International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930

DESIGN AND FABRICATION OF PEDAL BOX FOR FORMULA STUDENT VEHICLE

B. PRAVEEN[1], S. MAHESH[2], SK. MEHARAJ BASHA[3], T. SRAVAN KUMAR[4], T. VENKATESH[5]
[1]ASSISTANT PROFESSOR IN MECHANICAL DEPARTMENT & GNIT
[2]STUDENT OF MECHANICAL DEPARTMENT & GNIT
[3]STUDENT OF MECHANICAL DEPARTMENT & GNIT
[4]STUDENT OF MECHANICAL DEPARTMENT & GNIT
[5]STUDENT OF MECHANICAL DEPARTMENT & GNIT

Abstract - The main objective of this project is to Design and Fabricate the Pedal box for formula student vehicle. The purpose of making pedal setup as a box assembly is to reduce space consumption by mounting pedals in a box. The main advantage of pedal box is, it can be adjusted according to ergonomics of the vehicle as well as driver's comfort. To complete this project, several designs were made considering various parameters from given rules in formula student rule book. Best suitable design was selected based on required ergonomics among all designs. Materials were selected, machined, and assembled. ANSYS software was used to verify the design. The final step was manufacturing and assembling all the components together and placing them in the race car.

Key Words: DESIGN OF PEDALS, TESTING,

1.INTRODUCTION: -

About Formula Bharat:

Formula Bharat is a collegiate design competition that encompasses more than 70 teams around all over the world that compete in eight different competitions located across the globe. The purpose of the competition is to design and manufacture a small formula- style race car. The competition contains two events namely static and dynamics events. The static event consists of cost analysis, engineering design and presentation while the dynamic event consists of acceleration, skip-pad, auto cross, fuel economy and endurance.

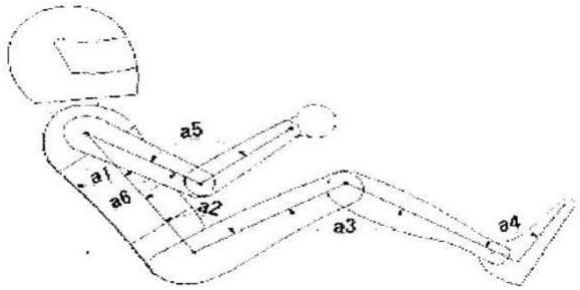
Of particular importance to the design of pedal box are the cost, design and overall dynamic events. There is a total of 1000 points in the competition, of which 100 points related to the cost, 150 points to the design, and 675 points are directly related to the performance of the vehicle in the dynamic events. Due to the tremendous point differentials, the focus of the design of the pedal box relies heavily on performance, then design, with cost being a major consideration.

The performance of the pedal box fundamentally can be measured by the effectiveness of the brake pedal, throttle pedal and possibly the clutch pedal to send a signal to the system for immediate activation. While performance is the top priority, the ergonomics of the pedal box together with the driver's feel must also be taken into consideration in designing the system as the driver is the only person that controls the car in a race. In recent year, the material competes 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 application. The main factors affecting the properties of the materials are strength, cost and weight. In automobile industries it is mandatory to look for cheap and lightweight materials and which should be easily accessible. The constituents of a composite are generally arranged so that one or more

discontinuous phases are embedded in a continuous phase. The discontinuous phase is termed the reinforcement and the continuous phase is the matrix. A brake pedal in motor vehicles has the task of providing the driver's command through foot leg on master cylinder of the brake system.

in a vehicle during stopping or reducing speed of a vehicle. Today the optimization of the product is the vision for reducing the weight and so the cost of the product.

BODY OF THE PROJECT:



Comfortable driving position

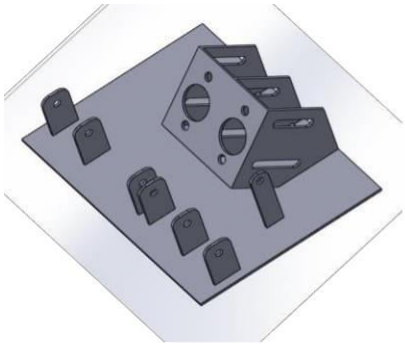
There are certain angles for each joint of the vehicle driver which makes his position more comfortable and relaxing inside the vehicle. Table 1 shows the position of the driver in the cockpit and the joint angle in a comfortable driving position.

