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Optimized Brake Disc Design using Topology Optimization

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***Abstract*— To outline a lighter brake plate than the current models utilized as a part of general bikes is the primary target of this paper. The recently enhanced brake circle is contrasted and existing BAJAJ Discover125M plate. Topology improvement for weight diminishment was performed by utilizing Altair INSPIRE 9.5 programming and the recently upgraded circle was dissected in ANSYS16.0.Using this strategy another light-weight brake plate is outlined. The consequences of the plan demonstrate that the heaviness of another brake circle is 26.68% less when contrasted with the current brake plate and it has comparable execution as the current plate.**

***Index Terms*— Weight Reduction, Topology streamlining, INSPIRE and brake plate.**

I. INTRODUCTION

The stopping mechanism changes over the dynamic vitality of the moving vehicle into warmth. Plate brakes are a sort of brakes that utilizations circles (rather than edges or drums) as the braking surface. This kind of brake is utilized on many sorts of vehicles, for example, autos, bikes, and bikes. In bicycles the circles which are as of now being used are plain plates without much improvement done on them. Their weight can be unquestionably decreased by utilizing weight diminishment through topology streamlining without consulting with the required quality. The fundamental segments of a circle stopping mechanism are the brake caliper, which houses cylinders and brake cushions, and the rotor. A run of the mill arrangement of plate brake caliper and rotor can be found in the cross sectional view appeared in Figure1. Cylinders are normally incited using pressurized water or mechanically. By lessening the heaviness of the vehicle we can enhance the fuel utilization. At the point when the mass of vehicle is diminished the inertialforces which must be overcome by motor likewise decreases, and the vitality required for vehicle to move is additionally less. For the most part for each 10% lessening in weight of the vehicle, the fuel utilization of vehicles is decreased by 5-7% [1].The diminishment in mass of a brake plate is a little rate of the aggregate mass, however it is an accumulation of segments that make up the aggregate mass of the vehicle. The aggregate weight of the vehicle weight has huge effect on execution. Generally, a light vehicle ought to perform better since the motor limit is settled. While decreasing the mass of the rotor alone may appear to be irrelevant, doing as such alongside mass diminishments of all other conceivable parts can be critical.

II. LITERATURE REVIEW

Topology streamlining utilizes a numerical way to deal with improve material format and it is done inside a given outline space. It utilizes fitting limit conditions for given specific application and illuminates the numerical model lastly it gives a streamlined outline which fulfills the necessities of the architect. This strategy for advancing the current geometries without yielding execution prerequisites has numerous applications. Cavazzuti et al. [2] utilized this strategy and outlined the skeleton of a car. Kaya et al. [3] with the assistance of this strategy overhauled a grip fork. Reaction surface technique was received for planning the grasp fork. Topology enhancement has given specialists an apparatus that helps them to build up the best plan meeting each part of execution. Limited component examination is utilized for investigation to execute the produced topologies.[4]Topology enhancement system is connected at first at the idea level to get an underlying outline which then further improved considering

its execution and also fabricating perspective. This spares the season of exorbitant and tedious outline cycles and thus lessening the general cost. Christo Ananth et al. [5] proposed a system about Efficient Sensor Network for Vehicle Security. Today vehicle theft rate is very high, greater challenges are coming from thieves thus tracking/ alarming systems are being deployed with an increasingly popularity .As per as security is concerned today most of the vehicles are running on the LPG so it is necessary to monitor any leakage or level of LPG in order to provide safety to passenger. Also in this fast running world everybody is in hurry so it is required to provide fully automated maintenance system to make the journey of the passenger safe, comfortable and economical. To make the system more intelligent and advanced it is required to introduce some important developments that can help to promote not only the luxurious but also safety drive to the owner. The system "Efficient Sensor Network for Vehicle Security", introduces a new trend in automobile industry. Christo Ananth et al. [6] discussed about Intelligent Sensor Network for Vehicle Maintenance System. Modern automobiles are no longer mere mechanical devices; they are pervasively monitored through various sensor networks & using integrated circuits and microprocessor based design and control techniques while this transformation has driven major advancements in efficiency and safety. In the existing system the stress was given on the safety of the vehicle, modification in the physical structure of the vehicle but the proposed system introduces essential concept in the field of automobile industry. It is an interfacing of the advanced technologies like Embedded Systems and the Automobile world. This "Intelligent Sensor Network for Vehicle Maintenance System" is best suitable for vehicle security as well as for vehicle's maintenance. Further it also supports advanced feature of GSM module interfacing. Through this concept in case of any emergency or accident the system will automatically sense and records the different parameters like LPG gas level, Engine Temperature, present speed and etc. so that at the time of investigation this parameters may play important role to find out the possible reasons of the accident. Further, in case of accident & in case of stealing of vehicle GSM module will send SMS to the Police, insurance company as well as to the family members.

