Optimization of Bike Brake Lever Design using ANSYS

Thontaraj Urs T.S.[1], Suresh Raddy[2]
[1,2] Assistant Professor, Department of Mechanical Engineering
Sri Krishna Institute of Technology, Bangalore-560090, Karnataka, India

Abstract— The basic function of brake levers is to activate the brake mechanism, which allows people to slow down or stop while they are riding a bike. There are two types of mechanism: mechanic brakes or hydraulic, and both functioning and effectiveness are really different. Also there are differences between all kind of modalities there are in the world of biking, without taking into account if they are hydraulic or mechanic and different kind of materials, depending on the quality of them. The task that brake levers have to carry out makes them to reach some essential properties. So they have not only hardness and stiffness but also lightness and resistance. And this has a simple explanation; these levers have to be able to support an extremely hand-push without breaking or deforming, so they make possible for people to slow down the bike without any danger. Making the brake lever design is an iterative process because we do not know at first how the pressure applied affects it. So we will need to make a simple design and use the ANSYS software for a simulation. With the results we will get we will see the parts of the lever that need to be stronger or that parts that do not support any stress. With this information we will be able to optimize the design and try again the simulation. In this project, the modeling of bike brake lever was done in Catia V5 and simulation had been carried out in Ansys Workbench considering two materials like structural steel and copper alloy under same loading conditions and fine meshing to assess the total deformation. It can be observed from the simulation results that the simple brake lever with thickness of 6mm, structural steel material gives the much lower deformation of about 172m compared to all other cases.

Keywords— Brake lever, Brake mechanism, Deformation.

I. INTRODUCTION

The functioning of brake levers is very simple. If we talk about a mechanic brake lever, first of all we need to push it. This action stretches a metallic sane that permits the two brake pads put pressure on one of the two wheel rims. The functioning of hydraulic brakes is a bit different. Here in order to stop the bike, the brake lever pushes special oil making pressure and making the bike slow down or stop.
The task that brake levers have to carry out makes them to reach some essential properties. So they have not only hardness and stiffness but also lightness and resistance. And this has a simple explanation; these levers have to be able to support an extremely hand-push without breaking or deforming, so they make possible for people to slow down the bike without any danger.

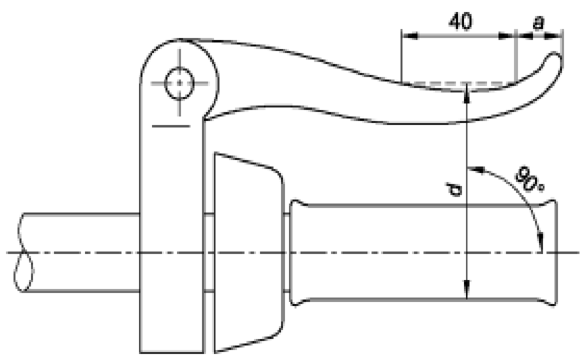


Figure 1: Bike brake lever.

To design our brake lever was important to know the maximum strength a man can do with one hand. That is because we want to make sure that this man riding the bike with our brake lever will not be able to break it just trying to make the bike stop for example in an emergency situation. But on the other hand, it is important to know the strength that this same man riding the bike in normal conditions would usually do to stop. This means, the hand brake lever must resist the maximum strength one man can do with one hand, for example, if he is in a risk situation and because he is scared he makes much more strength than necessary. But the normal strength to make the brake work must be comfortable for the man riding the bike. So, if someone using the bike wants to stop, the strength he must need must be a little high so he will only stop on purpose, but not that high that he would get tired by using the brakes.

It is important to highlight here that our decisions will be different doing this project than they would be if doing a real project design. This is due that we will not use the same data than we would because we want to be able to test the lever and compare the results with those we will get by simulation. So all along this section we will distinct the values we would use for a real design of a brake lever, and the values we decide to use for our prototype.

First of all, in this section we will try to find out the maximum force that a person can grip strength. The idea is getting an empirical statistical study and we will see what the result is. The best way to do it is with a tool called Jamar hydraulic Dynamometer. With this machine someone just grip strength and we get the force value he is doing. The problem is that a Jamar hydraulic Dynamometer costs about one thousand euros. Then we have two options: on one hand we can try to design an experiment that gets us an idea of this force. On the other hand we can look for other studies that have been done before. We took metallic recipient with a handle and we put it on a scale. The idea then was to start filling the recipient with dense materials like iron and start to increase the weight. In this way, we got the maximum weight that the subject is able to rise up, what is proportional to the maximum force that this person can grip strength. We tried with one member of our group and the maximum weight with one hand was 40kg ergo 392 N.

Figure 2: Jamar Hydraulic dynamometer.