Table 1: Joint angle for comfort driving position

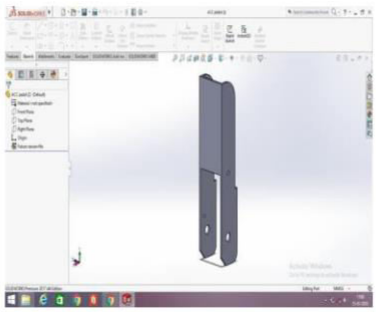
JOINT	ANGLE [DEGREE]
a1	10-30
a2	85- 100
a3	100- 120
a4	85-95
a5	80-90

-

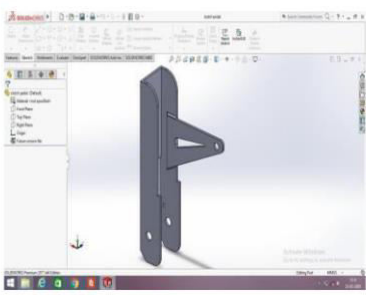
DESIGNED PARTS: -



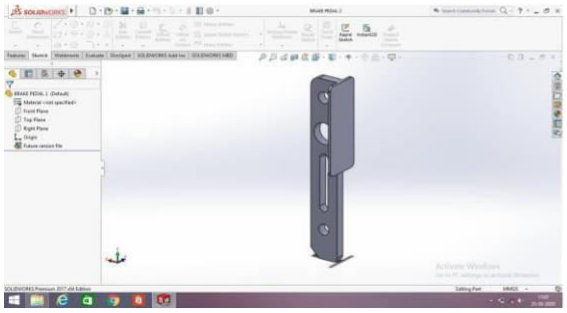
PEDAL BOX

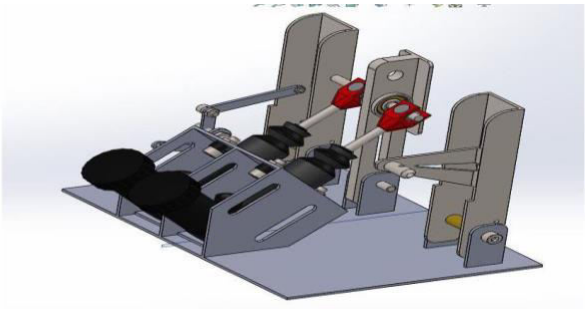


CLUTCH PEDAL



ACCELERATOR PEDAL





Assembly of Pedals in Pedal Box

The main function of the pedal box mounts is to locate the pedals and to house two master cylinders for the brake. The design of pedal box mounting focuses on excess material removal and weight reduction while maintaining is robustness.. Mostly in the design criteria we had chosen the MILD STEEL material which have highly weld ability rate, machinability rate, low cost, easily available, cheap.

. In designing the brake, the pedal itself requires important analysis due to the requirement of stability under a large impact load. Because of the high strength requirement, the design of the whole pedal box then must revolve around the design of the brake pedal and its accessories.

Clutch lever operation is performed by pushing the lever towards forward. Champ-Car is at the high end of commercially available formula car. Champ car, clutch operation is performed by left ankle motion on a foot pedal. Formula 1 is the ultimate of formula car competition..

The throttle system also affects the construction of the pedal box. The accelerator pedal has connections to the throttle system, which must be mounted on the pedal box. The throttle should be adjustable to the driver's needs based on angle and distance travelled. Also, the pedal should be able to return to the original position when there is no pressure on the pedal from the driver's foot.

The "ISOMETRIC" view of the pedal box assembly and the components used in the pedal box are mentioned above we also provided the brake over travel switch (BOTS) in order any damages takes place in the braking system the bots will acts as the kill switch and it will kill the engine power completely.

