

DESIGN AND ANALYSIS OF MOUNTAIN BIKE FRAME

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Abstract—The bicycle frame is the main structure in a cycle to support the external loads acting on it. Presently steel or aluminium alloy are used in cycles. For the purpose of reducing weight Kevlar, glass fibre and carbon & epoxy composite materials are used to make the bicycle frames nowadays. In this project the bicycle frame material is replaced with magnesium alloy (AZ91D) and perform the analysis such as FEM, structural, static analysis, dynamic analysis and report the deformation under different loading conditions. And ensure the implementation of modified mountain bike frame with magnesium AZ91D alloy. The bicycle frame is designed by using CREO PARAMETRIC 3.0 and the analysis of the bicycle frame is done by using ANSYS software tool.

Keywords—Analysis, ANSYS, mountain bike frame, Mg alloy, AZ91D

I. INTRODUCTION

A mountain bike or mountain bicycle is a bicycle designed for off-road cycling. Mountain bikes share similarities with other bikes, but incorporate features designed to enhance durability and performance in rough terrain. These typically include a front or full suspension, large knobby tires, more durable wheels, more powerful brakes, and lower gear ratios for climbing steep grades. Mountain bikes are typically ridden on mountain trails, single track, and other unpaved surfaces. Mountain bikes are built to handle these types of terrain and features. The heavy-duty construction combined with stronger rims and wider tires has also made this style of bicycle. The frame of the bicycle is the main structure to support the external loads acting on it. Traditional materials of the mountain bicycle frame are steel or aluminium alloy. For the purpose of reducing weight, the carbon/epoxy composite materials, Kevlar, carbon fiber materials are now widely used to make the bicycle frames. The structural analysis of the frame is a very important stage in the design process of the bicycle. Finite element method was adopted to analyze the structural behaviors of mountain bicycle frame. Mountain bicycle frame modeling was done in CREO 3.0 software. The element analysis of the frame was done using ANSYS 15 software. Shell element is used to model the mountain bicycle frame. The bicycle frame consists of tubular structures made of AZ91D material. The diameter of the tubular section in the

frame of the mountain bike is 30mm with thickness of 2mm is used in the design. Two testing methods for the bicycle

frame, i.e. frontal and vertical loads are adopted in the analysis. From the finite element analysis results, weak regions, i.e. regions with higher stress concentration are identified on the bicycle frame. In order to reduce this stress concentration, structural changes are done on the frame work.

II. METHODOLOGY

A. PROJECT DESCRIPTION : The mountain bike traditional material is replaced with the advanced composite materials to increase the strength and reduce the cost. The replacement of the material used for manufacturing bicycle frames with magnesium alloy and perform the strength, FEM, structural analysis, analysis, static analysis, dynamic analysis and report the variations under different loading conditions.

B. MATERIAL SELECTION : Material having high tensile and compressive strength, having high corrosive resistance, low cost are the material properties to be required for this frame. Magnesium alloy, Aluminium alloy (low cost), carbon-Kevlar (high cost) materials are selected for this process. Advanced composites having relatively high strength, high corrosive resistance and low cost, various mixtures usually consists of resin matrix, epoxy, polycyanate, vinyl ester, Kevlar and carbon fiber, MATERIAL FINALIZATION: AZ91DMg alloy)

C. DESIGN : The mountain bike is designing in the CREO 3.0 and the parts are design separately and the model is assembled and render in the separate file. The single and collective drawings of the mountain bike are made out by using the CREO 3.0

D. Mesh & Loading : Mesh generation is the practice of generating a polygonal or polyhedral mesh that approximates a geometric domain. The various mesh types are tetrahedra, pyramids, prisms, polyhedra. We use hexahedra (prism) for this bike structural analysis. There are various loads acting in the various parts of bicycle frame load acting in the bicycle frame is added and the constraints are given.

E. Analysis: FEM, Structural analysis, Static & Dynamic analysis, buckling analysis are the various analysis need to

perform in this frame analysis. All the listed analyses are made in ANSYS platform.

F. Report: All the designs, calculations, drawings, analysis of the structural frame of the mountain bike is compared between the selected materials and the result has been recorded.