A. Basic design

Making the brake lever design is an iterative process because we do not know at first how the pressure applied affects it. So we will need to make a simple design and use the ANSYS software for a simulation. With the results we will get we will see the parts of the lever that need to be stronger or that parts that do not support any stress. With this information we will be able to optimize the design and try again the simulation.

Anyway, there are three factors we know that will matter for the design:

1. The material, because of its properties such the modulus of elasticity, the Poisson coefficient and the tensile strength.
2. The pressure applied, what means the force made and the width of the surface where this force will be applied.
3. The part of the brake lever where this pressure will be applied and how close of the cotter pins is.

The first point is something we have already chosen and cannot change it to make it better or worse. The second point is information we already know, but we cannot change it either. The third point is someone we can decide and change to optimize our design at the same time as the rest of the shape.

B. Introduction to Catia & Ansys

CATIA (Computer Aided Three-Dimensional Interactive Application) V5 is developed by Dassault systems, France, is a completely re-engineered, next generation family of CAD/CAM/CAE software solutions for product lifecycle management. Through its exceptionally easy-to-use and state of the art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using featured based and parametric designs.

CATIA V5 provides three basic platforms: P1, P2, and P3.P1 is for small and medium- sized process- oriented companies that wish to grow towards the large scale digitized product definition. P2 for advance design engineering companies that require product, process, and resource modeling. P3 is for high end design applications and is basically for Automotive and Aerospace Industry, where high quality surfacing or class-A surfacing is used.

ANSYS, Inc. is an engineering simulation software (computer-aided engineering, or CAE) developer that is headquartered south of Pittsburgh in the South point business park in Cecil Township, Pennsylvania, and United States.

ANSYS offers engineering simulation solution sets in engineering simulation that a design process requires.

Companies in a wide variety of industries use ANSYS software. The tools put a virtual product through a rigorous testing procedure (such as crashing a car into a brick wall, or running for several years on a tarmac road) before it becomes a physical object.

ANSYS Workbench is a common platform for solving engineering problems. Typical tasks you can perform in Workbench are:

1. Importing models from a variety of CAD systems.
2. Conditioning models for design simulations using the Design Modeler.
3. Performing FEA simulations using Simulation.
4. Optimizing designs using Design Xplorer or Design Xplorer VT.

II. METHODOLOGY

A. Modeling of brake lever in Catia V5.

Design of the brake lever with changing the two design consideration to optimize results.

1. Simple design of brake lever
2. Modified design of brake lever

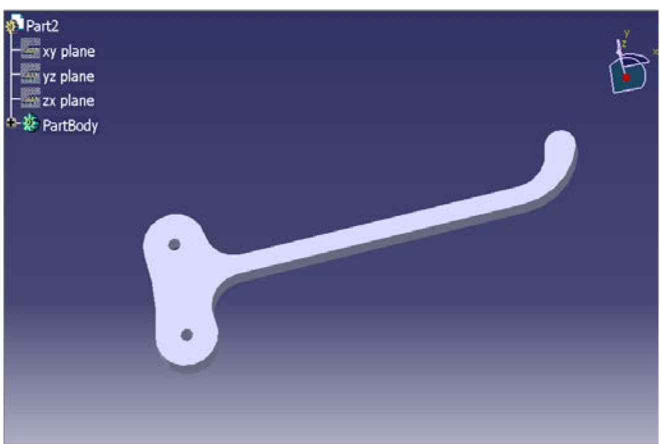


Figure 3. Shows the simple design of the brake lever with 6mm thickness.

B. Analysis of Shock absorber in Ansys Workbench.

Sl. No.	Meshing	Nodes	Elements
1	Coarse	636	67
2	Medium	2323	336
3	Fine	6855	1170

The analysis is carried out in Ansys workbench, where the model is modeled in the Catia workbench and imported in the Ansys workbench for meshing, applying the boundary condition and simulation.

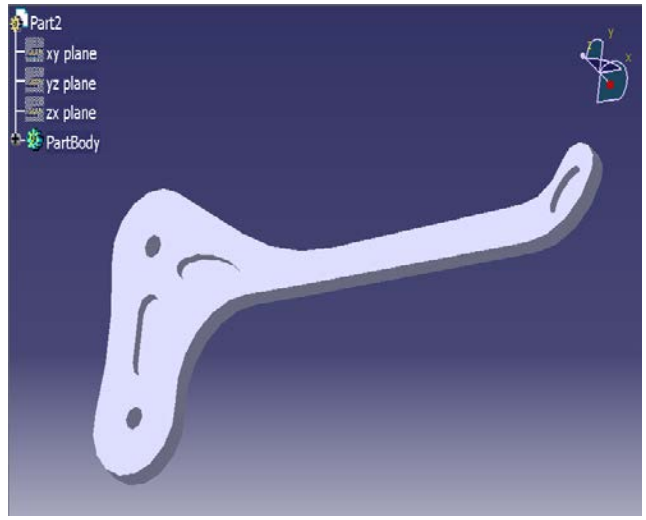


Figure 4. Shows modified design of the brake lever with 4mm thickness.

