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Lifecycle prediction analysis of optimized triple clamp

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Abstract

In this study, unlike conventional material such as cast iron and steel that are widely used in two wheelers, we are using lightweight materials such as aluminum alloy is used to achieve the weight reduction and reduce the fuel consumption of optimized design vehicles. The suspension parts operate under heavy load conditions so strength and fatigue analyses of the optimized aluminum triple clamp was accomplished by CAE (computer aided engineering) method with using Hypermesh and Ansys software. The boundary load conditions are derived by using mathematical representation. Iterative model Theory was used for optimization and estimation life of aluminum triple clamp part. It is aimed that the optimized bracket part should be at least 15% lighter and similar life span of the conventional steel or cast iron. In the result of study, it is concluded that reducing weight can be achieved and also beneficial in meeting the life cycle requirement. In this, we are going to model a triple clamp bracket in CATIA. Dimensions will be found out through reverse engineering (hand calculation on actual model). Design constraints are listed based on actual working conditions. Further, meshing and analysis is done on HYPERMESH and ANSYS. Optimization is carried out and part is fabricated based on optimum results. Design is tested and results are verified with available data for strength of design.

Keywords: Triple clamp, Aluminum Alloy 6061, FEA analysis, UTM

1. INTRODUCTION

The force on the front suspension system is sustained by part called triple clamp which is divided into two units upper triple clamp and lower triple clamp, in this study we are tacking upper triple clamp in consideration [1]. This system requires high structural capabilities of strength and stiffness to meet by increasing the size and weight of the triple clamp. A heavy bike is always difficult to maneuver and less efficient. Making the bikes lighter is always a challenge in motorsport [6]. Triple clamp connects the chassis to the front forks. The triple clamp has an upper clamp, a lower clamp and a stem connecting the two. The lower clamp is closer to the front tire and majorly for alignment and stability while the upper clamp bears the maximum load in different scenario of forces acting on the front tire like the braking force and the bump reaction from the road [6]. An optimized designed triple clamp of a two-wheeler is that fulfills the stiffness and strength requirement when compared to an existing steel triple clamp. we are considering longitudinal direction (a line connecting the two fork holes) forces as maximum load is transferred in this condition and part is more subjected to failure under such conditions.

Fatigue is an important analysis in determining the behavior of mechanical parts operating under constant or variable loads. Fatigue strength of a structural part is influenced by mechanical, metallurgical and environmental variables. It is observed that for almost 90% the fatigue is the main cause of engineering damage [7].

2. OBJECTIVES

The main objective in this project is to propose an optimized design of upper triple clamp which will have better strength, stiffness and reduced weight and increased fatigue life cycle. The main aim of this study is to reduce the weight of a part under dynamic loads without compromising the strength of the part and thus achieving the expected life expectancy.

In order to achieve such result, the study shows the methodology and the design consideration to be taken to get the optimized solution and post which validation by experimentation to cross verify our computer simulated data results

3. MATHEMATICAL CALCULATIONS

Specifications of Model Taken- Bajaj Avenger Street 160

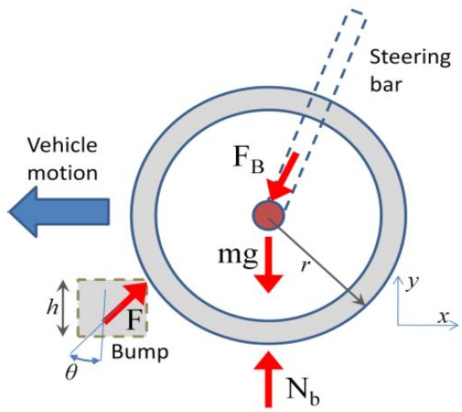

Figure 1 Bump force, weight and Normal reaction from road

Total weight of the Bike = 156 kg = 1529 N
Rider and pillion weight considered 70kg each Hence 140 kg = 1372 N
Total load acting = Bike kerb load + rider pillion load = 1529 N + 1372 N = 2901 N
This weight must be divided into front axle weight and rear axle weight.
Assumption based on bike geometry 50% of total weight is taken by front axle and 50% of total weight is taken by rear axle.
Front axle reaction = Nf = 50 % of total weight = 1450.5 N
The bump height is half the wheel radius; h = 100 mm. (assumption)
r = 675mm as 17inch rim size
v = 40 kmph

