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Manufacturing of Brake Pads and Brake Shoes Through Additive Manufacturing with Boron Carbide (B^4C) and Molybdenum Disulfide (MoS^2) as Additives

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Abstract: An essential component of car performance and safety is the production of brake shoes and pads. This study investigates how to improve these components by incorporating innovative materials using additive manufacturing techniques. Because of their special qualities, molybdenum disulfide (MoS2) and boron carbide (B4C) are used as additives. MoS2, which is well-known for its solid lubricating qualities, seeks to improve the frictional properties, while B4C, which is recognized for its extraordinary hardness, is added to increase wear resistance. Brake component performance can be maximized by precisely controlling the material composition and complex designs through the use of additive manufacturing. The combination of B_4C and MoS_2 provides a well-rounded solution by tackling the wear and friction issues that are essential for efficient braking. In order to obtain increased frictional stability, decreased wear rates, and greater durability, this study looks into the best ratios and distribution of these additives. This study seeks to contribute to the development of next generation brake systems, ensuring improved safety, efficiency, and lifetime in automotive applications by utilizing modern manufacturing techniques and combining B4C and MoS2. The results are anticipated to have an impact on the production of high-performance components with customized material qualities in the automobile industry as well as the larger field of additive manufacturing.
Keywords: Additive Manufacturing, material Fusion, Efficiency of Brake, Analysis of brake, Testing of brakes

I. INTRODUCTION

The automotive industry has witnessed significant advancements in recent years, driven by the pursuit of enhanced performance, increased durability, and sustainable manufacturing practices. Among the critical components contributing to vehicle safety and performance, brake pads and brake shoes play a pivotal role in ensuring reliable braking systems. Traditionally, these components have been manufactured using conventional methods, but the advent of additive manufacturing technology has opened up new avenues for innovation and improvement. Additive manufacturing, also known as 3D printing, offers unparalleled flexibility and precision in creating intricate structures and customized parts. By layering materials based on digital designs, additive manufacturing enables the production of complex geometries with minimal material waste. This technology has revolutionized various industries, including aerospace, healthcare, and automotive, by providing cost-effective solutions and shortening lead times.

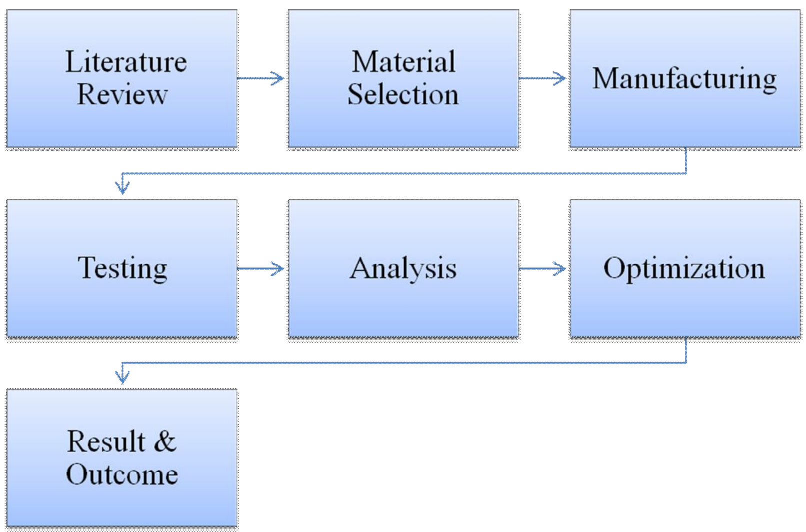
In the context of brake pad and shoe manufacturing, additive manufacturing presents unique opportunities for optimizing performance and durability. The integration of advanced materials such as Boron Carbide (B_4C) and Molybdenum Disulfide (MoS2) as additives further enhances the capabilities of these critical components. B_4C, known for its exceptional hardness and thermal stability, reinforces the brake pads and shoes, improving wear resistance and performance under high temperatures. MoS2, on the other hand, acts as a solid lubricant, reducing friction and heat generation during braking, thereby enhancing efficiency and longevity. The utilization of B_4C and MoS2 in additive manufacturing processes offers several advantages over traditional manufacturing methods. One of the key benefits is the ability to precisely control material composition and distribution, resulting in optimized performance characteristics tailored to specific application requirements. Additionally, additive manufacturing allows for rapid prototyping and iteration, facilitating faster product development cycles and time-to-market.Moreover, additive manufacturing with B_4C and MoS2 additives supports sustainability initiatives by reducing material waste and energy consumption compared to conventional manufacturing processes. The ability to recycle and reuse materials further contributes to environmental conservation efforts, aligning with the automotive industry's commitment to eco-friendly practices.

