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Mass Optimization of Braking Pedal and Simulating 3D Metal Printing Process to Study the Temperature Distribution

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ABSTRACT: Safety aspect in automotive engineering has been considered as a number one priority in development of new vehicle. Each single system has been studied and developed in order to meet safety requirement. Instead of having air bag, good suspension systems, good handling and safe cornering, there is one most critical system in the vehicle which is brake systems The main objective of the paper is to design of brake pedal and optimizing the brake pedal for minimum thickness and simulating for metal ADDITIVE MANUFACTURING process. Disc brake technology used for bikes has improved significantly as high performance is most desirable now days. More specifically, the paper deals with analysis of brake pedal for minimum mass condition and less weight when compare to that is available on commercial four-wheeler. The FEA analysis determines, the minimum stresses developed in brake pedal when load acting over it. Then simulating the brake pedal for optimal laser conditions to avoid the warpage during the printing process. We have found the optimal laser power for printing the brake pedal. The Brake pedal have more surface area, we need to apply more force on it. We optimize the surface area of Brake pedal to reduce the applying force.

Key words: Optimization, 3D Metal printing, Simulation, AM

I. INTRODUCTION

A brake is an instrument or equipment that makes use of artificial frictional resistance to stop the motion of a moving member. While performing this function, the brakes imbibe potential energy or kinetic energy of the moving member. The energy that is absorbed by the brakes is dissipated in the form of heat. The dissipated heat is in turn liberated into the surrounding atmosphere.

Fig 1.1-disc brake rotor

Fig 1.2-disc brake assemblies

1.2 BRAKING REQUIREMENTS:

- Brakes of a vehicle should be strong enough to stop the vehicle in a minimum time & distance.
- While braking the driver should have good control over the vehicle i.e. the vehicle should not skid.
- Brakes should be a good anti wear resistant.
- Brakes should have good anti fade characteristics.

1.3 CLASSIFICATION OF BRAKES:

- Based on mode of operation brakes are classified as follows:
- Hydraulic Brakes.
- Electrical Brakes.
- Mechanical Brakes.

The mechanical brakes according to the direction of acting force may be sub divided into the following two groups:

- Radial Brakes
- Axial Brakes.

Radial Brakes. In these brakes the force acting on brake drum is in radial direction for Radial brakes. These brakes are of two types: Internal Brakes and external brakes Axial Brakes. In these brakes the force acting on the brake drum is in axial direction for axial brakes.

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1.4 DISC BRAKE:

A disc brake is a device, composed of cast iron or ceramic composites that are connected to the wheel hub or axle and a caliper. In order to stop the wheel hub, friction material is automatically or hydraulically forced on both sides of the brake in the form of brake pads. This friction in turn originates the wheel hub and the disc to slow down and stop. Different views of Disc Brake Rotor are shown in the figure 1(a) and 1(b).

1.5 PRINCIPLE:

Disc brake is a very essential brake application device in a vehicle. This part of the brake helps in the slowing and stopping the motion of the vehicle. The principle of disc brake is to produce a braking force on the brake pads which in turn compresses the rotating disc.

ASSUMPTIONS

- Brakes are applied on two wheels.
- Thickness of 3.5mm is considered for all the models.
- Only ambient cooling is considered for dissipation of heat.
- This analysis does not determine the life of the disc brake
- The disc brake model used is of solid type.
- The thermal conductivity of the material is uniform throughout.
- The specific heat of the material is constant throughout and does not change with the temperature.
- The kinetic energy of the vehicle is lost through disc brakes i.e. there is no heat loss between the tire and the road side.

MAIN COMPONENTS OF A DISC BRAKE:-

- Rotor
- Brake Pads
- Caliper

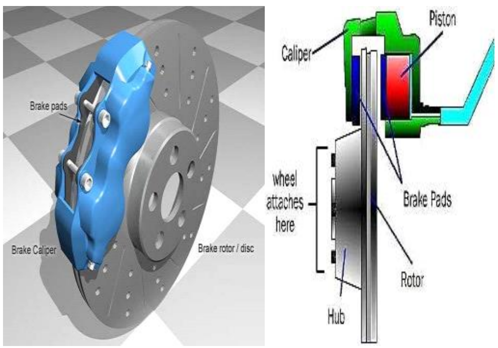

Fig1.3 various parts of disc brake

Rotor: The disc rotor is connected to the wheel and it rotates with respect to the wheel. When brakes are applied, the brake pads come in contact with the rotor in order to stop or slow down the vehicle.

