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Experimental and investigation of brake pad friction material with Corresponding Brake Disc for Toyota Hiace 5L Minibuses that used in Ethiopia City taxi

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Abstract*— Excellent control of braking system in automobile is the essential for safety of braking performance. The brake disc is affected by type of friction material of brake pad. For this investigation, the Toyota Hiace minibus taxi of 12 seats that used in Ethiopia City is taken as sample. The Environmental condition of Ethiopia city is varying in different area, but the brake pad that used for Toyota Hiace 5L minibus in Ethiopia city is uniform brake pad friction material at all environmental condition. While, the problem occurred in this automobile is most of time failure of brake pads when braking is applied, and wear and fade of brake disc is occurred. Due to this kind of problem some time accident is happen and the dust is produced from friction material of brake pad during braking time and affects the aquatic life. Hence, as result obtain from experimental and investigation of laboratory test, high content of copper in their ingredient of brake pad formulation was occurred. So free of Copper in brake pad composition is best for environmental protection and best braking performance.

***Index Terms*— Brake pad, Brake disc, Dust and Copper.**

I. INTRODUCTION

The brake system converts the kinetic energy of vehicle motion into heat. The friction materials used in brakes are required to provide a stable coefficient of friction and a lower wear rate at various operating speeds, pressures, temperatures and environmental conditions. The increase of friction moment is depending on the coefficient of friction, radius of rubbing path and forces that act on the pads. The Brake pads convert the kinetic energy of the vehicle to thermal energy by the action of friction. The two brake pads are contained in the brake caliper with their friction surfaces facing the rotor. When the brakes are hydraulically applied, the caliper clamps the two pads together into the spinning rotor to slow (or) stop the vehicle [1].

Several automobiles brake pad is seriously damaged in short period of time. The friction characteristics of friction material are different based on type of material. Then, if the friction characteristics of brake disk material are different, the coefficient of friction is different. That means the coefficient of friction of metallic matrix, semi-metallic matrix and non-metallic matrix is different. Since, the capability of coefficient of friction of brake pad is measure the quality performance of braking system. During the moving of automobiles and braking time, there is high heat dissipation in the interface of brake disk and brake pad, this heat dissipation between the interfaces, will deform the disk brake. Due to environmental condition, the strength of brake pad is reduced and the wear of brake pad is increase. In warm area, the temperature is high during repeated braking and the brake pad is losing the physical properties due to hot and dry environmental condition. Thus, these studies try to know the mechanical properties or friction properties of brake pad materials at hot and cold environmental condition and protect environmental protection of dust produced from scratching of brake pad during repeated braking and mixed with water by movement of rainfall [2], [3]. Statement of problem of this title of paper is friction material of brake pad that used in Ethiopian city taxi is semi metallic pad material with high content of copper in their composition; thus copper is naturally has high electric conductivity, high heat conductivity and it produce dust. The dust produced from copper is affect environment (affect aquatic life) by moving to the river (or) water way by the action of rainfall. Hence, to reduce such problem in braking system; the *best* hypothesis is use another alternative of brake pad like; Semi-metallic brake pad that contains free of copper in their composition.The objective of this study is to investigate the mechanical characteristics of Toyota Hiace 5L automobile brake pad friction material of free of Copper in their ingredient composition with corresponding interface of brake disc material in case of Ethiopia. The figure of Toyota Hiace 5L that used in Ethiopian City Taxi is shown below.

Fig 1: Toyota Hiace 5L minibuses

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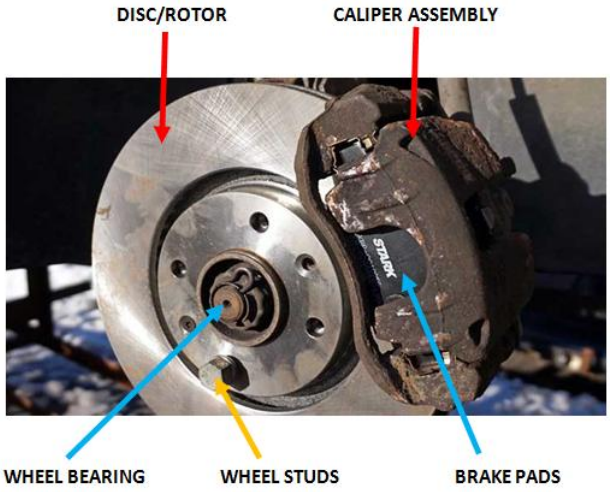

