DEVELOPMENT OF CERAMIC BRAKE PADS IN MOEDERN VEHICLES

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Abstract - This project aims to investigate, develop and optimize ceramic brake pads for improved performance in automotive applications in low cost with same performance as like the normal ceramic brake pads in the market. In today's scenario, the ceramic brake pads are majorly used in the high-cost cars due to its performance. Cost of the brake pads are high due to the performance. So, this project is based on to reduce the cost of the brake pad with alternate materials. The study will involve in comprehensive exploration of ceramic materials including fibers, fillers, binding resins and abrasive components with the objective of formulating an advanced brake pad composition. The project will employ various testing methodologies to assess the mechanical, thermal and frictional properties. This brake pad can be used in all types of modern vehicles due to its low cost and hence it replaces normal brake pads to ceramic brake pads. The result of the project will contribute in the development of ceramic brake pads in the normal modern vehicles.

Key Words: Silicon carbide, Titanium dioxide, Magnesium carbonate, Epoxy resin, Carbon, Aluminium oxide.

1. INTRODUCTION

Brake pads are integral components of automotive braking systems, crucial for ensuring vehicle safety and performance. Traditional brake pad materials, often composed of asbestos and heavy metals, pose significant environmental and health risks during production, use, and disposal. As the automotive industry moves towards sustainable practices, there is a pressing need for innovative brake pad formulations that offer improved performance while reducing costs and environmental impact. This study presents a novel approach to address these challenges through the development of low-cost ceramic brake pads. The primary objective of this project is to introduce a cost-effective alternative to conventional brake pad materials without compromising on safety or performance. To achieve this goal, we have leveraged a combination of advanced materials including silicon carbide (SiC), magnesium carbonate ($MgCO_3$), aluminum oxide (Al_2O_3), titanium dioxide (TiO_2), barium carbonate ($BaCO_3$), calcium carbonate ($CaCO_3$), carbon, and epoxy resin. By combining these materials in a carefully engineered formulation, we aim to demonstrate the feasibility of producing ceramic brake pads that meet or exceed industry standards for performance, durability, and cost-effectiveness. The outcomes of this research have the potential to significantly impact the automotive industry by offering a sustainable solution for braking systems, reducing environmental impact, and enhancing overall safety and reliability.

2. LITERATURE REVIEW

Mahammad Rasul, Byra Reddy, 2015, the author highlights the importance of the material selection in the addressing thermal elastic instability in disc brake rotors. Through transient thermal and structural analysis, it is evident that metal-ceramic and FGM materials offer superior thermal conductivity and structural integrity compared to traditional materials like gray cast iron. These findings underscore the potential of advanced materials in enhancing the performance and safety of automotive braking systems, paving the way for more efficient and reliable disc brake designs. Which can be useful for designing ceramic brake pads.

Guangyu Bian, the author concludes that with increasing concerns about environmental pollution and resource depletion, there is growing interest in developing sustainable brake pad materials. Ceramic brake pads offer several environmental benefits, including reduced emissions of harmful particulates, longer service life, and recyclability. By minimizing the use of toxic substances such as heavy metals and asbestos, ceramic brake pads contribute to a cleaner and healthier in an automotive ecosystem.

Briscoe B.J., Tweedale P.J. Aramid fiber friction: A replacement for asbestos in high friction materials. Proceedings of conference on tribology of composites materials, ASM international

