Modelling and Analysis of Double Sided Monoshock Swingarm

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Abstract

A swing arm, or "swinging arm", originally known as a swing fork or pivoted fork, is the main component of the rear suspension of most modern Motorcycles and ATV's. It is used to hold the rear axle firmly, while pivoting vertically, to allow the suspension to absorb bumps in the road. The purpose of this project is to do modelling of an existing swingarm and then modify it to make it robust then before design. To make it happen, we will do static Analysis to the redesigned swingarm and apply different materials to it and then compare the results and take the best output. This work is based on the analysis of a existing double-sided mono-shock swing arm with different materials in analysis software i.e. ANSYS 17.0. An existing swing arm will be modelled in a CAD software i.e. SOLIDWORKS2017. Analysis of this modified swing arm will be carried by using different materials such as mild-steel, Aluminium and carbon fibres. Then stresses, deflections, fatigue life, factor of safety and weights of the swingarm with that materials will be found.

1.Introduction

Nowadays, Motorcycles are the basic means of transport for common people. Mainly in these recent centuries, in the place I.C engine vehicles, electric vehicles are coming. Although recent days electric vehicles are used a little bit, there development is at a slow pace. A large number of motorcycles are manufactured every day both electric and I.C engine Motor vehicles. The design should be robust in order to increase their life and to avoid accidents. So, every part of the vehicle should be designed carefully. So, in motorcycle, a vital and most important part is swingarm. A swingarm, or "swinging arm", originally known as a swing fork or pivoted fork, is the main component of the rear suspension of most modern Motorcycles and ATV's. Swing arm will support the rare wheel and is attached to the frame of a motorcycle. The suspension at the rear side of a motorcycle is attached to swing arm. The forces like cornering forces while taking a turn, half weight of the bike, rider weight, vibrations, impact loads at bumps will be taken by the swing arm. There are many types of swingarms which will be used based on the type of application. In this work we are using double sided monoshock swingarm in which, it can accommodate a monoshock suspension.

2.Literature Review

Vidyadhar Sudarshan Dixit Shailesh S Pimpale [1] All machines, vehicles and buildings are subjected to dynamic forces which cause vibration. These vibrations cause noises and stresses in any structure or any part. Due to these vibrations fatigue takes place, which will decrease the life of the any part. So they done vibrational analysis of swingarm.

B Smitha, F Kienhöfer, university of Witwatersrand [2] The stiffness of a motorcycle swingarm plays a critical role in the response and stability of the motorcycle: the response time during cornering and the motorcycle weave mode stability are affected. It is important therefore to determine the swingarm stiffness characteristics that would give the designer insight into how the motorcycle might respond.

Eskinder Girma [3] this paper work is on motorcycle body optimization, how to carry a greater number of passengers with comfort and safety. The ordinary motorcycle has only one driver seat and passenger seat: and specified as one rear wheel and twins shock absorber.

Ashish Powar*, Hrishikesh Joshi, Sanket Khuley and D.P. Yesane [4] this article is based on optimization of a motorcycle swing arm. The modification process is based on material, topological modification and validation using finite element analysis. The results obtained from modified analysis are compared with the evaluation of the original component. The goal of the experiment is to reduce the mass of the component without compromising the other relevant factors.

P. Saritha, A. Satyadevi, P. Ravikanth Raju [5] In this work, fatigue's life of AL7075 and pure Aluminum has been tested under high cyclic loads on fatigue assessment device. Analysis software ANSYS has been used to analyze fatigue's life of different series of Aluminum specimens. The obtained experimental results compared with ANSYS results and conclusions made from them.

Swathikrishnan S, Pranav Singanapalli, A S Prakash [6] Study deals with the development of a structurally safe, lightweight swingarm for a prototype performance geared electric motorcycle. Goal of the study is to improve the existing swingarm design and overcome its shortcomings. The primary aim is to improve the stiffness and strength of the swingarm, especially under extreme riding conditions. Secondary aim is to reduce the overall weight of the swingarm, without sacrificing much on the performance parameters.

