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Design and Fabrication of Brake Pedal for All Terrain Vehicle

Designed in consideration with the leverage, sitting position and brake force.

[1]Nand Mangukia, [2]Nandish Mangukia
Student
Mechanical Department, A.D. Patel Institute of Technology, Anand, India

Abstract— The Brake pedal is again a very crucial component of an ATV as it would control the overall braking of the vehicle. Proper braking is very crucial in rough terrains with all four wheels locking so that the stopping distance is minimum. Hence a brake pedal needs to be designed in such a way it provides the necessary leverage and creates enough pressure for the brake fluid to reach all four wheels. A brake is a mechanical component that constrains the motion by absorbing the energy from the motion of the vehicle. When the brake pedal of the hydraulic braking system is pushed against the master cylinder, a piston pushes the brake pad against the brake disc which reduces the speed of the vehicle or stops the vehicle completely. Hence the brake pedal should be able to push the piston in the master cylinder completely with a full-length stroke and thereby provide equal pressure to all wheels.

Index Terms—Brake Pedal, Brake Force, Pedal, Pedal stress, ATV, All terrain vehicle.

I. Introduction

1.1 Problem Summary and Introduction

The design of brake pedal plays a very crucial role as it is the deciding factor for the force available at master cylinder end. Since there is space constraint for driver while designing an ATV, the resting position of leg on brake pedal is such that it is quiet difficult for the driver to produce exact amount of pedal force as compared to force produce by the leg in a regular vehicle. Based on the space constraint and resting position of the leg of the driver the brake pedal is needed to be designed so that the force produced is able to push in the master cylinder completely to its full-length stroke. The maximum force applied while sitting in an ATV can be supposed from human performance capabilities chart of NASA-STD-3000 206 (5th Percentile Male Data) [1].

1.2 Aim and Objectives

To design and fabricate a brake pedal that can withstand the maximum force applied by the leg of a human body and produce sufficient amount of force that is required for pushing full-stroke of the master cylinder.

1.3 Problem Specification

To design a brake pedal having brake pedal ratio of more than 5:1, as it is suggested that manual braking system (with no power booster) should have a ratio greater than 5.

The length of brake pedal should not be too short or too long that hinders the driving position of the driver's leg. The brake pedal ratio should be such that the driver would not feel fatigue while braking.

II. Design And Analysis

2.1 Design

The brake pedal was designed using SolidWorks considering the design constraints and parameters. Figure 1 shows the 2D sketch of the pedal. The length of brake pedal was decided by calculating the brake pedal ratio. Brake pedal ratio is the ratio of the perpendicular distance from pivot point center to lower end of the brake pedal by the distance from pivot point center to pushrod mounting point center. Figure 2 explains the brake pedal ratio for the proposed design.

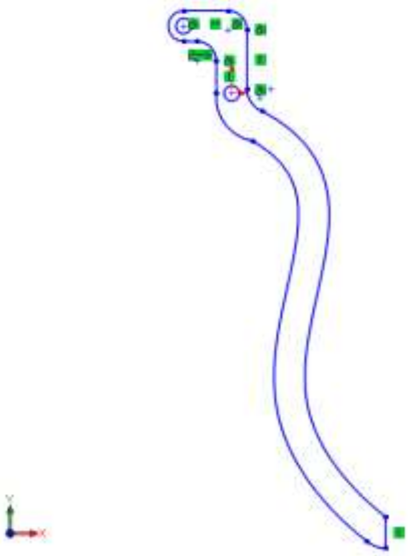


Figure 1: 2D Sketch of brake pedal

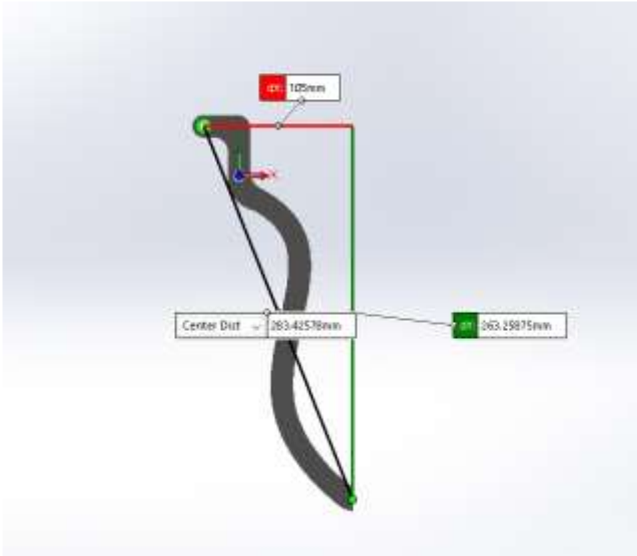


Figure 2: Brake Pedal Ratio

2.2 MATERIAL SELECTION

AISI 1018 and Al-7075 were chosen for comparison and various comparable properties are shown in Table1. Comparison of material is based on following factors [2]:

1.) Strength to weight ratio
2.) Cost
3.) Physical and mechanical properties
4.) Availability

Table 1: Comparison of AISI 1020 and Al-7075

Properties / Material	AISI 1018	Al-7075
Tensile Yield strength (MPa)	379.21	475.73
Fatigue Strength (MPa)	179.26	158.57
Elongation (%)	18	7.9
Density (kg/m^3)	7849.04	3043.50
Strength to weight (bending pts.)	46	24
Base metal Price (%)	1.8	10

2.3 ANALYSIS

The brake pedal was analyses using SolidWorks static structural analysis in which an axial force of 500N was applied [3]. The axial force has been supposed from human performance capabilities chart of NASA-STD-3000 206 (5th Percentile Male Data). The initial conditions of the part were: the pivot point on the brake pedal was specified roller/slider connection, the pushrod mounting point was specified fixed geometry fixture. The face where foot applies an axial force on brake pedal was specified with an axial load of 500N.

For meshing of the part, solid type mesh was provided to the part having element size 2mm and mesh control was applied to all the surfaces having a fillet, the element size in the fillet region was specified as 1mm. Table 2 and Table 3 gives the details about the mesh. Mesh control was provided on 7 faces so that accurate result data could be collected from analysis data which is depicted in Table 4. The total percentage of distorted mesh was 0%, which implies that the mesh was applied on the part accurately and thus the results deduced would be error-free. Figure 3 shows the solid meshed view of the brake pedal.

Table 2: Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Jacobian points	4 Points
Element Size	2.00 mm
Tolerance	0.107147 mm
Mesh Quality	High

Table 3: Mesh Information: Details

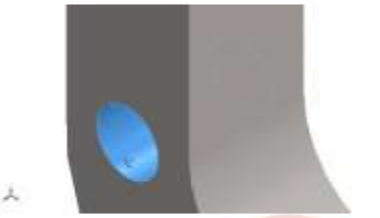
Total Nodes	182352
Total Elements	119540
Maximum Aspect Ratio	4.9586
% of elements with Aspect Ratio < 3	99.6

Figure 3: Meshed view of Brake Pedal

Table 4: Mesh Control Information

Mesh Control Name	Mesh Control Image	Mesh Control Details
Control-1		**Entities:** 7 face(s) **Units:** mm **Size:** 1.0 **Ratio:** 1.5

Table 5: Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 1 face(s) **Type:** Fixed Geometry

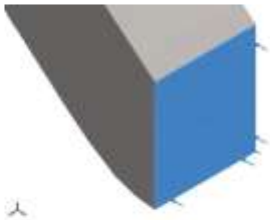
Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	**500.169**	**0.0559082**	**-0.0442009**	**500.169**
Reaction Moment(N.m)	**0**	**0**	**0**	**0**

Fixture name	Fixture Image	Fixture Details
Roller/Slider-1		**Entities:** 1 face(s) **Type:** Roller/Slider

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	**0**	**0**	**-0.0225688**	**0.0225688**
Reaction Moment(N.m)	**0**	**0**	**0**	**0**

Load name	Load Image	Load Details
Force-1		**Entities:** **1 face(s)** **Type:** **Apply normal force** **Value:** **500 N**

2.4 *Results of Analysis*

The analysis solver results show deformation and stresses under permissible limits. The maximum permissible von Mises Stress acting on the part was 229.621 N/mm^2 at Node: 541 shown in Table 6 and Fig. 4. The minimum factor of safety was achieved at Node: 541 which was 1.53109 shown in Table 7 and Fig. 5.

Table 6: Study results: Stress

Name	Type	Min	Max
Stress1	VON: von Mises Stress	3.63433e-005 N/mm^2 (MPa) Node: 147	229.621 N/mm^2 (MPa) Node: 541

