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MODELLING AND ANALYSIS OF SUSPENSION SYSTEM UNDER MECHANICAL LOADS

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ABSTRACT

Shock absorbers are a critical part of a suspension system, connecting the vehicle to its wheels. The need for dampers arises because of the roll and pitches associated with vehicle maneuvering, and from the roughness of road. This led to make the ride quality for the people very uncomfortable which led to invention and innovation of shock absorbers. Shock absorbers are devices that smooth out an impulse experienced by a vehicle, and appropriately dissipate or absorb the kinetic energy. Shock absorbers have become such an essential component of an automobile.

In this think about, mono suspension and double suspension was considered. And alluminium alloy and stainless steel are the materials which are considered to conclude which type of suspension system gives more comfort to the rider. Comparing the ride quality of mono suspension and double suspension of two-wheeler vehicles to know how they contrast from each other by performing inactive auxiliary examination beneath diverse stacking conditions by planning 3D demonstrate of suspension framework utilizing program like CATIA V5 and ANSYS for performing examination.

INTRODUCTION

Suspension Framework:

A motorcycle's suspension serves a double reason- contributing to the vehicle's taking care of and braking and giving security and consolation by keeping the vehicle's travellers comfortably disconnected from street clamour, bumps and vibrations. Stun safeguard may be a mechanical gadget planned to smooth out or soggy stun drive and disseminate dynamic vitality. In this work, suspension framework is planned and a 3D show is made utilizing

CATIA V5R21. Basic investigation is done on the stun safeguard by shifting distinctive sorts of materials and stacking conditions. Suspension sorts considered in this investigation are mono suspension and twin suspension frameworks. To approve the quality of the show, the auxiliary examination on the plan of suspension frameworks is performed. The investigation is done by considering diverse stacking conditions like bicycle weight, bicycle weight with single, and twofold rider. At long last, comparison is done for distinctive suspension frameworks by shifting diverse materials such as stainless steel, aluminium combination, and magnesium combination. Sorts of suspension frameworks utilized in this extend are Mono suspension and Twin suspension frameworks.

Mono Suspension framework:

Initially, Yamaha created the monoshock suspension to progress the execution of its bicycles in motocross competition. A few producers moreover utilize the term “flying suspension” for monoshock suspension. It provides a incredible bargain of soundness within the hops and arrivals of the bicycle. This suspension plan employments a single (mono) stun safeguard, greater in size. In expansion, it encompasses a more grounded spring fitted on the exterior. The monoshock is more often than not situated close the center of the bike's chassis. Besides, one of its closes connects to the chassis. In any case, the other conclusion to the raise swing- arm of the bicycle which connects to the raise wheel. As the wheel moves up or down, the monoshock safeguard either collapses or amplifies encourage.Thus, this empowers longer stroke for the stun safeguard. Hence, it comes about in longer travel for the raise wheel. Other than, this suspension is found closer to the bike's center. In this way, it makes a difference to make strides dexterity & taking care of of the bicycle.

Twin suspension framework:

Twin stun alludes to bikes that have two stun safeguards. By and large, this term is utilized to indicate a specific time of cruisers and is most regularly utilized when portraying off- street motorcycles. It is the most broadly utilized suspension in two-wheeler vehicle. It exchanges loads similarly to the chassis of the vehicle. There's not any sort of hurt to this suspension on the off chance that we increment load on the vehicle. It is broadly favored within the vehicle which is utilized in unpleasant landscape vehicle. As in unpleasant streets there's ceaselessly changing loads on the vehicle, so its suspension exchanges the load legitimately to induce superior ride consolation. The alteration of this suspension is troublesome. Ready to drive the vehicle in the event that any one of suspension gets oil spilled, harmed, and fizzled whereas driving.

