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Design and Analysis of Drum Brake

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Abstract — *The brake drum is a specialized brake that uses the concept of friction to decelerate .The deceleration is achieved by the assistance of the friction generated by a set of brake shoes or pads. During the brake operation heat is ejected out this causes damage to the brake. To satisfy this condition the drum material should possess a high thermal conductivity, thermal capacity and high strength .The common material used for construction of brake drum is cast iron. A thermal analysis of different materials such as aluminium alloy, cast iron and stainless steel 304 for a brake drum will be done. Grey cast iron is the conventional material used for making brake drums of light and heavy motor vehicle. The problems encountered in the cast iron material are described. An Al MMC brake drum has been designed to replace the heavy cast iron brake drum of a typical passenger vehicle. The design parameters such as inner radius, outer radius, and the width of drum, load and the allowable deformation are kept same for both cast iron and MMC brake drum. The maximum temperature that is generated is calculated with the help of the ambient temperature for all the three materials. The area of cross section is calculated and thus their weight is calculated for three different densities of the three materials. A model is created with the help of computer aided drafting software, namely CATIA. Steady state condition is studied for all the three materials. Then thermal deformation is calculated assuming a pressure of one Newton is applied as a braking energy or force. A comparison of all the three results is done and MMC material is proved better than the other materials.*

Keywords*-Brake Drum; Material Selection; Design; Thermal Analysis; Loading*

I. INTRODUCTION

Drum brakes were the first types of brakes used on motor vehicles. Drum brakes are still used on the rear wheels of most vehicles. The drum brake is used widely as the rear brake particularly for small car and motorcycle. The leading-trailing shoe design is used extensively as rear brake on passenger cars and light weight pickup trucks. Most of the front-wheel-drive vehicles use rear leading-trailing shoe brakes. Such design provided low sensitivity to lining friction changes and has stable torque production. A brake is a mechanical device which is used to absorb the energy possessed by a moving system or mechanism by means of friction. The primary purpose of the brake is to slow down or completely stop the motion of a moving system, such as a rotating disc/drum, machine or vehicle. The simplest way to stop a vehicle is to convert the kinetic energy into heat energy. The energy absorbed by brakes is dissipated in the form of heat. The heat is dissipated in surrounding, air, water etc. The braking equipment of a vehicle includes all of its brake system that is all of reducing velocity of a moving vehicle, halting the acceleration, increasing its rate of deceleration. A drum brake is a brake that uses friction caused by a set of shoes or pads that press against a rotating drum shaped part called a brake drum. The brake drum is generally made of cast iron that rotates with the wheel. In an automobile, the wheel is fitted on a wheel drum. The brake shoes come in contact with inner surface of this drum to apply brakes. The whole assembly consists of a pair of brake shoes along with brake linings, a retractor spring two anchor pins a cam and a brake drum.

II. Stages of Material Selection

[1]For material selection there are small numbers of methods that have evolved to a position of prominence. Material selection process is an open-ended and normally lead to several possible solutions to the same problem. This can be illustrated by the fact that similar component performing similar function, but produced by different manufacturers, are often made from different materials and even by different manufacturing processes. However selecting the optimum combination of material and process is not a simple task rather gradually evolved processes during the different stages of material selection. In this investigation, the stages of material selection method are shown using a flow chart 1

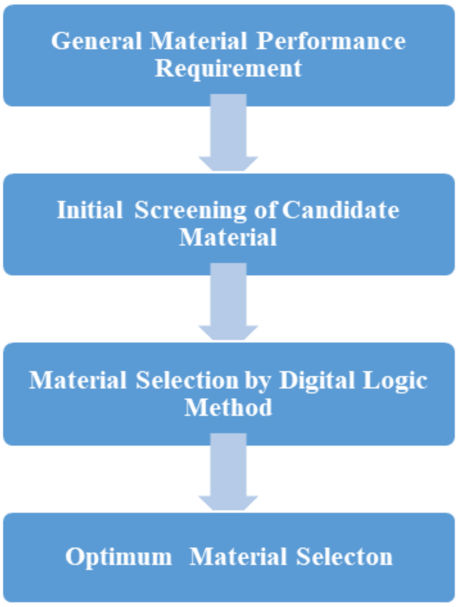


fig. Stages of Material selection method

- **Selection of Materials**

a) Cast Iron[1]

