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Research on Brake Pedal and Mounting to Adjust Different Parameters for Maruti Tandem Master Cylinder

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Abstract - *The purpose of this paper is to elaborate thr fesign and manufacturing of pedal box assembly for formula SAE car. The pedal box was researched by viewing previous designs, past researches, and current manufactured products. Taking loop holes from previous designs and focusing on driver's efforts, leverage ratio, weight reduction, serviceability and pedal compactness. This pedal box assembly was specially designed for Maruti Suzuki 800 TMC.*

Various iterations of different CAD models were created and analyzed using FEA software and results were verified. As driver directly interact with it, making ergonomics considerations essential. Other important factors such as material selection, force calculations, analysis and TMC positions are also discussed.

Key Words: **Brake Pedal, Mounting, Maruti Suzuki TMC, Overtravel stop, fsae pedal box design**

1. INTRODUCTION

Trinity College of engineering's formula SAE team is preparing for its 5th car for 2019 season. Formula SAE are the competitions where students from various engineering colleges built their own race car to compete with the other universities. Basically competition is not based on the speed but design capabilities of students. To qualify for the dynamic events teams has to go through some inspection tests and one of them is braking. As braking test has role to play in the qualifications the good design of pedals has an utter importance. As per the rule, it is essential to lock all the wheels of a car at a same time.

There are many types of brake systems in the use today. This paper explores three basic concepts for the pedals. The first is the pedal actuating bellow the axis of rotation which is generally seen in the commercial cars? This type of designs is not compatible to FSAE race cars. Second type of arrangement is having the axis of rotation near the center of the pedal. This is an easy arrangement to have on car but driver efforts required to operate brakes are high. Last concept is the pedal actuating above the axis of rotation. This arrangement is cost effective and easy to implement. This arrangement is followed by most of the FSAE teams.

The principles of operations are important to take into considerations. The goal is to create an optimal pedal assembly based on the Formula SAE vehicle team's need. This need includes envelope, weight, durability, adjustability, manufacturability and cost. The final assembly must be effectively integrated into the frame and integrate with hydraulic brake system. The pedal assembly must be in accord with the 2018-19 Formula SAE rules.

The final manufactured product must satisfactory work and should stop the vehicle when actuated by operated. Also it must conform to all the rules mentioned in Formula SAE rule book 2019. There must be provision for over travel switch for brake pedal that in case if the braking system malfunctions, the switch will operate and shutdown the system.

2. METHODOLOGY

For designing the pedal box different considerations were kept in mind such as operator's effort, weight, serviceability, packaging and geometry. By considering the different values of mentioned parameters the number of iterations was made.

Very first objective for the project was to select the geometry of pedals for Maruti Suzuki stock TMC. Based on the requirements of positive stops for the throttle and clutch pedal two geometries was selected as shown in figure 1.

In the first assembly as you can see has a curved portion on its rear face which will restrict the pedal after particular degrees of movement by making contact with flooring. And in the second it has a simple geometry with a special mounting serving the functions of supporting as well as acting as a positive stop itself. Second design is much simpler than the first if viewed from manufacturing point and also cost effective. So the second was finalized for 2019 season.