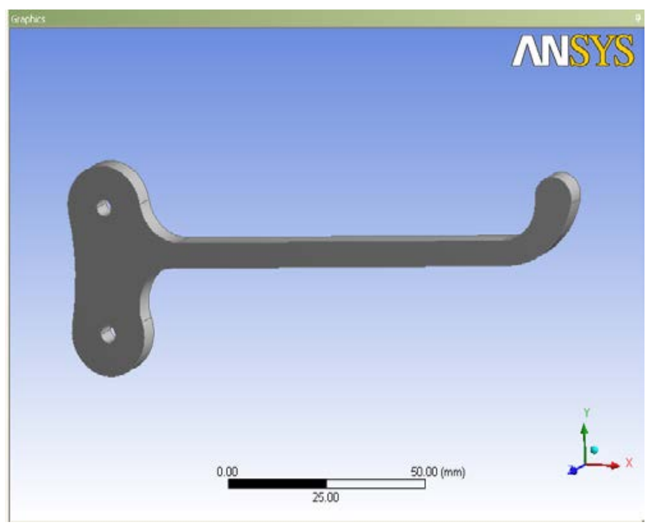


Figure 5.Shows the imported simple design of the brake lever in Ansys workbench.

1. Meshing the model in Ansys workbench with varying the three meshing parameter for simple design.

The model is meshed in coarse meshing, medium meshing, and fine meshing parameter to distinguish model number of node and element.

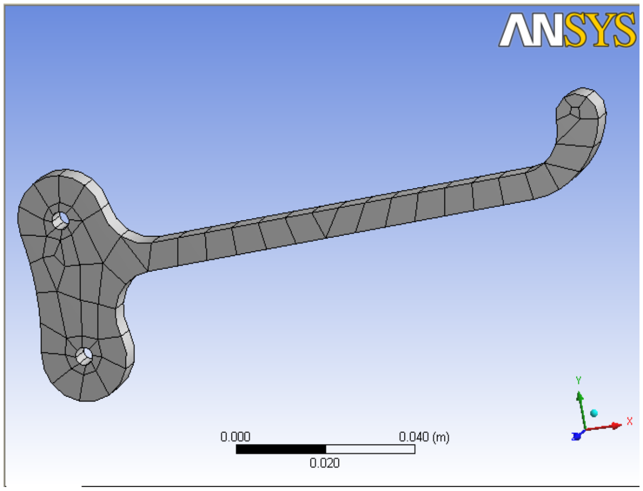


Figure 6. Shows the coarse meshing of brake lever model in Ansys workbench.

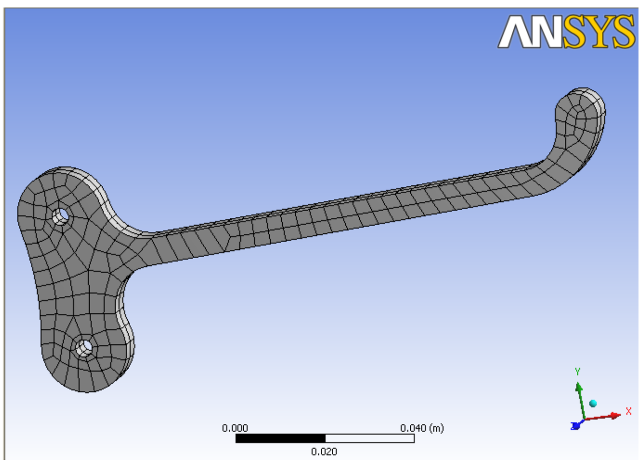


Figure 7. Shows the medium meshing of brake lever model in Ansys workbench.

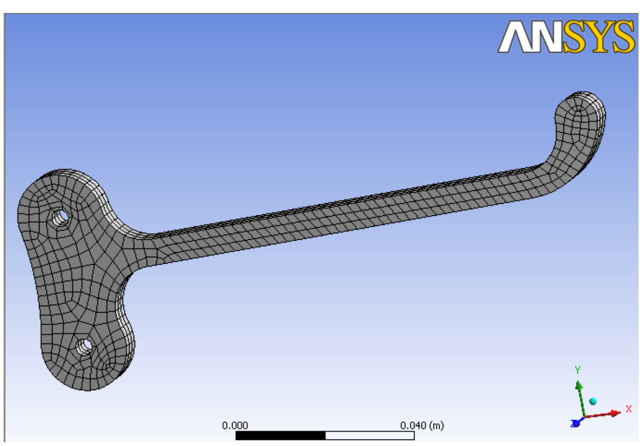


Figure 8.Shows the medium meshing of brake lever model in Ansys workbench.

