RESEARCH ARTICLE OPEN ACCESS

# Computer Aided Design and Analysis to Reduce the High Heat in Disk Braking System

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**ABSTRACT:** A braking system includes four major parts – the braking pads, the disk, the bracket and the pump. The wheel assembly consists of two parts – the rim and the tire. Traditional vehicles use brakes on all tires and for a modern car or truck they have disk brakes on all four tires while the heavy machinery still use drum brakes. When the brakes are applied, the braking pads are pushed against the drum or the disk to slow the movement by creating friction. This friction causes the vehicle to slow down its motion and even stop when the time is needed.

**KEYWORDS:** Braking System, thermal energy, braking pads, braking disk

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## I. INTRODUCTION

Almost every mode of transportation has some sort of braking system to help it stop or change the speed at which it is travelling. Most modes of transportations have a rubber lining around their rim that provides traction as well as insulation from the vibration caused from travelling on the road. Trains on the other hand have a different type of braking system as they do not have disk brakes or drum brakes. Rims are used to attach the tire assembly to the body of the vehicle and allow it to move between places. On a daily basis, rims are put under a lot of stress on a daily basis due to both the driving conditions and the weight of the vehicle, which can vary from 2,000 pounds to well over 6,000 pounds [1]. In the United States alone, there are approximately 5.6 million car crashes every year, with approximately 5% attributed to brake failure. This means that approximately 300,000 car accidents are caused due to an issue with the braking system of the vehicle [2].

## II. BRAKING SYSTEM

The braking system is a vital part of the vehicle as it allows the vehicle to stop when it needs to over a short distance. The more speed the vehicle has, the more distance is required to stop. The disk braking system when applied start to get hotter. The longer the brakes are applied and the warmer the outside temperature is, the hotter the brakes can get. They have been known to reach $343^{O}C$ (approximately 650 F) [3]. High temperatures over long periods of time end up deforming the braking disk, reducing the disk's ability to stop the vehicle in a timely manner which increases the odds of getting into an accident. Deformation of the disk also means that the both the braking disk and the braking pads would require maintenance at a more frequent rate.

## III. RIM DESIGN

The rim was designed off the rim for a super car. It has a 20 inch face diameter with a 10 inch depth. The design consists of five pieces and includes the outer shell, and inner shell, the blades, the disk and the pad for the braking system. Two rims were designed, one has twelve blades and the other has eighteen blades. The blades on the rim are designed to grab the air that is bypassing the vehicle while it is moving, and redirect it towards the braking system in order to prevent overheating. The below images show the blade design along with both rim designs.

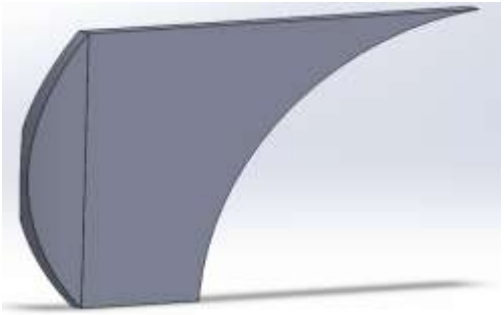


**Fig.1** Rim Blade

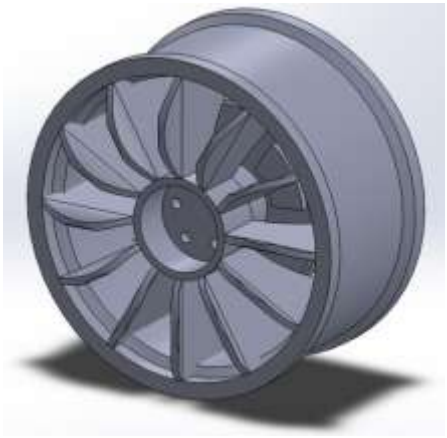


**Fig.2** 12 Bladed Rim

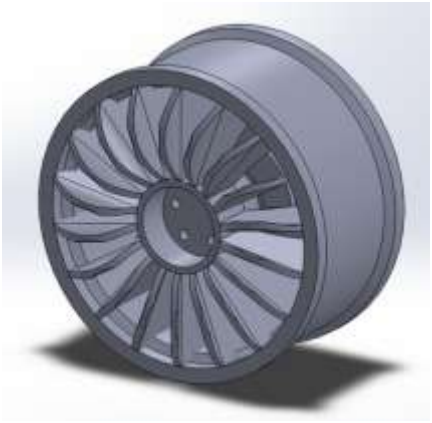


**Fig.3** 18 Bladed Rim

## IV. SIMULATION SETUP

The simulation setup had both thermal and stress conditions applied. The braking system included the thermal conditions while the rim itself included the stress conditions applied. The braking system had heat flux of 57 W/m$^{O}$C [4], convection temperatures and the specified temperature of 343$^{O}$C applied.

