Design Analysis and Optimization of Automotive Brake Pedal

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ABSTRACT

In all automotives, Brake pedals are widely used, which acts as a linkage between occupant and brake mechanism. Existing design seems to be overdesigned as per requirement FEA will be used to apply cantilever load optistruct solver will be used to perform topology optimization. The model of an existing brake pedal was generated using CATIA V5 solid modelling software. Finally, a new light weight design brake pedal is proposed. The result of the study shows that the weight of a new designed brake pedal was less as compared to an existing brake pedal without sacrificing its performance requirement.

Keywords: Brake Pedal, FEA, Optimization.

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1. INTRODUCTION

1.1 Background

In recent year, the material challenge with each other for existing and new market. Over a period of time many factors that make it possible for one material replace to another for certain applications. The main factors affecting the properties of the materials are cost, strength and weight. In automobile industries it is look for cheap and light-weight materials and which should be easily accessible. At present, brake pedals are largely made from metal but composite clutches and accelerator pedals are already successfully utilized in automotive vehicles. This study is mainly concentrated on variable-material for the conceptual design brake pedal profile, which is achieved 78% lighter in weight compared to the present metallic pedals and 64% light weight compared to aluminium. According to General Motors specifications.

The most of common class of ferrous metals and alloys (CI, steel, and NI) which represent 68% by weight, other non-ferrous metals used include copper, zinc, aluminium, magnesium, titanium and their alloys 10 to 15 &. The plastics contents commercial vehicles comprise about 20 to 30 % of all interior components. Today the optimization of the product is the vision for reducing the weight and so the cost of the product. The functional stiffness while keeping to comply the best functioning stiffness is the main challenge while reducing the material and the so the cost. In this study we are planning to find the max functional stress locations for the baseline design and then optimizing it using Finite Element Analysis Software and checking the functionality for this optimized design as well.

In Design,With the application of optimization ,the aims and scope is to reduce the weight of an existing brake pedal design of a car without the substitution of material. By reviewing the design constraints, load and boundary condition the optimization was run and the analysis. However the result of optimization process needs for further refinement as it has manufacturability deficiency. Thus knowledge of design engineers to interpret and refine the proposed design is vital to ensure it is possible for production. In conclusion, the application of optimization with the integration of engineering knowledge of design engineer able to produce an optimal brake pedal design in a short time.

1.2 Problem Statement

Brake pedal is one of the most important components of an automobile. Currently, brake pedal contains excess material, leads to increase in weight of the vehicle. Directly affects the mileage and cost. In this thesis, modeling existing brake pedal in CAD software and analyzing it for induced structural stresses and deformation in CAE software. Then using Topology optimization material will be removed. Again, analysis will be done on optimized model for stresses and deformation.

1.3 Objectives

1 Modeling existing brake pedal.
2 Analyzing for stresses and deformation.
3 Topological optimization for the model.
4 Analyzing for stresses and deformation on optimized model.

ISSN: 2321-8169
227 – 232

2. FE Analysis

2.1 CAD Model of Brake Pedal.

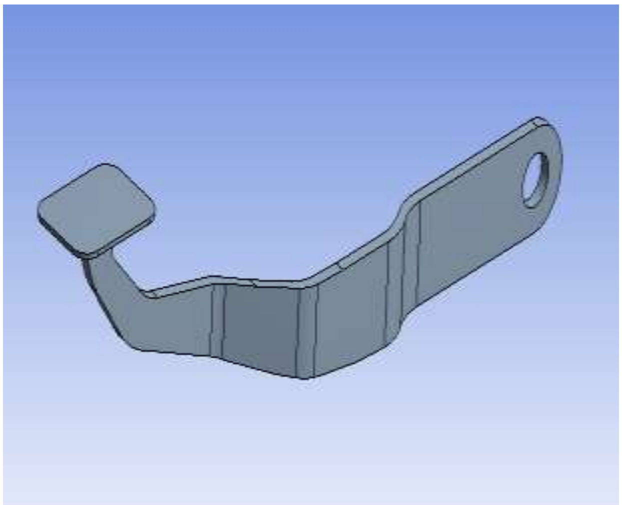
CATIA V5R20

CATIA (computer aided three-dimensional interactive application) is a multi – platform computer - aided design (CAD) / computer - aided manufacturing (CAM) / computer - aided engineering (CAE) software suite developed by the French company Dassault Systems. CATIA delivers the unique ability not only to model any product, but to do so in the context of its real-life behavior: design in the age of experience.

3. OPTIMIZATION

3.1Topology Optimization

Topology optimization is a mathematical approach that optimizes material layout within a given design space,for a given set of loads and boundary conditions such that the resulting layout meets a prescribed set of performance targets.