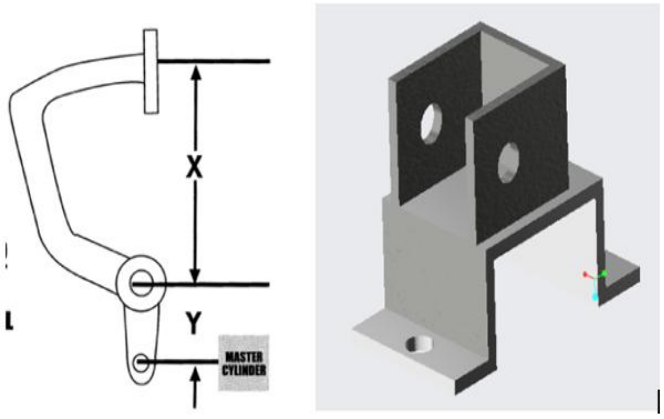

Fig -1: Concept design of pedal

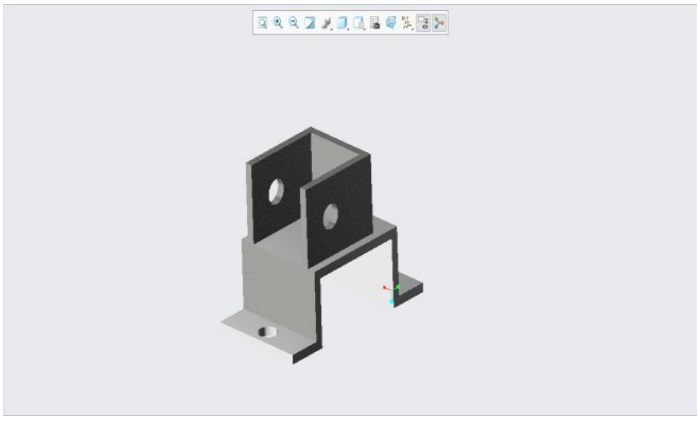

Fig -2: Brake pedal mounting

Material selection is limited to steel and aluminum by the rules. There will be high amount of bending stresses on the both pedal and had to sustain under high loads without deformation. Preliminary Aluminum 6061 T6 was chosen for the pedal as it has high strength to weight ratio, excellent machinability and high resistance to shock loads. And for the mountings mild steel was choose.

While making assumptions for the first iteration past designs of brake box were seen and the particular good things were chosen to keep as it is. For designing purpose PTC Creo 4.0 was used. Initially with the feedback from both the drivers dimensions of pedals was assumed and iterations on shape of pedals was done. After completion of design, prototype from wood was made to see the pedal travel. While designing, pedalover travel position was calculated directly by CAD software considering initial and final position of pedal at same pivot point.

The main problem of using Maruti Suzuki TMC is that it should be installed at minimum 4 inches above the floor because of its geometry and optimum pedal height for drivers foot size is 8 inches making it very difficult to adjust leverage ratio as it automatically turns to be 1:2. As the position of TMC is also restricted to horizontal the operator has to exert the maximum amount of force in order to actuate brakes.

Hence in order to comply with the said objective, the mounting for pedals made such a way that it will act as a positive stop to clutch and throttle pedal itself and for brakes it will provide a required leverage ratio as shown below.

With this mounting, it is now possible to vary the leverage ratio of pedal for same TMC with reduced driver's effort to actuate brakes.

3. FINITE ELEMENT ANALYSIS

For analysis of pedal box assembly Ansys 18.1 was used. The final results were obtained by analyzing the product.

Forces acting on brake pedal are only the force exerted by driver and force from TMC against the force of driver. For the clutch and throttle pedal only the drivers force is acted in order to actuate clutch or throttle by cable. And finally fixed support is given at bottom pivot point.

3.1 Force considerations for Brake pedal

According to the rule T7.1.8, the brake pedal shall be designed to withstand 2000 N without any failure of brake system of brake pedal or pedal assembly. Hence 2000 N force is applied at the top of the pedal. Another force is coming from TMC and is calculated by simple formula, Pressure= force/area. Area being the area of TMC and can be calculated by formula $= \pi r^2$, where r is the radius of bore of TMC.

Driver applied force on the clutch and throttle pedal can be taken as the weight of driver as the human cannot exert force more than his self-weight.

Fine meshing of product is done by taking element size as 1 mm so as to get close results and tetrahedron shape of element is chosen.

Following figures shows the behavior of pedals and its mountings under the application of forces.