In this context, this paper aims to explore the potential of additive manufacturing for the production of brake pads and shoes integrated with B_4C and MoS2 additives.
Through comprehensive analysis and experimentation, we seek to elucidate the impact of additive manufacturing parameters on the performance, durability, and sustainability of these critical automotive components. By harnessing the capabilities of additive manufacturing and advanced materials, we aim to contribute to the advancement of brake technology and pave the way for safer, more efficient vehicles in the future.

II. OBJECTIVE

The main objective of our project is to
1) Develop and enhance brake pad and shoe materials using B_4C and MoS_2 additives.
2) Improve the structural integrity of additive manufacturing parameters.
3) Tests on friction coefficient and wear resistance are used to gauge braking performance.
4) Evaluate the longevity and dependability under various circumstances.
5) Examine the environmental and cost-effectiveness effects.
6) Make sure safety standards are met and regulations are followed.

III.METHODOLOGY



IV..DESIGN

FIG 0: CAD Model

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V. MATERIALS USED

A. Boron Carbide (B_4C)

A substance that is notable for its exceptional hardness and distinct chemical characteristics is boron carbide, or B4C. Boron carbide, which is made up of carbon and boron in a 1:4 ratio, is considered to be the second hardest substance in the world after diamond. Its remarkable mechanical strength is attributed to the icosahedral (B12) and linear (CBC) structural units found in its crystal lattice structure. Boron carbide is a highly desirable material for use in cutting tools, abrasives, and ballistic armour because of its remarkable resistance to wear and abrasion and high density, which ranges from 2.50 to 2.62 g/cm³. In addition to being hard, boron carbide has good thermal conductivity and a very high melting point of about 2,350 degrees Celsius.

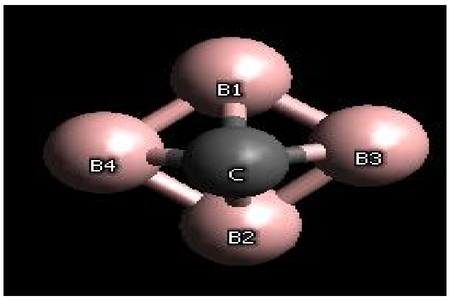


FIG 1– B4C structure


FIG 2– Boron Carbide material

B. Molybdenum Disulfide (MoS_2)

One substance that stands out for its wide range of qualities and adaptable uses in a variety of sectors is molybdenum disulfide (MoS2). Made up of atoms of sulphur and molybdenum stacked one on top of the other, MoS2 is known for its solid lubricating qualities. The structure is made up of layers of molybdenum atoms sandwiched between layers of sulphur atoms. This allows the layers to readily slide past one another and provides great lubrication. MoS2 exhibits exceptional thermal stability, rendering it appropriate for use in settings with increased temperatures. Because of its inert and oxidation-resistant chemical makeup, MoS2 offers stability under a range of operating circumstances. MoS2 is useful for lubrication, but it also has semiconductor qualities that make it interesting for materials science and electronics.

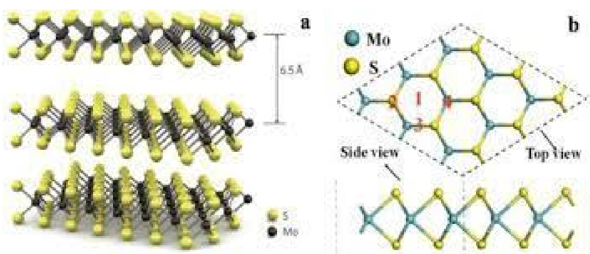


FIG 3 MoS2 Structure


FIG 4 Molybdenum Disulphite material

C. Phenol Resin

Phenol resin, also known as phenolic resin, is a thermosetting polymer derived from the chemical reaction between phenol (an aromatic hydrocarbon) and formaldehyde. This versatile and widely used synthetic resin is valued for its excellent mechanical and thermal properties, making it a popular choice in various industrial applications. Phenol resins are characterized by their three-dimensional cross-linked structure, formed during the curing or hardening process. This chemical structure contributes to the material's exceptional durability and resistance to heat.