Top Tube (TT)	630	30
Head Tube (HT)	260	30
Down Tube (DT)	660	30
Chain stays (CT)	435	30
Seat stays (SS)	510	30
Seat tube (ST)	570	30
Suspension tube	210	40

III. MATERIAL PROPERTIES

TABLE 1; COMPOSITION OF AZ91D:

Aluminum (Al)	8.3%-9.7%
Manganese (Mn)	0.15%-0.5%
Zinc (Zn)	0.35%-1.0%
Silicon (Si)	0.1 % (max)
Copper (Cu)	0.03%(max)
Iron (Fe)	0.005%(max)
Nickel (Ni)	0.002 % (max)
Magnesium (Mg)	90.8%(max)
RoHS complaint	✓

MECHANICAL PROPERTIS OF AZ91D:

Tensile strength = 240MPa
 Yield strength = 160MPa
 Elongation = 3% in 50mm
 Compressive yield strength = 140MPa
 Poisson's ratio (μ) = 0.29
 Elastic modulus, tension = 55GPa
 Elastic modulus, Shear = 17GPa
 Density (ρ) = 1.89/cu.cm @ 20°C
 Melting temperature = 788°C -815°C
 Brinell hardness = 70

IV. DESIGN:

The mountain bike frame modeling was done in CREO3.0 software. The main dimension of the mountain bike consists of many tubes made of AZ91D. The frame is the main component of a bicycle, in which that the wheels and other components are connected. The modern and modest design for an upright bicycle is based on the safety bicycle, and consists of two triangle and a paired rear triangle, this is known as the diamond frame. Frames are required to be strong, stiff and light. The main parts of the mountain bike frame can be divided into top tube, seat tube, front tube, rear tube, suspension.

TABLE 2; MAIN DIMENSIONS OF MOUNTAIN BIKE FRAME:

Part	Length (mm)	Outer Diameter (mm)
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Tube Thickness = 4mm

DIMENSIONS OF SUSPENSION:

Spring type = CYLINDRICAL SUSPENSION
 HELICAL COMPRESSION SPRING
 Coil diameter = 30mm
 Wire diameter = 8mm
 Spring length = 150mm
 Spring material = Carbon Steel 98 C4 (SAE 1095)
 Suspension rod diameter = 20mm
 Length of suspension rod = 125mm
 Bolt length = 50mm
 Nut diameter = 8mm

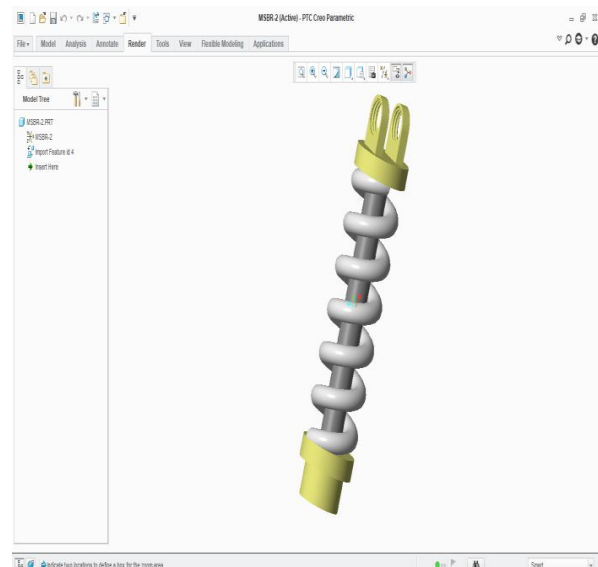


Fig 1

DESIGN OF SUSPENSION

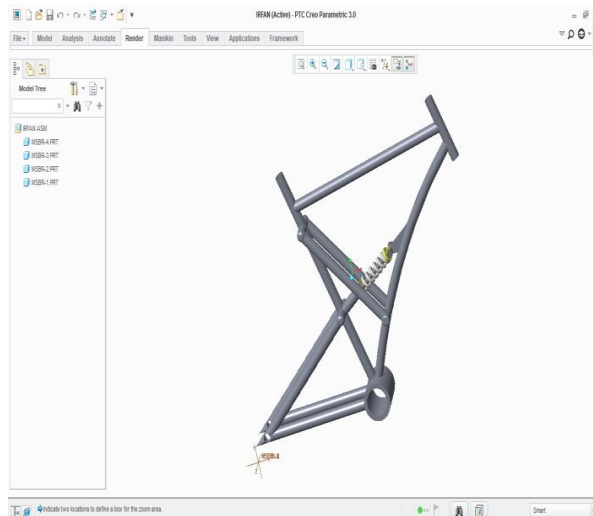


Fig 2

MODIFIED DESIGN OF MOUNTAIN BIKE FRAME

V. LOAD ACTING ON THE FRAME:

There are several loads acting on the mountain bike frame in both off-road and on-road conditions, the load impact is severe and higher in the off-road conditions like mountain, hills, slopes, forest. During the mountain drive there is both horizontal and vertical loads acting on the frame. The total mass of the cyclist acts vertically downwards in the top of seat rod, and the obstacles like speed breakers, rock or even small bumps made a horizontal impact on the frame.

