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Design of A Fine-Enhanced Brake Drum Model for Better Heat Dissipation

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ABSTRACT

The brake drum of an automobile can get so hot that it fails, killing anybody in the car and perhaps wrecking the vehicle. Several sources state that adding fins to the outside of a brake drum can boost braking performance through air cooling and that this is the finite element approach for quicker heat dissipation from a vehicle or truck brake drum. To make the brake drum more efficient at dissipating heat through conduction and convection, this idea calls for converting one to twelve percent of its total height and thickness into fins. The revised process for developing the braking drum accounted for the relevant fin design calculations. Modelling and simulation analysis were carried out using the appropriate software package, and theoretical finite element analysis was employed for validation. Through the use of computational modelling, the lowest temperatures were ascertained.

Key words: Modified Brake Drum Development and Validation.

1.INTRODUCTION

To slow down a moving vehicle, its brakes transform the vehicle's kinetic energy into thermal energy. The systems' primary function is to absorb kinetic energy at the wheels by slowing their movement through friction. Drum brakes are often found on passenger vehicles' rear axles, but disc brakes, thanks to their superior directional stability, are commonly seen on front axles. A pair of shoes rubs against the inside of a spinning brake drum, creating friction. The drumare shoes have a layer of friction material within. The piston within the wheel cylinder applies pressure to the braking drum, which in turn presses down on the brake shoes. The wheel cylinder's hydraulic fluid operates the pistons, pressing the brake shoes against the brake drum. On the rear plate are the wheel cylinders and shoes attached. The big, important component of the braking system that revolves around the brake shoes is the brake drum. Hard braking heats the drum, which expands its diameter and requires a deeper push of the brake pedal to achieve an efficient braking action. Brake fading is the cause of drivers' anxiety and, in the worst cases, brake failure. The purpose of this work was to address this issue as well. Improving heat transmission from a surface is a common application of fins. One method of thermal management is to employ fins, which are basically expanded surfaces, to increase the available surface area and, by extension, the overall dissipation of heat. Electronics, engines, and industrial machinery are just a few examples of the many mechanical devices that use fins.

To be operational, an item must be able to dissipate excess heat; failure to do so may cause the gadget to malfunction or even break (Dannelley 2013). Hence, adding extension (fins) to the surface of the brake drum greatly improves its convective heat removal performance. In this research, we do this by keeping the two models' weights constant and by modifying them so that extended surfaces (fins) cover one-fourth of the original model's overall height thickness. We then stimulate these two models to study how forces and temperature affect them.

A brake is a tool for stopping or slowing down an object in motion. One of the first forms of vehicle braking technology was the drum brake. Drum brakes are still commonly utilised on most cars' rear wheels, even over a century after they were originally deployed. the third To slow down or stop moving objects, brakes are utilised. The conversion of kinetic energy into heat energy occurs as a result of friction. Convection is transferring the heat energy to the surrounding environment. In order for the brake to work smoothly and last a long time, it must meet the following requirements:

- ✓ The heat that is produced when the brake is applied must be quickly dispersed in order to lower the temperature. Since the drum swells at high temperatures, the effective pedal travelling is increased.
- ✓ A material with a low thermal coefficient for expansion, a high thermal coefficient of convection and conduction, and enough strength with a minimal weight is required.
- ✓ It ought to fit in the designated area for wheels.

The brake needs to be highly resistant to wear.A less loud and more efficient design is required of the brake. Drum brakes are more likely to fade or fail than disc brakes, and this might be because drum brake equipment is indirectly exposed to air, which slows down convective heat transfer and causes it to release a low quantity of heat (Sinha & Gahir, 2018). According to Alin- Marian et al. (2015), Travaglia and Lopes (2014), Rong et al. (1997), and Puhn (1985), adding fins to the outside surface of the brake drum is one technique to improve heat transmission. But Sinha & Gahir (2018) modified the drum brake design to get three distinct models by varying the amount of fins added to the circumference in their critical quest for efficient approaches to boost heat dissipation in the brake drum. Among other things, they simulated the heat transfer rate in the models by computational fluid dynamics (CFD) analysis using ANSYS fluent software. According to their findings, the heat transmission rate was shown to rise as the number of fins increased. Hsueh (2012) created a thermoelectric cooling system–based solution for braking drums. The brake pads' temperature was reduced by bringing the cooling side of the system into touch with them, while the heat was dissipated via a water-cooled radiator and released into the environment. The device's performance study showed a 30% increase in braking force and a 20% drop in working temperature of the brake system. He made the observation that the system ensures a strong braking power when the brake is engaged, allowing the driver to safely lower the vehicle's speed for an extended duration.

