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Study on Tribological Investigations of Alternative Automotive Brake Pad Materials

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Abstract: *Brake is a component which plays an important role in automobile with respect to safety and performance. The function of the braking system in an automobile is to slow down or completely stop the vehicle by converting its kinetic energy into heat energy by means of friction. Due to friction heat is generated at the pad and rotor interface; therefore the brake pad should quickly absorb heat to withstand at the higher temperatures and not to wear out. Hence the objective of this paper is to discuss different environment friendly and healthy alternative materials to asbestos. In order to meet different requirements of brake performance, friction materials for brake pads is made up of various constituents like binders, filler material, additives ,modifiers, reinforcing elements and by changing them or altering their percentage will affect the triboligical properties. Generally the brake pads are made up of asbestos material which has ample mechanical, physical and tribological properties but it has found to be carcinogenic in nature, thus its use is obsoleted. Formulations are made by varying the compositions of fillers, binders, fiber and its effect on tribological properties such as friction and wear of brake pad are studied.*

Keywords: *Asbestos, friction material, reinforcing elements, tribological properties, wear*

I. Introduction

Brake is a vital component of the automobile system. The braking operation starts with the application of pedal force by the driver which squeezes the brake pads against the rotor which slows down or stop the vehicle. Due to squeezing, pads transfer the friction force to the rotor causing the deceleration in the speed of rotor[2]. Friction between pad and rotor causes tremendous release of heat. To withstand such a high temperature the brake pad material should quickly absorb the heat and also sufficiently high coefficient of friction with brake disc and it should not break down at high temperatures. The friction at the interface on sliding between pad and disc contact causes wear of pad material surface. Wear makes the brake pad thinner and increase clearance between pad and disc surfaces which causes decrease in a brake performance.Brake pads systems in automobiles should possess good wear resistance, stable coefficient of friction for its service life, high thermal conductivity, and low thermal expansion properties.

I.1 Characterization of Materials:

Friction lining has a direct contact with rotor converting kinetic energy into thermal energy. Therefore it is the most critical from high performance point of view. In the past years asbestos is used for brake pads because of its ample physical, mechanical and tribological properties, but because of its carcinogenic behavior which leads to cancer, its use is obsoleted. This generates the need for alternative to asbestos which can compensate for all the required mechanical, physical and tribological properties.A composite of brake pads consist of structural materials, matrix, filler, abrasives and lubricants, with each component plays different role for enhancing braking performance. In braking application there is a release of wear particles in the form of elements with organic and inorganic compounds. In order to achieve certain properties, the formulation of brake pads are continuously changed for improvements[4]. A commercial brake pad consists of more than 10 ingredients. These are like reinforcing fibers, fillers, binders, frictional additives (abrasives and lubricants). The reinforcing elements are added to provide mechanical strength. Generally glass fiber or aramid are added as a reinforcing elements. Fillers are used in excess quantity to balance the composition and also to reduce the cost. It increases the manufacturability. Functional fillers are added to the composition to enhance particular characteristic like resistance to fade. Binders are induced to hold all the constituents together [5]. The heat generated during braking operation increases the temperature at the interface resulting in the degradation of frictional force, therefore a binder resin such as phenolic resign should be heat resistant. Frictional additives like lubricants and abrasives are used to increase the friction coefficient and to remove the undesirable film form during braking and to stabilized the developed friction coefficient respectively.

In this review paper some environment friendly alternatives to asbestos material are suggested with their characteristics. Also the materials with different percentage of ingredients are studied for their wear and friction characteristics.

I.2 Characteristics of Brake lining Material [5]:

The brake lining material should have following characteristics:

1. It should have high coefficient of friction.
2. The material should resist wear effect.
3. The material should have good thermal conductivity and high heat capacity.
4. The material should not decompose or break down at high temperature so that the coefficient of friction should compromised.
5. The material should be light in weight i.e have a low specific weight.
6. The material should be cost effective and available easily.

I.2.1 Semi metallic Pads:

These type of pads constitutes about 30 to 40% of metallic fibers and fillers like steel, copper, iron with others elements like binders and lubricants. These pads have excellent heat resistance[8]. Semi-metallic pads are more susiptible to cause noise and vibrations and also produces dust. They provide medium coefficient of friction ranges from 0.28- 0.38 with a good fade resistance[11]. Generally these are inferior to noise, vibration and harshness compared to NAO's. Also they have comparatively of low cost. In this composition elements like zircosil, copper fibers, barrites, nitride butadiene rubber are used which gives good tribological properties.