3.Materials

There are a wide variety of materials in this world and these materials will have different grades. Among most of the material steels will be used mostly. In steels there are different grades. Among those, we are using AISI 1020 steels as one of our materials. Even it has more weight it is cheap for the commoners to buy a motorcycle with swingarm made of these steels. Its mechanical properties are:

Table 1. Mechanical Properties of AISI 1020

S No.	Properties	Values
1	Density	7.87 g/cc
2	Youngs modulus	205 GPa
3	Poisson's ratio	0.33
4	Ultimate tensile strength	460 MPa
5	Ultimate yield strength	294 Mpa

Another material we are using is aluminium alloy. A pure aluminium is little bit smooth and won't withstand heavy loads. So, impurities are added to make increase its strength. Among Aluminium alloys we are using aluminium 7050 grade. We selected this material because, it has good strength, less weight and mostly used in automobile frames and aerospace applications. Mechanical properties if AL7075.

Table 2. Mechanical Properties of AL7075

S No	Properties	Values
1	Density	2.81 g/cc
2	Youngs Modulus	71.7 GPa
3	Poisson's ratio	0.33
4	Ultimate tensile strength	572
5	Ultimate yield strength	503

By using the above materials, we are doing analysis on the swingarm.

4. Design Calculations

4.1 Design

Considering one person is sitting on the bike. Total dead is 320 kg. In most two-wheelers, the distribution of weight on rear axle is 58% to 65%. For the model selected, the weight distribution is taken to be 60%on rear axle. Thus, net load on swing arm can be calculated as,

Ls=[Ms+Mp]x0.6(1) = [250+70]x0. The Weight of the motorcycle is 300kg.Considering average weight of person is 70 kg 6=192 Kg.

This 192 Kg which will be distributed equally on the one side of beams. The load will be acting at an angle of about 50° at which damper is mounted. Thus, the loads are separated into vertical and horizontal components.

Vertical load, $L_{vs}=L_s \sin \theta_s$ =192x9.81xSin 50°=1444N.

horizontal load $L_{vh}=L_s \cos \theta_s$=192x9.81xCos 50°=1211N.

Longitudinal force acting on Swingarm,

The maximum acceleration of the motorcycle is found to be =5 m/s^2.

Also, total mass m_T=320 kg. Hence longitudinal force acting on the swing arm can be found as

$F_L= m_T \times a$= 320 x 5=1600 N.

4.2 Cornering Condition

Cornering is one of the important criteria in design on motorcycle components. During cornering, different components are subjected to variation in loads in magnitude as well as direction. In case of swing arm, high lateral forces act in unbalanced state. The magnitude of variation depends upon the angle of inclination and the vehicle speed.

Loads and boundary conditions- It is assumed that 20% more load are transferred to the inner side during cornering. Thus, the inner side beam will have 70% of the total weight and remaining 30% on the outer side beam. if we consider a maximum cornering angle of 40° and divide the forces into vertical and horizontal components.

There will be torsional and lateral imbalance on the middle part

So, 70% of weight,

Fmax= 0.7 x m x g = 0.7 x 320 x 9.81=2198N

And remaining 30%

Fmin= 0.3 x m x g =0.3 x 320 x 9.81=942N

Horizontal components (acting as lateral imbalance):

FiH= FmaxCosθ= 2198 x Cos40°=1648N

FoH= FminCosθ=942 x Cos40°=722N

Vertical components (acting as torsional imbalance):

FiV= FmaxSinθ=2198 x Sin40°=1413N

FoV= FminSinθ=942 x Sin40°=606N.

5. Modelling and Analysis of the Swingarm

In this project we considered an existing conventional 150 cc Motorcycle Swingarm. We modelled it and then we perform analysis with different materials. We made a model of the swingarm using SOLIDWORKS 2017. The final model of the swingarm that was modified is in Fig 3.

Fig. 1 Model of the Swingarm.

5.1 Analysis

The forces that were considered before performing analysis are:

- Force acting on the suspension slot.
- Pressure acting at the rear axle while moving forward.
- Cornering forces while taking a right turn.

Analysis of the swingarm is carried in the analysis software i.e. ANSYS 17.0.