$$\theta = \frac{\pi}{2} - \sin^{-1}\left(\frac{r-h}{r}\right)$$

$$F_y = 1 + v\cos\left(\frac{\pi}{2} - \theta\right)$$

$$F_x = F_y \tan(\theta)$$

Ø = 31.5 °
Fy = 21.88 N
Fx = 12.9 N

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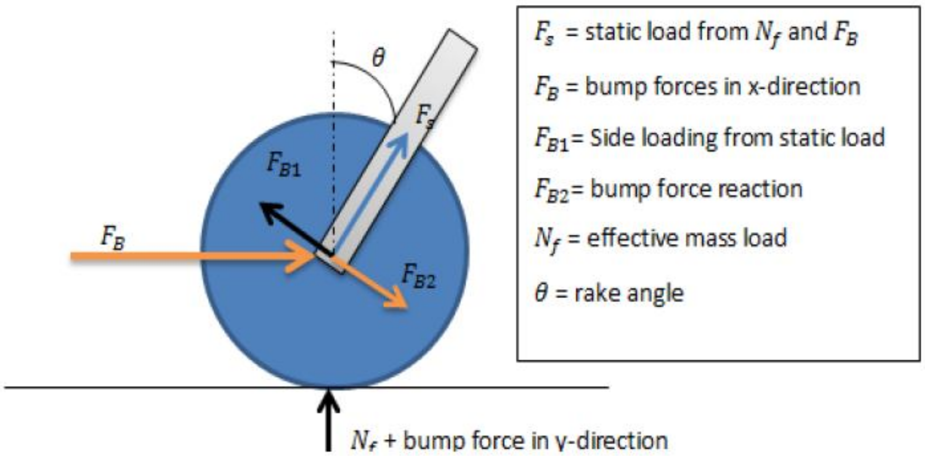

Figure 2 Resolved forces on front wheel

θ = rack angle = 32 º
FB = Fx = 12.9 N
Fs= (Nf + Fy Cos θ) + (FB Sin θ)
= (1450.5 N + 21.88 N Cos 20 º) + (12.9 N Sin 20 º)
= 1475.5 N

As two forks fitted on each side of the clamp bracket hence dividing the force in equal proportion on eat fitment force acting on each fork = 738 N

4. EXPERIMENTAL VALIDATION

4.1 Fabrication is done in following steps

Aluminum 6061 is selected for fabrication. Profile is cut by the help of laser cutting machine. As per drawing the machining is done on milling machine to obtain desired thickness, and drilling as required.

4.2 Testing setup:

Test specimen is fixed on Universal Tensile Machine. Fixture has been designed in such a way to carry out 3 point bending load test with total force of 1476 N to be applied on the middle of the clamp and other two junction points are fixed.