3. METHODOLOGY

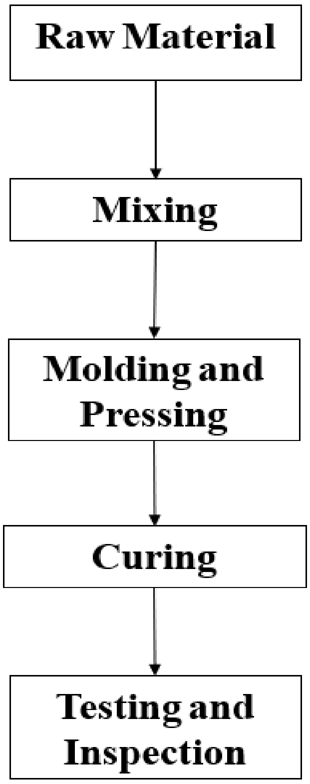


Figure 1 Methodology

4. PROPOSED SYSTEM

The proposed system represents a comprehensive approach to the development and implementation of low-cost ceramic brake pads. Beginning with meticulous material selection, including silicon carbide (SiC), magnesium carbonate ($MgCO_3$), aluminum oxide (Al_2O_3), titanium dioxide (TiO_2), barium carbonate ($BaCO_3$), calcium carbonate ($CaCO_3$), carbon, and epoxy resin, the system prioritizes components that balance the performance and the cost-effectiveness, and also the environmental sustainability. Through careful formulation design, the system optimizes the composition of the brake pads to meet stringent performance standards, encompassing friction coefficient, wear resistance, thermal stability, and mechanical strength. The manufacturing process is meticulously orchestrated, encompassing mixing, compounding, molding, curing, heat treatment, and finishing stages, ensuring the production of brake pads with consistent quality and durability. Rigorous performance testing validates the efficiency of the developed ceramic formulations, with metrics including friction coefficient, wear rate, thermal conductivity, compressive strength, and noise levels evaluated under simulated braking conditions. Continuous analysis and optimization drive refinement, with a focus on enhancing performance while minimizing costs and environmental impact. Ultimately, the integration of these ceramic brake pads into automotive applications promises to revolutionize braking technology, offering a sustainable and cost-effective solution that prioritizes safety, performance, and environmental responsibility.

5. MANUFACTURING PROCESS

Purchase and keep the raw materials in a closed and safe place. First take the silica carbide, weight it and add 18 grams into the mixing bowl. Then take the Aluminum oxide, Barium carbonate and add 26 grams each. After that, take Calcium carbonate and add 26 grams of it. Now take Titanium dioxide, Carbon and add 24 grams and 18 grams each. At last, add 36 grams of epoxy and hardener as the bonding agents. Now mix all the materials perfectly for 10 to 15 minutes. Apply the mold wax on the mold and pour the mixed material into it. Keep the mold in the Hot Press machine and apply the hydraulic pressure of 120 bar at 150 centigrade temperatures. After pressing, keep the mold in oven (curing process) for 30 minutes at 160 centigrade. Keep the mold aside for cooling and after cooling grind the material for the good surface finish. Now different test will be performed on the brake pad.

Figure 2 Pouring material

Figure 3 Curing Press

Figure 4 Final product

5. MANUFACTURING PARAMETERS

S. No .	Materials	Compo sition %	Composit ion weight
1	SILICA CARBIDE	9	18
2	ALUMINIU M OXIDE	13	26
3	BARIUM CARBONAT E	13	26
4	CALCIUM CARBONAT E	13	24
5	MAGNESIU M CARBONAT E	9	18
6	TITANIUM DIOXIDE	12	24
7	CARBON	13	26
8	EPOXY RESIN AND HARDENER	18	36

Table 1 Material composition

Hot press pressure > 120 bar

Hot press temperature > 150 centigrade

Hot press time > 15 minutes

Heating medium > steam

Curing temperature > 160 centigrade

Curing time > 30 minutes

6. DESIGN & SOFTWARE ANALYSIS

At first, before starting the manufacturing process the brake pad will be designed in some software's to find out some properties like hardness, strength, wear or abrasion test and thermal conductivity test.