BRAKING CALCULATIONS

- Force applied = 50×9.81= 490.5N
- Force at master cylinders = Force at pedal × Mechanical advantage (Pedal ratio)

  = 490.5 ×1.45= 711.225N

- Pressure inside master cylinders = Force at master cylinder / Area of Master cylinder

  = 711.225 / 0.785× $(15.75\times10^{-3})^2$ = 3650530.794N/m^2

- Total braking force (F_f) = 2× 2×4×μ_d × Pressure at master cylinder × Area of calliper piston

= 22478.22N **μd** =coefficient of friction Finally, the

Total braking torque = Total braking force × Disc radius= 22478.22 × 0.1= 2247.822Nm

- Frw = Fr × **wcosΘ** **Fr** = Rolling resistance coefficient
  = 0.02 × 330 ×9.81
  = 64.746N

- Ff=μ×w
  μ = Coefficient of friction b/w wheels and roads
  = 0.7 ×330×9.81
  = 2266.11 N

STOPPING DISTANCE

= 8m w = Total weight of vehicle + driver weight

v = initial velocity

DECELERATION: -

$D = [f_b + f_{rw} + f_d + F_f] / m$ $D = 19.5\ m/s^2$

Where, m = mass of vehicle with driver

Ff = Frictional force

fb = Braking force

frw = Rolling resistance

fd = Drag force

STATIC LOAD TRANSFER:

$W_f = wl_2/L$

$W_f = \frac{330 \times 9.81 \times 0.6885}{1.524 \times 10}$

= 145.67 Kg

Static load transfer at rear: - Wr = 330-145.67

= 184.33 Kg.

DYNAMIC LOAD TRANSFER

$W_f = \frac{\times \times .}{}$

$= \frac{7.95 \times 330 \times 0.3}{1.524}$

W_f = Weight transfer at front

L=wheel base

C.G=centre of gravity

m = Mass of the vehicle + driver

W_r = Weight transfer at rear wheel

D=decceleration

ANALYSIS OF DESIGNED PARTS: -

The procedure for static analysis consists of these main steps

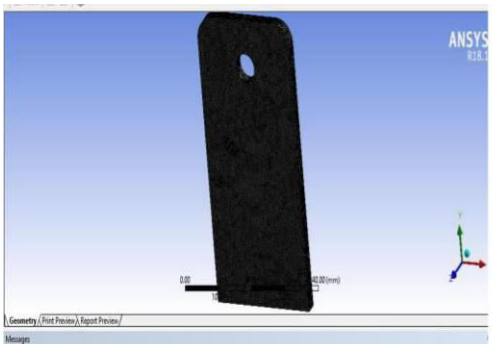
1 Building the model

2 Obtaining the solution

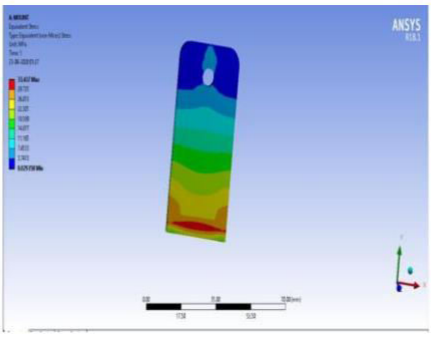
3. Reviewing the results

SERIES OF ANALYSIS ON COMPONENTS

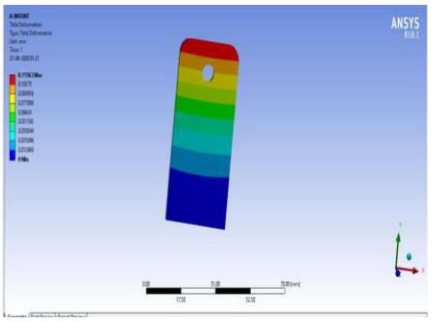
Analysis of Pedal Mounts



MESHING OF MOUNTS



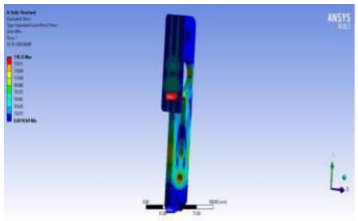
STRESS ANALYSIS



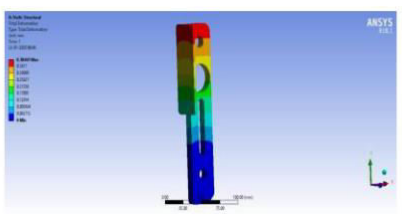
TOTAL DEFORMATION

The dimensions of the mount are 3×6×3 cm and type of meshing we considered as the tetrahedron of element sizing of 1mm and relevance of 30. The order of the element is linear and number of nodes are 70529 and elements are 308143. The equivalent stress analysis is done the mount of dimensions maximum stress obtained the analysis is 11.427 MPa. The applying of the force taken along x-axis of 10 N. The maximum deformation that has been obtained is 0.11561 mm. We can also go for the TOPOLOGY for optimization the pedal mounts if any we required