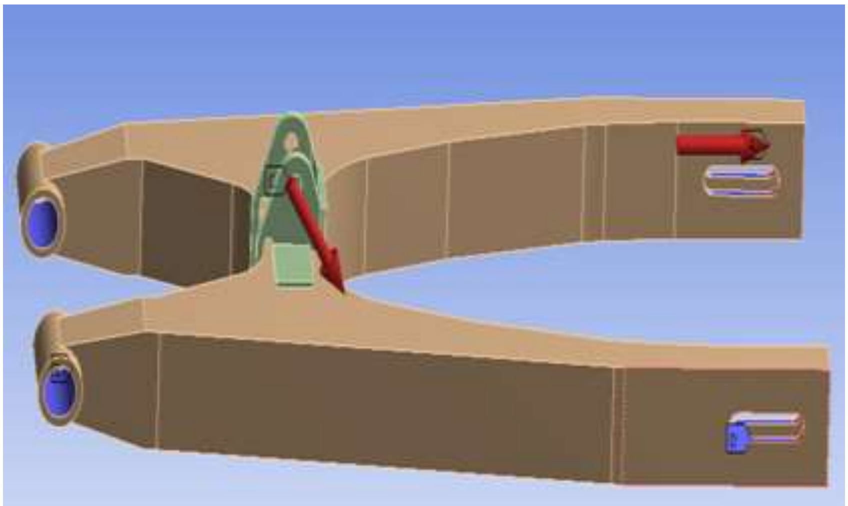

Fig 2. Forces That Were Acting On the Swingarm

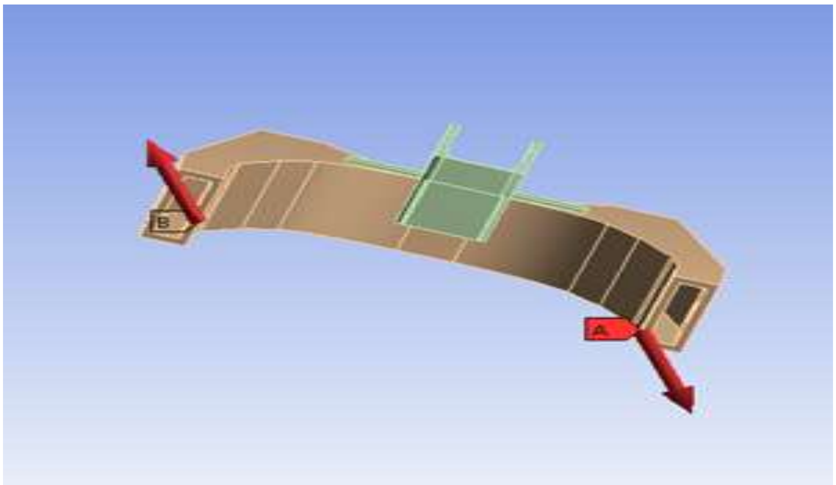

Fig 3. Cornering Forces Acting On the Swingarm.

Fig 4. Meshing of Swingarm

6. Results

6.1 Analysis results with AISI 1020

In this we are testing this swingarm for fatigue strength. For that we are using fatigue tool. In this tool, it gives the result of life and factor of safety of the swingarm. The results of the fatigue life will be given by the software with some data as the input. The input is nothing but the values of the S-N curve of the particular material. The data of AISI 1020 is