Fig 2: Brake disc with brake pad assemble

Different combinations of metallic powders as copper substitutes remained used within astandard formulation to prepare experimental brake pads, which were subsequentlycharacterized in their physical properties, thermal properties andtheir mechanicalproperties. Friction surfaces of padsand discs were investigated through Scanning Electron Microscopy (SEM), EnergyDispersive Spectroscopy (EDS), Focused Ion Beam (FIB) analysis and roughness profiles.The awareness about materials behavior and relations was then executed in the reformulation of copper-based industrial mixes and substituting it without cooperating brakingperformance [4].The replacing the aluminum metal matrix composite (Al-MMC) brake disc instead of conventional cast iron brake disc due to provided better thermal and mechanical performance. And also, Al MMC brake disc dissipate high maximum temperature compare to cast iron brake disc. The Performance of Al-MMC brake disc were high wear resistance, high specific mechanical properties, lower density and high thermal conductivity compare to cast iron brake disc. Thus, Al-MMC brake disc are ideal materials for the manufacture of lightweight automotive of Toyota Hiace 5L brake disc. Further, the performance comparison of Al-MMC brake disc in terms of stress and strain was lower than cast iron brake disc [5].The harmonic pattern of brake pad during braking time is closely related to the distributed friction force and the nature of the contact. The distributed friction force on the brake pad acts as an energized force along the contact points of the friction light. That is the brake pad being energized at the same time along the contacting surface of the friction pairs. The simultaneous energized coupled with the rotation of the disc produces the harmonics. Each point on the brake pad is energized by the friction force upon contact; the motion of the brake pad due to the excitation is transferred to the disc, which is the approach union occurrence [6].Sawdust of 100µm particles size has properties that can effectively replace asbestos in brake pad manufacture, since it gives better brake pad properties. The properties such as compressive strength, hardness, density, ash-content and water absorption of the produced samples decreased with increasing particles size. The results showed that sawdust has properties comparable to that needed for use as brake pad material to replace asbestos in the manufacture of brake pads since it gave results which were within the range for brake pad manufacture. The materials used during the course of this work include sawdust, steel powder, silicon carbide, graphite and epoxy resin [7]. The influence of the geometrical designs of brake pad on brake squeal is studied using a simplified brake setup consisting of an annular disc in contact with one brake pad. The various configurations of a brake pad studied here have been influenced by those used in the industrial testing of a full brake system. Unstable vibration modes were first identified by the conventional complex eigenvalue analysis of a finite element model of the simplified brake system. Then, the sound power was calculated for a range of frequencies and friction coefficients using the acoustic boundary element method. It is shown that the performance of the various pads, in terms of brake squeal propensity caused by their geometric differences, could be ranked based on shape plots of acoustic power with friction coefficient and frequency as the independent variables [8].

II. METHODOLOGY

Observe and Interview the driver of 5L Toyota Hiace, Collect Data of damaged brake from center of maintenance of Automobiles and review literature, take a sample and test in the laboratory in order to now the composition of friction material content, Interpret the result of laboratory, give suggestion and conclusion.

Table 1: Geometrical dimensions [9], [10].

Item	Value
Disk inner radius (mm)	195
Disk outer radius (mm)	295
Pad inner radius (mm)	207.5
Pad outer radius (mm)	282.5
Disk thickness (mm)	24
Cover angle of (θ) of pad	65
Size of pad(L x W x H mm)	75 x 150 x 69
Gross Vehicle Weight (kg)	2,800
Max speed (mph)of Automobile	91
Tire Size	195/70 R15
Effective Radius of Rotor, R_r	122.5
Mass of the disc (kg)	5
Specific Heat(J/kg.K), C_p	800
Acceleration 0-62mph (sec)	22.4

a) Sample preparation for testing composition of brake pad

The sample is produced by scratching a piece of brake pad and changing the scratched material in to fine particles, then the small fine particle is packed and taken to the laboratory to know the composition particle of brake pad that used in Ethiopian city taxes. The sample of brake pad is taken from the brake pad that used for TOYOTA-HIACE of 5L and tightened with six bolts.

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Fig 3: Sample preparation

b) Result obtain from laboratory

As the result of tested material obtain from laboratory of Ethiopian geological survey and tested under base metal analysis report, the analytical method is by four acid attacks (HCI, HNO_3, $HCIO_4$, and HF), the sample preparation is 200 mesh and the analytical result is in part per million (ppm). And tested under Complete Silicate Analysis Report with analytical method of $LiBO_2$ fusion, HF attack, gravimetric and colorimetric, the sample preparation under this category of test is the sample preparation is 200 meshes. The analytical result is given in percent. But, under this tested category the result is can't fit their procedure of laboratorial techniques. So, we take the result obtained under **base metal analysis report**. The laboratory result obtain from Ethiopian geological survey is illustrated in the table below.

Table 2: Experimental result of brake pad composition content used in Ethiopia

Collector's Code	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Cobalt (ppm)	Nickel (ppm)
O.D-01	13360	686.4	<0.01	58.6	30

III. RESULT AND DISCUSSION

The Composition of brake pad that use in Ethiopian city taxi is stated with the high amount of copper in their semi-metallic brake pad composition; thus this high amount of copper content is affect the brake pad by generating high heat during braking application, then the high heat dissipation is bring the wear of brake pad. As result obtains from Ethiopian geological survey laboratory, from the result listed in table 2 and the amount of ingredient in composition is shown by graph description in figure4.