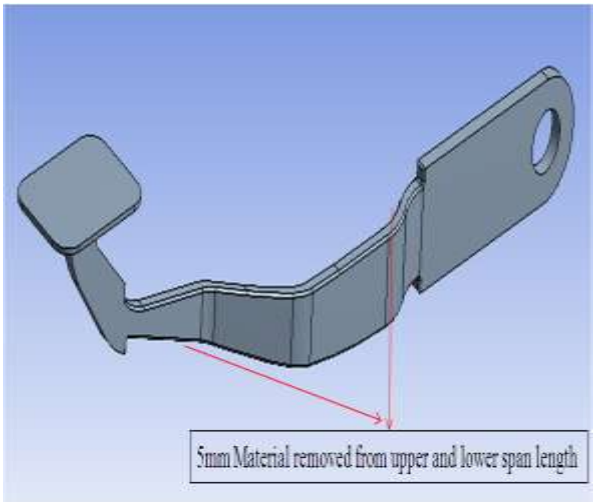


Fig.1 CAD Model of Existing Brake Pedal.

Fig.2 CAD Geometry of Optimized Model

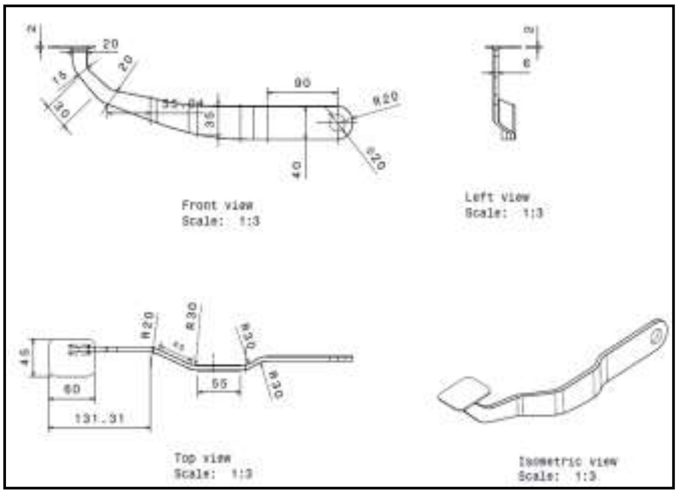


Fig.3 Drafting of Brake Pedal.

3.2 Mesh Generation

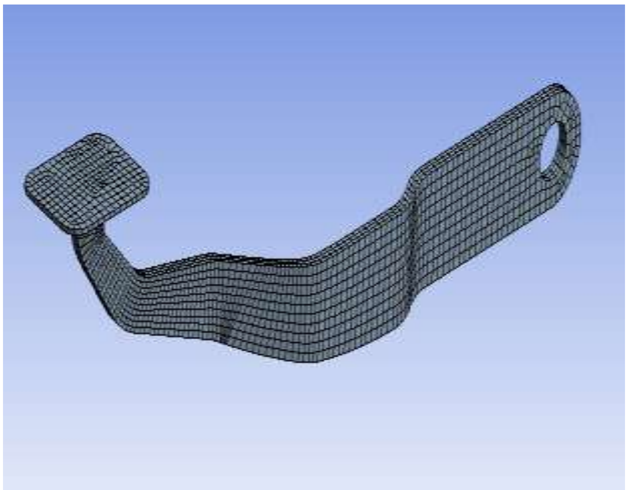


Fig. 4 Discretized Existing Model

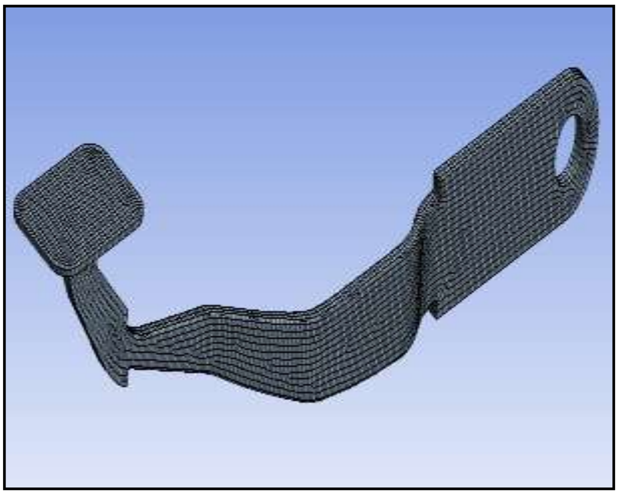


Fig. 5 Discretized Optimized Model

Parameters	**Original Model**	**Optimized Model**
Element type	Second order Hexahedron	Second order Hexahedron
No. of Elements	3742	15076
No. of Nodes	20671	61726

3.3 Static Structural Analysis

The three basic FEA process are
a) Pre processing phase
b) Processing or solution phase
c) Post processing phase

- **FEA Pre Processing**

The pre-processing of the brake pedal is down for the purpose of the dividing the problem into nodes and elements, developing equation for an element, applying boundary conditions, initial conditions and for applying loads. The information required for the pre-processing stage of the brake pedal is as follows

• **Material properties**:
The values of young's modulus, poisons ratio, density, and yield strength for brake pedal are taken from material library of the FEA PACKAGE.