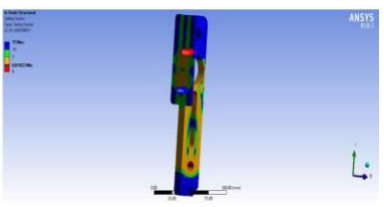
ANALYSIS OF BRAKE PEDAL



STRESS ANALYSIS



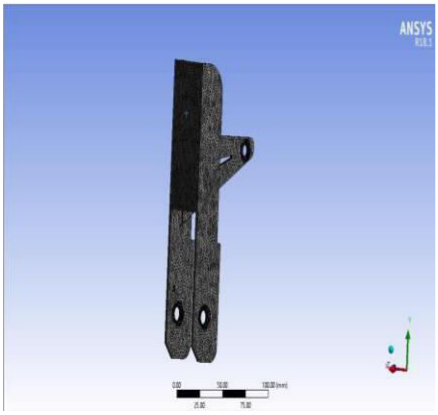
TOTAL DEFORMATION



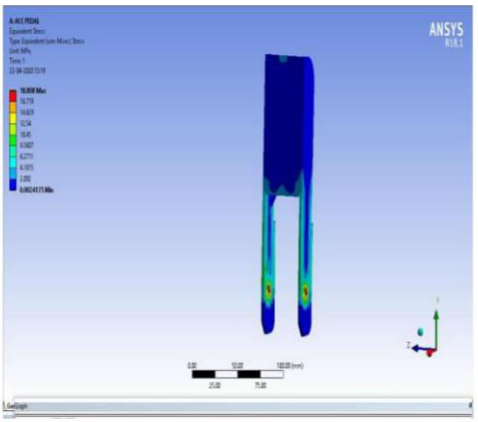
FACTOR OF SAFETY

The equivalent stress analysis is done the brake pedal of dimensions 3.5×20×10 cm..The maximum stress obtained the analysis is 176.32 MPa. The red colour region indicates the maximum stress concentrated area in the region. The maximum deformation that has been obtained is 0.38441 mm. We can also go for the TOPOLOGY for optimization the pedal If any we required. maximum stress is applied is 2000N The above fig gives the details of factor of safety of the pedal with minimum value is 0.81422. The maximum value of F.O.S is 15