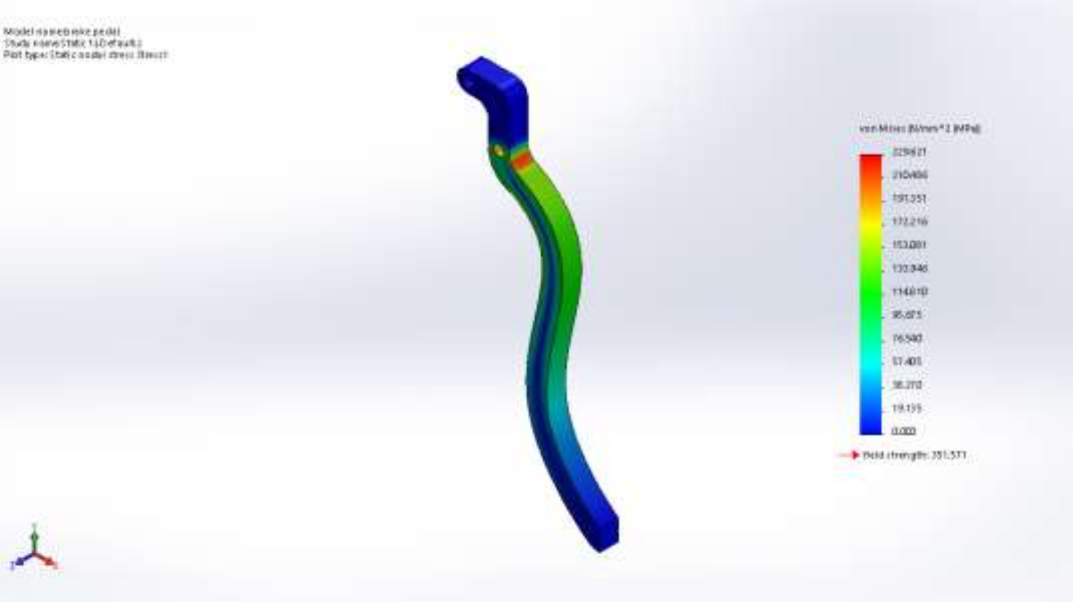


Figure 4: Stress Results

Table 7: Study results: Factor of Safety

Name	Type	Min	Max
Factor of Safety1	Automatic	1.53109 Node: 541	9.67361e+006 Node: 147

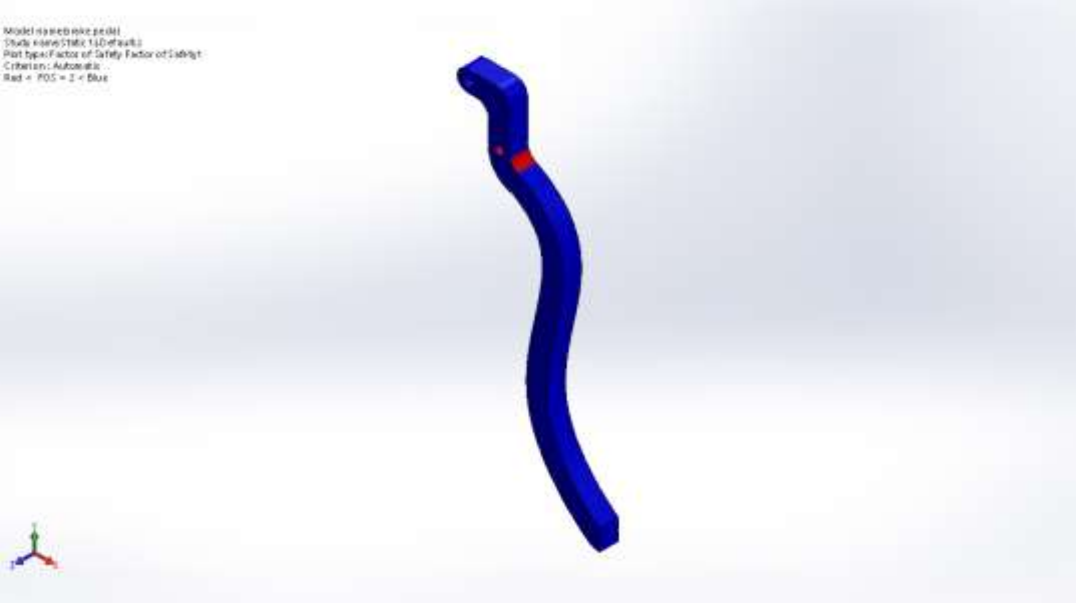


Figure 5: Factor of Safety Results

2.5 Fabrication

The part was manufactured from AISI 1020 plate of thickness 15mm. Figure 6 shows the job. The 2D front view sketch of the part was used for fabricating the part on plasma cutting machine. The part was then grinded on platform grinder to remove burrs and sharp edges.

Figure 6: Fabricated image of the Brake pedal

III. Calculations

Brake pedal ratio:
X/Y = 263.25/35 = 7.52:1
So, 100N of pedal pressure would yield 752N of pressure at the master cylinder.

Force Calculation:
Max. foot pedal force= 500N.
Force at master cylinder pushrod end= 500*7.52= 3760 N.

IV. Conclusion

The static structural analysis of brake pedal infers that the stresses generated are under permissible tensile strength limit and the factor of safety confirms that the design is safe. The brake pedal ratio of 7.52:1 is recommended for manual brakes (with no

power booster). Above 7:1 pedal ratio can be used for non-assisted disc brakes (4 disc brakes can be powered). Higher brake pedal ratio provides a better mechanical advantage.
The weight of the fabricated brake pedal is 621 grams. To reduce the weight of the brake pedal without having a constraint of cost, Al 7075 can be used to reduce it to 221 grams. Also, by using Al 7075 a lighter, non-corrosive and better-finished brake pedal can be fabricated.

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