Brake pads: Brake pads are present in the disc which scrapes against the disc that rotates with the wheel hub and creates high friction.

Caliper: A caliper is a motionless housing which is clipped to the frame of a vehicle containing a piston. This piston forces the pads onto the rotor in order to stop or slow down the vehicle.

In order to bring the vehicle to a slow or stop position, the driver applies pressure on the brake pedal which activates the caliper that in turn compresses the brake pads against the disc rotor. The Rotor is then connected to the wheel which halts the vehicle. When the brakes are applied the kinetic energy of the moving vehicle is converted into heat and dissipated into the surrounding atmosphere.

APPLICATIONS OF DISC BRAKES

- Cars
- Motorcycles
- Bicycles

II. MODELING OF BRAKE PEDAL

- Prefer cloud-based simulation software for faster performance, but use local solvers if needed to comply with confidentiality policies.

Laser parameters

1. **Laser Power / Laser Energy**
   Aside from energy density, a second important parameter in lasers measurement is apower density.

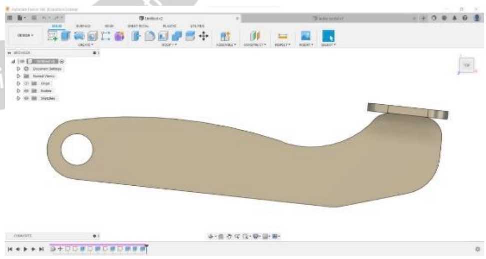

Fig.2.4 front view of brake pedal

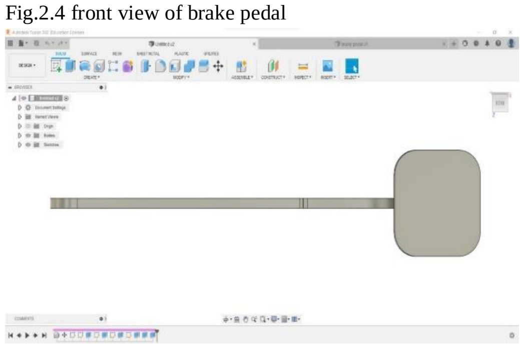

Fig.2.5 top view of brake pedal

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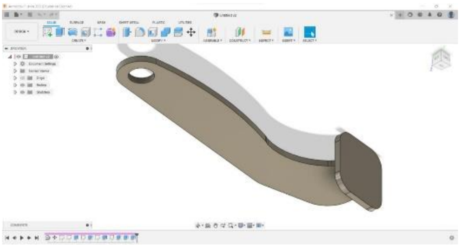

Fig.2.6 Isometric View of brake pedal

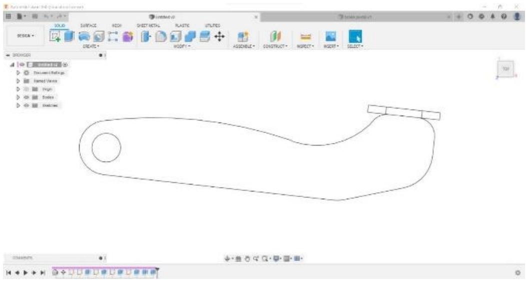

Fig.2.7. line view of brake pedal

SLM 280 Machine

Ideal for medium to high volume metal part production and prototypes, the robust second generation SLM®280 2.0 selective laser melting system offers a 280 x 280 x 365 mm build envelope and patented multi-beam laser technology with up to two fiber lasers exposing the build field via a 3D scan optic. Multi-laser systems can achieve build rates 80% faster than a single laser, and patented bi-directional powder recoating minimizes manufacturing time by reducing the number of passes required to lay fresh powder during a build.

Outfitted with a standard PSM powder sieve, overflow bottles transfer material between sieve and machine reducing operator contact with loose powder. PSM sieves and powder change kits allow users material flexibility while maintaining powder quality in an inert atmosphere.

