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Al 6351 T6 as a Brake Rotor Material

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Abstract- Braking system is important and necessary safety system for automobiles. Whole brake system is unsprung mass of automobiles and the use of lightweight material to produce component for brake system gives more advantage. It can be said that lessor the unsprung weight of vehicle, greater the performance can be achieved. In this paper, properties of Al 6351 T6 alloy has been discussed and it was found that it is 48% light in weight compared to cast iron. Quality and different properties of this material is additionally great.Testing of braking efficiency using new rotor also gives positive result. At the end, it can be concluded that Al 6351 T6 material is suitable for brake rotor.

Keywords- Brake rotor, cast iron, Light weight material, Alternative material, Al 6351 T6, Stopping Distance and time, speed.

I. INTRODUCTION

Every single vehicle needs more and more safety features. But, rather than performance, safety also required strongly today. Braking system is one of the most impotant safety systems of an automobile. Entire brake system is considered as unsprung mass of a vehicle and it is known that less unsprung mass gives more efficiency.

Mostly, Cast iron is used as a brake rotor material which contains carbon and various additives. Density of cast iron is high and it leads to more fuel consumption. Some sports cars are equipped with Silicon-carbide or stainless steel rotor. Alloys are light in weight and have good mechanical properties.

Aluminum alloys are being extensively used in various field of life, especially in aerospace and automobile industries, because of good thermal stability and excellent specific strength. [1]

All the properties of Al 6351 T6 are referred and brake rotor from this material is also made for testing. After testing, it can be concluded that Al 6351 T6 composite is one of the best suitable materials compared to cast iron and some other alternative materials.

II. LITERATURE SURVEY

S.J. Kwon et al. [1]:- In this study, three kinds of full size organic pads are tested for 205 ceramic particle dispersed aluminum alloy composite brake disc that is also full size. Author concluded that the aluminum alloy disc and three kinds of organic disc pads show interesting friction and wear characteristics. The obtained instantaneous friction coefficient range is 0.25-0.5 and the obtained mean friction coefficient range is 0.31-0.47. The friction coefficient of the brake pad B is the highest, which seems to result from the more quantity of the steel fiber. Aluminum alloy has good heat conduction, the temperature of the brake disc is below 160 C and temperature of the brake pad is below 140 C. The temperature rise of the pad B is lowest. No heat cracks were occurred during the braking test. The pad A shows the best friction and wear characteristics.

Faiz Ahmed, et al. [2]:- Aluminum matrix composites are well known for high strength to weight ratio, and high temperature applications. In this study, wear behavior of alumina particles reinforced aluminum matrix composites and brake disc material has been investigated. AMC's used in this study is 30% vol. alumina particles in Al alloys and was developed by squeeze casting. Wear rate was measured at 25, 50, 70, and 100 N and sliding speed of 250, 500, 750, and 1000 rpm. The coefficient of friction of both AMCs and brake disc was measured. The microstructures of both materials were also examined after each load. At the end, the result showed that wear rate increased with increase in load. The coefficient of friction was consistent up to 50 N loads and then decreased at 75 N and 100 N. The microstructure showed that the AMCs experienced the combination of adhesive, abrasive and fatigue type of wear under various loading conditions. The coefficient of friction decreased as the surface of the AMCs become rougher at higher load. This was considered because of alumina particles removal from the surface of AMCs during wear test and the remaining aluminum alloy without alumina particles made the material softer.

Graham Withers, et al. [3]:- In this article, author has discussed about ULTALITE-A low cost, light weight, aluminum metal matrix composite for braking applications. ULTALITE is a low cost (AL-MMC) that uses ceramic particles extracted from fly ash as the reinforced particulate. Australian developed ULTALITE composites use ceramic particles to increase the wear resistance, provide high thermal conductivity, and give good machinability for metal components. The ceramic particles used are low cost because the fly ash is sourced as a byproduct of coal fired power plants. Author shows that the density of ULTALITE composites is about 2.3 g/cm3, or less than one third the density of gray cast iron. Components made from this material provide a weight saving of about 60% compared to similar cast iron parts and thus provide improved fuel efficiency with reduced greenhouse emission. This attractive combinations of properties and low cost make ULTALITE

AL-MMC an ideal material for the manufacture of wear resistant, light weight automotive components such as brake drum, brake calipers, disc brake rotor, engine blocks, cylinder heads, transmission casing and internal components such as piston, connecting rod, oil pumps, extras.

Rathod Abhik, et al. [4]:- In designing application, MMC has been comprehensively utilized due to their physical and mechanical properties. They are extensively utilized in the field of aviation and cars on account of their high quality of wear proportion, lighter weight, lower cost and great conduct. In this investigation, the mechanical and wear conduct of aluminum metal framework composite and SiC has been examined. Brake cushion is fabricated by course of powder metallurgy which is generally favored due to its minimal effort, high volume generation, simplicity of activity, appealing assembling procedure and maintainability. Brake cushions are created with light compound aluminum 2014 strengthened with SiC to enlarge the quality and wear obstruction and investigate the upside of low thickness of the framework. Test 1 is 20% strengthened and test 2 is 10% fortified. Toward the end, creator infers that as a result of lower thickness of test 1 has higher wear rate than test 2. Test 1 has higher hardness than test 2. The hardness esteem get is too lower than the unadulterated aluminum example in light of less sintering time and compaction weight.