Christo Ananth et al. [7] discussed about an eye blinking sensor. Nowadays heart attack patients are increasing day by day."Though it is tough to save the heart attack patients, we can increase the statistics of saving the life of patients & the life of others whom they are responsible for. The main design of this project is to track the heart attack of patients who are suffering from any attacks during driving and send them a medical need & thereby to stop the vehicle to ensure that the persons along them are safe from accident. Here, an eye blinking sensor is used to sense the blinking of the eye. spO2 sensor checks the pulse rate of the patient. Both are connected to micro controller.If eye blinking gets stopped then the signal is sent to the controller to make an alarm through the buffer. If spO2 sensor senses a variation in pulse or low oxygen content in blood, it may results in heart failure and therefore the controller stops the motor of the vehicle. Then Tarang F4 transmitter is used to send the vehicle number & the mobile number of the patient to a nearest medical station within 25 km for medical aid. The pulse rate monitored via LCD .The Tarang F4 receiver receives the signal and passes through controller and the number gets displayed in the LCD screen and an alarm is produced through a buzzer as soon the signal is received. Christo Ananth et al. [8] discussed about a system, GSM based AMR has low infrastructure cost and it reduces man power. The system is fully automatic, hence the probability of error is reduced. The data is highly secured and it not only solve the problem of traditional meter reading system but also provides additional features such as power disconnection, reconnection and the concept of power management. The database stores the current month and also all the previous month data for the future use. Hence the system saves a lot amount of time and energy. Due to the power fluctuations, there might be a damage in the home appliances. Hence to avoid such damages and to protect the appliances, the voltage controlling method can be implemented. Christo Ananth et al. [9] discussed about a project, in this project an automatic meter reading system is designed using GSM Technology. The embedded micro controller is interfaced with the GSM Module. This setup is fitted in home. The energy meter is attached to the micro controller. This controller reads the data from the meter output and transfers that

data to GSM Module through the serial port. The embedded micro controller has the knowledge of sending message to the system through the GSM module. Another system is placed in EB office, which is the authority office. When they send "unit request" to the microcontroller which is placed in home. Then the unit value is sent to the EB office PC through GSM module. According to the readings, the authority officer will send the information about the bill to the customer. If the customer doesn't pay bill on-time, the power supply to the corresponding home power unit is cut, by sending the command through to the microcontroller. Once the payment of bill is done the power supply is given to the customer. Power management concept is introduced, in which during the restriction mode only limited amount of power supply can be used by the customer. Christo Ananth et al. [10] discussed about Positioning Of a Vehicle in a Combined Indoor-Outdoor Scenario, The development in technology has given us all sophistications but equal amounts of threats too. This has brought us an urge to bring a complete security system that monitors an object continuously. Consider a situation where a cargo vehicle carrying valuable material is moving in an area using GPS (an outdoor sensor) we can monitor it but the actual problem arises when its movement involves both indoor (within the industry) and outdoor because GPS has its limitations in indoor environment. Hence it is essential to have an additional sensor that would enable us a continuous monitoring /tracking without cutoff of the signal. In this paper we bring out a solution by combining Ultra wide band (UWB) with GPS sensory information which eliminates the limitations of conventional tracking methods in mixed scenario(indoor and outdoor) The same method finds application in mobile robots, monitoring a person on grounds of security, etc. Christo Ananth et al. [11] discussed about Nanorobots Control Activation For Stenosed Coronary Occlusion, this paper presents the study of nanorobots control activation for stenosed coronary occlusion, with the practical use of chemical and thermal gradients for biomedical problems. The recent developments on nanotechnology new materials allied with electronics device miniaturization may enable nanorobots for the next few years. New possibilities for medicine are expected with the development of nanorobots. It may help to advance the treatment of a wide number of diseases: cardiovascular problems, neurosurgery, cancer, diabetes and new cell therapies. The implementation of new methodologies to help on manufacturing analyses and system design for the development of nanoscale molecular machine is one of the most important fields for research. The use of 3D physically based simulation in conjunction with clinical data may provide ways to design practical approaches for control and transducers development. Christo Ananth et al. [12] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

III. TOPOLOGY OPTIMIZATION IN BRAKE DISC

Brake Disk is for the most part composed by iterative strategies and it is improved under topologies which are not all around streamlined. They are frequently in light of static stacking conditions. To get the ideal design taking after strides were done. Firstly a CAD model of the plate was set up on SOLIDWORKS16.0.Figure3 demonstrates the underlying model. The general dimensionsions and the mounting positions were made. The plate was isolated into two fundamental districts, The Design and Non-Design space. Christo Ananth et al.[13] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles.

The following parameters are considered [15].

