International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 03 | March - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Design & Analysis Of Disc Brake By Using Aluminium Matrix Composite

Mayur D Sandbhor [1], Swaraj R Patil[2], Bhaskar P More[3] Harshada S Sawant [4]

Prof. Mr. Nilesh Shinde [5]

[1] Student Of Mechanical Engineering & Datta Meghe College Of Engineering, Airoli, Navi Mumbai
[2] Student Of Mechanical Engineering & Datta Meghe College Of Engineering, Airoli, Navi Mumbai
[3] Student Of Mechanical Engineering & Datta Meghe College Of Engineering, Airoli, Navi Mumbai
[4] Student Of Mechanical Engineering & Datta Meghe College Of Engineering, Airoli, Navi Mumbai
[5] Assistant Professor Of Mechanical Engineering & Datta Meghe College Of Engineering, Airoli, Navi Mumbai

---

Abstract - Metal Matrix Composites (MMCs) have shown great interest in recent times due to its potential of applications in aerospace and automotive industries because of having superior strength to weight ratio. The wide use of particular metal matrix composites for engineering applications has been obstructed by the exact use of silicon carbide (SiC) by weight %, hence high cost of components. Although there are several technical used for casting technology rather it can be used to overcome this problem. Materials are frequently chosen for structural applications because they have desirable combinations of mechanical characteristics. Development of hybrid metal matrix composites has become an important area of research interest in Materials Science. In view of this, the present study focuses on the behavior of aluminium silicon carbide (AL Sic) hybrid metal matrix composites.

An automotive brake disc or rotor is a device for slowing or stopping the motion of a wheel while it runs at a certain speed. The widely used brake rotor material is cast iron which consumes much fuel due to its high specific gravity. The aim of this paper is to develop the material selection method and select the optimum material for the application of brake disc system emphasizing on the substitution of this cast iron by any other lightweight material. Two methods are introduced for the selection of materials, such as cost per unit property and digital logic methods. Material performance requirements were analysed and alternative solutions were evaluated among cast iron, aluminium alloy, titanium alloy, ceramics and composites. Mechanical properties including compressive strength, friction coefficient, wear resistance, thermal conductivity and specific gravity as well as cost, were used as the key parameters in the material selection stages. The analysis led to aluminium metal matrix composite as the most appropriate material for brake disc system.

The suitable material for the braking operation is selected and all the values obtained from the analysis are less than their allowable values. Hence the brake Disc design is safe based on the strength and rigidity criteria. By identifying the true design features, the extended service life and long-term stability is assured.

Key Words: Aluminium(Al), silicon carbide (SiC), Metal Matrix Composites (MMCs), Disc Brake,

1. INTRODUCTION

Aluminium silicon carbide metal matrix composites are combinations of two or more materials. They made by combining two or more materials in such a way that the resulting materials have certain design properties or improved properties. The properties of aluminium metal matrix composite mostly depend on the processing method which is capable of producing good properties to meet the industry need. Al-SiC composites can be more easily produced by the stir casting technique due to its good casting ability and relatively inexpensive. The stir casting method is economical as well as easy to apply and convenient for mass production. Study of wear properties of AlSiC composite is found that wear rate decreases linearly with increasing SiC content. Mechanical characterization of Al-SiC composite like density, hardness, elongation%, toughness and tensile strength were evaluated. The improved value of tensile strength for Aluminium composites is one of the reasons they are widely used in industry it has been found that particle reinforced aluminium matrix composites can improve considerably the strength and hardness of aluminium and its alloys.

These materials having a lower density and higher thermal conductivity as compared to the conventionally used gray cast irons are expected to result in weight reduction of up to 30- 40% in brake systems. Moreover, these advanced materials have the potential to perform better under severe service conditions like higher speed, higher load etc. which are increasingly being encountered in modern automobiles. Since brake disc or rotor is a crucial component from safety point of view, materials used for brake systems should have stable and reliable friction and wear properties under varying conditions of load, velocity, temperature and environment, and high durability. There are several factors to be considered when selecting a brake disc material. The most important consideration is the ability of brake disc material to withstand high friction and less abrasive wear. Another requirement is to withstand the high temperature that evolve due to friction. Weight, manufacturing process ability and cost are also important factors those are need to be considered during the design phase.

2. Body of Paper

.