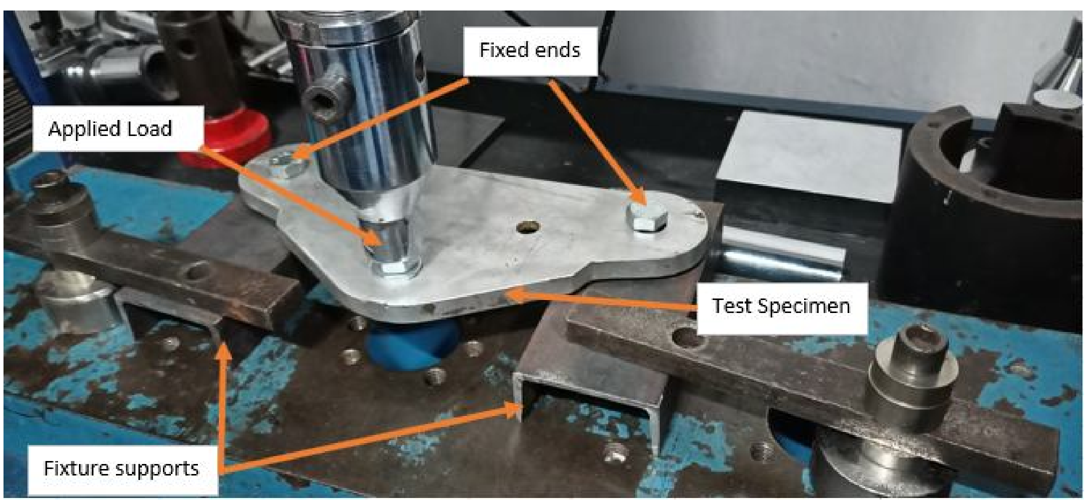

Figure 3 Experimental setup in UTM

4.3 Test Results

Deformation found at 1780 N load is 0.74 mm

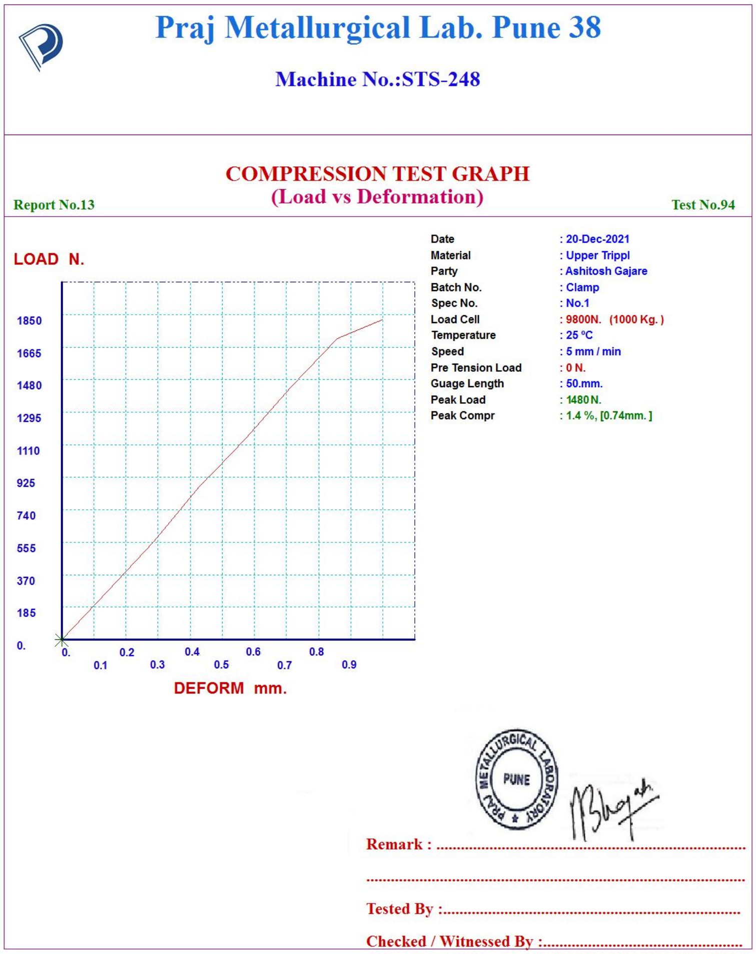

Figure 4 load vs deformation graph

5. FINITE ELEMENT ANALYSIS

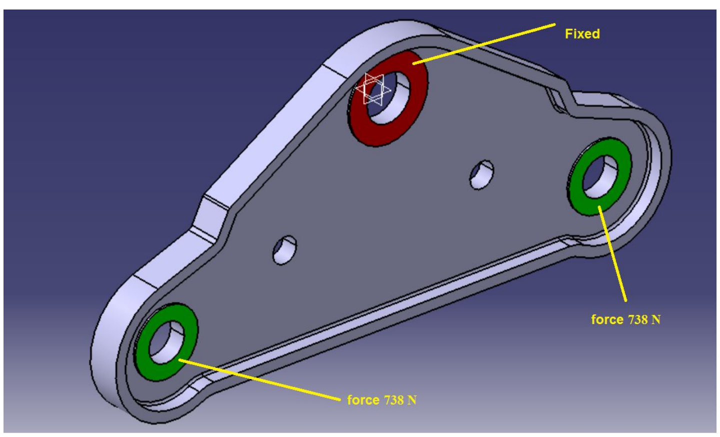

Figure 5 FEA analysis - Boundary conditions and applied load