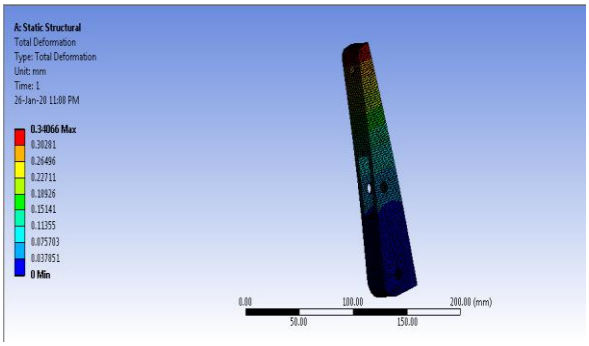

Fig -3: Deformation of Brake Pedal

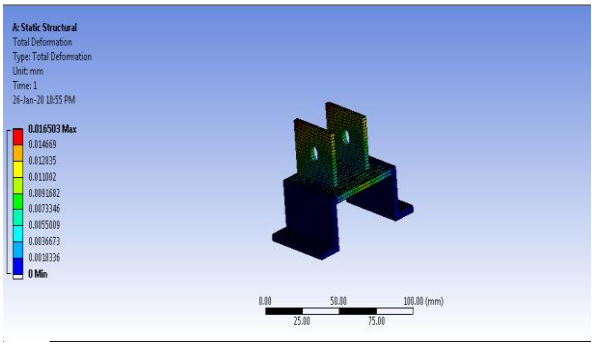

Fig -7: Deformation in Brake Pedal Platform

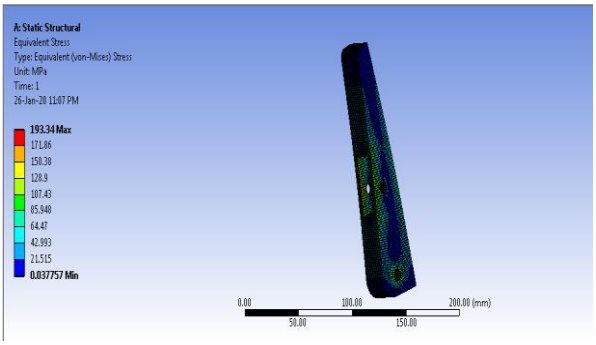

Fig -4: Stress Generated in Throttle/Clutch Pedal

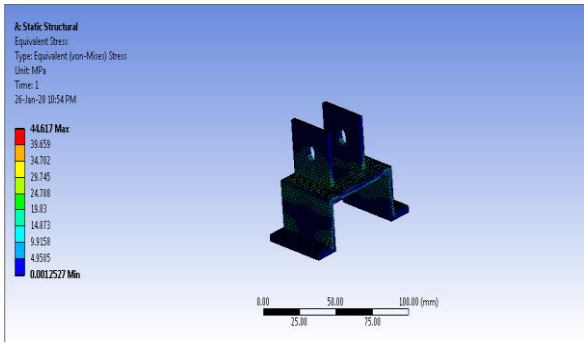

Fig -8: Stress Generated in Brake Pedal Platform

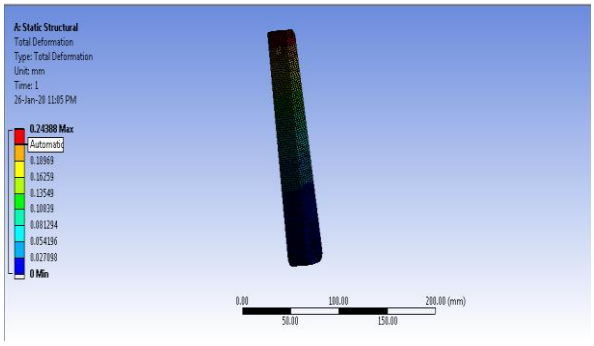

Fig -5: Deformation in Throttle/Clutch Pedal

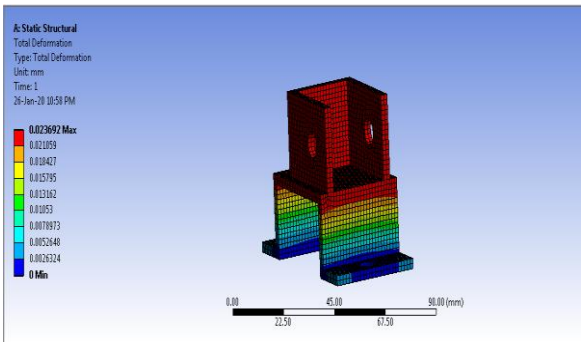

Fig -9: Deformation in Throttle/Clutch Pedal Mounting

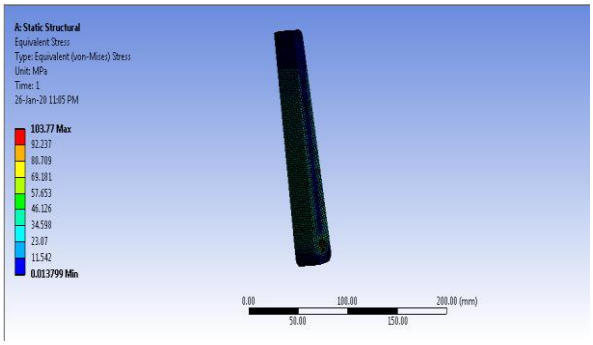

Fig -6: Stress Generated in Throttle/Clutch Pedal

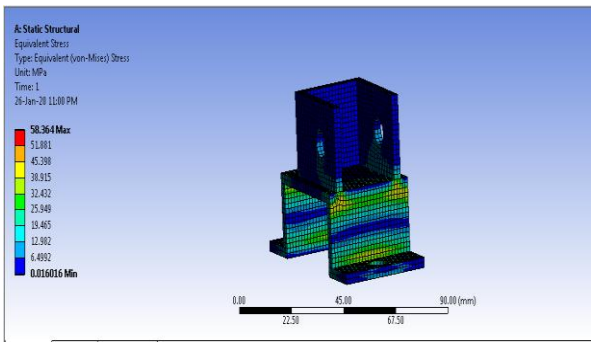

Fig -10: Stress Generated in Throttle/Clutch Pedal Mounting

4. CONCLUSIONS

On the basis of finite element analysis results for pedals and its mountings, following conclusions are drawn.

- For the pedals maximum stresses are obtained at the top where driver applies the force for the operation.
- For mountings Max stresses are generated near the joining mounting plates and its base.

There is significant reduction in driver efforts by adjusting the leverage ratio for Maruti TMC.

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