I.2.2 Non- Asbestos Organic Pads:

These pads are also referred as ceramic pads. They typically contain non- ferrous metals and organic fibers, lubricants, abrasives and property modifiers such as glass, rubber, Kevlar and carbon. They constitutes for about 15% of metal fibers with remaining other constituents. An advantage of this material is that they do not pollute as they wear of and their disposal is also easier[11]. Ceramics have better heat transfer capacity because of metal fiber and they are also light in weight. Ceramic pads work with the coefficient of friction ranges from 0.33-0.40. They provide relatively poor wear under heavy duty conditions and at higher friction levels. Because of various fillers and lubricants which dampen vibrations and noise, these are quite in operation.

I.2.3 Metallic Pads:

These type of pads are made up of iron, copper, steel and graphite all mixed together and bonded to form the brake pad material. These pads are good at transferring heat generated by friction with brake rotors[11]. As they are made up with more content of metal these are hard and can cause more wear on brake rotors. Generally they do not work well in cold condition and also they are noisy in operation

II. Literature Review

Sr. No.	Author	Observations
1.	K.K Ikpambese[27]	Investigations are done on pad material made up from natural fibers like palm kernel because it is environment friendly with $CaCO_3$, graphite and Aluminum oxide which gives better properties and are well suited as a substitute for asbestos.
2.	A. O. A. Ibhadode[27]	Agro waste like palm kernel shells used as a friction lining material can be a good alternative for asbestos material with good physical and mechanical properties.
3.	C. M. Ruzaidi[27]	Material containing palm slag, calcium carbonate and dolomite increases performance to cost ratio. 1. Palm slag shows better thermal stability within a range of 50^0- 1000^0 c compared to other two. 2. Phenolic resin cannot be used at higher temperature since curing of binder starts at 150^0 temperature.
4.	Arnab Ganguly[27]	New composite consisting phenolic resin with epoxy resin as toughener, graphite and silica for wear resisters and silicon as a fire retardant are used the results were analyzed using scanning Electron Microscopy technique.
5.	P. Thiyagarajan[28]	Materials with carbon as reinforcement and graphite powder as friction modifiers will gives modifications in coefficient of thermal expansion and thermal conductivity.
6.	A. Saffar[28]	Investigations are done for different amount of rubber content to explore mechanical, physical, frictional, wear and fade characteristics. 1. The COF is higher for rubber based material as compared to resin base at high velocities. 2. Wear resistance is high for resin based than rubber based.
7.	R. B. Mathur[28]	Materials formulated with the reinforcement like glass, carbon, Kevlar pulp, phenolic resin for binder, graphite dust used as friction modifier and for filler barium sulphate which maintains the hardness of the pad material as substitute for asbestos.
8.	T. Singh[28]	Investigations has been carried out with on phenolic composites based on lapinus aramid fiber for mechanical, physical and tribo-performances. 1. Physical properties such as compressibility, void, ash contents, water absorption are directly influenced by content of lapinus fiber. 2. Mechanical properties like tensile strength, hardness and thermo-mechanical properties are increased with aramid fiber.
9.	K.W. Liew[30]	Tribological analysis for non-commercial asbestos based, asbestos free and commercial

		brake pad were studied and experimentation is done with pin-on-disc tribo test rig.
10.	Bijwe and Mukesh[30]	With the addition of steel and brass density of composite increases also the void content increases as the larger size of particle compared to barite.
11.	Suresha[31]	Studied the effect of inorganic fillers like silicon carbide and graphite. 1.Wear volume loss is directly proportional to the sliding velocity 2. COF showed an increase in load and sliding velocity
12.	Hee and Filip[31]	Materials containing potassium titanate enhances the stability of coefficient of friction and resistance to fade and wear.