Cast iron is iron or a ferrous alloy which has been heated until it liquefies, and is then poured into a mould to solidify. Carbon (C) and silicon (Si) are the main alloying elements, with the amount ranging from 2.1 to 4 wt% and 1 to 3 wt%, respectively. Cast iron tends to be brittle, except for malleable cast irons. With its relatively low melting point, good fluidity, cast ability, excellent machinability, resistance to deformation and wear resistance, cast irons have become an engineering material with a wide range of applications and are used in pipes, machines and automotive industry parts. The chemical composition of the cast iron which is being taken into consideration for this particular study is stated as below. Iron - 95%, Carbon - 4%, Silicon - 1%

b) Aluminium Alloy

Aluminum alloy is a lightweight panel material which is designed for interior and exterior applications. The chemical composition of the aluminium alloy which is being taken into consideration for this particular study is stated as below. Alumina – 30 %, Magnesium – 1 %, Balance is Aluminum. Aluminum oxide is an amphoteric oxide with the chemical formula Al_2O_3. It is commonly referred to as alumina, Aluminum oxide is a chemical compound of aluminium and oxygen with the chemical formula Al_2O_3. Al_2O_3 is an electrical insulator but has a relatively high thermal conductivity (30 $Wm^{-1}K^{-1}$) for a ceramic material.

$Al_2O_3 + 6\,HCl \rightarrow 2\,AlCl_3 + 3\,H_2O$

$Al_2O_3 + 6\,NaOH + 3\,H_2O \rightarrow 2\,Na_3Al(OH)_6$

c) Stainless Steel 304

Type 304 stainless steel is a T 300 Series Stainless Steel austenitic. It has a minimum of 18% chromium and 8% nickel, combined with a maximum of 0.08% carbon. It is defined as a Chromium-Nickel austenitic alloy. Grade 304 is the standard "18/8" stainless that you will probably see in your pans and cookery tools. Stainless steel has excellent corrosion resistance and good resistance to inter granular corrosion. Excellent hot and cold forming process and performance. Better low temperature performance. At -180 ℃ condition, strength, elongation, area reduction rate is very good. In the absence of brittle transition temperature, often used at low temperatures. It has good weld ability. Welding method can be used often, both before welding without heat treatment after welding.

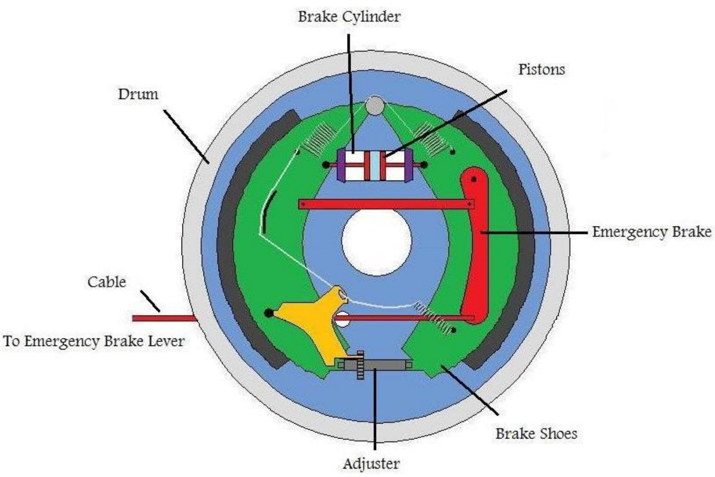
d) Aluminium-Metal Matrix Composite (AMC):

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 50-60% in brake systems. The repeated braking of the AMC brake rotor lowered the friction coefficient μ 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.

III. DESIGN OF COMPONENTS

➢ **Designing of Drum Brakes by using Solid Works[3]**

The commercial brake system uses disc brake for front wheels and drum brake for the rear wheels. Gray cast iron is the conventional material used for making brake drums of light and heavy motor vehicle. The problems encountered in the cast iron material are described in the second chapter. An Al MMC brake drum has been designed to replace the heavy cast iron brake drum of a typical passenger vehicle. The design parameters such as inner radius, outer radius, and the width of drum, load and the allowable deformation are kept same for both cast iron and MMC brake drum. The theoretical formulation for the evaluation of stress, deformation and temperature rise has been described in this chapter. The finite element analysis of the cast iron and MMC brake drum has been also presented in this chapter.