Material- Steel
Young's Modulus- 200 GPa
Poisons Ratio- 0.3
Density- 7850 kg/m^3

• **Constraints**:
The nodes around the brake pedal holes have a rigid element connecting them to the centre of the hole which has of its degree of freedom fixed.

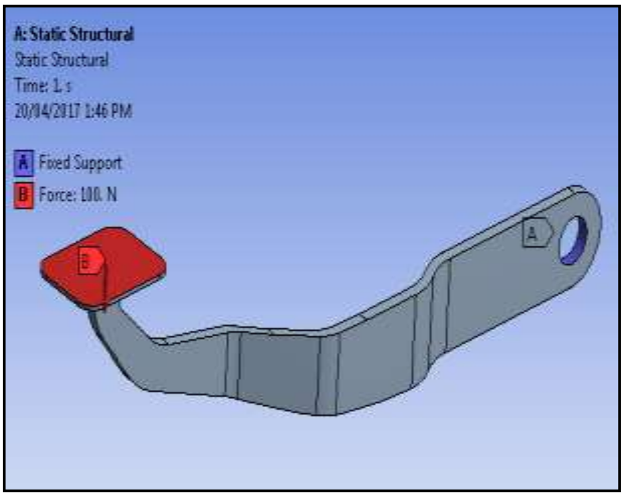


Fig. 6 Boundary Condition of Existing model

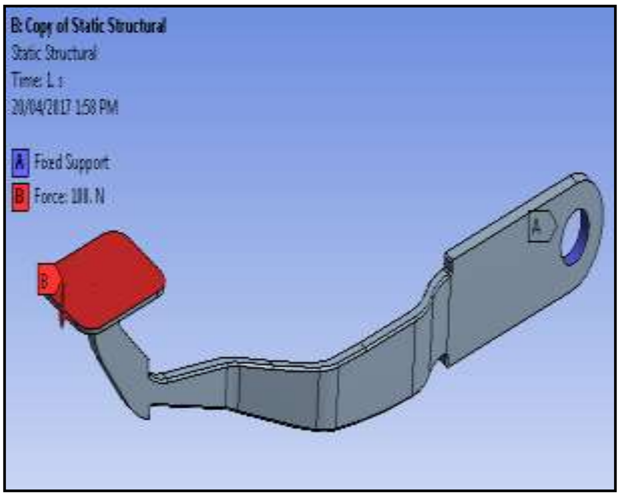


Fig. 7 Boundary Condition of Optimized model

Post Processing

The acceptability of the design of the brake pedal needs to be considered from the results of the analysis. The guidance for the modification of the brake pedal need to be available if the design is not considered to be acceptable for the brake pedal is as follows.

Model acceptance criteria: the maximum von-Mises stress must be less than the material yield strength for the duration of the component.