III. Results And Discussion

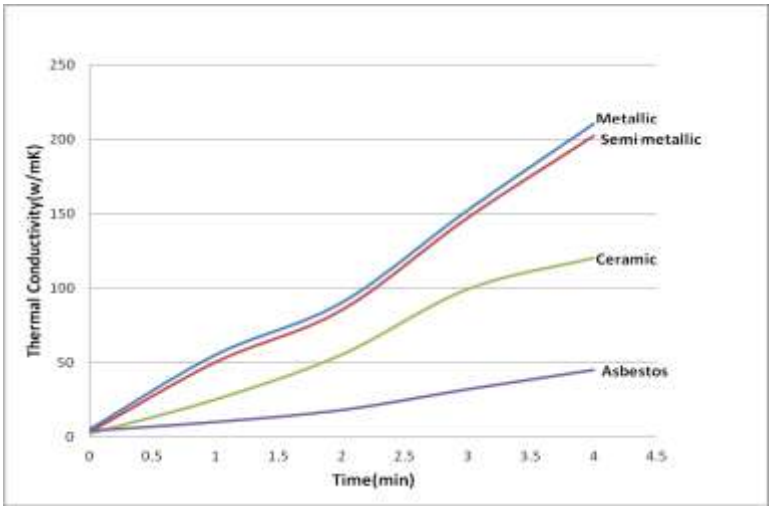

Fig 1: Thermal Conductivity v/s time

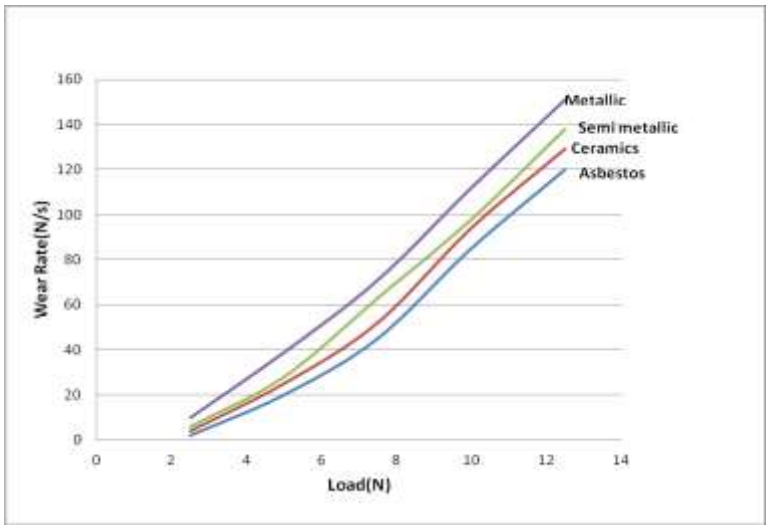

Fig 2: Wear rate v/s Load

From Fig 1, it has been seen that asbestos is a poor conductor of heat with respect to other braking materials. Metallic brake pads are having good thermal conductivity as they contain more amount of metal than semi metallic one. From Fig 2, it is seen that asbestos gives less amount of wear rate as compared to metallic, semi metallic and ceramic materials [32].

IV. Conclusion

In this paper the different alternatives to asbestos as braking material (e.g Semi metallic, Non asbestos organic, metallic) are studied. From the suggested alternatives it has been seen that their performance is same as that of asbestos one. The constituents used such as binders, fillers, friction materials, abrasives enhances the performance of the brake pad material with increase in a coefficient of friction, wear resistance, thermal conductivity etc.

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1]. E. Surojo, Jamasri a, V. Malau a, M.N. Ilman, "Investigation of Friction Behaviors of Brake Shoe Materials using Metallic Filler" *Tribology in Industry, vol. 37, 473-481, pp 473-481, 2015*

[2]. Vibhav A. Lalhapure and Dr. H. P. Khairnar, "Wear Mechanism and modeling for Automotive Brakes with Influence of pressure, Temperature and Sliding Velocity: A Review Article*", European Journal of Advances in Engineering and Technology, vol. 5*, pp 333-343, 2018

[3]. N.S.M. El. Tayeb Kia Wai Liew, Vc Venkatesh, "Evalution of new frictional brake pad material", *International Journal for Manufacturing Science and Technology, vol. 10, pp 97-103, 2008*

[4]. Xingming Xiao,Yan Yin, Jiusheng Bao, Lijian Lu and Xuejun Feng, "Review on the friction and wear of brake materials", *Advances in Mechanical Engineering, vol. 8, pp 1-10, 2016*

[5]. Harshvardhan Zula, N. D. Ghetiya Dipali Pandya, "Development of friction pad and study of its wear characteristics", *International Journal of Mechanical and Production Engineering, vol. 5*, pp 5-8,2017

[6]. Farhad Ahmadijokani, Yasaman Alaei, Akbar Shojaeil, Mohammad Arjmand, Ning Yan,"Frictional Behavior of Resin-based Brake Composites:Effect of Carbon Fibre Reinforcement", *Wear, pp 1-27,2018*

[7]. Hareesha M, Jeevan T. P. "Modification of Abrasive Wear Testing Machine and Testing of Materials", *International Journal of Science and Research (IJSR), vol. 3*, pp 263-268, 2014

[8]. Selva Babu, Nagireddypalli shiva kumar, Mohammad Athar and Mani, "A Study of Braking Materials their testing and analysis", *Journal of industrial pollution control,* pp 1655-1658, 2017

[9]. P. V. Gurunath, J. Bijwe, "Friction and Wear studies on brake pad material based on newly developed resin", *Wear(263),* pp 1212-1219, 2007

[10]. C Pinca-Bretotean, A Josan and C Birtok-Baneasa, "Laboratory testing of brake pads made of organic materials intended for small and medium vehicles" , *Materials Science and Engineering 393*, pp 1-7, 2018

[11]. Joel Jeremiah Gachoki, Marangu Dickson Kathenya, "Design of Brake pad Friction Material" , *Department of Mechanical and Manufacturing Engineering, University of Nairobi, 2011*

