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Modelling and Analysis of Carbon Fibre Brake Pedal for BAJA SAE

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Abstract *– Nowadays the weight of the vehicle plays a very important role in the performance of the vehicle, the brake pedal, accelerator pedal and the clutch are usually metallic in most teams I have come through at the SAE BAJA competition, which plays a role in adding 1,2 kgs more to the vehicle's total weight, and yes! 1 or 2 kg increase also matters a lot when it comes to performance of the vehicle at a competition level. In this research paper, all the possible tweaks in the configuration and design of the brake pedal are considered and a brake pedal is design with carbon fibre Epoxy 290, and static structural analysis of the design is done as well. Basically, here we have reduced the weight substantially and as well as that we have increased the strength of the pedal profoundly.*

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I. Introduction

The brake pedal on cars is responsible for this to give the driver , command with the foot by pressing the master cylinder for brake system in vehicle during stopping or slowing down the car. Currently, brake pedals are widely used made of steel (Brunings et al., 1989; Baumann, 1991) but clutches are a combination accelerator pedals already successful used in automobiles. According to Specification of General Motors, heavy load of 2700 N was applied to the brake foot (Hansmann and Bartczak, 1991). It is thought that this a Potential panic on the brake pedal (Hansmann and Bartczak, 1991).[1]

Manual or standard brakes use only the pedal effort by the driver 10 press the shoes against the drum, or pads against the rotors. No additional energy SOU fee is used. Manual brakes are commonly used on small and lightweight vehicles. Application of the ~dal force displaces the foot pedal, which in turn presses the pushrod into the master cylinder. The pedal linkage is designed to produce a mechanical force advantage or gain between the pedal and the master cylinder piston, resulting in a master cylinder piston travel which is less than the foot pedal travel. The cross-sectional area of the master cylinder and the cross-sectional areas of the wheel cylinders are chosen to produce an increase of force transmitted between the master cylinder and the wheel cylinders.(Rudolf Limbert).

II. Material

Selection of polymeric-based materials the composite automotive brake pedal depends on a number of features such as equipment, physical, and chemical properties as well and production issues. Selected assets should be used for the injection moulding process where high volume production is possible with the unit costs can be reduced. Selected items must have low specific weight to average power ratio with metal objects to reduce stress the weight of the motor vehicle can be adjusted. Proper selection of items involves thousands of data analysis on a few thousand types of polymeric-based compounds. Short stained-glass items are preferred as a suitable object from which it can be used producing brake pedals. There is a short polyamide (nylon) strands of glass by various percentages. A long glass fibres are not suitable for fibre intermeshes and its corners may be covered. So, since considering the strength and durability of the material (Bunsell, 1988; Lee, 1990; Schwartz, 1992; Gibson, 1994; Peters, 1998), short glass fibre is simple among building materials, with very low density. In addition, nylon with a short glass fibre has other advantages of car brakes pedals. For example, it has a modulus of elasticity in the depression and depression of major failure. Short nylon Glass fibre has a high impact strength, namely an important aspect of pedal design. When elongation and other structures have contemplated, nylon with a short glass fibre is selected for the use of the brake pedal.

So, according to the research we have selected Carbon Fibre Epoxy 290. Following in the table 1. are the properties of the same.

Properties	Carbon Fibre
Young's Modulus	127.7GPA
	7.4GPA
Poisson's Ratio	0.33
	1.88
Shear Modulus	6.9GPA
	4.3GPA
Tensile Strength	1717MPA
	30MPA
Compressive Strength	-1200Mpa
	-216MPA
Shear Strength	33

DESIGNING PEDAL

The brake pedal is designed keeping in mind the pedal ration of 6:1. After immense research I came down to the conclusion that the more the leverage in the pedal the lesser is the pedal effort and the more will be the pedal force.

As per the Baja rule book the pedal is designed to withstand a force of 2000N. the maximum force the pedal can withstand is 2700N. But, according to Sir Rudolf Limpert, the normal force that can be applied by the male drive is 823N and by a female driver is 445N.

The designed brake pedal is shown in the image 1.

CALCULATION OF BRAKE PEDAL PRESSURE

The analysis of the brake pedal is carried out with the help of master cylinder pressure on the on end of the lever.

Basically, the brake pedal acts as a class 1 lever. Where the fulcrum is the fixed part at the centre where it is mounted and the force is on one side and the pressure from the master cylinder is on the other side, hence we calculate the master cylinder pressure and apply the pressure along with bearing pressure on the top on the pedal and the force on the bottom of the pedal.