FIG 5 Phenol resin

D. Reinforcements

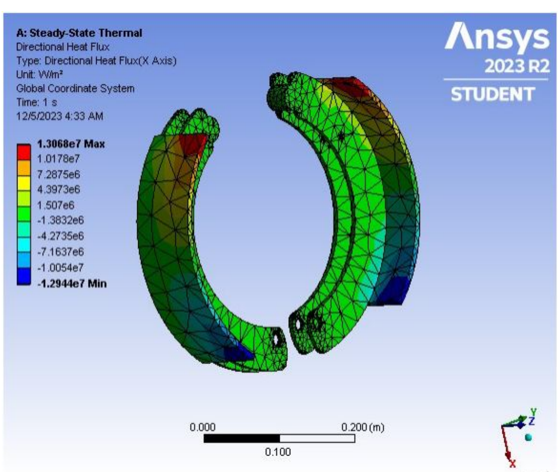
1) *Aramid Fiber:* Synthetic fibres with a high modulus, remarkable strength, and abrasion resistance are known as Aramid fibres. One example of an Aramid fibber is Kevlar. Aramid fibres are made up of long-chain polyamide molecules and have an amazing range of characteristics, one of which is a high tensile strength-to-weight ratio. This makes them the perfect option for uses requiring lightweight, high-strength materials, like advanced composites, aerospace components, and ballistic protection. Aramid fibres are also well-known for being heat- and chemical-resistant, which makes them useful reinforcements in a variety of sectors.

FIG 6 Aramid fiber

2) *Steel Fiber:* To improve the structural integrity and toughness of concrete and other composite materials, steel fibres are metallic reinforcements that are usually added. These fibres come in a variety of diameters and forms and are frequently constructed from carbon steel or stainless steel. Steel fibres boost tensile strength and ductility in materials like concrete, which lowers the risk of brittle fracture. Steel fibres are very useful in materials that are subjected to dynamic loads, such shot Crete for tunnel support, industrial floors, and tunnel linings.

FIG 7 Steel fiber

VI. ANALYSIS (VIA ANSYS)



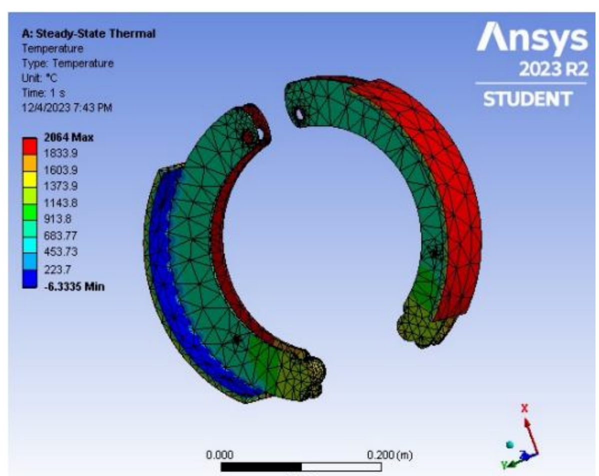


Fig 8- directional heat flux analysis Fig 9 -Temperature analysis

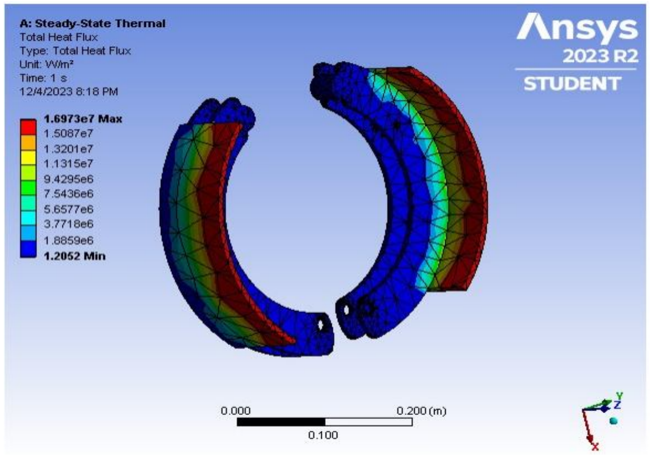


FIG 10 - TOTAL Heat flux Analysis

VII. RESULTS AND DISCUSSION

The manufacturing of brake pads and brake shoes through additive manufacturing, incorporating Boron Carbide (B4C) and Molybdenum Disulfide (MoS2) as additives, represents a cutting-edge approach to enhance the performance and durability of braking systems. Boron Carbide, known for its exceptional hardness, is utilized to improve the wear resistance and abrasion durability of the brake components, ensuring prolonged service life. Molybdenum Disulfide, with its solid lubricating properties, serves as an effective friction modifier, reducing the coefficient of friction and enhancing the overall braking efficiency while minimizing wear on the braking surfaces. The additive manufacturing process allows for intricate designs and precise control over material composition, enabling the production of customized brake components tailored to specific performance requirements. This innovative combination of B4C and MoS2 in additive manufacturing not only contributes to superior braking performance but also addresses challenges related to heat dissipation and friction, ultimately leading to the development of advanced and efficient braking systems for diverse applications.