[12]. A.W. Orłowicz, M. Mróz, G. Wnuk, O. Markowska, W. Homik, B. Kolbusz, "Coefficient of Friction of a Brake Disc-Brake Pad Friction Couple", *Archives of Foundry Engineering, vol. 16,* pp 196-200, 2016

[13]. Andrzej Gajek, Wojciech Szczypiński-Sala, "Some Tribological Characteristics of Disc Brake Pads", *Cracow University of Technology*, pp 33-46, 2012

[14]. Namdeo Rajeev, Tiwari Sudhir, Manepatil Smita, "Development of Rubber Wheel Abrasion Testing Machine for Estimation of Three Body Abrasive Wear of Automobile Components", *International Journal on Design & Manufacturing Technologies, vol. 9,* pp 1-5, 2015

[15]. Eui-Sung Yoon , Hosung Kong, Oh-Kwan Kwon, Jae-Eung Oh, "Evaluation of frictional characteristics for a pin-on-disk apparatus with different dynamic parameters", *Wear(203-204),* pp 341-349,1997

[16]. Yoginder P. Chugh, Peter Filip, Samrat Mohanty & Kok-Wai Hee, "A Collaborative Program for Development of Frictional Materials Using Industrial Wastes", *International Conference on Engineering Education and Research*, pp 609-621, 2004

[17]. Jayashree Bijwe, "Multifunctionality of nonasbestos organic brake materials", *Industrial Tribology Machine Dynamics and Maintenance Engineering Centre,* pp 551- 572, 2015

[18]. M. P. Natarajan, B. Rajmohan and S. Devarajulu, "Effect of Ingredients on Mechanical and Tribological Characteristics of Different Brake Liner Materials", *International Journal of Mechanical Engineering and Robotics Research*

[19]. Arnab Ganguly and Raji George, "Asbestos Free Friction Composition for Brake Linings", *Bull. Mater. Sci., vol. 31,* pp. 19-22, 2008

[20]. Jang A H, Koa K and Kima S J, "The Effect of Metal Fibers on the Friction Performance of Automotive Brake Friction Materials", *Wear, vol. 256,* pp. 406-414, 2004

[21]. Min Hyung Cho and Seong Jin Kim, "Effects of Ingredients on Tribological Characteristics of a Brake Lining: An Experimental Case Study", *Wear, vol. 258,* pp. 1682-1687, 2005

[22]. K.Vijaya Bhaskara, S.Sundarrajan, B.Subba Rao, K.Ravindrad, "Effect of Reinforcement and Wear Parameters on Dry Sliding Wear of Aluminum Composites: A Review", *materials today proceedings, vol.5*, pp 5891–5900, 2018

[23]. Farazuddin Zafaruddin1, Dr. Dhananjay R. Dolas, "Experimental Investigation Of Organic Brake Pad", *IJARIIE, vol 2,* pp 2395-4396, *issue 6* , 2016

[24]. Rongping Yuna, Peter Filipb, Yafei Lua, "Performance and evaluation of eco-friendly brake friction materials", *Triobology International,* pp 2010-2019, 2010

[25]. Jung-Ju Lee1,2, Jung-A Lee1, Sungwook Kwon2, Jeong-Joo Kim, "Effect of different reinforcement materials on the formation of secondary plateaus and friction properties in friction materials for automobiles", *Tribology International*, pp 30578-79, 2017

[26]. Dinesh Shinde, K. N. Mistry, "Asbestos base and asbestos free brake lining materials: Comparative study", *Worlds Scientific News 61(2),* pp 192-198, 2017

[27]. Dr. Umamaheswara Rao, G. Babji, "A Review paper on alternate materials for Asbestos brake pads and its characterization", *IRJET vol. 02, Issue 02*, pp 556-562, 2015

[28]. S.B Chandgude, S. G. Ganiger, "Review on Development of Composite Material for Disc Brake Pad", *JETIR, vol. 3, Issue 5,* pp 63-65, 2016

[29]. G. S. Darius, M. N. Berhan, N. V. David, A. A. Shahrul & M. B. Zaki, "Characterization of brake pad friction materials", *Computational Methods and Experiments in Material Characterisation II,vol. 51*, pp 43-50, 2005

[30]. Shiv Pal Singh, "Analysis of Brake-Pad Friction Material Formulation", *International Journal of Advanced Engineering Research and Science (IJAERS), vol.2*, pp 6-13, 2015

[31]. K. W. Liew, Umar Nirmal, "Frictional performance evaluation of newly designed brake pad materials", *Materials and Design 48,* pp 25-33, 2013

[32]. Mohd Zaki Bahrom, Eida Nadirah Roslin, Muhammad Amir Aezmi, Muhammad Khairuddin Zainal,"Evaluation of Wear in Aftermarket Brake Pads for Enhancing Braking Performance in a Passenger Vehicle" *Science & Engineering Technology National Conference 2015,2015*