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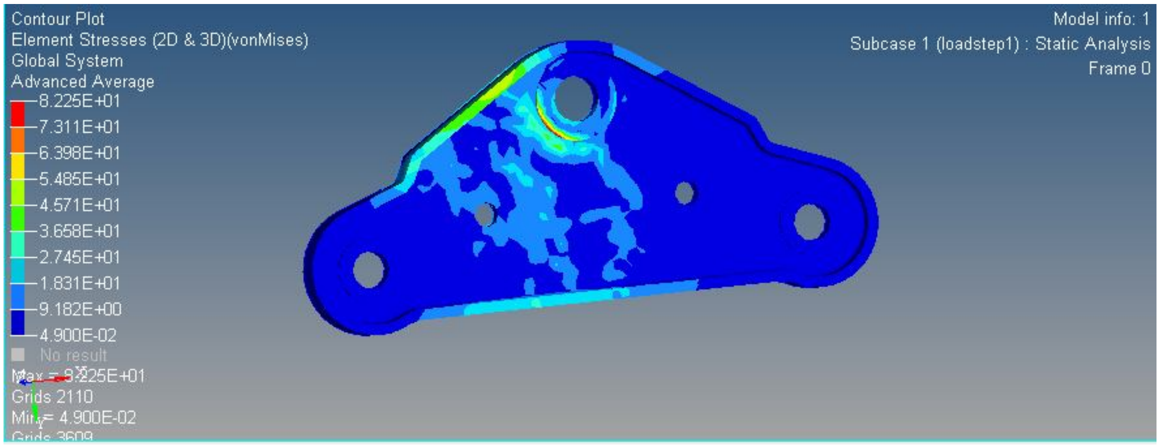

Figure 6 FEA analysis - Von mises stress for 8 mm Aluminum clamp Bracket

Von mises stress produced in Aluminum clamp bracket is 82.25 MPa. As stress produced in bracket is less, which is lower than its yield stress. Hence design is safe.