DISC BRAKE

A disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called calliper. The calliper is connected to some stationary part of the vehicle like the axle casing or the stub axle as is cast in two parts each part containing a piston. In between each piston and the disc there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the calliper for the fluid to enter or leave each housing. The passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston

The main components of the disc brake are:

1. The Brake Pads
2. The Calliper which contains the piston
3. The Rotor, which is mounted to the hub

When the brakes are applied, hydraulically actuated pistons move the friction pads in to contact with the rotating disc, applying equal and opposite forces on the disc. Due to the friction in between dies and pad surfaces, the kinetic energy of the rotating wheel is converted into heat, by which vehicle is to stop after a certain distance. On releasing the brakes, the brakes, the rubber-sealing ring acts as spring and retract the fiction pads away from the disc

2.1 Problem Identification

In automotive industries, to achieve reduced fuel consumption as well as greenhouse gas emission is a current issue of utmost importance. To reduce automobile weight and improve fuel efficiency, the auto industry has dramatically increased the use of aluminium in light vehicles in recent years. Aluminium alloy-based metal matrix composites (MMCs) with ceramic particulate reinforcement have shown great promise for such applications. These materials having a lower density and higher thermal conductivity as compared to the conventionally used gray cast irons are expected to result in weight reduction of up to 30-40% in brake systems. Moreover, these advanced materials have the potential to perform better under severe service conditions like higher speed, higher load etc. which are increasingly being encountered in modern automobiles.

2.2 Looking For Appropriate Solution

Aluminium alloy-based metal matrix composites (MMCs) with ceramic particulate reinforcement have shown great promise for brake rotor applications. These materials having a lower density and higher thermal conductivity as compared to the conventionally used gray cast irons are expected to result in weight reduction of up to 30-40% in brake systems. The repeated braking of the AMC brake rotor lowered the friction coefficient u and caused significant wear of the brake pad. The friction properties of the AMC brake disc are thus remarkable poorer than those of conventional brake disc. After increasing hard particles content, the result showed that the repeated braking operations did not lower the friction coefficient. Wilson et. al. studied the abrasive wear resistance of the AA6061 with 20 vol% Sic reinforced composite in short sliding distance testing (about 20m). Adding 20 vol.% Sic particulate greatly enhanced the wear resistance, raised room-temperature strength and stiffness, and improved high-temperature strength.

2.3 Objective

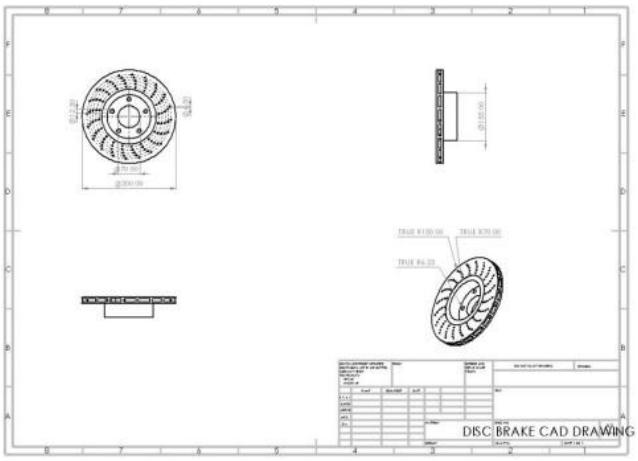
1) WEIGHT REDUCTION
The main objective of this to reduce the weight of braking system to reduce overall weight reduction of vehicles because reduced automobile weight improves fuel efficiency, this will make vehicles more efficient in all the ways.

2) DURABLE
The one of the objectives of this project is to make rotor of braking system more durable than before this will happen only if we select better and more durable material than before. Moreover, these advanced materials have the potential to perform better under severe service conditions like higher speed, higher load etc.

3) INCREASE STRENGHT
Strength is important aspect for brake rotor, our objective for this is to increase the strength of brake rotor for better performance and for efficient braking system. Aluminium alloy-based metal matrix composites (MMCs) with ceramic particulate reinforcement have shown great promise for such applications.

