineering. This approach supports the development of a circular economy while ensuring industrial competitiveness and ecological responsibility.

6. Future Recommendations. Future research should expand on:

- Exploring hybrid materials combining metals and polymers for enhanced performance.
- Developing advanced recycling technologies to increase the purity of recovered materials.

- Conducting long-term field tests to validate industrial-scale applications.
- Establishing industry standards for recycled material-based bearings.
- Investing in automated processing systems to reduce production costs.
- Strengthening partnerships between academia, industry, and government to accelerate innovation.

These measures will pave the way for a more sustainable and efficient bearing production industry while fostering technological advancement and ecological responsibility.

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