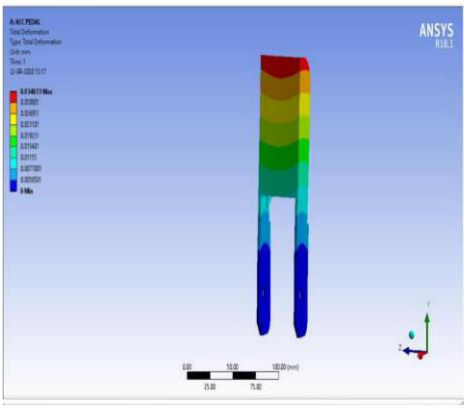
ANALYSIS OF CLUTCH PEDAL



MESHING



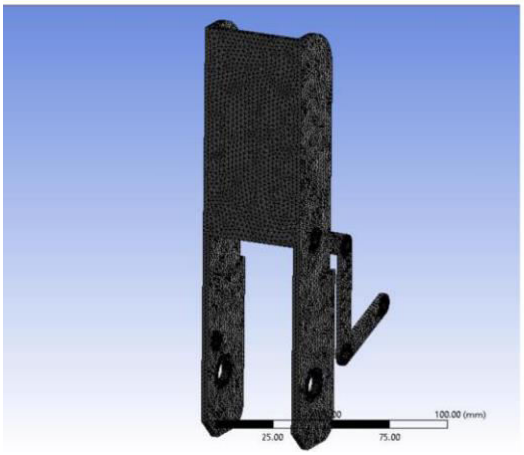
STRESS ANALYSIS



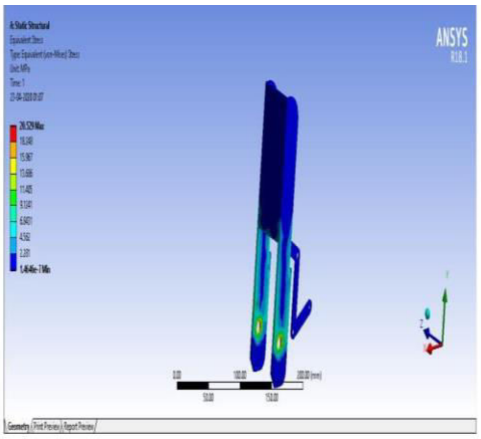
TOTAL DEFORMATION

The dimensions of pedals are 3.5×200×3 cm.We have chosen the tetrahedron type of for clutch pedalThe element sizing of the is 3mm.We have given the reinforcement at holes so that there will more force distribution will take place.The from the pedal is used for the purpose of attachment of clutch wire for the pedal.Mass = 70.90 grams and the Volume = 70901.88 cubic millimetres Surface area = 41990.66square millimetres.The material used for the clutch pedal is mild steel. The red colour region is the region where we can able to see maximum stress concentration on the pedal of 18Mpa.The blue colour region has the minimum concentration of the stress of 0.002Mpa.The amount forced received by the pedal is about 50 N, normal to the pedal face but there is no stress developed at that point only at fixed support we can able to see the stress concentration. The maximum deformation of pedal is 0.034 mm and the minimum deformation of is 0 mm.

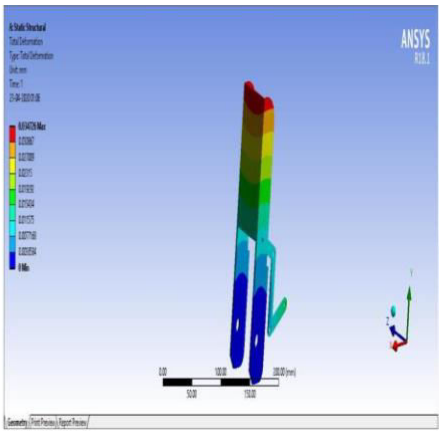
ANALYSIS OF ACCELERATOR PEDAL



MESHING



STRESS ANALYSIS

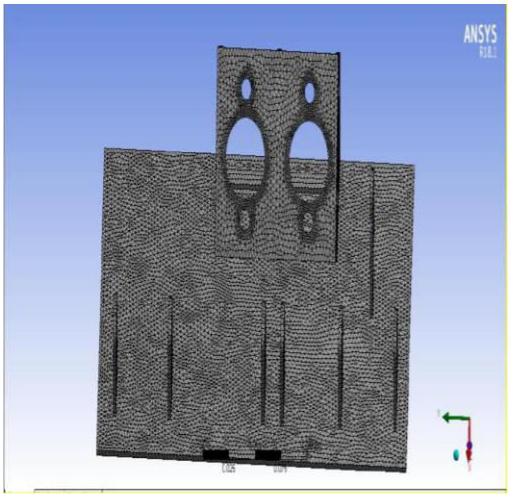


TOTAL DEFORMATION

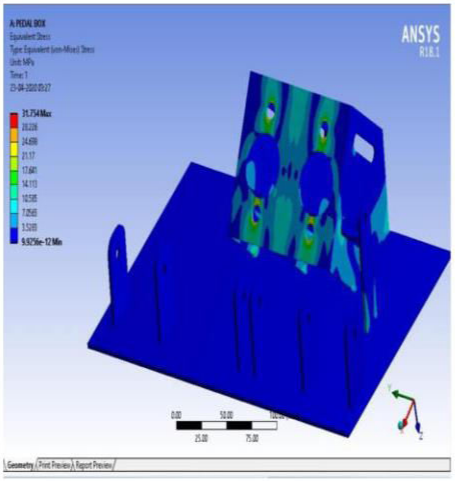
We have chosen the tetrahedron type of for accelerator pedal.The element sizing is 3mm.We have given the reinforcement at holes so that there will more force distribution will take place.The extension that is given for pedal is used for the purpose of attachment of accelerator wire for the pedal.Mass = 51.55 grams and the Volume = 5155.03 cubic millimetres Surface area =

38198.88 square millimetres. The red colour region is the region where we can able to see maximum stress concentration on the pedal of 20.529 Mpa. The blue colour is the region where there is minimum concentration of the stress of 1.4646 e-7 Mpa.The material used for the clutch pedal mild steel. The maximum deformation of pedal is 0.034 mm and the minimum deformation of is 0 mm.