Research by Putti Srinivas Rao et al. [1] found that adding a fin to the outside of a drum brake increases the amount of heat transfer from the drum. For optimal heat transmission, a drum brake with a rectangular cross-section and an annual fin made of a highly conductive substance is ideal; however, this design comes at the cost of increased weight. Therefore, a triangular fin is ideal since it allows for more heat transmission while being lighter. Based on the current braking drum, Professor Vidyadhar R. Bajaj and colleagues [2] suggested two other designs. The unique grey cast iron FG260 (SS:4404) is used for all of the designs. To improve the heat transmission area, the material of the drum is removed from the outside surface in the first suggested design. He managed to save 4.74 percent of the weight from the current drum using his invention. Reducing the wall thickness from 13 mm to 7 mm optimises the section in suggested design-2. When compared to the current drum, the second design results in a 4.06% weight reduction. This technology successfully reduces drum weight without compromising performance, according to CAE study. The structural and thermal study of drum brake research by Anup Kumar et al. [3] to the conclusion that the drum brake is an essential part. Brakes are often employed to stop or slow down moving bodies, decreasing acceleration and velocities. Over the course of a single cycle, the transient temperature rises noticeably. It is evident that the specified cooling time is insufficient to adequately cool the drum. Of all the applications of the finite element method, structural analysis is by far the most prevalent. Brakes are able to disperse energy by releasing heat. In order to bring the 8 vehicle to a halt, this heat is dispersed in the surrounding environment. The design check was completed by comparing the highest stress that was produced. Under the specified load conditions, it was determined that the design is safe and that the drum brake functions correctly. A fin or expanded surface is used in studies by Bako Sunday et al. [4] to boost the rate of heat transfer. With the addition of fins, the current drum brake loses one-fourth of its weight. For the purpose of brake drum examination, grey cast iron is used. The type incorporates six fins onto the exterior of the drum, with a width of 7 mm and a distance between them of 20 mm. When designing brake drums in Solid Works 2013, the Kicreyco drum brake catalogue is utilised. Results show that the suggested fin-equipped drum model experiences less stress and has a higher heat transfer capacity at 150 N brake shoe force and 120 °C internal temperature than the current model. Scientists Amit Phatak et al. [5] investigate drum brake sounds. A basic measuring function for non-vibrational harmonic analysis (NVH) is the frequency response function (FRF), which, similar to a transfer function, gives the relationship between the displacement output and the force input in the frequency domain for a specific structure that is being tested. The structural resonances, material damping, and deformation pattern at resonances may be determined using this function. The analysis and mitigation of NVH rely heavily on all of these data. Critical features including vehicle comfort, fuel efficiency, and affordability contribute to the intense competitiveness in the car market's passenger vehicle category. An assembly's noise, vibration, and harshness levels are highly dependent on its individual parts. In a braking state, the liner-drum interaction cannot be controlled. Braking performance suffers when the coefficient of friction is reduced. Therefore, the best approach to stiffening at the design stage and using the FRF quality control procedure before manufacturing is to address squeal noise. When all the numbers are in, there's a simple solution to the brake squeal: just increase the stiffness to change the pattern of natural frequencies. Taking the back plate's rib structure into account yields better outcomes. A thermal examination of several materials, including cast iron, aluminium alloy, and stainless steel 304, will be conducted for a brake drum, according to K.Gowthami and K. Balaji et al. [6]. Stainless steel and cast iron brake drums reach higher maximum temperatures than aluminium alloy brake drums, which only reach 32.83°C. A braking drum cross section made of cast iron weighs 11.305 kilogrammes. Aluminium alloy material results in a 58.52% weight reduction, while stainless steel 304 material causes a 9.53% weight increase. The aluminium alloy brake drum has a thermal deformation of 0.006329 millimetres, which is somewhat higher than the stainless steel brake drum's thermal deformation of 0.004328 millimetres but lower than that of cast iron brake drums. In this examination, aluminium alloy material was found to be superior to the other two materials. In order to improve the design of the drum brake, Meenakshi Kushal et al. [7] uses a reverse engineering technique and runs an experiment. According to the results, the CE (Control expansion) alloy brake experiences far less deformation than the aluminium alloy drum brake. In comparison to AL alloy brake drums, CE alloy brake drums have a lower surface temperature rise, which extends the life of the lining material and improves braking performance. Drum braking causes a temperature increase that is 65–66% higher than progressive braking because of quick breaking. Light commercial vehicles benefit more from drum brake applications made of CE alloy material because of its reduced weight, deformation, and temperature rise.