TABLE 1. Shows the number of nodes and elements in the simple brake lever model in Ansys workbench.

2. Meshing the model in Ansys workbench with varying the three meshing parameter for modified design.

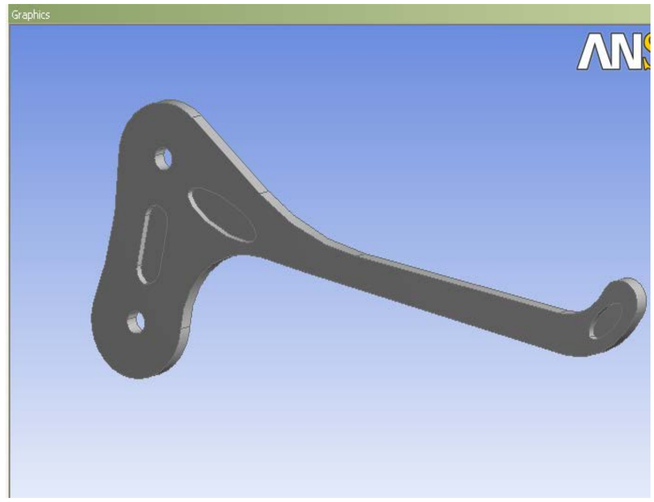


Figure 9.Shows the imported modified design of the brake lever in Ansys workbench.

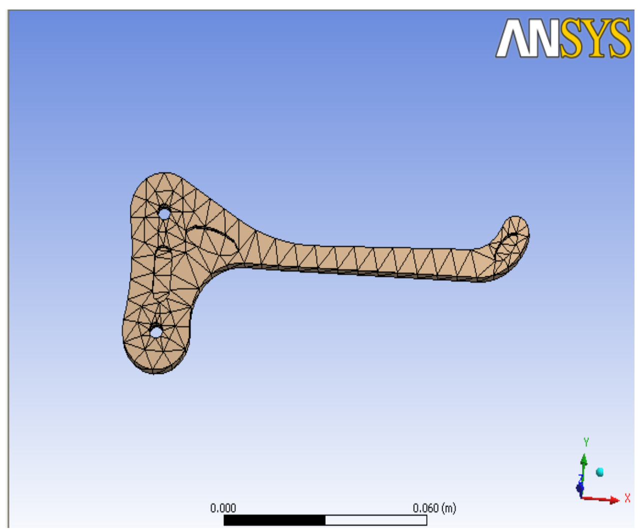


Figure 10. Shows the coarse meshing of modified brake lever model in Ansys workbench.

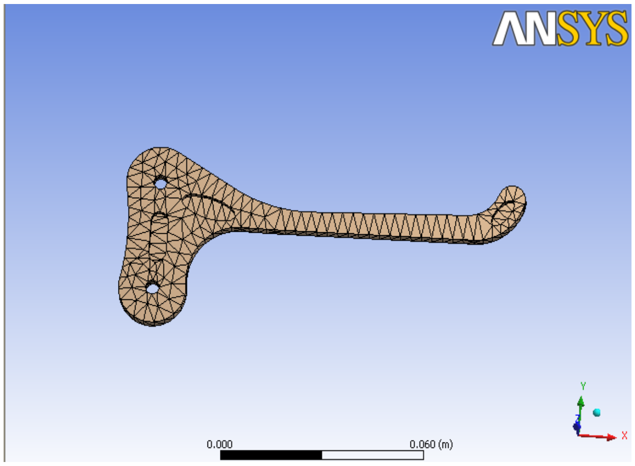


Figure 11. Shows the medium meshing of modified brake lever model in Ansys workbench.

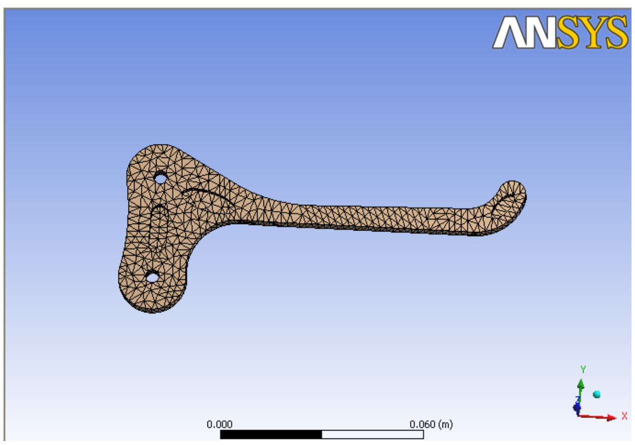


Figure 12. Shows the fine meshing of modified brake lever model in Ansys workbench.