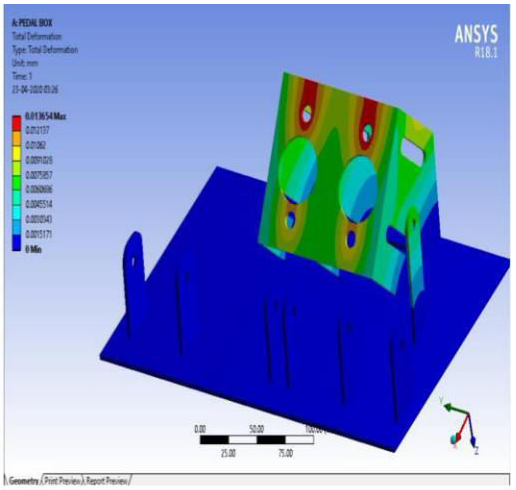
ANALYSIS OF PEDAL BOX



MESHING



STRESS ANALYSIS



TOTAL DEFORMATION

The above fig gives the meshing analysis of the pedal box having the dimensions of the 150×100×30 mm.We have chosen the tetrahedrons types of meshing with linearThe element sizing of the meshing is 3mm and zero relevance.The number of elements is 21080 and nodes are 42819.The maximum force is applied on the master cylinder plate.The base will act as a fixed support.The total mass of the pedal box (m)=316.55gmThe surface area of the pedal is 220051.31 mm^2 and the total volume is about 316548.83 m^3. The red colour region is the region where we can able to see maximum stress concentration on the pedal box of 31.754 Mpa.The blue colour is the region where there is minimum concentration of the stress of 9.9256 e-12 Mpa.The amount forced received by the pedal box is about 500N, normal to the master cylinder face but there is no stress developed at that point only at fixed support we can able to see the stress concentration. The red region indicates the total deformation of the pedal box.The maximum deformation of pedal box is 0.013654 mm and the minimum deformation of is 0 mm.We can able to see the minimum deformation at blue region.

FABRICATION

Fabrication is the process of making something from semi-finished or raw materials rather than from ready-made components. In other words, it is the process of making something from scratch rather than assembling something.

Fabrication process carried out for the pedal box is like making from the scratch as from the definition of the fabrication process. It involved sequence of operations to complete the assembly of the pedal box (i.e. pedals along with linkages and the pedal box)

For the fabrication of pedal box sequence of operations carried out is as follows

- Raw material procurement.
- Production planning.
- Production process.Assembly.

The above sequence of steps we followed for fabrication played a crucial role for

- Reduced material wastage.
- Reduced time wastage.
- Quality of components.

PROCUREMENT OF RAW MATERIALS

All the procurement is done by a group of specific people in the team who are having a good idea about the availability of materials in local market. As per the design of the pedal box, the material we used is MILD STEEL, which has a density of 7.858 gm./cm^3.The chemical properties and mechanical properties of mild steel are listed below in tables 3 and 4 respectively.

THE CHEMICAL COMPOSITION OF MILD STEEL

ELEMENT	CONTENT IN (%)
Iron, Fe	99.06-99.51
Manganese, MN	0.30-0.60
Carbon, C	0.19-0.25
Sulfur, S	≤ 0.050
Phosphorous, P	≤ 0.040

THE MECHANICAL PROPERTIES OF MS

Mechanical Properties	Metric
Tensile strength	425 MPa
Yield strength	360Ma
Shear modulus	80.0 GPa
Bulk modulus	140 GPa
Elastic modulus	1902G Pa
Poisson's ratio	0.27-0.30
Elongation at break	15%
Reduction of area	40%
Machinability	65

The above material is ordered with certain specifications

3mm Thickness steel sheet with dimensions 1000*1000 mm

5mm thickness 200*200mm

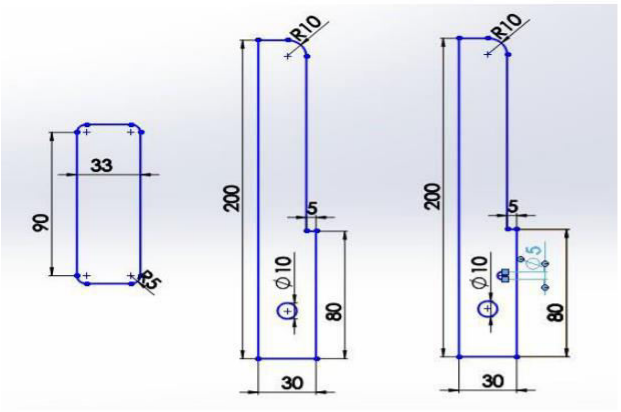
Brass rod of diameter 13mm and length 30mm.