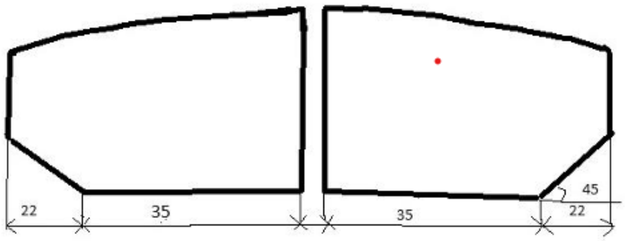


Figure 5 Basic design

6.1 STRUCTURAL ANALYSIS

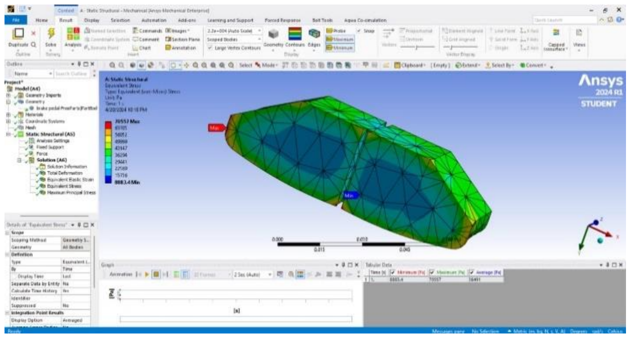


Figure 6 Structure analysis

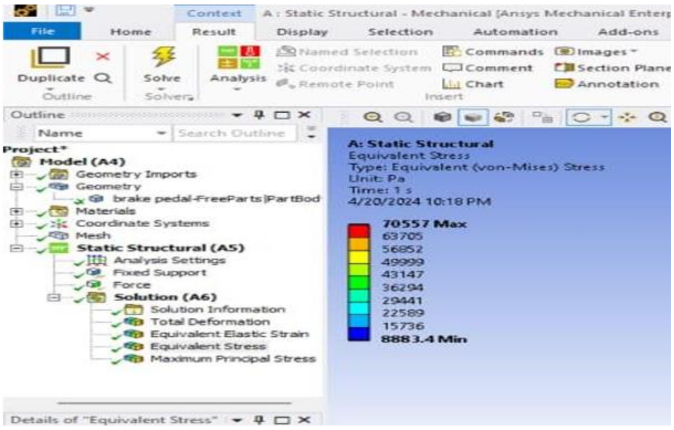
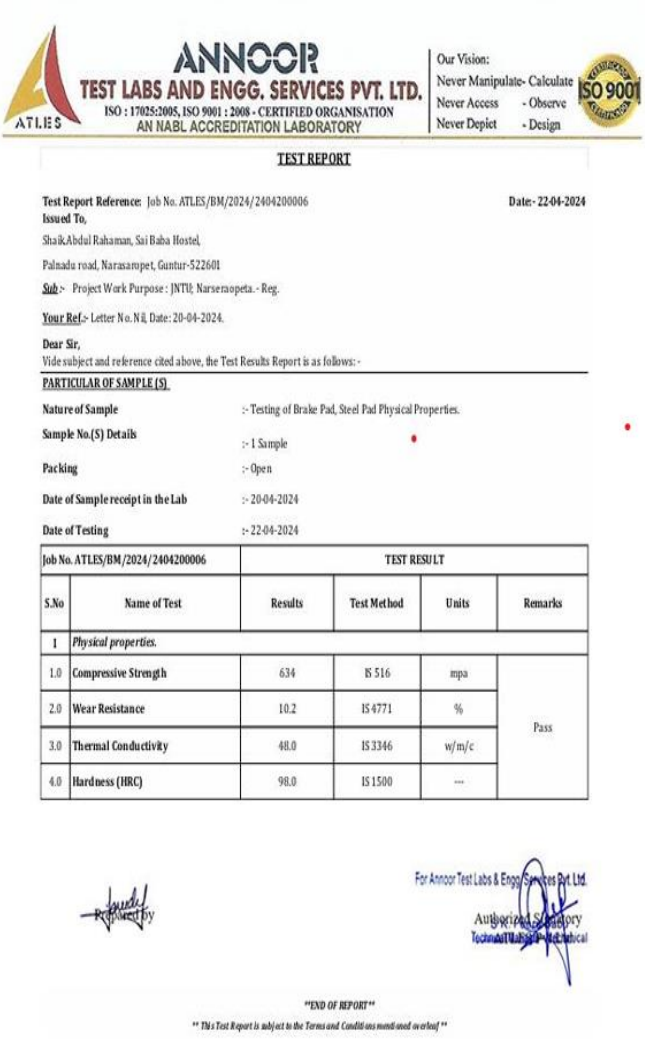


Figure 7 Stress result

7. RESULT

We have done four tests for our brake pads which are compression test on UTM machine, wear resistance test, thermal conductivity test and hardness test on Rockwell hardness testing machine and we found the result values as shown in the figure.