The types of loads were categorized into four load cases and these were: a road bump at the front wheel(LC1), a road bump at the rear wheel(LC2), climbing whilst seated in the saddle(LC3), climbing whilst not seated in the saddle(LC4). Boundary conditions in the form of load and restraints were applied to the various locations around the bicycle (bottom bracket, steering tube, seat post, front and rear axles) using a rigid link which eliminated the need to include superfluous components such as saddle, handlebar, wheels, crank, bearing. Material properties assigned to frame where those of AZ91D ($E = 55\text{GPa}$, $\nu = 0.29$)

VARIOUS LOAD ACTING IN THE FRAME:

- Load at handle bar: $F_x = 400\text{N}$, $F_z = 400\text{N}$
- Load at seat rod : $F_x = 450\text{N}$, $F_z = 750\text{N}$
- Load at spokes joint : $F_x = 150\text{N}$, $F_z = 500\text{N}$, $F_y = 100\text{N}$.

SELECTION OF FRAME SIZE

Standard cyclist height(in cm)= 168 to 185

Standard frame size = "M" (medium)

VI. ANALYSIS:

The analysis is done in ANSYS 18.0, the analysis is the imitation of the operation of practical conditions, the mountain bike frame is subjected to horizontal loading test and vertical loading test. The boundary conditions and loading conditions are entered in the ansys platform. From the Finite element analysis the normal and shear stress of each points under the different loading conditions are obtained



Fig 3

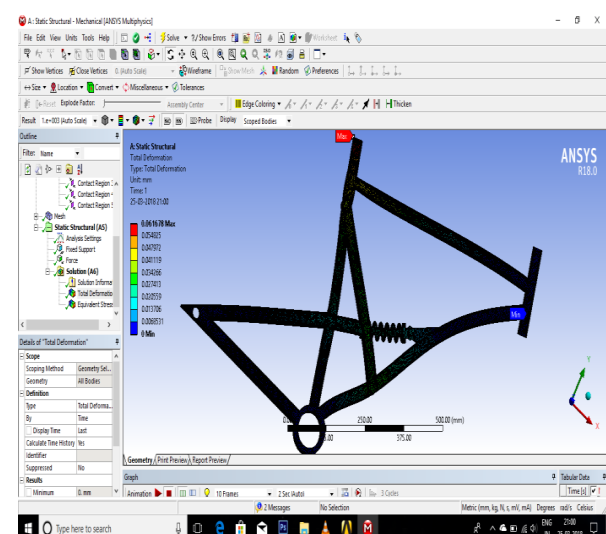


Fig 4

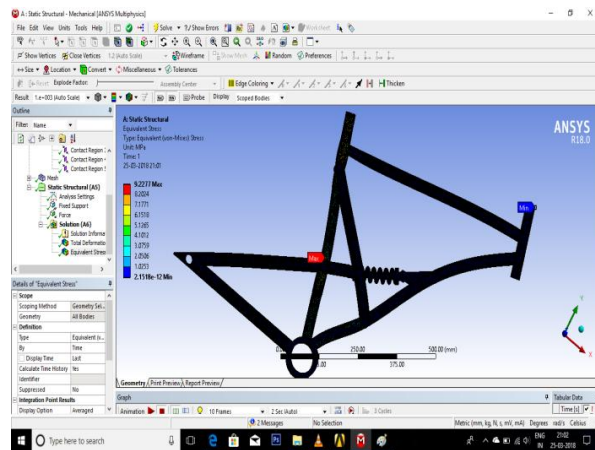


Fig 5

VII. CONCLUSIONS:

A modified mountain bike frame model was created to simulate the behavior of the frame under a range of measured load cases. And the mountain bike frame material is considered as magnesium alloy(AZ91D),and the various analysis are performed under different loading conditions, structural analysis in both static and dynamic conditions are taken, Highly stressed areas correlate reasonably well in terms of being similarly located with those simulations presented in the literature for similar load cases, although our values tend to be somewhat lower than the existing model. This model is suited for off road conditions and best in on road conditions By this model the frame weight is reduced and the other structural properties remains the same. The mountain bike frame in magnesium alloy is designed, and analyses under different parameters and the results are noted, and this shows lesser deformation than the traditional model.

VIII. REFERENCES

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