Fig.3.1 SLM 280 machine

Fig.3.2 SLM product

PSM manual powder sieve

The PSM unit sieves and separates metal powder under inert gas conditions. Metal powder collected from overflow cans in the selective laser melting system is manually supplied to the sieving station. The sieved GO grain and oversized powder are collected in separate cans underneath the system for further use.

The sieving process runs automatically without influence on the running build process, reducing ancillary times. To support and speed up the sieving procedure, an additional ultrasonic cleaning device can be added.

Melt Pool Monitoring (MPM)

Tool for visualizing thermal emission of melt pool in the SLM®process. The system records the thermal radiation produced from the melt during the entire production process.

Sequential output of thermal emission plot images of individual layers

Detect irregularities and defects in parts

Log and document build jobs in MPM-Files

Laser power monitoring (LPM)

Permanent on-axis laser power monitoring system that measures and illustrates nominal and actual power during the ongoing manufacturing process.

Active warnings, highlighting spots with critical laser power deviation

Documentation of the laser power for each scan vector over the entire build job

Recoater cleaning station

Developed to simplify cleaning, maintenance and installation work on the SLM®Recoater.

Stable mount for maintenance

Safe handling

Station features 360° rotation for full maintenance access

Drip tray included for easy residual powder collection

Safe storage of recoating mechanisms

Station Dimensions: 730mm x 310mm x 250mm

Layer Preparation Tool

Tool to level recoater height and adjust overlap area. Enables reproducible adjustments to the recoating lip height, independent from operator, within 1 µm. Resulting in recoating and the laser exposure level consistency for each build job

SLM 280 Technical Specification

Build Envelope (L x W x H)	280 x 280 x 365 mm 11 x 11 x 14 in (reduced by substrate plate thickness)
3D Optics Configuration	Single (1x 400 W or 1x 700 W) IPG fiber laser Twin (2x 400 W or 2x 700

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	W) IPG fiber laser
Build Rate	88 cm³/h (400 W Twin)
Variable Layer Thickness	20 µm - 75 µm
Minimum Feature Size	150 µm
Beam Focus Diameter	80 µm - 115 µm
Maximum Scan Speed	10 m/s
Average Inert Gas Consumption in Process	2.5 l/min (argon)
verage Inert Gas Consumption Purging	70 l/min (argon)
E-Connection / Power Input:	400 Volt 3NPE, 63 A, 50/60 Hz, 3.5-5.5 kW
Compressed Air Requirement / Consumption	ISO 8573-1:2010 [1:4:1], 50 l/min @ 6 bar
Dimensions (L x W x H)	2600 mm x 1200 mm x 2760 mm
Weight	1300 kg dry 1800 kg with powder