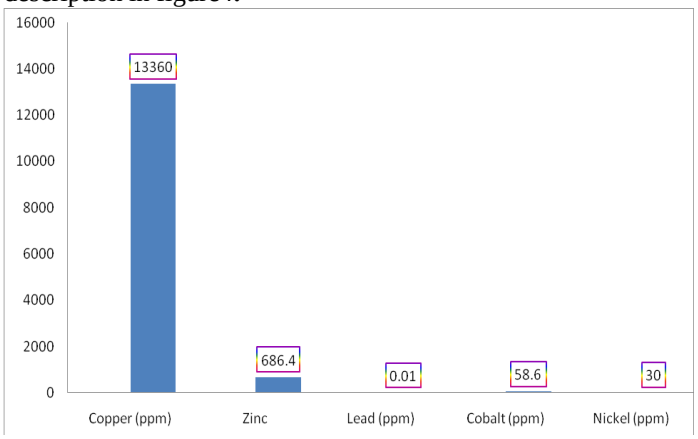

Fig 4: Composition of brake pad ingridient that used in Ethiopian City taxi

Further, the copper in brake pad is produce dust, those dustiest are removed on roads when braking is applied, the removed dust on road is moved by rainfall mixed with river or lakes, thus copper is toxic metal that can be affect organism. Hence, the brake pad that used in Ethiopian city taxi is contain more amount of composition of copper; then the reduction of copper in composition of semi-metallic brake pad distinctly that used in Ethiopian automotive city taxi vehicle is reduce the environmental pollution of Ethiopia for saving the life of organism that live in water (river, lakes etc.).

IV. CONCLUSION

The friction material of brake pad composition that used in Ethiopian city taxi automotive is investigated experimentally; as the result obtains from laboratory result the highest amount of ingredient in the friction material of brake pad that used in Ethiopian city taxi is Copper. Hence, Copper is naturally it produce high heat transfer and it produce more noises, thus due to produce more noise can be damage. Also it produces dusts; the dust scratched from the pad during braking time on the road is moved by rainfall a mixed with water (river, lakes, etc.) affect the aquatic life and affect human health.

V. FUTURE WORK

- Investigating the behavior of brake pad of light vehicle at hot and cold Temperature.
- Substitution of Composite material instead of Copper in brake pad friction material of automotive.
- Comparison of friction performance of metallic, semi-metallic and Ceramic brake pad of light vehicle on down slope road to hold and stop the movement of vehicle at short braking distance.

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Oliyadi Dereje Fikedu; is Lecturer at Mizan Tepi University in the mechanical Engineering; faculty of Engineering, Ethiopia. He is Graduate by MSc in Mechanical Engineering (Mechanical Design) from Addis Ababa Institute of Technology (AAiT), Addis Ababa University in School of Mechanical and industrial Engineering, Ethiopia. His Research work is included Analysis of mechanical properties of automotive Disc Brake by Finite element method; Comparison of fatigue sensitivity of Ceramic brake pad, Aluminum alloy brake pad and Kevlar brake pad with interface of aluminum metal matrix composite (Al-MMC) brake disc by ANSYS software. for the future achievement, he is planning to work research on Design and Developing material of light Automotive Cabin; investing Accident happen due to automotive Braking performance and interest to applying his intelligence on automatic recording faulty of driver on automotive dashboard; Develop and substitute the body of automotive cabin by lighter and strengthen composite material from around available materials.

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APPENDIX: EXPERIMENTAL RESULT

GEOLOGICAL SURVEY OF ETHIOPIA	Doc.Number GLD/F5.10-2	Version No: 1
GEOCHEMICAL LABORATORY DIRECTORATE		Page 1 of 1
Document Title: Base Metal Analysis Report	Effective Date:	May, 2017

Issued Date: 16/04/2018

Originator: - Oliyadi Dereje

Request No; GLD/TR//0154/18

Sample type: - Rock

Report No: - GLD/TR/0211/18

Date Submitted: - 23/03/2018

Sample Preparation: - 200 Mesh

Analytical Result: - ppm

Number of Sample: - One (1)

Analytical Method: - Four acid attack (HCl, HNO3, HClO4, HF) and AAS finish.

Collector's Code	Cu(ppm)	Zn(ppm)	Pb(ppm)	Co(ppm)	Ni(ppm)
O.D-01	13,360.00	686.40	<0.01	58.60	30.00

N.B:

- ppm: parts per million
- Cu for Copper, Zn for Zinc, Pb for Lead, Co for Cobalt and Ni for Nickel
- Dup Duplicate

Analysts

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