VIII. CONCLUSIONS

In conclusion, a promising path toward revolutionizing the production of brake pads and shoes is presented by the combination of additive manufacturing techniques with the addition of additives such as molybdenum disulfide (mos2) and boron carbide (B4C). Manufacturers can obtain unmatched control over material composition and distribution by utilizing additive manufacturing's accuracy and versatility. This will result in brake components with improved performance characteristics. Mos2 functions as a solid lubricant, lowering friction and heat generation during braking, while the addition of B4C improves wear resistance and thermal stability. These developments lead to increased efficiency and safety as well as the development of more ecologically friendly manufacturing techniques. Furthermore, although though the initial costs of the materials may be greater, the brake components' longer lifespan may result in cost savings due to increased performance and durability. All things considered, the car industry may make great strides toward safer, more effective, and environmentally friendly braking systems if additive manufacturing using B_4C and MoS_2 additives were to become more widespread.

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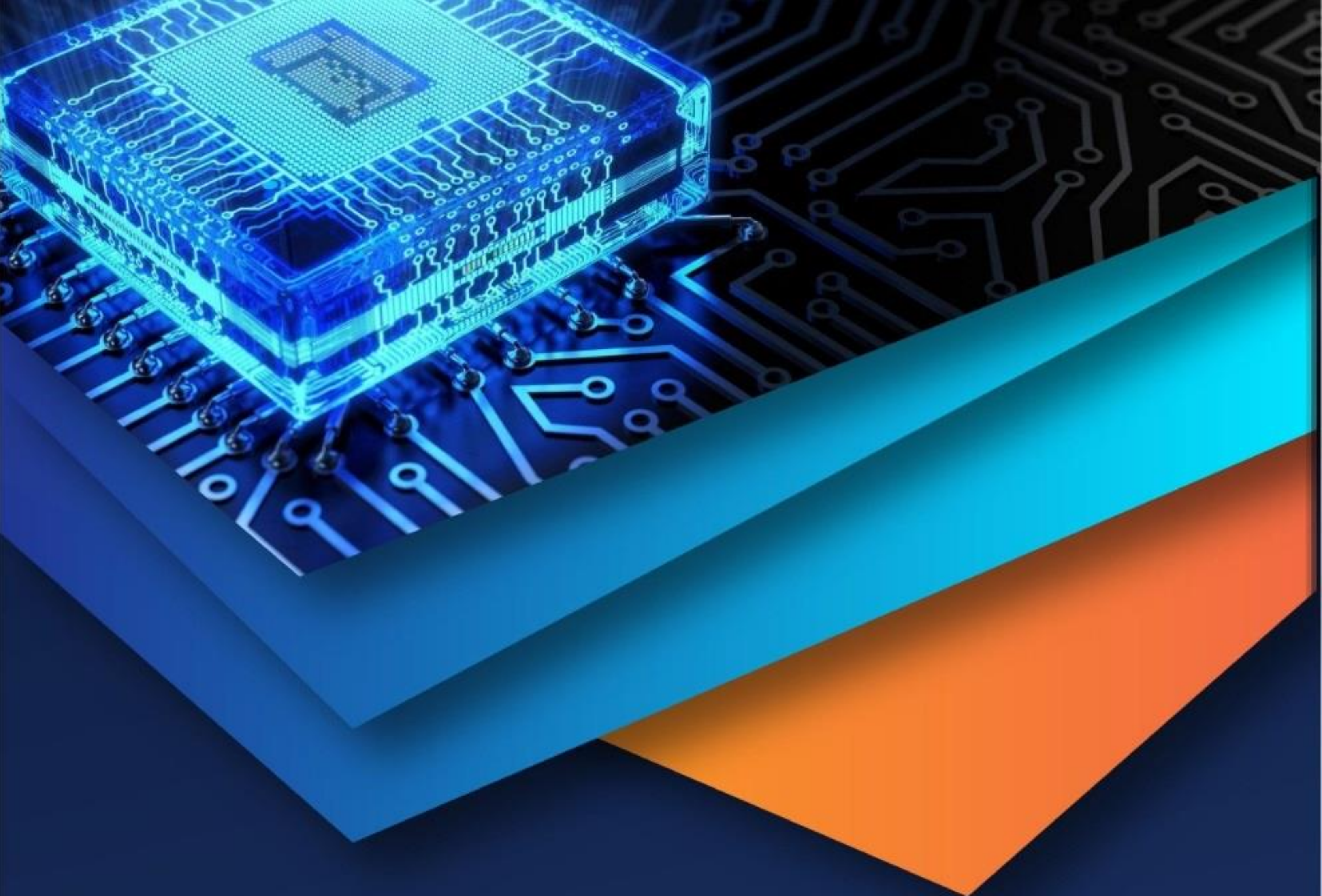

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