Table.3.1 SLM 280 Technical specifications

Fig.4.3 Inspire software interface

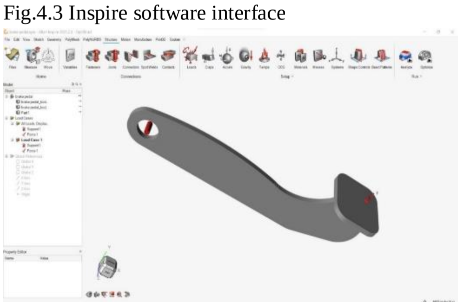

Fig.4.4 defining loading condition

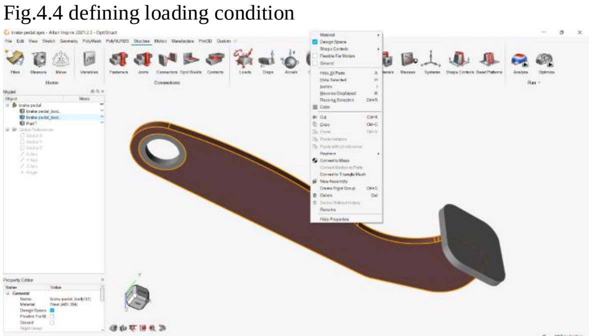

Fig.4.5 defining design space

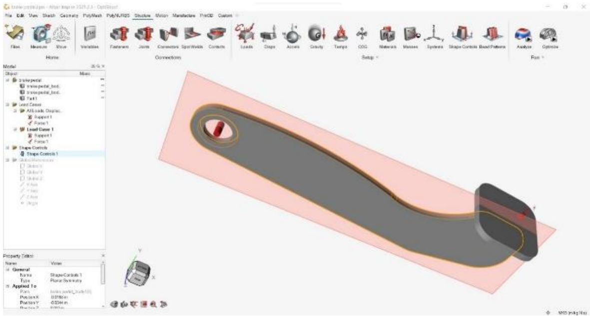

Fig.4.6 defining shape controls

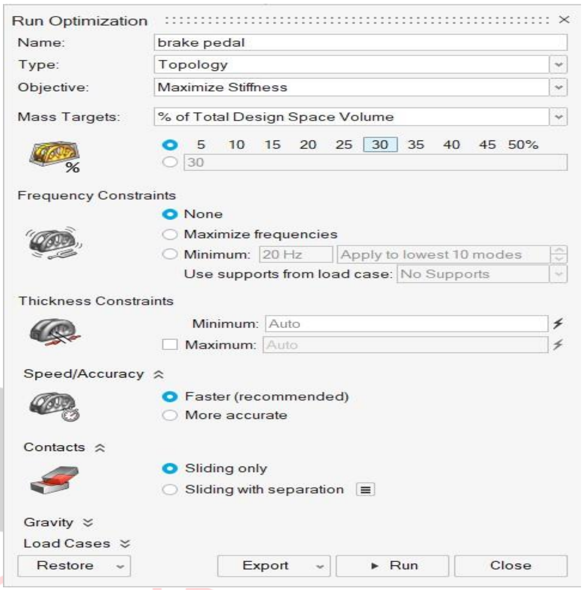

Fig.4.7 Optimization process parameters

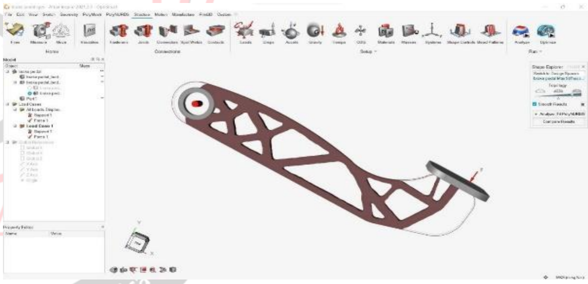

Fig.4.8 Optimization of brake pedal

4.3 Metal AM analysis

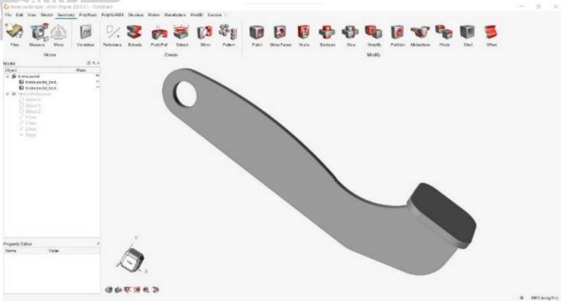

Fig.4.9 loading cad model

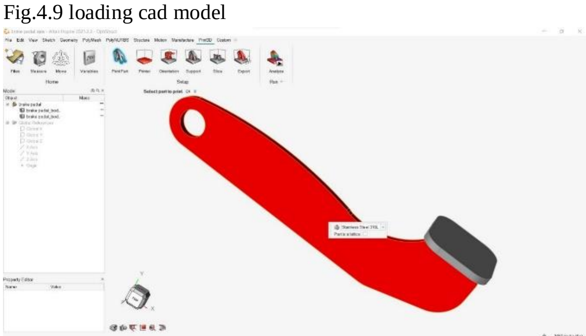

Fig.4.10 material selection

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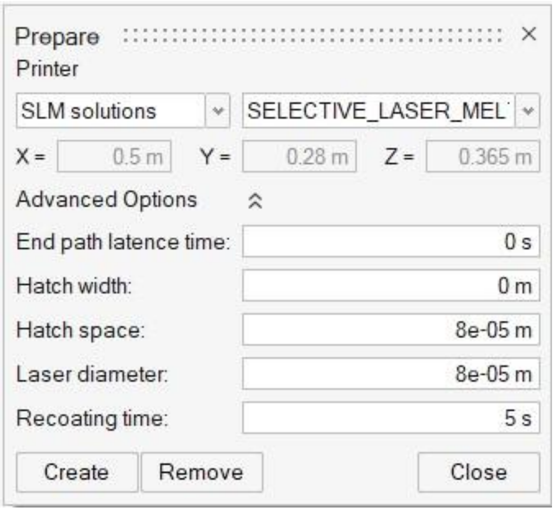

