Tribological Investigations Of Brake Pad By Using Hybrid Metal Matrix Composites

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***Abstract* - The applications of Metal Matrix Composites (MMCs) are being increasing day by day within the aerospace, automobile and lots of more industries, due to their improved properties compared to uniform metals. Presently several grades of Aluminium Matrix Composites (AMCs) are utilized in high-tech structural and practical applications including aerospace, defence, locomotive, and thermal management areas, also as in sports and recreation. This trend has been recognized to their greater specific strength and specific stiffness, heat ability, lower coefficient of thermal expansion, better wear resistance, enhanced dimensional stability, and responsiveness to standard metal forming techniques. This report cares with Aluminium Matrix Composites and more specifically on the Aluminium (Al) based carbide (SiC) metal matrix composite Embedded with Copper. the most aim of this project is to see practicality of the Aluminium based carbide metal matrix composite for passenger vehicle lining. Through this dissertation an effort is formed to check the tribological behavior of the Aluminium based carbide metal matrix composite. The composite is formed by metallurgy route followed by hot extrusion. The composites are prepared for the testing, composite of Al and SiC embedded with Copper. the wear and tear test is administered for these composites both at ambient and elevated temperature by using pin on disc method. Pins are made from composite and tested against forged iron disc. the wear and tear affecting parameters like normal load, sliding speed and temperature are varied and tribological properties are observed. Also, the results of the composite are compared with one another. The results reveal that the addition of carbide and copper reduces wear of the composite.**

***keywords* - MMC, Brake Pad, Copper, Wear**

I. INTRODUCTION

Brake pad is one among the foremost important parts of braking system which is mounted on a brake disc rotor on each wheel. Braking system also contains many other parts like cylinders (master cylinders, wheel cylinders, tandem cylinders) and system which can be operated by mechanism or pneumatic system. in several sorts of braking system sorts of materials are used for restraint. Binders, fillers, friction modifiers and reinforcement are four important classes of ingredients into which they're often categorized. Asbestos is most often used brake pad material during which asbestos fibers are embedded in matrix of polymer alongside other several ingredients. Many research works are administered for the asbestos free brake pad materials over few years. Current trend has begin for the use of composite brake pad materials which give more economical benefits and also preservation of environment. Recent research has been focused on the compaction method to manufacture cost effective and highly dense material through metallurgy method. The possibility of obtaining uniform parts and reducing tedious and expensive machining processes is that the prime reason for using metallurgy method.

Table 1. Historical Compositions of Brake Materials.

Material Description	Applications	Approximate Year
Cast iron on steel	Railroad car brake blocks and tires	1870
Hair or cotton belting (limited by charring at about 300” F)	Wagon wheels and early automobiles	1897
Woven asbestos with brass and other wires for increased strength and performance	Automobiles and trucks	1908
Molded linings with shorter chrysotile fibers, brass particles, and low-ash bituminous coal	Automotive and trucks	1926
Dry-mix molded material to replace cast iron brake blocks that produced metallic dust that shorted electric train rails	London underground	1930
Flexible resin binders developed along with complex formulations	More brake drum linings	1930’s
Resin-bonded metallic brake linings	Industrial and aircraft applications	1950’s
Glass fibers, mineral fibers, metal fibers, carbon and 1960’s synthetic fibers to provide semi-metallics with higher performance than asbestos [beginning of safety issues with asbestos)	Automotive and trucks	1960’s

Non-asbestos (fiber glas) materials	Brake drums on original equipment	1980's
Suggested use of carbon fibers	Automotive brakes	1991
Semi-metallic and nonmetallic	Automobiles and trucks	2002-2008
Ceramic brake pad	Automobiles and trucks	2012

Below table shows the list of materials: Table No.2: List of Materials.

Sr.no.	Materials
1	Aluminium(AL)
2	Silicon Carbide (SIC)
3	Copper(CU)

II.LITERATURE REVIEW

Rathod Abhik a, Umasankar Va, M. Anthony Xaviora presented Evaluation of Properties for Al-SiC Reinforced Metal Matrix Composite for Brake Pads(2014), The aim of this research is to develop carbon fiber and SiC reinforced hybrid Aluminium metal matrix composite for automotive brake pad application. Recent research has been focused on the compaction method to manufacture cost effective and highly dense material through metallurgy method. the likelihood of obtaining uniform parts and reducing tedious and expensive machining processes is that the prime reason for using metallurgy method.[1]

Telang A K,Rehman A,Dixit G,Das S presented Alternate Materials In Automobile Brake Disc Applications With Emphasis On Al Composites-A Technical Review(2014), Composite materials provide such unique combination of properties. during this review the alternate materials for automobile brake applications with special attention to aluminum composites has been done. Al-Si alloys are used extensively due to their properties like low coefficient of thermal expansion, bearing properties, good corrosion resistance in association with the strength.[2]
E. Surojo a,b, Jamasri a, V. Malau a, M.N. Ilman developed Investigation of Friction Behaviors of shoe Materials using Metallic Filler(2015), during this paper, friction behaviors of shoe material using metallic filler were investigated. Machining chips of forged iron and copper wire of electrical motor used were incorporated in composite as metallic fillers with amount 0, 2, and 4 vol. %. Friction testing was performed to live coefficient of friction by pressing surface specimen against the surface of rotating disc [3].

