CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Of late, the automobile industry has been facing substantial technical challenges as it seeks to improve fuel economy, reduce vehicle emissions and enhance performance. It is important to reduce the overall weight of the vehicle for improving the fuel economy. Since the brake drum represents the unsprung rotating masses, the reduction in their weight is essential to increase the vehicle dynamics and acceleration. The possibility to substitute alternate materials, in order to improve brake performance and to reduce weight has made the development of advanced materials. Increased traffic density in cities requires brakes with more energy absorbing capability at more frequent intervals. Increased speed of automobiles with a demand of fuel economy, vehicle comfort and cost reduction envisages the suitable selection of materials for brake drums. Thus the need arises for searching a suitable material and designing comparatively smaller and light weight brakes.

The use of light weight materials in vehicles has been increasing as the need for higher fuel efficiencies and higher vehicle performance increase. Cast iron is the traditional material used for making brake drums and rotors of both light and heavy vehicles. The wide availability and the low cost are the advantages of these materials. Disadvantages include its heavy weight, high wear rate, noise and vibration. There has been interest in using aluminum
based metal matrix composites (Al MMCs) for brake disc and drum materials in recent years. While much lighter than cast iron, they are not as resistant to high temperatures and are sometimes only used on the rear axles of automobiles because the energy dissipation requirements are not as severe compared with the front axle. Therefore, from the performance standpoint it is very much essential to study the behaviour of MMC brake drum before using it in the actual applications. In this study, an attempt has been made to study and compare the behaviour of MMC with the conventional cast iron for brake drum applications.

1.2 AIM AND SCOPE OF THE PRESENT WORK

Aim

To evaluate the suitability of Aluminium Metal Matrix Composite for light weight automotive brake drum applications based on theoretical analysis, finite element analysis and experimental analysis.

Scope

a. To evaluate and select a suitable alloy system and reinforcement for the metal matrix composite (MMC) brake drum.

b. To design an aluminum metal matrix composite brake drum to replace the existing heavy cast iron brake drum.

c. To optimize the dimensions of the brake drum using genetic algorithm to minimize the temperature rise at the surface of the brake drum.
d. To fabricate a dispersion casting set-up to manufacture MMC brake drum.

e. To manufacture the MMC brake drum and the MMC specimens.

f. To design and fabricate a brake drum test rig to test the performance of MMC brake drum and the cast iron brake drum.

g. To determine and compare the dynamic friction coefficient of cast iron and MMC brake drum.

h. To determine and compare the heat generation and dissipation in the MMC brake drum with the existing brake drum.

i. To perform static analysis on the brake drum to determine and compare the stress and deformation in the cast iron and the MMC brake drum.

j. To perform thermal analysis on the brake drums using theoretical and finite element techniques.

k. To perform wear analysis to compare the wear and the friction coefficient of MMC with the cast iron while sliding against brake shoe lining material.

l. To evaluate the suitability of the MMC brake drum by comparing the weight, strength, braking effect, thermal characteristics and cost with that of cast iron brake drum.
1.3 A BRIEF INTRODUCTION ABOUT THE PRESENT WORK

1.3.1 Literature Survey

Literature is available on general manufacturing and wear analysis of MMCs. From the available literature, it is found that the MMCs have excellent wear resistance and friction coefficient which are essential for brake drums. A few literature is available on the applications of MMCs for brake drums. Literature is also available on the brake dynamics, brake torque and temperature rise during braking. In the second chapter, the collected literature are discussed in detail.

1.3.2 Design and Optimization of MMC Brake Drum

The design and optimization of the MMC brake drum has been presented in the third chapter. The brake drum of a commercial passenger car has been selected for the study. The MMC brake drum has been designed by having the same inner radius and inner width. The dimensions of the brake drum are optimized for minimum weight and minimum temperature rise using genetic algorithm, a powerful nontraditional optimization technique. The optimization procedure and the results are presented in this chapter. The mass and temperature rise before and after the optimization also has been presented.

1.3.3 Fabrication of Manufacturing Set-up and Manufacturing of MMC Brake Drum

The development of manufacturing set-up and the manufacturing of MMC brake drum are presented in the fourth chapter. A stir casting setup has been fabricated for manufacturing the MMC brake drum. Provisions are made for feeding and mixing the reinforcements with the melt. The MMC brake
drum has been manufactured using A356 aluminium alloy and 25% silicon carbide particles and machined to the required size.

1.3.4 Fabrication of Experimental Set-up and Testing

In the fifth chapter, the fabrication of experimental setup and testing of the MMC brake drum has been elaborately presented. A brake drum test rig has been fabricated for the test. The test rig has the provision to mount the brake drum and to rotate it at different speeds. A commercial carrier plate which contains the shoe assembly has been mounted on the drum shaft using a bearing and it is kept stable using a load measuring device. A master cylinder with a pressure gauge has been mounted on the test rig to apply different braking forces. The brake torque developed at the friction surface has been measured using a spring balance. The applied brake force has been measured from a pressure gauge. Thermocouples are inserted in the brake drum to measure the temperature rise as per the SAE standards. The brake torque, brake factor and temperature rise have been determined for different applied brake line pressures using the experimental setup. From the results, improved brake torque, high brake factor and reduced temperature rise have been observed for the MMC brake drum.

1.3.5 Static Analysis

The stress induced and the deformation of the brake drum during braking has been computed using theoretical and finite element techniques. The results are discussed in the sixth chapter. The steps followed in the analysis and the results are also presented in this chapter.
1.3.6 Thermal Analysis

The temperature rise has been theoretically computed and using finite element techniques. Finite element technique has been used to predict temperature rise in brake drums under single stop, repeated and continuous braking conditions. The steps followed in the analysis and the results are also presented in the seventh chapter.

1.3.7 Wear Analysis

In eighth chapter, the wear behaviour of Al MMC sliding against automobile friction material has been compared with the conventional grey cast iron. The MMC disc specimen has been manufactured using A356 aluminium alloy and 25% silicon carbide particles and machined to the required size. The wear tests have been carried out on a pin on disc machine, using pin as brake shoe lining material and discs as A356/25SiC\textsubscript{p} Al MMC and grey cast iron materials. The procedure of the wear test and the details of the investigations are presented in this chapter.

1.3.8 Evaluation of Al MMC Brake Drum

The suitability of Al MMC for light weight automotive brake drum has been studied by considering the weight, wear, friction coefficient, temperature rise, strength and the cost. Comparison of MMC brake drum with the cast iron brake drum has been presented in the ninth chapter.

1.3.9 Conclusions

The contributions of the present work are reported in the tenth chapter. The results obtained from the theoretical analysis, finite element
analysis and experimental analysis for cast iron and MMC brake drums under single stop, repeated and continuous brake applications are presented in this chapter. The scope for further research also has been indicated.

1.4 CONCLUDING REMARKS

The present study shows that the Al MMC brake drum has better wear resistance, high friction coefficient and less weight than the traditional cast iron brake drum. The study on temperature rise showed that even under severe braking, the temperature rise is within the maximum operating temperature of Al MMC. So, it is concluded that the Al MMC is a better alternate material for using it in the automotive brake drum applications.