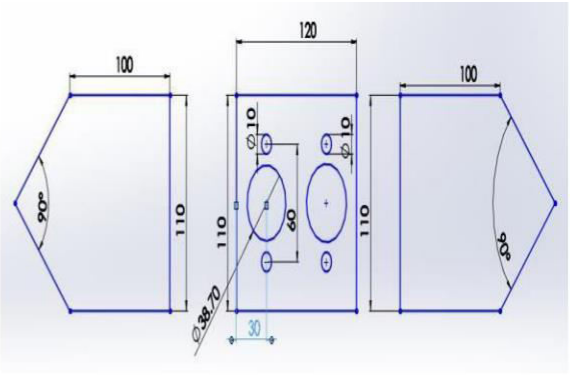
Production process

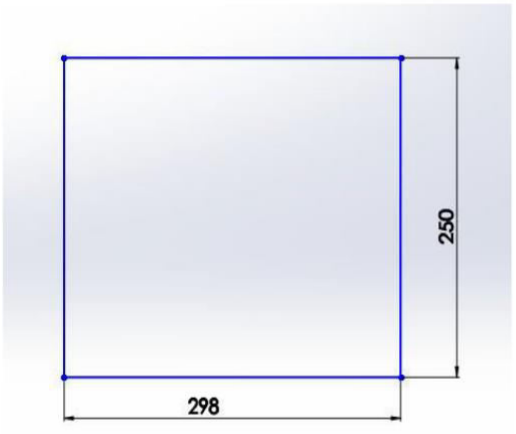
The production process carried out is explained as follows The production operations carried out are

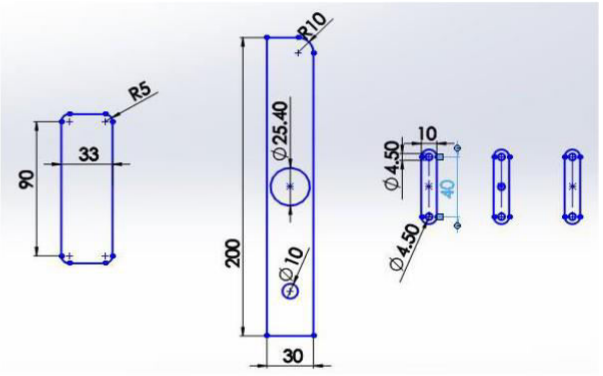
- Sheet metal cutting.
- Grinding.
- Drilling.
- Facing, Turning, drilling of brass rod.
- Welding.