TABLE 2. Shows the number of nodes and elements in modified brake lever model in Ansys workbench.

Sl. No.	Meshing	Nodes	Elements
1	Coarse	1435	615
2	Medium	2330	990
3	Fine	5070	2263

C. Applying the boundary conditions for both design of brake lever.

Boundary conditions for the both simple and modified design of the brake lever are same

1. Pressure is applied to the lever at one of the brake wire attached slot of 20 Pa.
2. Force of 100N is applied on the top of the lever surface in y direction.
3. Applying the moment on the lever fulcrum of 20 Nm, where it is attached to rotated.

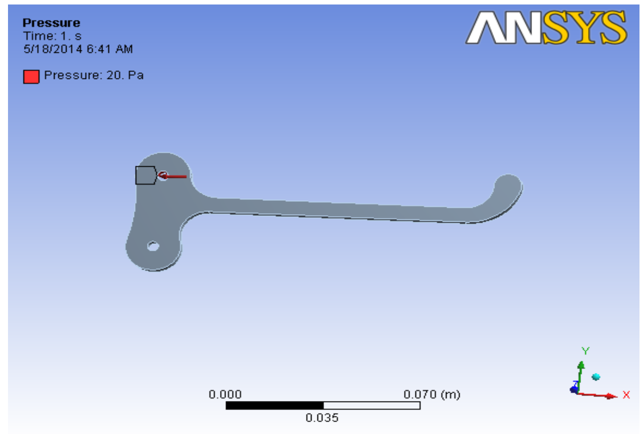


Figure 13. Applying the pressure of 20 Pa.

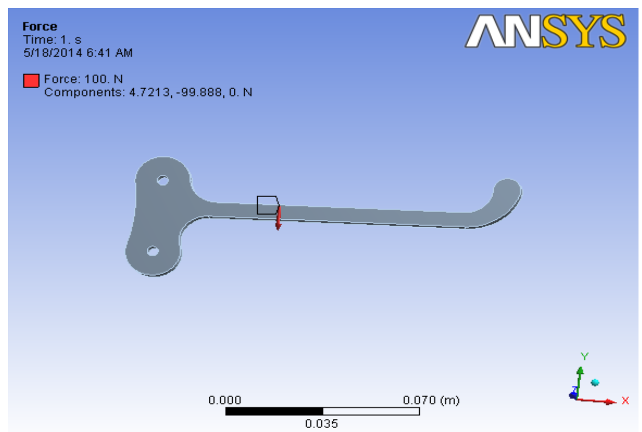


Figure 14. Applying the force of 100 N.

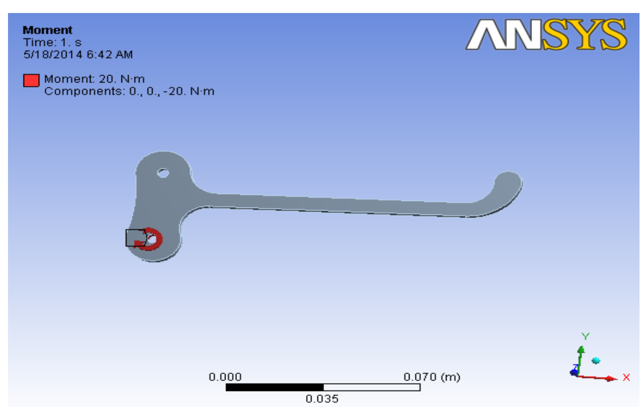


Figure 15. Applying the moment of 20 Nm.