T. Ram Prabhua,n, V.K. Varmaa, Srikanth Vedantamb presented Tribological and mechanical behavior of multilayer Cu/SiC þ Gr hybrid composites for brake friction material applications, during this paper(2014), we study the wear and tear resistance of multi-layered composites of Cu/SiC þ Gr hybrid composites prepared by layer compaction and pressure sintering. The tribological behavior and wear resistance of the composites were evaluated at a variety of sliding speeds (5, 10, 30 and 35 m/s) during a laboratory scale inertia brake dynamometer for brake friction material applications.[4]

P. Vijaya Kumar Rajua, S. Rajesha, J. Babu Raob, N.R.M.R. Bhargavab reported the Tribological behavior of Al-Cu alloys and innovative Al-Cu metal matrix composite fabricated using stir-casting technique. Tribological behaviour of an Al–5-wt% Cu alloy, Al–10-wt% Cu alloy (hypoeutectic alloy), and an innovative composite combination of an Al–5-wt% Cu alloy because the matrix and a 5-wt% Cu powder because the reinforcement are investigated. The metal matrix composite was prepared and fabricated by employing a stir-casting process by dispersing the Cu powder (average particle size of 105 μm) within the molten base Al–5-wt% Cu alloy. the wear and tear and frictional properties of the metal matrix composites was studied by performing dry sliding wear test employing a pin-on-disc wear tester.[5]

Peter J. Blau presented Compositions, Functions, and Testing of Friction Brake Materials and Their Additives (2001), This report was prepared as an information resource for the event of advanced brake materials for heavy vehicles. This research is sponsored by the U.S. Department of Energy, Office of Transportation Technologies. it's a part of an initiative aimed toward reducing the running resistance while improving the security of on-highway heavy trucks.[6]

R. Dhatrak & Dr. K. B. Kale presented the wear and tear Rate Investigation of Aluminium Based carbide Metal Matrix Composite Embedded with Copper(2016), This report cares with Aluminium Matrix Composites and more specifically on the Aluminium (Al) based carbide (SiC) metal matrix composite Embedded with Copper. the most aim of this project is to see practicality of the Aluminium based carbide metal matrix composite for passenger vehicle lining. the wear and tear test is administered for these composites both at ambient and elevated temperature by using pin on disc method. Pins are made from composite and tested against forged iron disc. the wear and tear affecting parameters like normal load, sliding speed and temperature are varied and tribological properties are observed. Also, the results of the composite are compared with one another. The results reveals that the addition of carbide and copper reduces wear of the composite. [7]

M.S.Maske and U.M.Shirsath presented the investigations of tribological behavior of AL-SiC MMC for automobile brake

pad. Alternate Materials in Automobile Brake Disc Applications with Emphasis On Al Composites-A Technical Review (2014), Composite materials provide such unique combination of properties. during this review the alternate materials for automobile brake applications with special attention to aluminum composites has been done. Al-Si alloys are used extensively due to their properties like low coefficient of thermal expansion, bearing properties, good corrosion resistance in association with the strength.[8]

III. PROBLEM STATEMENT

During braking action brake pad comes in touch with disc & with increase in braking results in maximum wear of lining material, increase in temperature of brake pad, formation of hot spots on brake disc and formation of grooves on restraint, brake fading, surface cracks, plastic deformation excessive wear resulting in failure of brakes. This problem gives out how for development of composite & evaluation of its tribological characteristics. the target of this report is to match friction & wear behavior of hybrid Metal Matrix Composite as pin materials (Al+Sic+Cu) with Grey forged iron as disc material having chemical composition same as that of brake disc of actual passenger vehicle on pin on disc apparatus under ambient & elevated temperature by pin heating.

Figure 1. Brake Pad crack View

IV. OBJECTIVE

The main objective is to determine

1. To study the failure of brake pad.
2. To evaluate mechanical properties of brake pad.
3. Fabrication of a series of friction composites using hybrid metal matrix composites.
4. Evaluation of sliding wear performance using Pinon-Disc test rig of existing and new material at elevated temperature and ambient temperature.
5. To Carry out scanning electron microscopy.

V. PROPOSED METHODOLOGY

The following material are used in manufacturing of the composites.

[1] Aluminium (AL)
[2] Silicon carbide (SiC)
[3] Copper (Cu)

1)Aluminium:

The strength and hardness of Aluminium at temperatures are high enough to be used in such applications. The machinability of Aluminium is superior. Resistance to atmospheric corrosion is sweet. it's going to be anodized adequately by the vitriol process. Anodizing, which produces an oil absorbing surface, is usually wont to give improved bearing qualities to pistons. the actual characteristics which determine the applications of Al are its retention of strength and hardness at elevated temperatures, its low coefficient of thermal expansion and its high resistance to wear.