Fig.4.11 machine set up

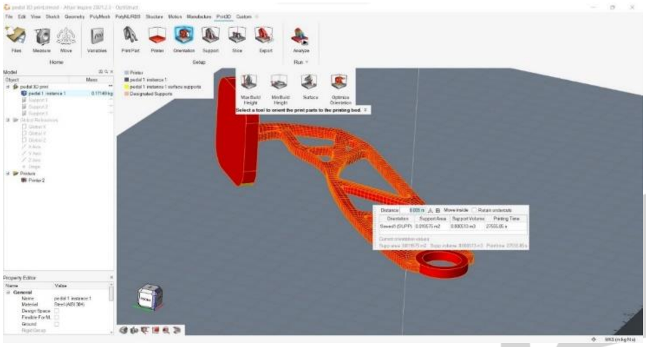

Fig.4.12 orienting the part to best position to print

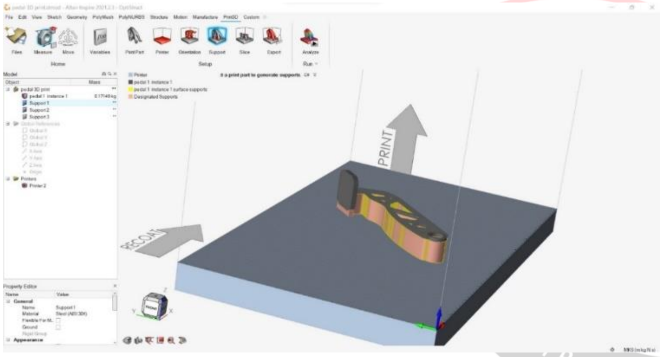

Fig.4.13 generating supports

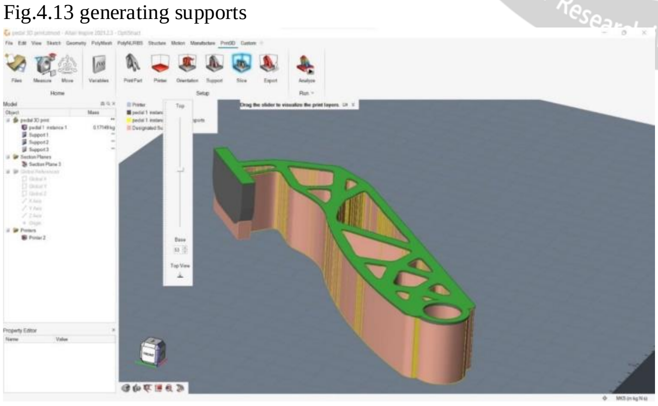

Fig.4.14 slice view of the model

III. RESULTS AND DISCUSSIONS

5.1 simulation of actual brake pedal

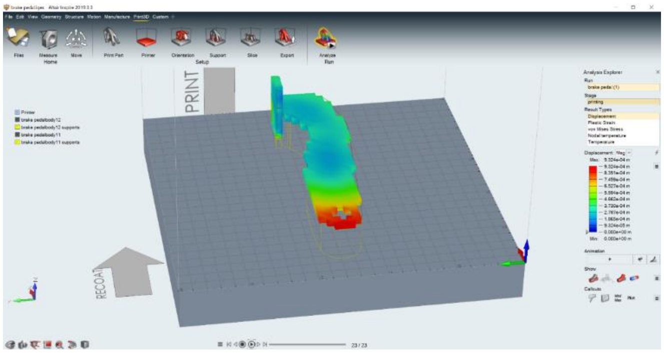

Fig.5.1 displacement of actual brake pedal

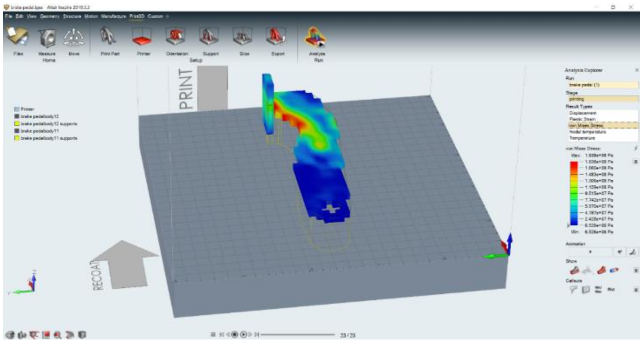

Fig.5.2 stresses developed in the actual brake pedal

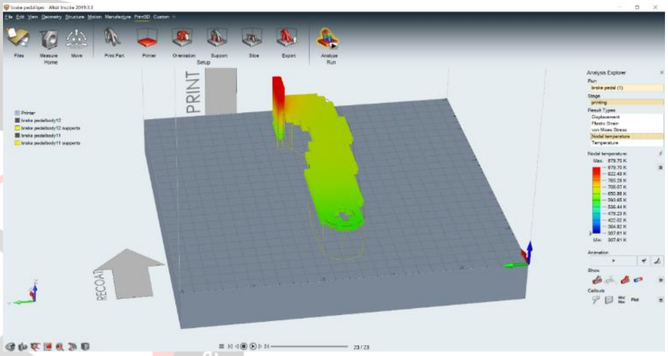

Fig.5.3 Temperature distribution in the actual brake pedal

5.2 simulation of mass optimized brake pedal

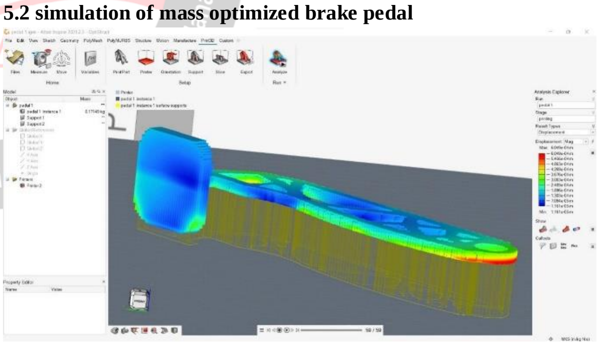

Fig.5.4 displacement of the model

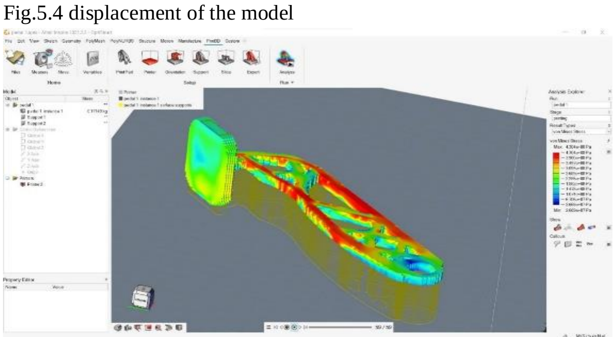

Fig.5.5 stresses developed in the model

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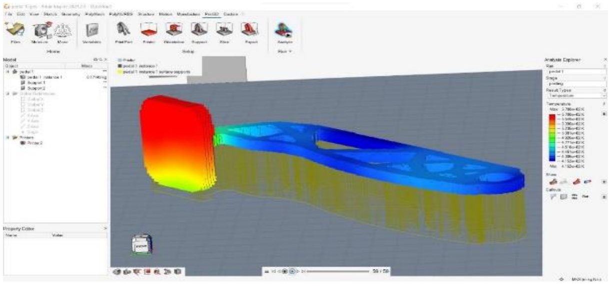

Fig.5.6 Temperature distribution in during the printing parameters

IV. CONCLUSION

Brake pedal are most widely used component in the field of automobile. Here we performed the mass optimization and 3D printing simulation for the brake pedal.

We conclude that the optimized model gives better performance than the actual model:

1. We performed the mass optimization to reduce the weight of the brake pedal for maximum stiffness condition. By performing the simulation, we reduce the weight by 83 grams for a scaled model.

2. Stresses in the actual model are more when compare to optimized model. Due to multiple cross sections in the actual model causes more stresses as compared to the optimized model.

3. We performed 3D printing simulation, we found that when compare to actual model, optimized model gives better displacement results.

4. Actual model consumes more support material and printing time whereas optimized model consumes very less material and easy to print.

5. Due to large surface area in the cad model temperature are high in the actual brake pedal when compare to optimized model

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