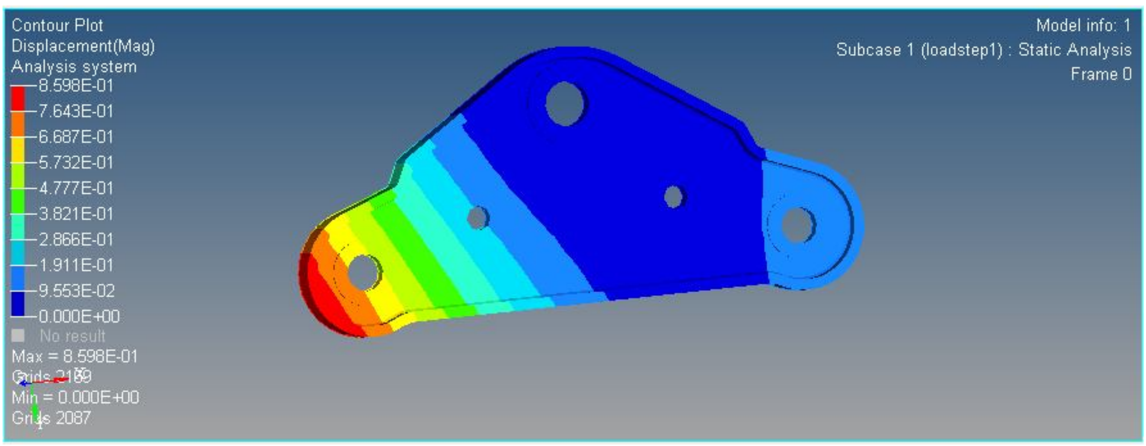

Figure 7 FEA analysis - Deformation produced for 8 mm Aluminum clamp Bracket

Deformation produced in clamp bracket is 0.85 mm

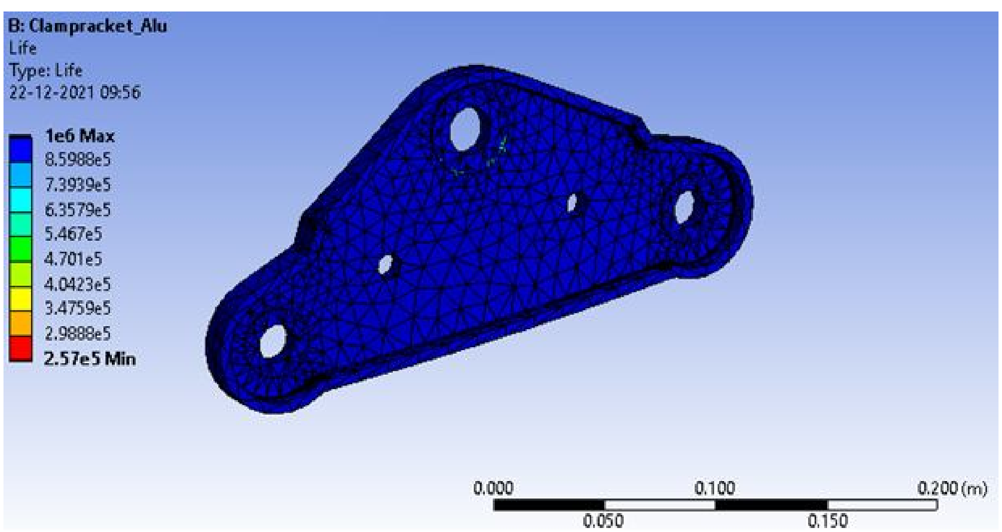

Figure 8 FEA analysis – Fatigue Life Cycle of Aluminum Clamp Bracket with thickness of 8mm

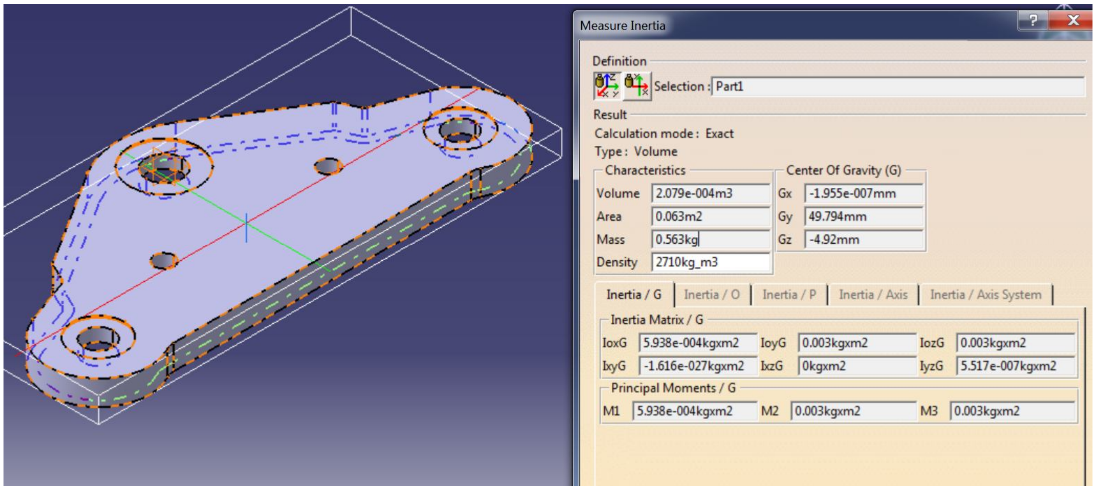

Figure 7 FEA analysis – Optimized weight of 8 mm Aluminum clamp

5.1 Tables

Table 1: Actual Test deformation vs FEA deformation

UTM Test result deformation	0.74 mm
FEA deformation	0.85 mm

As the difference 0.85-0.74 = 0.11 mm which is approximately 11% variation in the results.

6. Conclusion

As per test results of deformation from UTM as well as FEA analysis for Aluminum specimen of thickness of 8mm & weight of 0.563 kg, the results of this iteration are safe and under yield point. The triple clamp that is currently used in Avenger bike is made up of Steel and has weight of 1.16kg which is much higher than analyzed aluminum part. Hence, the expected results of weight optimization are achieved by 46% of weight reduction and expected lifecycle is achieved by even better life span under static and dynamic loading conditions. As looking into life cycle prediction analysis, model has a life cycle of 10 lakh and the existing cycles are 3 lakhs, which is much higher than existing, and as a thumb rule if the system withstands 1 lakh cycle it can be considered as infinite cycle. Hence, we conclude that selected model as our final optimized design and validated with tested results which can give us limited deformation and infinite life cycle of 10 lakh under peak loading conditions.

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