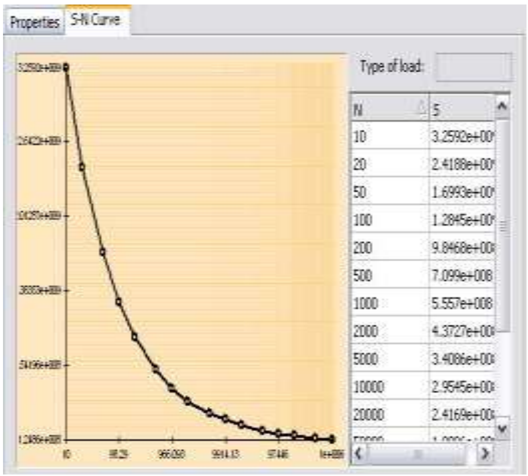

Fig 5. S-N curve of AISI 1020

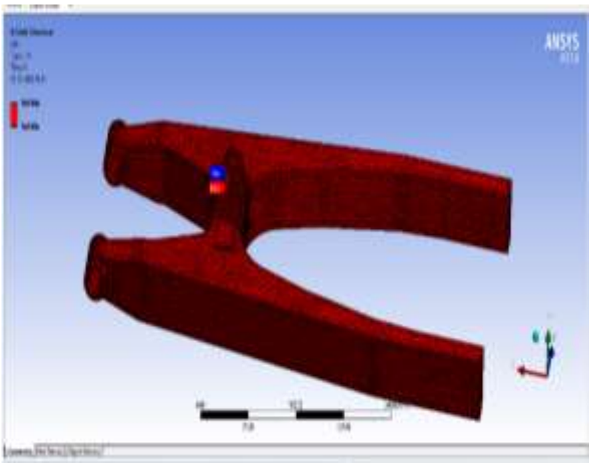

Fig 6. Life of The Swingarm with AISI 1020 As Material

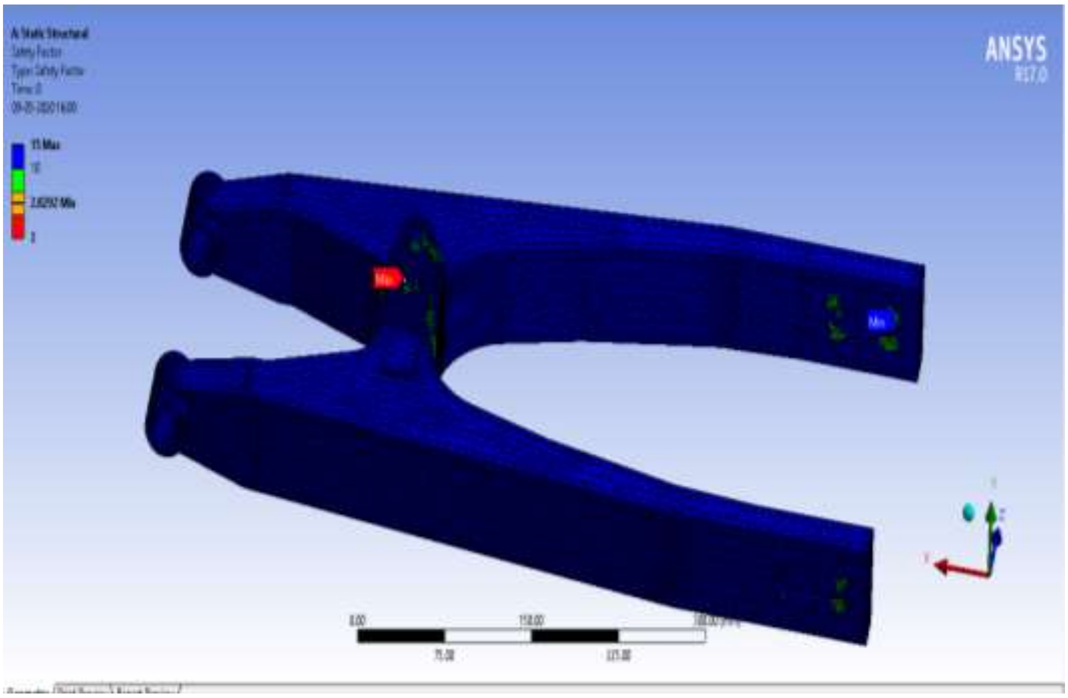

Fig 7. Factor Of Safety of the Swingarm With AISI 1020 As Material

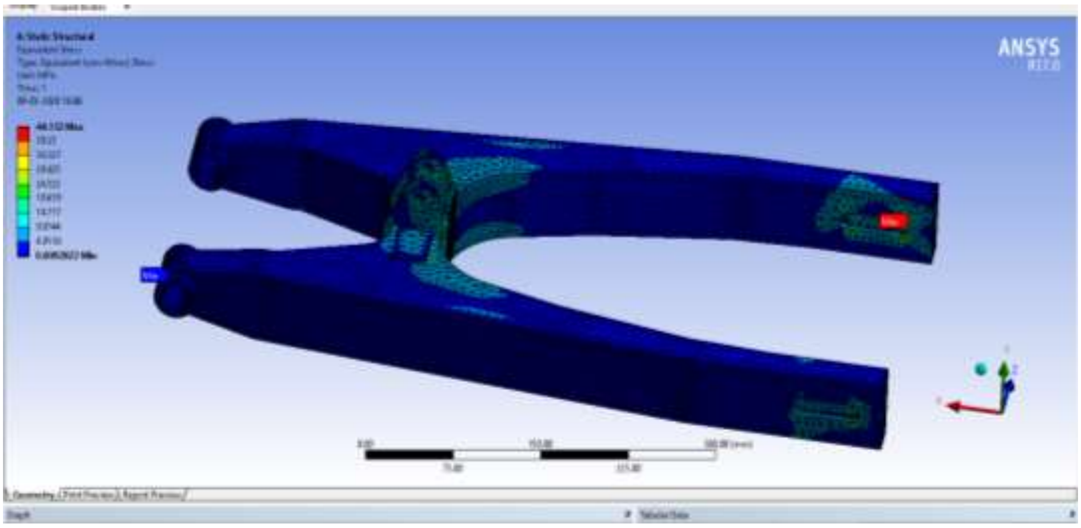

Fig 8. Stresses Developed In Swingarm With AISI 1020 As Material

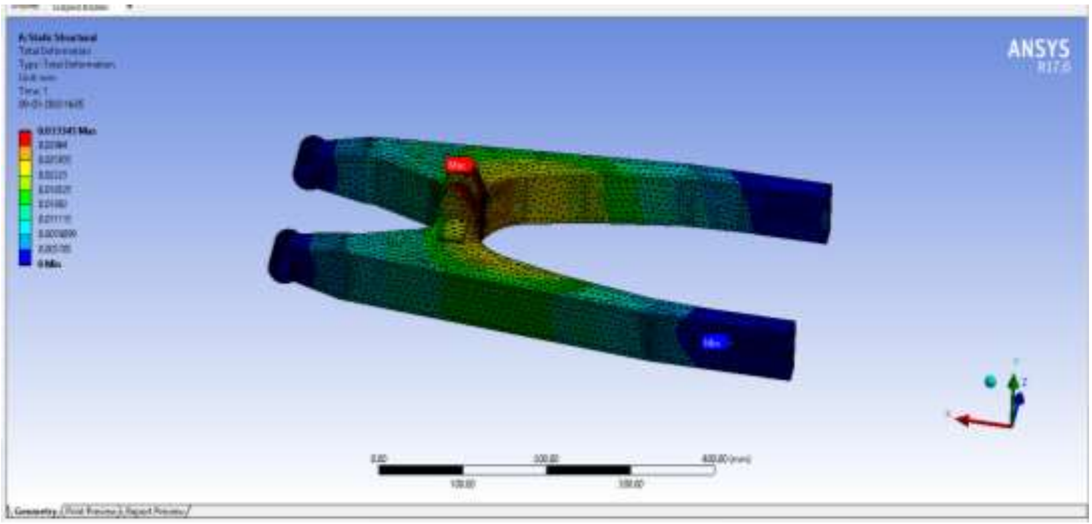

Fig 9. Deformation Of The Swingarm With AISI 1020 As Material

6.2 Analysis results with AL7075

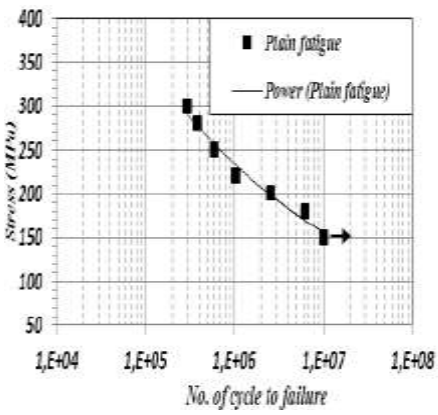

Fig 10. S-N curve for AL7075

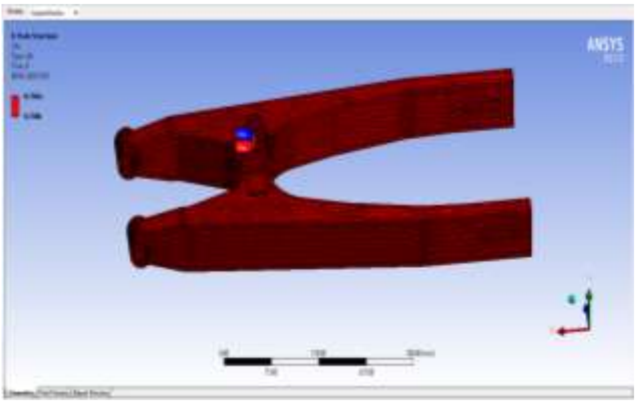