Equation for heat flux:

$$S_C = \{Q\}^T\{n\} = h(T_p - T_f)$$

$S_c$ – Surface in Convection
h – Convective heat transfer coefficient
$T_p$ – Temperature imposed
$T_f$ – Fluid temperature

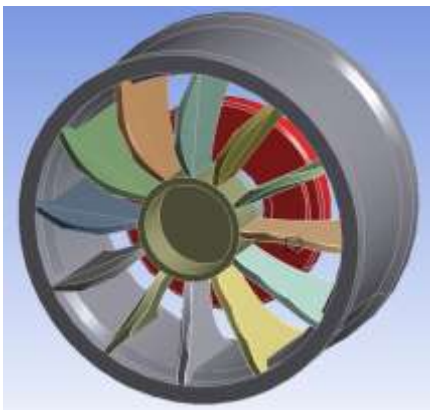


**Fig.4** Temperature application

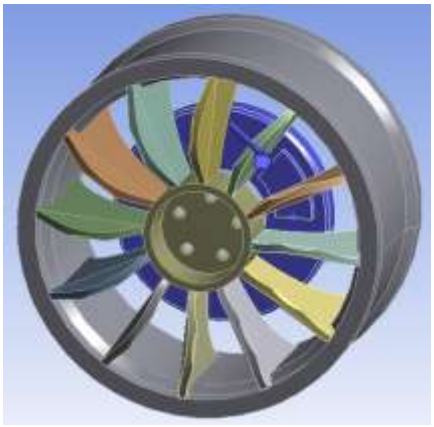


**Fig.5** Heat Flux application

**Fig.6** Convection Temperature applied

A force of 9806 N was applied to the inner shell to resemble the weight of the vehicle on the rim. Since the inner shell is the section that attaches the wheel assembly to the front and rear axles, it was best to apply the load there.

**Fig.7** Load application and direction

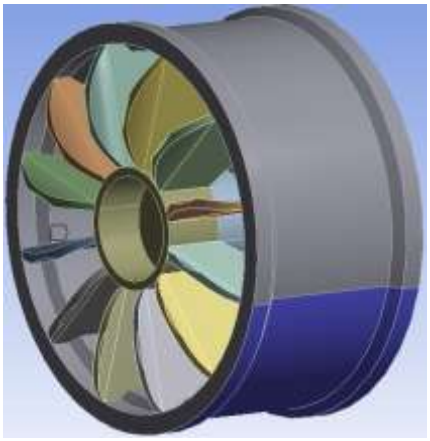


**Fig.8** Fixed Support application

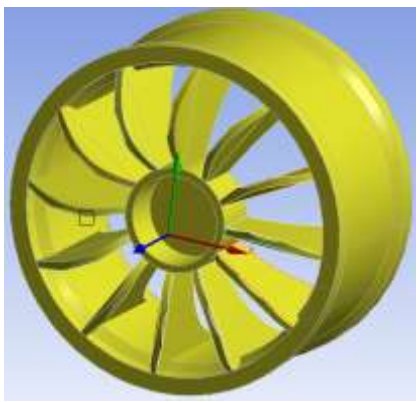
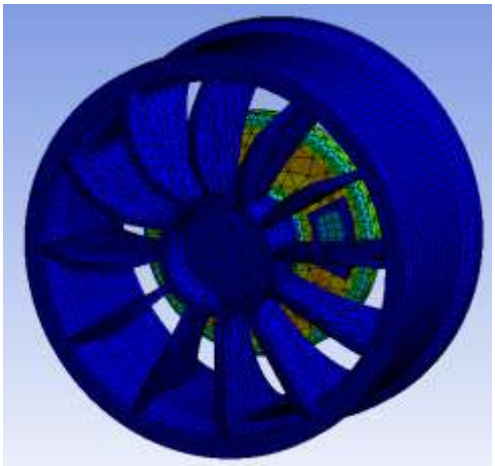


**Fig.9** Displacement application

Material Assignment
Aluminium Alloy – Rim Assembly
Grey Cast Iron – Braking Disk, Braking Pad

## V. RESULTS



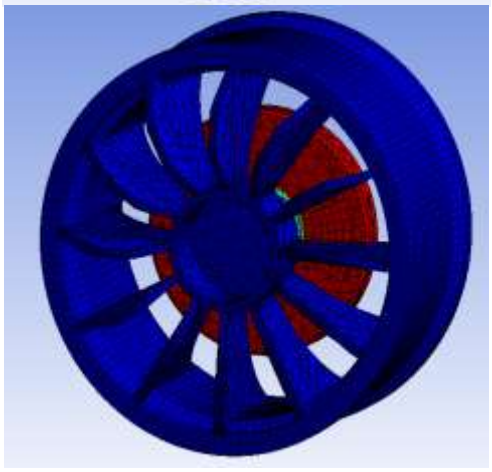


**Fig.10 12** Bladed Rim Heat Flux

As seen from the above results, the temperature has been reduced. The original temperature of 343$^{O}$C was reduced to almost 22$^{O}$C in some areas. The areas that cool the fastest are the edges while the area that is the hardest to cool is the area immediately after the end of the braking pad. Due to the friction that happens when the braking system is applied. The maximum temperature reached after the simulation was 307$^{O}$C.