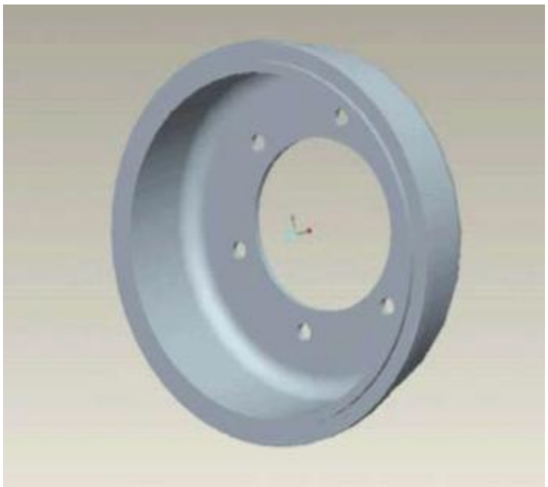


Fig. **Assembly of Brake Drum**

A brake drum assembly of a light passenger vehicle which is used for the analysis is shown in Figure 3.1. The drum brake consists of backing plate, brake shoes, brake drum, wheel cylinder, return springs and a self-adjusting system. Brake shoes consist of a steel shoe with the friction material lining riveted or bonded to it. The brake drum has holes in the hub which are 27 used to mount the brake drum on the hub of the wheel and the design parameters are listed in the Table 3.1.[4]

Parameter	**Value**
Inner Diameter (mm)	110
Outer diameter (mm)	164
Outer width (mm)	10
Inner width (mm)	38
Contact angle per shoe	120^{o}
Width of shoe (mm)	25
Number of shoe	2

Fig.1 **Table for Parameter of Hero Honda Passion Brake Drum**

➢ **Backing plate** [4]

The plate, attached to the axle assembly, holds the components of the drum brake assembly. A backing plate is stamped steel and has various holes for springs, parking brake cables, and wheel cylinder attachment, and support pads for the shoes. The labyrinth seal is formed around the outside of the backing plate to keep water from entering the brake assembly.

➢ **Brake shoes**

The shoes are the metal backing on which the lining material is attached. The brake lining is either riveted or glued to the shoe Depending on the brake design, all four shoes may be the same, allowing them to be installed on either side in either the leading or the trailing position. Some applications require a specific shoe be used in one location only. The brake shoe lining material varies but often contains abrasives, such as aluminium, iron and silica, friction modifiers including, graphite and ceramic compounds, fillers, and binders. Linings for many years contained asbestos to improve the wear and ability to provide friction at very high temperatures. Research showed that asbestos dust could lodge in the lungs and lead to lung cancer. Because of the health concerns, asbestos was phased out of use in brake linings. However, it is possible that linings produced outside of the United States contain asbestos, and it is impossible to know whether asbestos dust is present in the brake system. For this reason, special brake dust collection and containment procedures are used when working on the brake system.

➢ **Brake drum**

The drum has an internal friction surface for the shoes to rub against. Compared to a brake rotor, a drum has significantly less contact area, however, the contact area between the shoes and drum is large, much larger than the contact area between brake pads and the rotor. Drums are usually cast iron, but some vehicles use a composite aluminium outer shell and an iron friction surface to save weight. Many larger drums have cooling fins cast into the outer circumference to aid in heat dissipation.

➢ **Springs and Pins**

a) Return springs

The return springs pull the shoes back when the brakes are released. Some designs use one return spring per shoe, while others use one spring bridging both of the shoes.

b) Hold down springs and pins

These springs and pins hold the shoes to the backing plate and keep the shoes in position on the raised pads. One hold down spring per shoe is the most common. A few designs use two springs per shoe.

➢ **Wheel cylinder**

when the brakes are applied, hydraulic pressure pushes the two pistons in the Swept area one surface Swept area two surfaces **60 Square Inches 100 Square Inches**. A brake drum has less surface area than a brake rotor, but there is much more contact area between the brake shoe linings and the drum than there is between the brake pads and rotor. The fins increase the drum's external surface area, which allows for more rapid heat dissipation. Wheel cylinder outward against the shoes, the parts of the wheel cylinder. The spring prevents the cups and pistons from retracting too far into the cylinder when the brakes are released. The cups seal the fluid in the cylinder. External dust boots prevent brake dust and debris from entering the cylinder.

IV. FOOTNOTES

As brake drum is having a modified geometry, it necessary to check that it function properly under given load every time. a steady state thermal analysis may be either linear, with constant material properties or nonlinear with material properties. Depend on temperature. We cannot exactly predetermine the thermal properties of most material with temperature. For steady state and braking state environmental factors affect example humidity .Material properties varies along with temperature which play vital role on result .As such when load on bike is less result is different so can't predict exactly determine analytical result values.

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