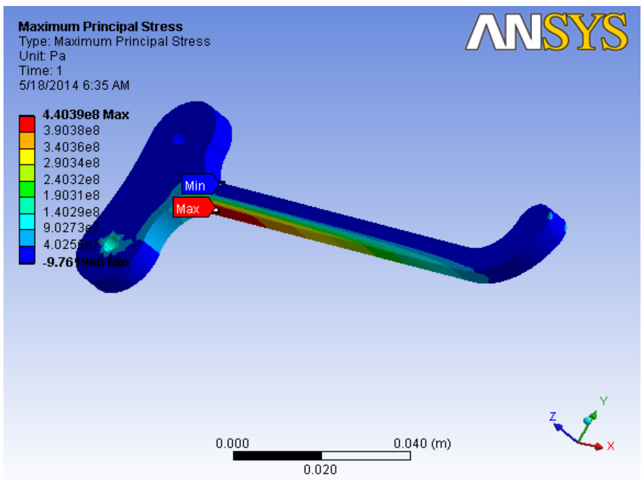
III. RESULTS AND DISCUSSIONS

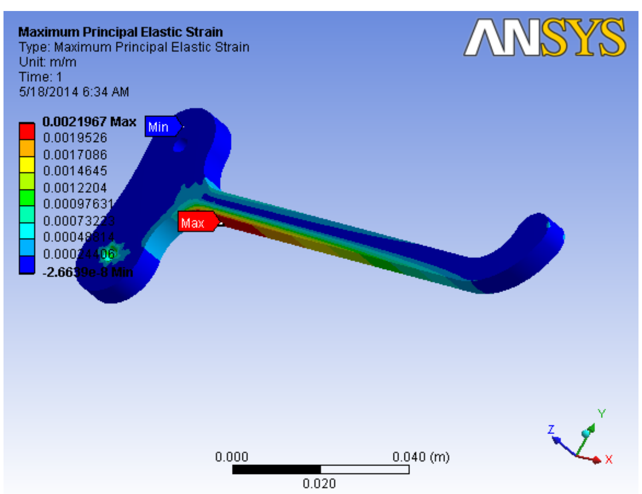
Analysis for the both simple and modified design of the brake lever is of same conditions

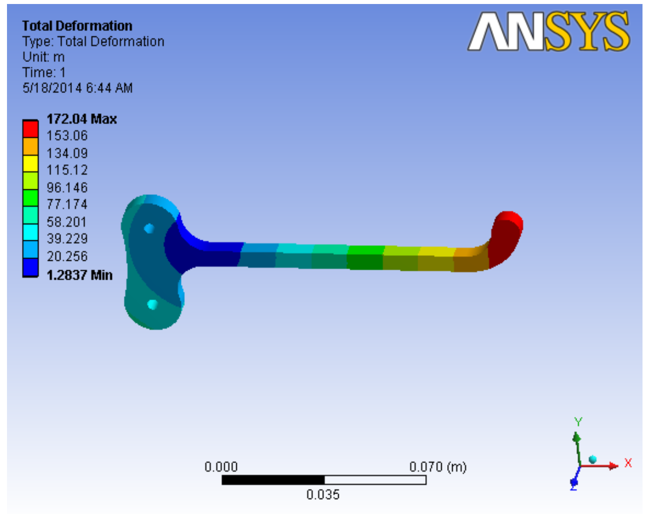
1. Pressure is applied to the lever at one of the brake wire attached slot of 20 Pa.
2. Force of 100N is applied on the top of the lever surface in y direction.
3. Applying the moment on the lever fulcrum of 20 Nm, where it is attached to rotated.
4. The changing of the material properties brake lever structural steel and aluminum alloy.
5. Comparing the results for the both the design and the material properties with the fine meshing parameter.