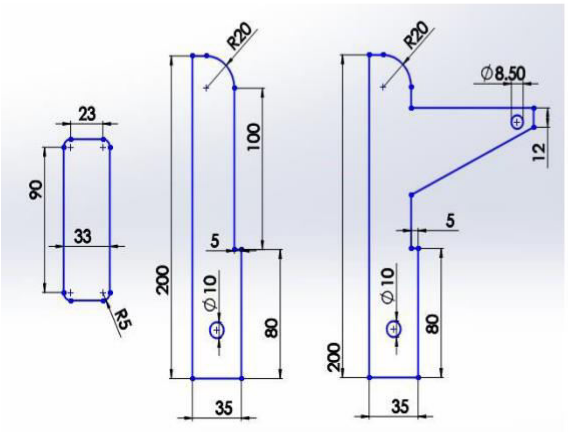
THE TEMPLATES FOR LASER CUT

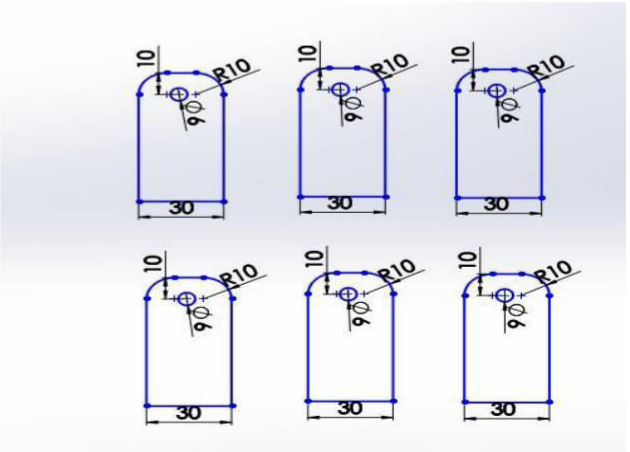




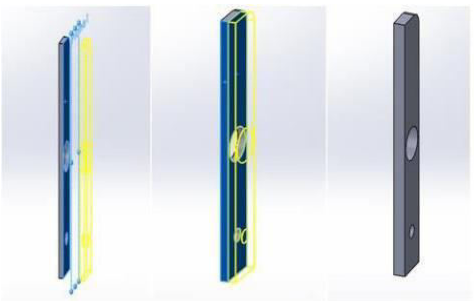








Welded parts



WELD JOINT OF BRAKE PEDAL ASSEMBLY

After completion of production of all the components the assembly of the parts is done using fasteners as per the design, which completes the pedal box.

The fasteners used are

1.8mm Allen bolts and 8mm lock nuts.

2.10mm Allen bolts and 10mm lock nuts.

3.10mm jam nuts and 10mm washers.

4.4mm hexagonal bolts and 4mm

FUTURE SCOPE

Further development can be done majorly in the selection of material. We chose the material which is best suited for the application and at the same time which is locally available at less cost. Choosing other standard yet costly material may become a burden to the team management and a time taking process if the material is not available in local market. Future team can surely choose a costly material as they are capable of cutting unnecessary costs in various departments.Selecting other high standard material will significantly reduce the overall weight of the pedal box which in turn enhances the performance of the vehicle. As we all know lesser the weight of the car, maximum are the chances for better speed.The other area for a chance of development is pedal ratio. Betterment of pedal ratio will significantly improve the on-road performance of the car. As well as the driver will experience better pedal interaction in driving.

CONCLUSION

We have gone through the design and analysis of the pedal box and its components which have been contained in the pedal box are designed and analysed for the racing vehicles but not for the SUV, SEDAN, TRUCKS etc. I.e. depending upon the sitting position of the driver in the cockpit which is far different when compare with normal vehicle and racing vehicle. The component pedal box should be rigid when we are going to mount in any racing vehicle. The material which we preferred according to the cost that had been allotted to the individual department. The material we used is mild steel rather than any steel alloys, aluminium alloys, polymers, etc.., we had more than two iteration on the pedal box to understand behaviour of the pedal in all circumstances. So that by all consideration we can able say that the pedal box was design and fabricated by our team members suitable for **“FORMULA STUDENT VEHICLE”.**

REFERENCES

1.2009 Formula SAE Rules (2008). Society of Automotive Engineers, USA.

2.Schiller, B. W. (2007) 2007 Formula SAE Pedal Box. Bachelor of Science thesis, Department of Mechanical Engineering Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.3.Enomoto, H., Miyazaki, Y., Mizuno, H., Hirano, E., K.itayama, S., Yamazaki K., et a!. (2007). Development of CFRP Monocoque Front Impact Attenuator for FSAE with VaRTM. Society of Automotive Engineers of Japan, Inc.

4.Wagner, Dan. http://dsr.racer.net/brake bias.htm

5.Moody, B. J. (2005) Control and Instrumentation for USQ Formula SAE-A Race Car. Bachelor of Engineering(Mechanical) and Bachelor ofBusiness(Logistics and Operation) thesis, Faculty of Engineering and Surveying University of Southern Queensland, Toowoomba, Queensland,Australia.

6.Enomoto, H., Morita, H., Fukunaga, Y. and Uota, N. (2007) Simplification ofthe Shift/Clutch Operations for the Formula SAE Vehicles.Society of Automotive Engineers ofJ apan,Inc.http://http://www.researchpublish.com/ http://eprints.utem.edu.my/10249/1/Design_And_Fabrication_Of_Pedal_Components

7.Carroll Smith,"Tune to Win",year 1978.

8.Conceptual Design and Analysis of Brake Pedal Profile", by authors K.K.Dhande,N.I.Jamadar, SandeepGhatge

9.Topology Optimization in Automotive Brake Pedal Redesign", by the authors Mohd Nizam Sudin, Musthafah Mohd Tahir, Faiz Redza Ramli, Shamsul Anuar Shamsuddin.

10.Design and Analysis of Composite Brake Pedal: An Ergonomic Approach" by the authors K KDhande, N I Jamadar, Sandeep Ghatge.

.