We are all aware that there are a number of problems, such as noise, vibration, inefficiency, corrosion, and deformation of the drum. While the surgery is underway, these are the parameters that we may change or lower. Based on our extensive literature review, we have arrived at this proposed problem definition.

- ✓ The brake drums' convective cooling is enhanced by the fins or enlarged surface, which further improves the rate of heat dissipation from the surface. Fins were added to the original brake drum model, taking up one-twelve of its total height thickness.
- ✓ Our suggested research is to address the heating problem in drum brakes, improve braking effectiveness, lower costs, promote dependability and safety, modify shoe material, add drum fins, and increase efficiency.

- ✓ The brake drums and braking systems have been examined. Brake drums made of various materials, including cast iron and aluminium alloy, have been the subject of static and thermal investigations. Because no one has ever done it before, we will conduct a thermal study on a variety of materials, including brake drums made of aluminium, carbon composite, stainless steel, and grey cast iron.
- ✓ With the goal of determining the amount of thermal deformation caused by the force exerted by the brake on the materials mentioned earlier.

In order to determine the optimal material for a brake drum, it is necessary to compare all three outcomes.The hydraulic pressure supplied to the brake shoes might be diminished if the brake fluid vaporises due to the braking drum becoming overheated. With the same amount of pedal pressure, the brakes do not provide enough deceleration.Heat may change the friction material's properties, making it less frictional. Due to the shoes being enclosed in the drum and not exposed to the ambient air's cooling properties, this issue can be far more severe with drum brakes compared to disc brakes.High-speed automotive manufacture is one example of how the world is changing due to new technology.

Typically, overheating is not the reason why brake shoes fail. There is a theoretical upper limit to the amount of energy that can be converted by any friction-braking system. Once the speed is reached, increasing the pedal pressure has no effect on it.

2. DISCUSSION OF RESULTS

For two models subjected to 150N brake shoe force and 20°C and 120°C temperatures, respectively, this simulation forecasts stress, displacement, and thermal stress. The von Mises stress and displacement are at their lowest on the adjacent side of the inner section of the two brake drums.

This is because these surfaces do not experience any direct forces. The braking drum walls are subjected to the maximum von Mises stress in both kinds.

The friction between the brake drum and the brake shoes causes this. Compared to the previous model, the revised brake drum model exhibits reduced stress, strain, and displacement values. The fins strengthened the braking drum along its circumference. Brake drum circumferential resistance to force from brake shoe increased with increasing circumferential strength. Because of this, the brake drum also gets stiffer. As a result, the brake drum's inner wall experiences less circumferential stress. When you brake, the brake shoes press down on the brake drum, creating a circular tension.

Despite starting at identical temperatures, the modified model reduces more quickly than the original, according to the thermal studies. Heat transmission rates were lower in the older model than in the updated one. As a result, a portion of the heat is kept. In the original brake drum, very little heat is transported from the inside to the outside. Drum brake systems are vulnerable to brake fade and damage caused by retained heat energy. Heat is transferred more quickly from the inner to the outside surface of the brake drum in the updated model, as seen by the quicker rate of temperature change from maximum to minimum. Moreover, the freezing point is The lowest temperature is greater in the revised model compared to the old one.

This demonstrates that there is a great deal of surface area available for heat dissipation in the revised model due to the impact of the flowing air stream on the brake drum's outside. This means that the upgraded brake drum's heat dissipation rate and conductivity have been enhanced thanks to the fins (expanded surface).

3. CONCLUSION

Results from comparing the two brake drum models' simulations led to the following conclusions:Smaller von Mises stress and displacement values in the modified model suggest that it is more stiff and robust than the original. The upgraded variant offers more circumferential strength while maintaining the same mass as the original. The fins' positioning around the brake drum's outside edge is responsible for this. This led to enhancements in the last three characteristics of the brake drum, which were already discussed.This simulation shows, however, that without precise specification of the design and material specifications, drum brakes are thermally and structurally susceptible to failure under large braking forces. Automotive engineers may use this knowledge to develop brake drums that are more efficient and dependable. Analyses of various fin designs have shown that 1. Rectangular fins result in a high dissipation-based heat transmission rate.When compared to rectangular fins, the heat dissipation rate of circular fins is lower.The rate of heat dissipation in a triangle fin is the same as that in an intermediate flow between two fins.

- ✓ The brake shoe and brake drum now have better coefficients of friction, which provide safe braking.
- ✓ The brake drums and shoes do not wear out quickly.
- ✓ The braking system has a longer lifespan;
- ✓ There is less pollution of the brake fluid;
- ✓ The braking system has better thermal performance.

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