A. Simple design of brake lever

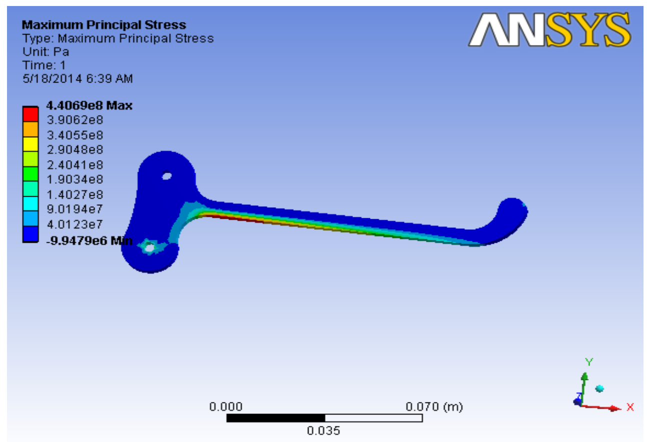
1. For structural steel material

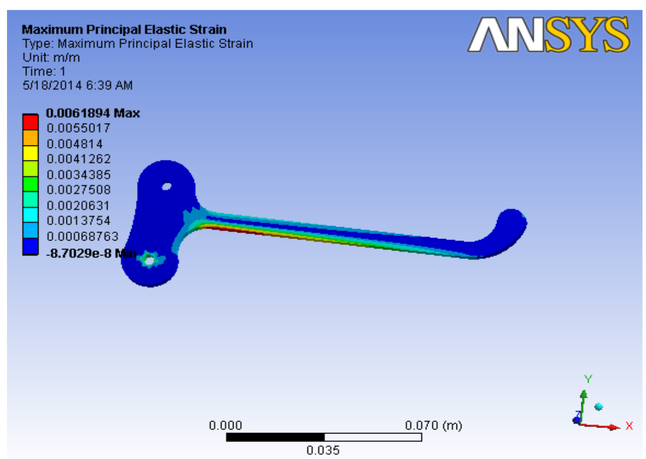


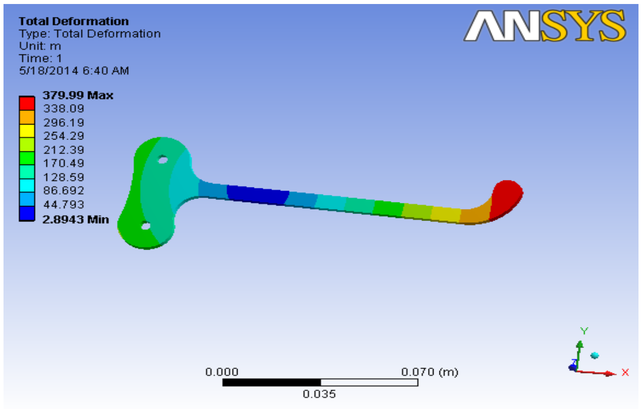




2. For aluminum alloy material

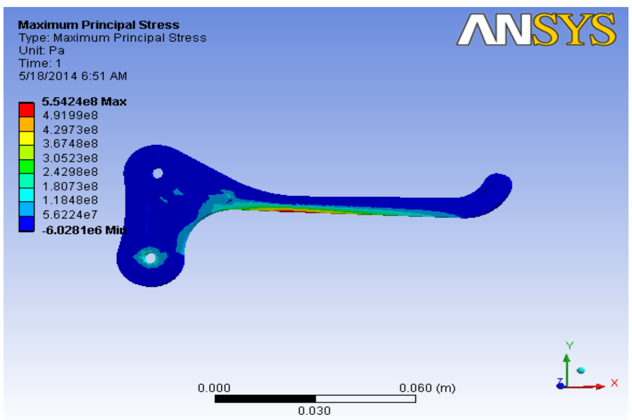


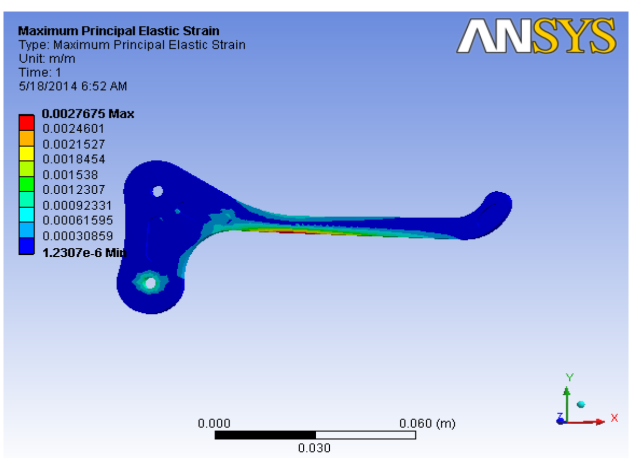


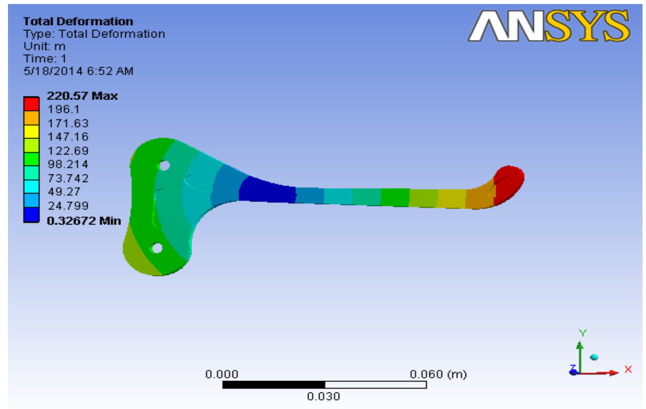


B. Modified design of brake lever.

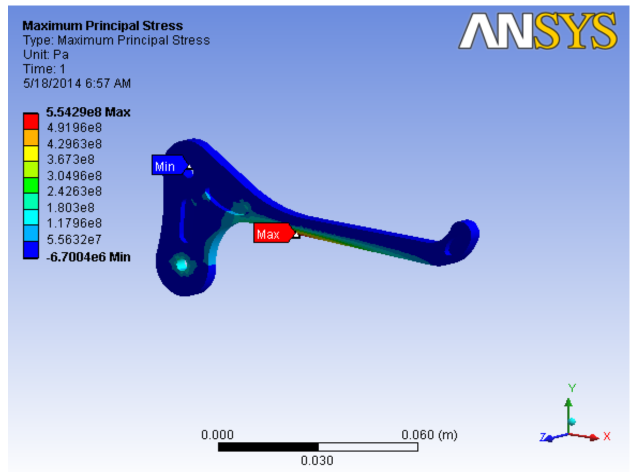
I. For structural steel material

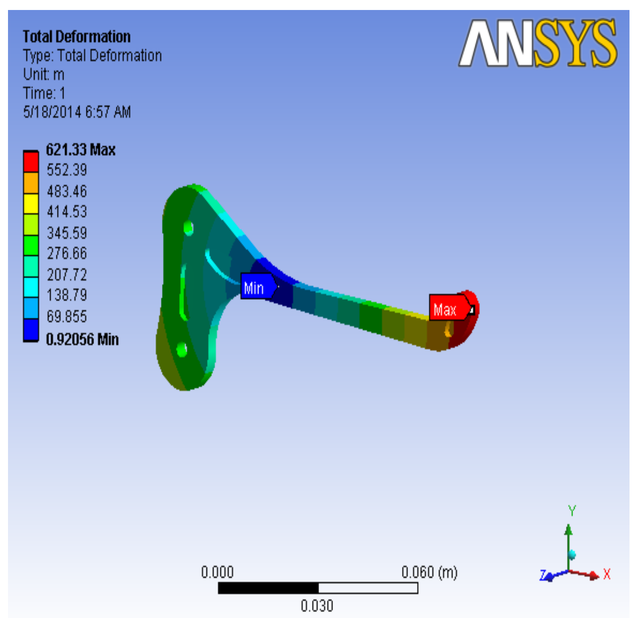


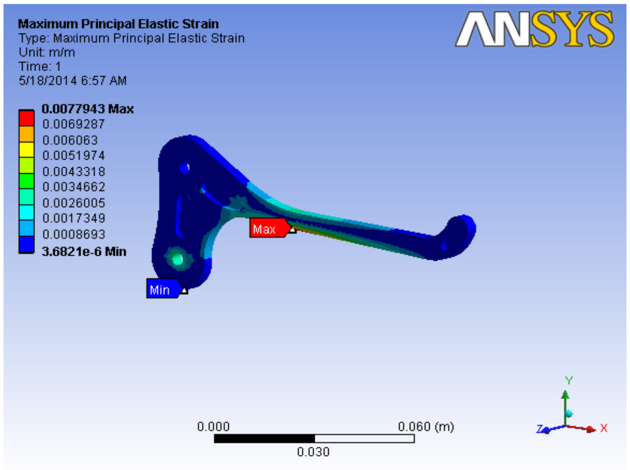




II. For aluminum alloy material







C. Comparison of simulation results of brake lever.

In this project, the simulation had been carried out for simple brake lever and modified brake lever with material of structural steel and aluminum alloy for total deformation. The simulation results shows that, simple design of brake lever with thickness of 6mm with structural steel material under fine meshing gives total deformation of 172 m, which is less compared to all other cases.

TABLE 3. Shows the value of maximum principle stress, maximum principle elastic strain and total deformation of simple design of brake lever.

Sl. No.	Force	Pressure	Moment	Material	Meshing	Solution	Minimum	Maximum
1	100 N	20 Pa	20Nm	Structural steel	Fine	Maximum Principal Stress	-6.0281e6 Pa	5.542e8 Pa
						Maximum Principal Elastic Strain	-1.23e-6 m/m	0.00276 m/m
						Total Deformation	0.3267 m	220.57m