2)SiliconCarbide:

carbide is that the only compound of carbon and silicon. carbide is a superb abrasive. Today the fabric has been developed into an excellent quality technical grade ceramic with very decent mechanical properties. The freezing point is 2700oC with density 3.2 g/cm3. it's utilized in refractories, abrasives, ceramics and various high-performance applications. carbide is tough and powerful material. The high thermal conductivity including low thermal expansion and high strength give this material exceptional thermal shock resistant qualities. carbide ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600oC with no strength loss. a number of the properties of carbide are rarity , high strength, Low thermal expansion, High thermal conductivity, high hardness,High coefficient of elasticity and excellent thermal shock resistance.

3)Copper:

Properties of Copper are Good thermal conductivity, Ductile, Easy to alloy, Nonmagnetic, Tough and Corrosion resistant.

4)Grey forgediron:

The Grey forged iron material consists of Iron as a serious constituent and additives as Carbon, Manganese, Phosphor, Sulphur and Silicon.

FABRICATION PROCESS

[1] BALL MIL- Granules are converted in to powder by planetary Ball mill machine.

FIG 2 - planetary ball mill machine.

[2] Injection molding- It produce tubes, rods and other shaped continues from length. Heated polymer is fed in to shaped die by using screw.

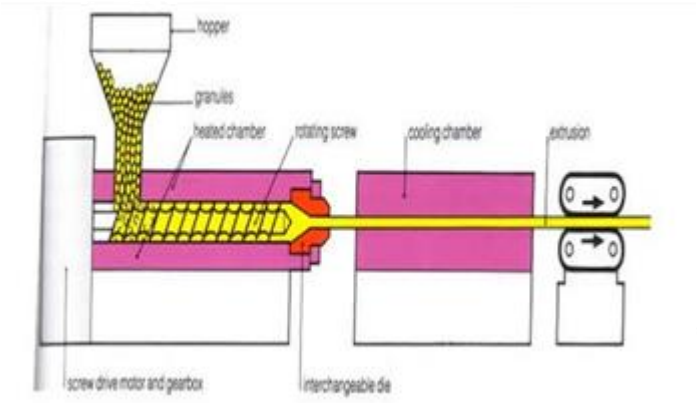

FIG 3- extrusion injection molding.

VI. DESIGN OF EXPERIMENT

TAGUCHI METHOD-

The experimental layout is obtained from different material composition, load and sliding velocity by L9 mixed design in Minitab. In this experiment we consider mixed level and 3 factors. First factor is material which has four level, second factor is load which has two level. Third factor is sliding velocity which has two level.

TABLE 1– Mixed L9 Array of design

Experiment	Load(N)	Sliding velocity(m/s)	% of Sic
1	A	P	X
2	A	P	Y
3	A	P	Z
4	B	Q	X
5	B	Q	Y
6	B	Q	Z
7	C	R	X
8	C	R	Y
9	C	R	Z

ABLE 2– Mixed L9 Array of design

Sr. No.	Process Parameters	Range	Level 1	Level 2	Level 3
1	Load	10-30 N	10	20	30
2	Sliding Velocity	2.5-7.5 m/s	2.5	5	7.5

3	% of Sic	10-20 %	10	15	20

VI. EXPECTED OUTCOMES

Many factors have to be considered like stable coefficient of friction and lower wear rate at different operating speed, pressure, temperature, environmental condition etc. For the fulfilment of above requirement, it is important of having appropriate combination of materials and selection of materials is not an easy task rather it is a complex process which require lot of experience.

As compared to existing materials the hybrid (Al+sic+cu) metal matrix composites have:

1) Their high strength to weight ratio,
2) Lighter weight,
3) High temperature ability,
4) Lower coefficient of thermal expansion,
5) Improved strength and stiffness,
6) And good Wear behavior**.**

ACKNOWLEDGMNET

Firstly, I would like to express my deep sense of gratitude and indebtedness to my Guide **Prof. M. S. Mhaske** for his invaluable encouragement, suggestions and support from the very beginning of this Project and providing me extraordinary experiences throughout the work. Above all, his priceless and meticulous supervision at each and every phase of work inspired me in innumerable ways. I am proud to that I had the opportunity to work with an exceptionally experienced Professor like him.

I am highly grateful to **Dr. S, M.Gulhane**, Principal, **Prof. M. S. Mhaske**, P.G coordinator and **Prof. R. R. Kharde,** HOD, Department of Mechanical Engineering, Pravara Rural Engineering College, Loni for their kind support and permission to use the facilities available in the Institute. Last but not least, I would like to thank all my friends for their help, moral support and inspiring me to face the challenges in my life.

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