Finding the pressure, we use the following formula (Rudolf Limbert)

The hydraulic brake line pressure p_ℓ produced by the pedal force F_p is determined by

$$p_\ell = F_p \ell_p \eta_p / A_{mc} \quad , \quad N/cm^2 \text{ (psi)}$$

where A_{mc} = master cylinder cross-sectional area, cm^2 ($in.^2$)

F_p = pedal force, N (lb)

ℓ_p = pedal lever ratio

η_p = pedal lever efficiency

Hence, we are going to apply a very powerfully tool of Excel calculator for the calculation of the pressure.

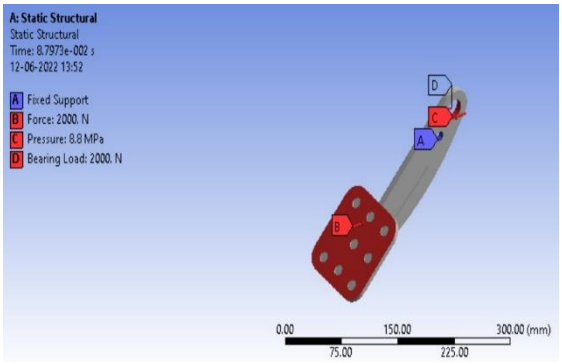
We put in the variables on an excel sheet and use excel function to calculate the answer, not only that we recalculate using CASIO calculator.
Here, the image below shows the calculation with and the final answer of the value of brake pressure or master cylinder pressure.

Area of master cylinder Bore	(pi/4)*(D)^2	A	mm2	176.714587 m2	0.000176715
Area of calliper bore	(pi/4)*(D)^2	a	mm2	660.519856 m2	0.00066052
Balance bar force and TMF	pedal force x 5		N	1500	
Pressure on master cylinder	F/A	pf	N/mm^2	8488263.63 Bar	84.882

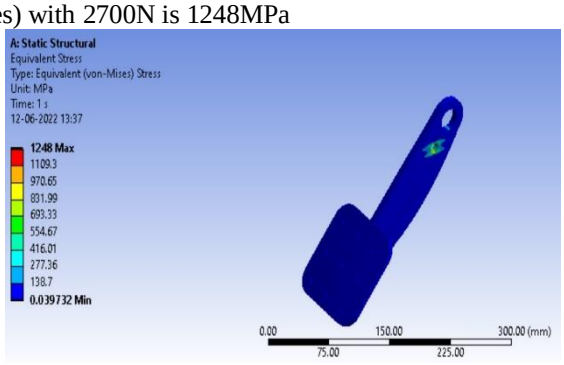
The calculation has given us te values for Master cylinder pressure, which is 84.83 Bar, we would be further using this for the analysis.

ANALYSIS OF BRAKE PEDAL USING ANSYS
Ansys static structural is tool which we have employed for the analysis of my designed pedal.

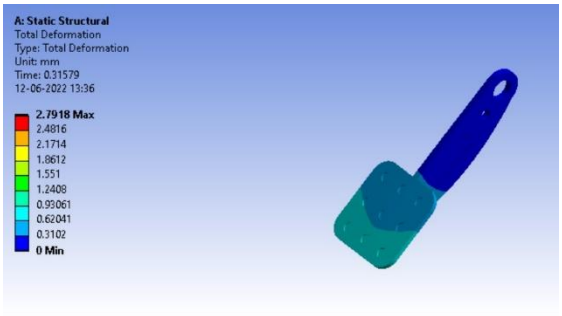
The boundary conditions are as follows –



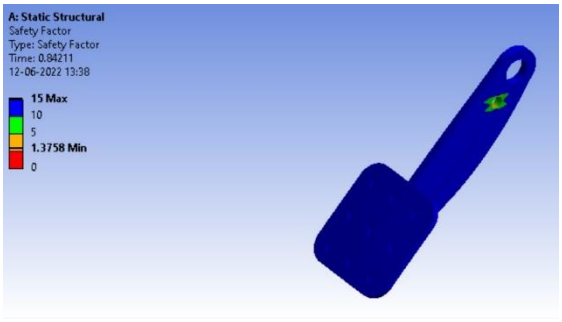
The nodes and elements obtained after messing of the structure are as follows –
Nodes – 2236672
Elements – 1578698
The analysis is carried out,
The value of Stress (von-mises) with 2700N is 1248MPa



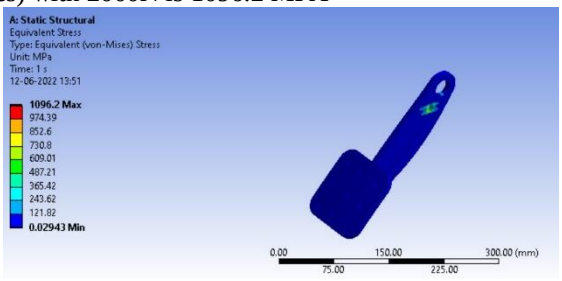
The value of total Deformation with 2700N is 2.79mm.