2	100 N	20 Pa	20 Nm	Aluminum alloy	Fine	Maximum Principal Stress	-6.670e6 Pa	5.542e8 Pa
						Maximum Principal Elastic Strain	3.682e-6 m/m	0.007794 m/m
						Total Deformation	3.682e-6 m/m	0.7794

TABLE 4. Shows the value of maximum principle stress, maximum principle elastic strain and total deformation of modified design of brake lever.

Sl. No.	Force	Pressure	Moment	Material	Meshing	Solution	Minimum	Maximum
1	100 N	20 Pa	20Nm	Structural steel	Fine	Maximum Principal Stress	-9.76e-6 Pa	4.40e8 Pa
						Maximum Principal Elastic Strain	-2.66e-8 m/m	0.0021967 m/m
						Total Deformation	1.2837 m	172.0 m
2	100 N	20 Pa	20 Nm	Aluminuim alloy	Fine	Maximum Principal Stress	-9.947e6 Pa	4.406e8 Pa
						Maximum Principal Elastic Strain	-8.702e-8 m/m	0.006189 m/m
						Total Deformation	2.8943 m	379.99 m

IV. CONCLUSION

Brake lever is the predominant component of the bike, so need to analyze the static structural behavior. In this regards, modeled two designs of brake lever in Catia V5 and carried out simulation in Ansys workbench for total deformation considering two materials like structural steel and aluminum alloy. Simple brake lever with thickness of 6mm, structural steel material under fine meshing gives the less deformation of about 172m, which is much lower compared to other designs. So, simple design of brake lever is considered as feasible for bike.

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