Fig 11. Life of the Swingarm with AL7075as material

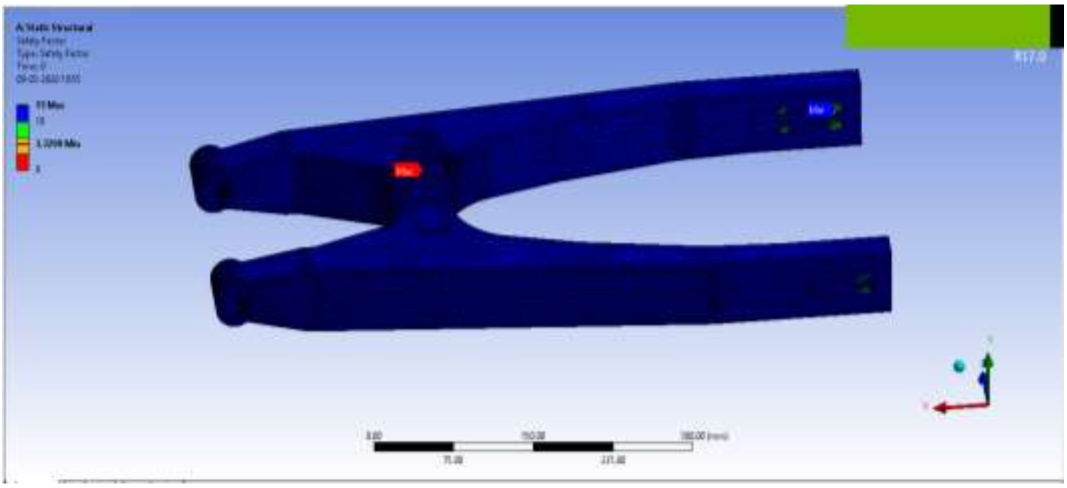

Fig 12. Factor of Safety of The Swingarm With AL7075 As Material

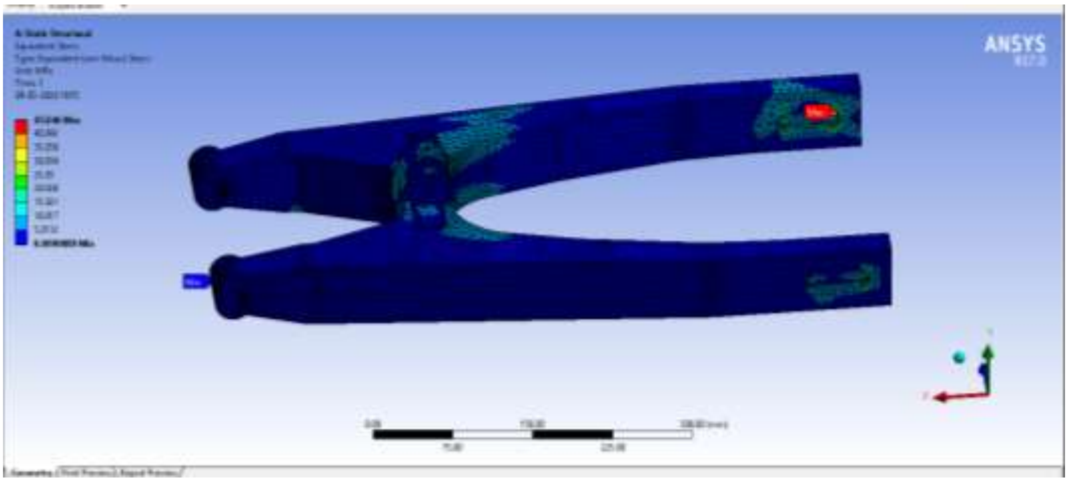

Fig 13. Stresses Developed In Swingarm With AL7075 As Material

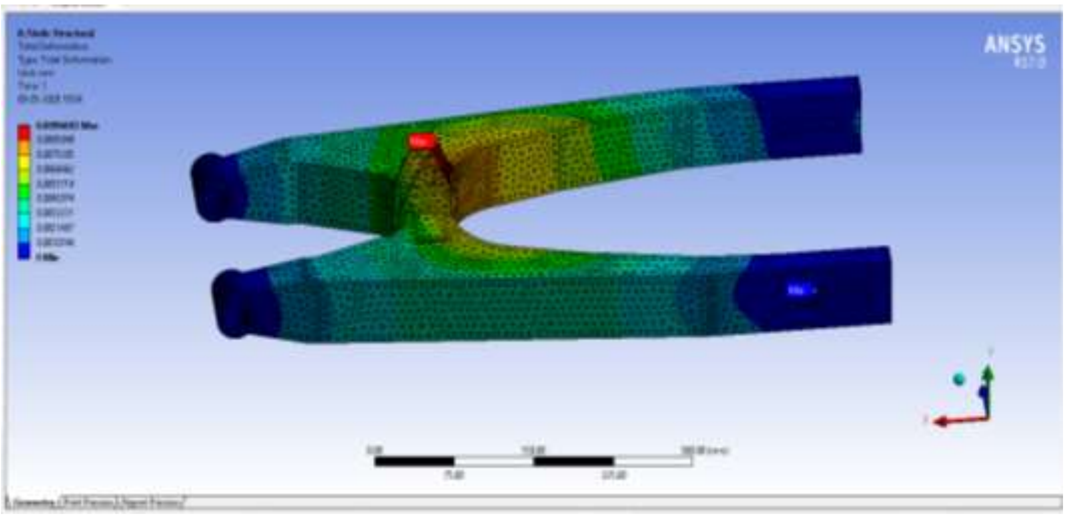

Fig 14. Deformation of Swingarm With AL7075 As Material

Table 3. Comparing the Results of the Different Materials

S. No	Material	Deformation (mm)	Stress (MPa)	Life (No of cycles)	Factor of safety	Weight (kg)
1	AISI 1020	0.033345	44.132	1E6	2.829	9.79816
2	Al7075	0.0096692	45.046	1E7	3.329	3.5068

7. Conclusions

The objective of the work is to study the behaviour of the swingarm which is a part of the motor bike under static and fatigue load conditions. For this Analysis, two different materials are carried out which include AISI 1020 and AL7075 and following conclusions are drawn. The Modelling was done in SOLIDWORKS 2017 and analysis in ANSYS 17.0. It is observed that AL7075 is the best material of construction for swingarm from both static and fatigue load conditions. The stresses developed for both AISI 1020 and AL7075 is nearly same i.e. 44.132 MPa and 45.046 MPa. The factor of safety that should be taken for AISI 1020 is less i.e. 2.829 where for AL7075 3.329 is taken which is more compared to AISI 1020 swingarm. The deformation is also low in the swingarm with AL7075 material i.e. 0.0096692 mm compared to AISI 1020 i.e. 0.33345 mm. The weight is also less for the swingarm with Al7075 i.e. 3.506 kg when compared to AISI 1020 i.e. 9.7981 kg. Taking, the results of analysis into perspective, it can be finally concluded that Al7075 is the optimum suitable material with low deflection, stress, weight and high life and factor of safety to use as a material for swingarm.

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