Deformation

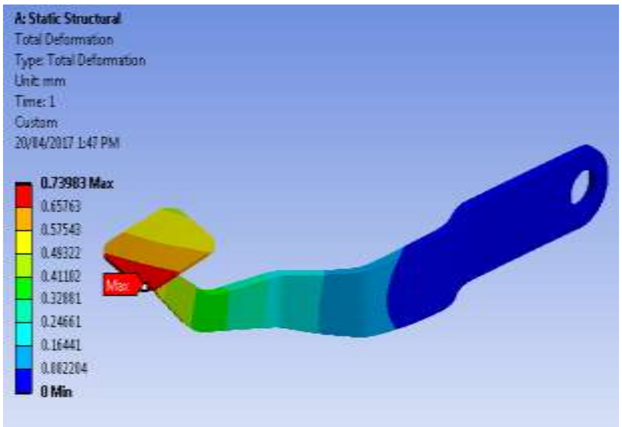


Fig.8 Deformation of existing model

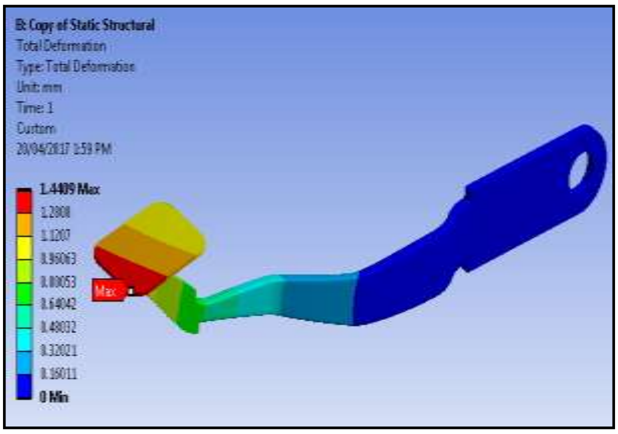


Fig.9 Deformation of Optimized model

Von- Mises

ISSN: 2321-8169
227 – 232

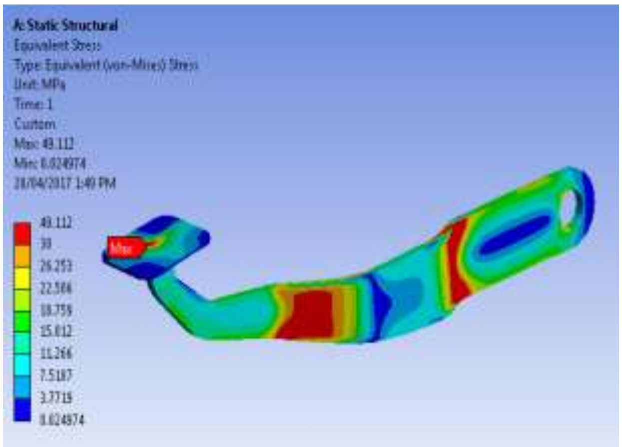


Fig. 10 Von- Mises of existing model

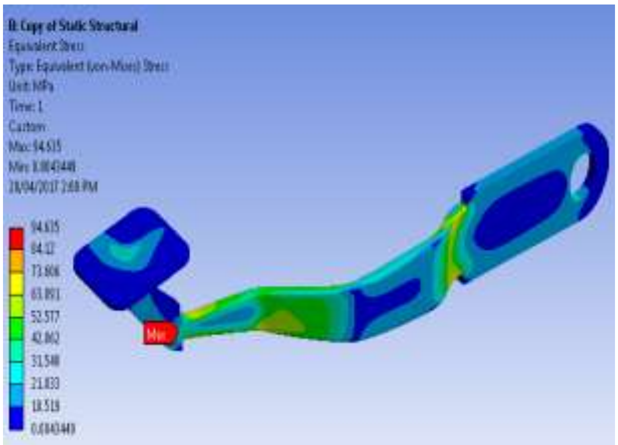
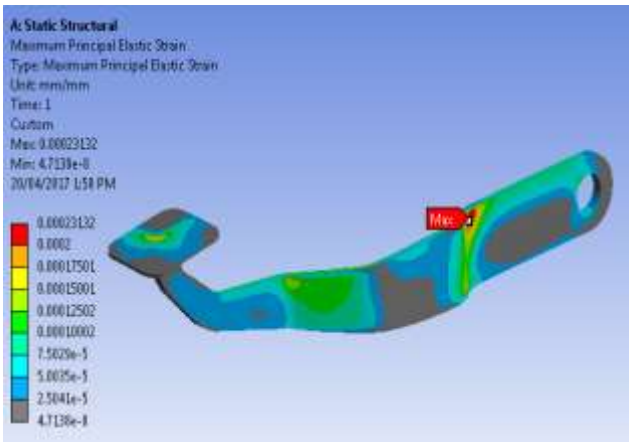
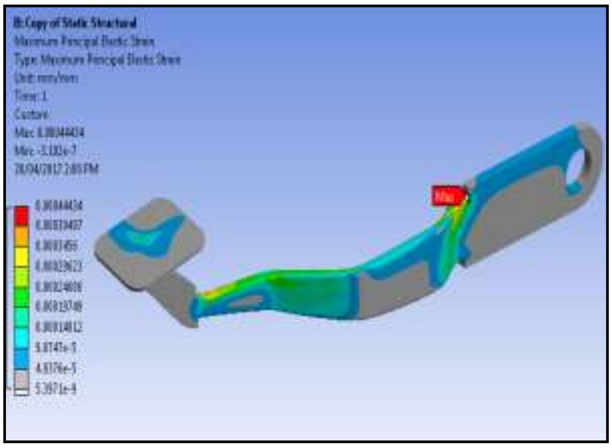


Fig. 10 Von- Mises of existing model

Fig.11 Von- Mises of Optimized model





*231- MICROSTRAINS IS STRAIN DEVELOPED

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Fig.12 Equi-Elastic Strain of existing model

Fig.13 Equi-Elastic Strain of Optimized model

4. CONCLUSIONS

From results of finite element analysis it is observed that the maximum stress value is within the safety limit. There is a great potential to optimize, this safety limit which can be done by removing material from low stressed region thus optimizing its weight without affecting its structural behavior. The maximum displacement value is also very less. So, the material from low stressed region is can be removed without affecting its strength and is within the yield strength.

- Both design produces stress within yield limit of material i.e 200 MPa
- Total mass reduction of 16.45 % has been achieved due to optimization of part.

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