Outcome From Literature Survey

From the literature survey it is observed that some other composite materials can also be used as brake rotor material. Aluminum composite materials are well known for high strength to weight ratio [2] and have good heat conduction [1]. Aluminum composite material is also light in weight compared to cast iron [3] and it is suitable as brake rotor material.

III. METAL COMPOSITION OF AL 6351 T6 MATERIAL

TABLE I. AL 6351T6 METAL COMPOSITION

Aluminum	96 – 98.5 %
Silicon	0.7 – 1.3 %
Magnesium	0.4 – 0.8 %
Manganese	0.4 – 0.8 %
Iron	0 – 0.5 %
Titanium	0 – 0.2 %
Zinc	0 – 0.2 %
Copper	0 – 0.1 %

IV. PROPERTIES OF AL 6351 T6 COMPARED TO CAST IRON

TABLE II. CAST IRON VS. AL 6351 T6 PROPERTIES [14, 15]

property	Cast iron	Al 6351 T6
Density (Kg/m3)	7850	2700
Poison's ratio	0.27	0.33
Melting point (^{0}C)	300	600
Thermal conductivity (W/m-K)	48	180
Ultimate Tensile Strength (Mpa)	200	320
Yield Strength Mpa	130	260
Modulus of Elasticity (Gpa)	67	72
Hardness	260	155
μ	0.46	0.92

V. FABRICATION AND TESTING

For the experiment purpose, the brake rotor from Al 6351 T6 material is manufactured with same dimension as cast iron brake rotor which is already exist. The reason for making holes on the rotor is to remove material and better heat dissipation. Figure I shows the manufactured brake rotor.

FIGURE I: AL 6351 T6 ROTOR

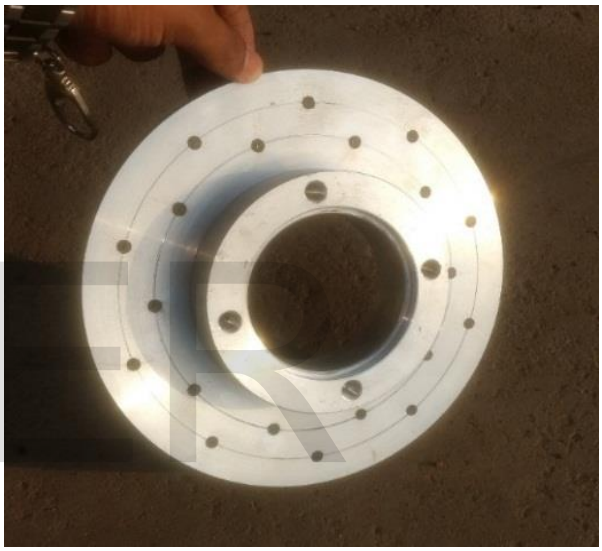


Figure II shows the brake assembly of the vehicle with new manufactured brake rotor as experimental setup.