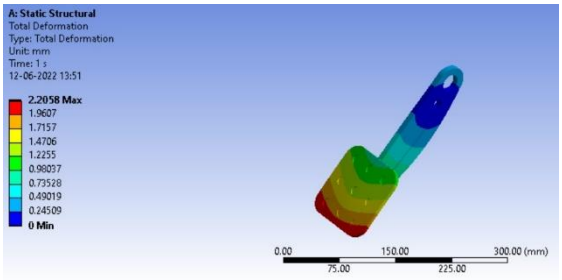
The value of FOS with 2700N is 1.375



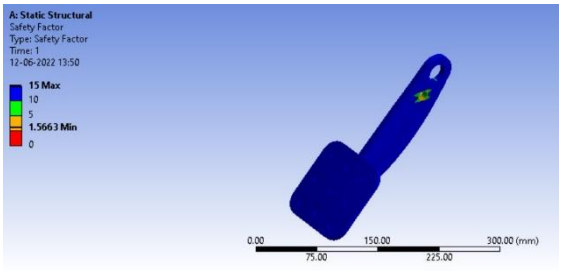
Now, we alter the boundary condition according to the BAJA SAE rue book which is 2000N of brake pedal force.
All the other boundary conditions are the same.
The no of nodes and elements are –
Nodes – 2236672
Elements – 1578698
The results of the analysis carried out,
The values of stress (von-mises) with 2000N is 1096.2 MPA



The value of total Deformation with 2000N is 2.20mm.



The value of FOS with 2000N is 1.566.



III. Result And Discussion Of Analysis

The analysis was carried out and the following results were obtained,

1. The value of Stress (von-mises) with 2700N is 1248MPa
2. The value of total Deformation with 2700N is 2.79mm
3. The value of FOS with 2700N is 1.375
4. The values of stress (von-mises) with 2000N is 1096.2 MPA
5. The value of total Deformation with 2000N is 2.20mm
6. The value of FOS with 2000N is 1.566

The results say that the material used that is Carbon Fibre being a strong polymer is the best and the lightest material for pedal manufacturing and implementation on your BAJA ATV.
The approximate weight of the pedal is 0.21kg in comparison to the mild steel of aluminium pedal it is almost 2x lighter and stronger.
The Mild steel pedal weights around 700gm and Aluminium pedal weighs around 500gm.

IV. Conclusion

In this paper, we have performed the designing and analysis of brake pedal to withstand the maximum pedal force a human can apply, along with the maximum pedal force the assembly can withstand according to SAE BAJA rule book of 2022,
Hence the material which is the strongest for pedal manufacturing is Carbon Fibre Epoxy 290.

References

[1]. CONCEPTUAL DESIGN OF AN AUTOMOTIVE COMPOSITE BRAKE PEDAL Mohd Sapuan Salit*, Mohd Syed Ali Molla and Md Liakot Ali
[2]. Brake design and Safety by Rudolf Limbert.
[3]. Analysis on Multi Linkage Brake System with Variable Pedal Ratio Author links open overlay panelA.DeepaD.Yashwant SinghS.V.Mukesh VarmaPranshuKhakhar
[4]. ANALYSIS OF A REGENERATIVE BRAKING SYSTEM FOR HYBRID ELECTRIC VEHICLES USING AN ELECTRO-MECHANICAL BRAKE J. K. AHN, K. H. JUNG, D. H. KIM, H. B. JIN, H. S. KIM and S. H. HWANG*
[5]. International Journal of Automotive and Mechanical Engineering (IJAME) ISSN: 2229-8649 (Print); ISSN: 2180-1606 (Online); Volume 13, Issue 3 pp. 3555 - 3563, December 2016 ©Universiti Malaysia Pahang Publishing DOI: https://doi.org/10.15282/ijame.13.3.2016.2.0292 3555 Dynamic simulation of brake pedal force effect on heavy vehicle braking distance under wet road conditions M. Zamzamzadeh1*, A.A. Saifizul1, 2, R. Ramli1 and M.F. Soong1.

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