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TEST REPORT

Test Report Reference: Job No. ATLES/BM/2024/2404200006 **Date:- 22-04-2024**
Issued To,
Shaik Abdul Rahaman, Sai Baba Hostel,
Palnadu road, Narasaropet, Guntur-522601
Sub :- Project Work Purpose : JNTU; Narseraopeta. - Reg.
Your Ref.:- Letter No. Nil, Date: 20-04-2024.

Dear Sir,
Vide subject and reference cited above, the Test Results Report is as follows: -

PARTICULAR OF SAMPLE (S)

Nature of Sample :- Testing of Brake Pad, Steel Pad Physical Properties.
Sample No.(S) Details :- 1 Sample
Packing :- Open
Date of Sample receipt in the Lab :- 20-04-2024
Date of Testing :- 22-04-2024

Job No. ATLES/BM/2024/2404200006		TEST RESULT			
S.No	Name of Test	Results	Test Method	Units	Remarks
1	*Physical properties.*				
1.0	Compressive Strength	634	IS 516	mpa	Pass
2.0	Wear Resistance	10.2	IS 4771	%	
3.0	Thermal Conductivity	48.0	IS 3346	w/m/c	
4.0	Hardness (HRC)	98.0	IS 1500	---	

Prepared by

For Annoor Test Labs & Engg Services Pvt Ltd.
Authorized Signatory

END OF REPORT
** This Test Report is subject to the Terms and Conditions mentioned overleaf **

Figure 8 Lab test results

PARAMETERS	AVERAGE VALUES	OUR VALUES
HARDNESS	90-120HRC	98HRC
COMPRESSION STRENGTH	650-800MPA	634MPA
WEAR RESISTANCE	9-15%	10.2%
THERMAL CONDUCTIVITY	50-55w/m/c	48w/m/c

Table 2 Comparison of test values

PARAMETERS	OUR'S COST IN RUPEES	MARKET PRICE IN RUPEES
MATERIAL COST	3000	-
MATERIAL COST PER GRAM	1.133	-
MATERIAL COST PER PIECE	226.33	-
FOR SET OF 4 PIECES	906.66	-
MANUFACTURING AND OTHER COST	230+70	-
TOTAL COST	**1206.66**	**1400-1600**

Table 3 Cost comparison

6. CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

In conclusion, the proposed system for the development of low-cost ceramic brake pads offers a promising solution to the challenges facing the automotive industry. By leveraging a carefully engineered formulation and advanced manufacturing techniques, this system demonstrates the feasibility of producing ceramic brake pads that meet or exceed industry standards for performance, durability, and cost-effectiveness.

Throughout the development process, key considerations such as material selection, formulation design, manufacturing processes, and performance testing have been meticulously addressed. The integration of innovative materials such as silicon carbide and magnesium carbonate, along with optimized compositions of aluminum oxide, titanium dioxide, barium carbonate, calcium carbonate, carbon, and epoxy resin, has resulted in brake pads with superior frictional properties, thermal stability, and wear resistance.

Furthermore, the systematic approach to manufacturing, including mixing, compounding, molding, curing, heat treatment, and finishing, ensures the production of brake pads with consistent quality and reliability. Comprehensive performance testing validates the efficiency of the developed ceramic formulations, highlighting their suitability for a wide range of applications in the automotive industries.

Moreover, there are the emphasis on cost-effectiveness and also the environmental sustainability underscores the broader implications of this system. By minimizing production costs, reducing reliance on hazardous materials, and optimizing manufacturing processes, the developed ceramic brake pads offer a viable alternative to traditional friction materials while mitigating environmental impact.

6.2 FUTURE SCOPE

In the future, ceramic brake pad development holds immense potential for advancing automotive safety, performance, and sustainability. Further research into advanced materials, such as nanocomposites and alternative binders, promises to enhance frictional properties and durability while reducing costs. Optimization of manufacturing processes and integration of smart technologies offer opportunities for improved efficiency, reliability, and predictive maintenance. Environmental sustainability remains a key focus, with ongoing efforts to reduce the environmental footprint through eco-friendly materials and production methods. Expansion into emerging markets, customization for specific applications, and comprehensive lifecycle analysis are essential for driving market growth and informing decision-making. By embracing innovation and collaboration, the future of ceramic brake pads is poised to revolutionize automotive braking technology, paving the way for a safer, cleaner, and more efficient transportation ecosystem.

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