FIGURE II: BRAKE ASSEMBLY

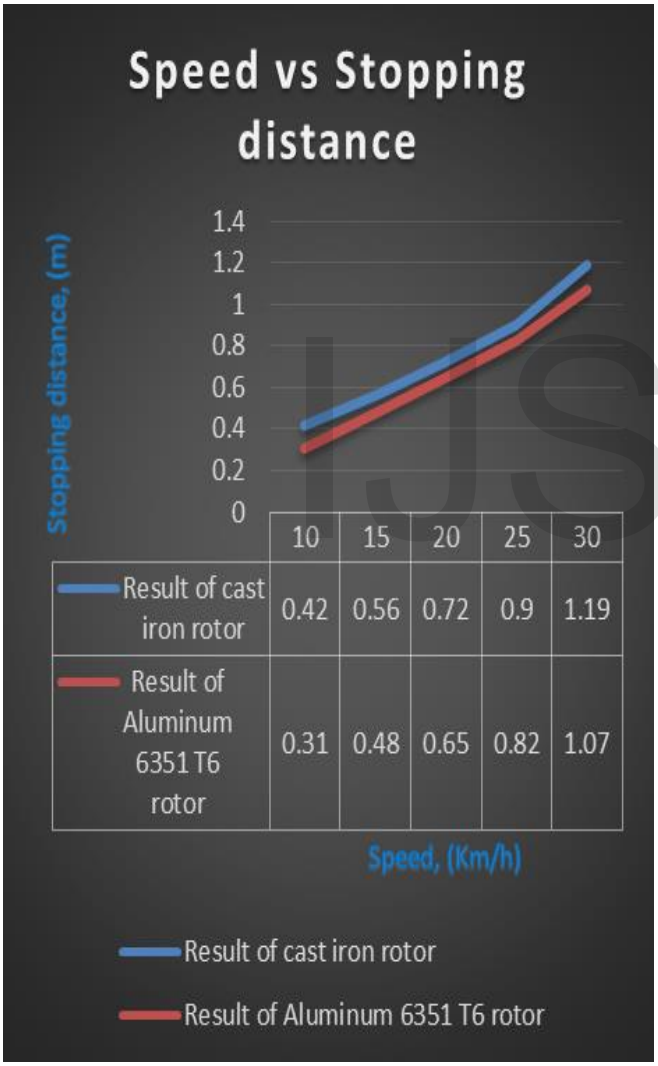
TESTING

After the production of this new brake rotor, it is assembled with braking components of Maruti Omni and vehicle performance testing is done with different speed of 10km/h, 15km/h, 20km/h, 25km/h and 30km/h. Both the rotor made from cast iron and Al 6351 T6 is compared on the basis of their weight, vehicle speed, Stopping distance and time to stop the vehicle.

VI. RESULT

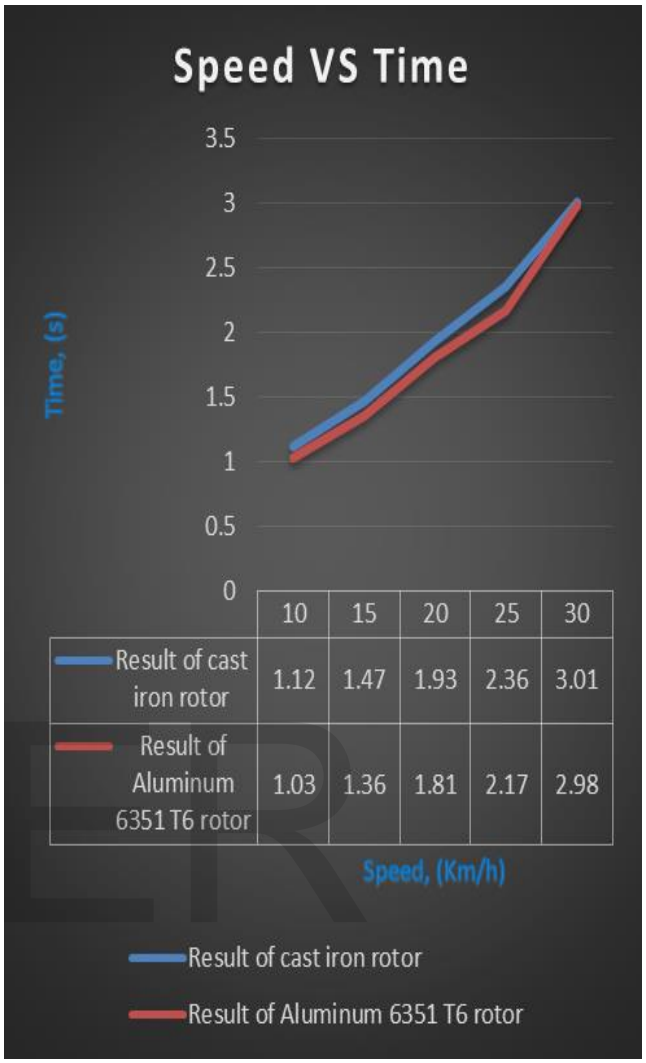
- Weight comparison shows that weight of cast iron rotor is 2.3 Kg and Al6351 T6 rotor is 1.2 Kg which is 48 % lighter than cast iron.

FIGURE III. COMPARISON OF SPEED VS STOPPING DISTANCE BETWEEN CAST IRON AND ALUMINUM 6351 T6 ROTOR



- At the speed of 10km/h, 15km/h, 20km/h, 25km/h, 30km/h the stopping distance is 0.31m, 0.48m, 0.65m, 0.82m, and 1.07m respectively which are shown in figure III that there is reduction in stopping distance for Al6351 T6 rotor compared to Cast iron rotor.
- At the speed of 10km/h, 15km/h, 20km/h, 25km/h, 30km/h the time taken to stop the vehicle is 1.03sec, 1.36sec, 1.81sec, 2.17sec and 2.98sec respectively which is shown in figure IV that stopping time is reduced in case of Al6351 T6 rotor compared to Cast iron rotor.

FIGURE IV. COMPARISON OF SPEED VS TIME BETWEEN CAST IRON AND ALUMINUM 6351 T6 ROTO



VII. CONCLUSION

After the performance testing, it can be concluded that Al 6351 T6 material is comparatively 48% light in weight compared to cast iron brake rotor. Stopping distance reduction percentage of Al 6351 T6 is 26.19%, 14.28%, 9.72%, 8.88%, 15.96% at the speed of 10km/h, 15 km/h, 20 km/h, 25 km/h, 30 km/h respectively compared to cast iron. Similarly, stopping time reduction percentage of Al 6351 T6 compared to cast iron is 8.03%, 7.48%, 6.21%, 8.05%, 0.99% at the speed of 10km/h, 15 km/h, 20 km/h, 25 km/h, 30 km/h respectively compared to cast iron. On the basis of above result, it can be concluded Al 6351 T6 composite is suitable material and can be used as an alternate material of brake rotor.

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