2.4 Literature Review

In this chapter, literature related of the problem definition is studied which focuses on determining the objective, scope and expected outcomes of the project. The literature deals with the following scope: a. Analysis of disc rotor b. Redesign for maximum strength with minimum weight c. best material for disc rotor for obtaining high strength d. Performance testing of existing disc rotor The AMC's disc rotor is a great alternative to current rotor which remains to be tapped to its potential. Much research has been taking place on how to increase strength with less weight. Metal-matrix composite brake rotors and drums are typically produced by casting processes such as semi-permanent gravity casting. Aluminium-magnesium and aluminium- silicon matrix alloys and both Sic and A1203 particle reinforcements have been used, typically of at least 20% by volume. A number of automobiles now use MMC brake components. The Lotus Elise used four discontinuously reinforced aluminium (DRA) brake rotors per vehicle from 1996 to 1998, and the specialty Plymouth Prowler has used DRA in the rear wheels since production started in 1997. Discontinuously reinforced aluminium rotors are particularly attractive in lightweight automobiles and are featured in the Volkswagen Lupo 3L and the Audi A2. In addition, a number of electric and hybrid vehicles, such as the Toyota RAV4, Ford Prodigy, and the General Motors Precept, are reported to use MMC brake components (Miracle and Hunt, 2004). Figure shows a selection of discontinuously reinforced aluminium (DRA) brake rotors. Aluminium-based MMCs offer a very useful combination of properties foe brake system applications in replacement of cast iron. Specifically, the wear resistance and high thermal conductivity of aluminates MMCs enable substitution in disk brake rotors, with an attendant weight savings on the order of 30 t 40%. Because the weight reduction is unsprung, it also reduces inertial forces providing an additional benefit in fuel economy. In addition, lightweight MMC rotors provide increased acceleration and reduced braking distance. It is reported that, based on brake dynamometer testing, MMC rotors educe brake noise and wear, and have more uniform friction over the entire testing sequence compared to cast Iron rotors (Miracle and Hunt, 2004). Table I shows the advantages of metal matrix composite over metals and other composites (Chawla and Chawla, 2006)



SolidWorks Design

Table -1:

AlSic	Tensile strength (Mpa)	Initial length mm	Final length (mm)	Net change in length mm	Elongation (e) %
Al 80% + SiC 20%	187.55	160	187.04	27.04	16.9

Results

Material	**Speed (Km/Hr)**	**Maximum Temperature (K)**
Grey Cast Iron	80	440
	90	476
	100	502
Aluminium Metal Matrix Composite	80	432
	90	464
	100	488

3. CONCLUSIONS

Aluminium alloy-based metal matrix composites (MMCs) with ceramic particulate reinforcement have shown great promise for brake rotor applications. These materials having a lower density and higher thermal conductivity as compared to the conventionally used grey cast irons are expected to result in weight mien of up to 30-40% in brake systems. These advanced materials have the potential to perform better under severe service conditions like higher speed, higher load etc.

Future Scope

- ❖ Enhanced Performance

1. Improved Wear Resistance: The addition of SiC particles can significantly enhance the wear resistance of the disc brake, leading to longer lifespan and reduced maintenance costs.
2. Increased Thermal Conductivity: Al-Si MMC can provide better heat dissipation, reducing the risk of brake fade and improving overall braking performance.
3. Higher Strength-to-Weight Ratio: The composite material can offer improved mechanical properties, enabling the design of lighter and more efficient brake systems.

- ❖ Emerging Applications

1. Electric and Hybrid Vehicles: Al-Si MMC disc brakes can be particularly beneficial for electric and hybrid vehicles, where regenerative braking systems require high-performance brake components.
2. Autonomous Vehicles: The improved safety and reliability offered by Al-Si MMC disc brakes make them an attractive option for autonomous vehicles, where braking systems must be highly robust and efficient.
3. High-Performance Vehicles: The enhanced performance characteristics of Al-Si MMC disc brakes make them suitable for high-performance vehicles, where exceptional braking capabilities are critical.

4. REFERENCES

1. Adiasmak, M.(2006), „„Selected properties of aluminium base composites reinforced with intermetallic particles"", J. Achiev. Matls Manufac. Tech., 14(1–2), pp. 43–47.

2. Alaneme, K.K. and Aluko, A.O.(2012), „„Production and age-hardening behaviour of borax pre-mixed SiC reinforced Al–Mg-Si alloy composites developed by double stir casting technique"", West Indian J. Eng., 34 (1–2), pp. 80–85

3. ASTM E 8M „„Standard test method for tension testing of metallic materials (metric) in annual book of ASTM standards"", Philadelphia, ASTM (1991).

4) Balasivanandha, S., Kaarunamoorthy, L., Kaithiresan, S. and Mohan, B. (2006),"Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite", Journal of Material Processing Technology, Vol. 171, pp. 268-273

5) R.M. Wang and M.K. Surappa, Microstructure and interface structure studies of SiCp-reinforced Al (6061) metal-matrix composites Materials Science and Engineering, A, 254 (1-2), (1998), 219- 226 • → Shaoyang Zhang, Fuping Wang Comparison of friction and wear performances of brake material dry sliding against two aluminum matrix composites reinforced with different SiC particles, Journal of Materials Processing Technology 182 (2007) 122-127

6) Jahazi M, Hossein-Nejad S. The development of an optimum manufacturing and material selection process for the fabrication of labyrinth seal strips. Journal of Materials Processing Technology 152 (2004), 272-275