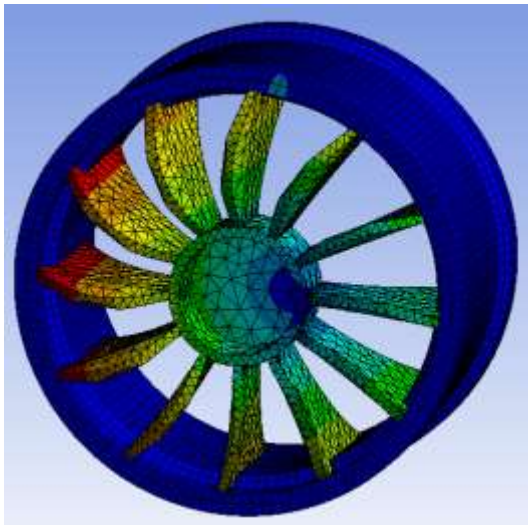


**Fig.11** 12 Bladed Rim Total Deformation

After the load was applied, most of the deformation happens on the blades where the bottom blades experience compression and the top blades experience extension. The side blades also experience deformation as they are bent and the highest point of deformation and stress is at the edges where they are the weakest. The outer rim on the other hand, experienced little deformation at the top edge where the it was compressed a bit due to the blades.

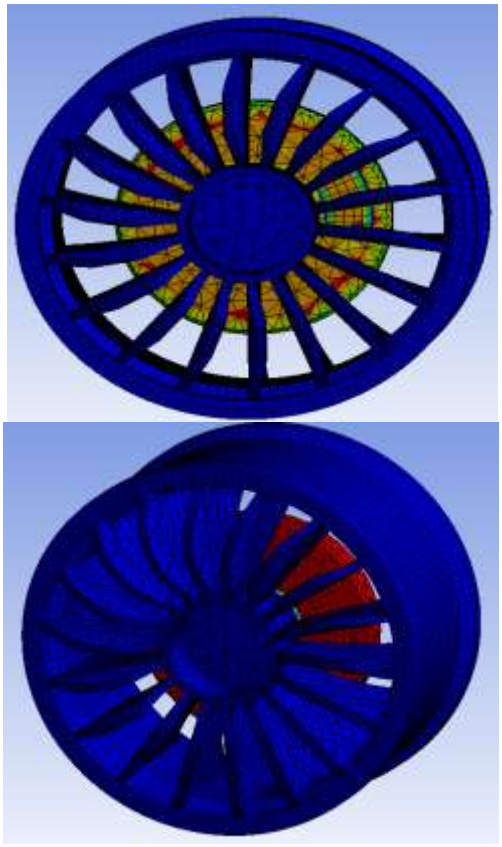


**Fig.12** 18 Bladed Rim Heat Flux

Both rims have similar results, however temperatures on the eighteen bladed rim did not reach as low temperatures as the twelve bladed rim due to the distance between the blades as well as the number of blades. While the other rim has twelve blades at $30^{O}$ apart, this rim has eighteen blades at $20^{O}$ apart which makes a big difference in the amount of air that the rim can grab and redirect. In this case, the higher number of blades were interfering with each other.

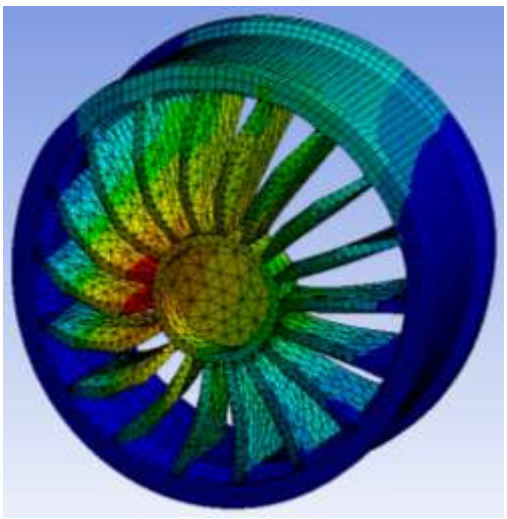


**Fig.11** 12 Bladed Rim Total Deformation

Due to the number of blades, the rim experienced less overall deformation. The outer shell experienced more deformation due to the fact that it had more blades attached and when the tension happened, it was stretched. The higher number of blades also allowed the blades to experience less deformation

## VI. CONCLUSION

Rims and braking systems are essential when driving a vehicle as it allows the driver to stop or slow the vehicle depending on what needs to be done. The tire assembly allows the vehicle to go from point A to point B. When a vehicle comes to stop, the braking system experiences a lot of heat due to the friction. The higher the speed, the longer it takes to stop and the more heat gets generated. When high heat is generated from the braking force required to stop the vehicle, deformation on the disk can occur which leaves the braking system unable to stop in a timely manner.

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