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TABLE-1: BRAKE SYSTEM PARAMETERS

Sr. No.	Parameters	Symbol	Value	Units
1.	Input driver force	F	160	N
2.	Pedal ratio	n	4	-
3.	Bore diameter of master cylinder	dm	0.013	m
4.	Diameter of caliper piston	dc	0.0315	m
5.	Disc-Pad coefficient friction	μ	0.4	-
6.	Area of master cylinder	A	1.326 e^-4	m^2
5.	Area of caliper	a	7.7891e^-4	m^2
6.	Effective radius of disc	Re	0.085	m

Calculations

1. FORCE AT MASTER CYLINDER (FM) = F × N = 640 N
2. PRESSURE (P) = FM/A = 4824181.2083 PA
3. Force at caliper (Fn) = P/a = 3757.63 N
4. Total Clamping force (Fc) = 2× μ × Fn = 3006.1 N
5. Clamping force on each side = 1503.053 N
6. Braking Torque (T) = Fc × Re = 255.51 Nm

The brake circle is mounted to center point of wheel by five M6 jolts. The jolts are thought to be completely tight and rotor is completely compelled to wheel. Cyclic symmetry was connected to the framework and clipping power of 3006.1 N was connected at cushion area. The cushion segment region is of the span of real brake cushion of the caliper utilized as a part of BAJAJ Discover bicycle. The plate was isolated into aggregate 12 segments. The dim area is the outline space and light hued district in Non-plan space. The red bolts demonstrates the heading of connected compel and the red circles demonstrates the settled tube shaped support.Material of disc: SS430 [16].
Maximum ultimate tensile strength: 517 MPa Maximum yield strength: 345 MPa

Finally optimization was run on INSPIRE 9.5 for maximum stiffness and minimum mass criteria.
The outcomes got demonstrates that where the material diminishment should be possible. The product INSPIRE 9.5 gives the thought regarding the underlying outline with help of which real plan is made. Considering the acquired outcomes the CAD model of circle was made on Solidworks 16.0. Weight lessening spaces were made at appropriated areas and fundamental thickness of circle which is required was given.To approve the current arranged model, a limited component examination was done to ensure that the plan is inside security limits. The investigation was carried on ANSYS 16.0. A bracing power of 1503.053 N was connected on both sides of cushion district distracting to the bearing on pivot. The circle was given settled support at the mounting points.The material of the plate is thought to be homogenous and isotropic. The space of the issue is expected as pivot symmetric. Amid the examination of plate dormancy and body drive impacts are little and henceforth ignored. Christo Ananth et al.[14] presented a brief outline on Electronic Devices and Circuits which forms the basis of the project.

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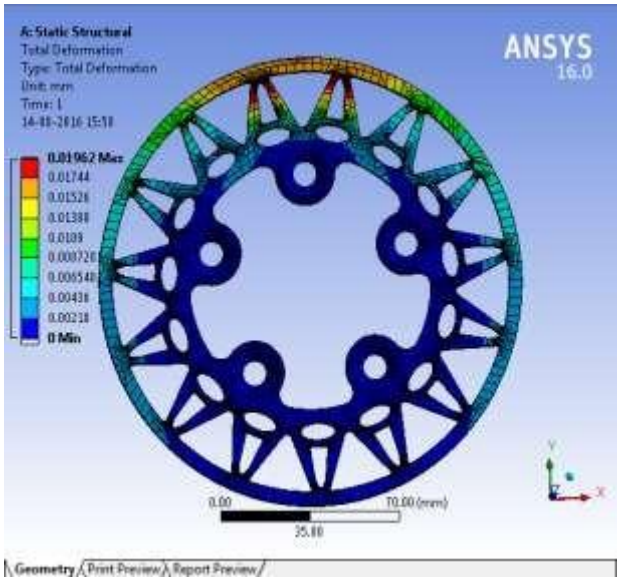
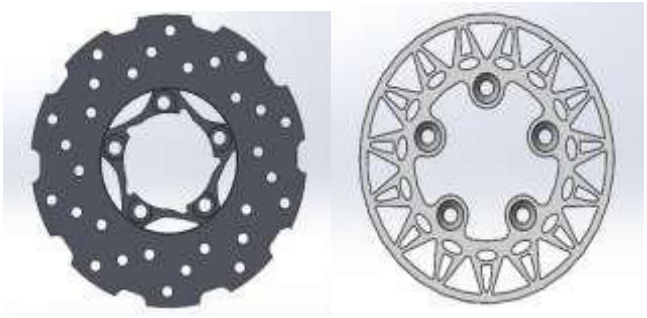


Fig.1 Total Deformation

Using maximum shear stress theory [17] the yield strength in shear is half of the yield stress in tension.

Ssy = 0.5Syt

Factor of safety = Ssy/shear stress in disc



BAJAJ Discover 125M Optimized Disc

Fig.2 Comparison with Previous Disc

TABLE-2: COMPARISON

	BAJAJ Discover 125M disc	**New optimized disc**
Weight	539.39g	395.45g
Maximum Deflection	0.0174mm	0.0196mm
Max shear stress	106.48 Mpa	108.99 Mpa
Factor of safety	1.62	1.5827

IV. CONCLUSION

To outline a lighter brake plate than the current models utilized as a part of general bikes is the primary target of this paper. The recently enhanced brake circle is contrasted and existing BAJAJ Discover125M plate. Topology improvement for weight diminishment was performed by utilizing Altair INSPIRE 9.5 programming and the recently upgraded circle was dissected in ANSYS16.0.Using this strategy another light-weight brake plate is outlined. The consequences of the plan demonstrates that the heaviness of another brake circle is 26.68% less when contrasted with the current brake plate and it has comparable execution as the current plate.

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