DIMENSIONAL DETAILS:

Mono Suspension:

Spring:

Wire diameter (d)= 11mm

Coil outer diameter (Do)= 46mm

Coil inner diameter (Di)= 26mm

Coil free height (h)= 100mm

No. of active coils (n)= 5

Pitch (P)= 18mm

Base:

Radius= 22.5mm

Shaft radius= 5mm

Shaft length= 75mm

Top part:

Length= 110mm

Diameter=13.5mm

Inner diameter=5mm

Nut:

Outer diameter= 54mm

Inner diameter= 24mm

Twin Suspension:

Spring:

Wire diameter (d)= 7.8mm

Coil outer diameter (Do)= 68mm

Coil inner diameter (Di)= 52mm

Coil free height (h)= 165mm

No. of active coils (n)= 8

Pitch (P)= 19mm

Bottom part:

Radius= 24mm

Height= 94.5mm

Top Bearing:

Base Diameter= 20mm

Bearing diameter= 20mm

Height= 58mm

Shaft diameter= 6.5mm

Length= 200mm

Nut:

Outer diameter= 54mm

Inner diameter= 40mm

Thickness= 10mm

CONSIDERATIONS:

The properties of the below considered materials aluminium alloy and stainless steel are

Aluminium Alloy:

Modulus of rigidity= 27×10^3Mpa

Modulus of elasticity= 70×10^3Mpa

Tensile yield strength= 310Mpa

Compressive yield strength= 310Mpa

Density= 2.7g/cm^3

Stainless steel:

Modulus of rigidity= $77.2x10^3$Mpa

Modulus of elasticity= $210x10^3$Mpa

Tensile yield strength= 505Mpa

Compressive yield strength= 505Mpa

Density= $7.83g/cm^3$

In this project three loading conditions are considered and they are

1. Weight of the bike
2. Weight of the bike with one person
3. Weight of the bike with two people

As we are working on the rear suspension systems of the bike so only 65% of the weight isconsidered and while considering dynamic load multiplication factor 2 is used.

Average weight of bike = 110 kg Average weight of a person = 65 kg

Mono Suspension:

1. Weight of the bike

   65% of the weight of the bike= $110x\frac{65}{100}$= 71.5kg

   W1= (71.5x9.81) x2= 1402N

2. Weight of the bike

   65% of the weight of the bike= (110+65) $x\frac{65}{100}$= 114.1kg

   W2= (114.1x9.81) x2= 2238.6N

3. Weight of the bike

   65% of the weight of the bike= (110+65+65) $x\frac{65}{100}$= 156.7kg

   W3= (156.7x9.81) x2= 3074.4N

Twin Suspension: In this suspension system the load is distributed across two shock absorbers so the actual load will be 50% of the obtained load.

1. Weight of the bike

   65% of the weight of the bike= $110x\frac{65}{100}$= 71.5kg

   W1= (71.5x9.81) $x2x\frac{50}{100}$= 701N

2. Weight of the bike with one person

   65% of the weight of the bike= (110+65) $x\frac{65}{100}$= 114.1kg

   W2= (114.1x9.81) $x2x\frac{50}{100}$= 1119.3N

3. Weight of the bike with two persons

   65% of the weight of the bike= (110+65+65) $x\frac{65}{100}$= 156.7kg

   W3= (156.7x9.81) $x2x\frac{50}{100}$= 1537.2N

CALCULATIONS:

Mono Suspension (Aluminium Alloy)

Mean coil diameter(D)= $\frac{Di+Do}{2}$= 36mm

Spring index (C)= $\frac{D}{d}$ = 3.27

Wahl's stress factor (K)= $\frac{4C-1}{4C+1}+\frac{0.615}{C}$= 1.51

Maximum shear stress (τ) at W1= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*1402*60}{\pi*11^3} = 140.02\ Mpa$

Maximum shear stress (τ) at W2= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*2236.6*60}{\pi*11^3} = 208.97\ Mpa$

Maximum shear stress (τ) at W3= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*3074.4*60}{\pi*11^3} = 286.95\ Mpa$

Factor of safety at W1= $\frac{310}{140.02}$= 2.21

Factor of safety at W2= $\frac{310}{208.97}$= 1.48

Factor of safety at W3= $\frac{310}{286.95}$= 1.08

Mono Suspension (Stainless steel)

Mean coil diameter(D)= $\frac{Di+Do}{2}$= 36mm

Spring index (C)= $\frac{D}{d}$ = 3.27

Wahl's stress factor (K)= $\frac{4C-1}{4C+1}+\frac{0.615}{C}$= 1.51

Maximum shear stress (τ) at W1= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*1402*60}{\pi*11^3} = 143.06\ Mpa$

Maximum shear stress (τ) at W2= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*2236.6*60}{\pi*11^3} = 214.57\ Mpa$

Maximum shear stress (τ) at W3= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*3074.4*60}{\pi*11^3} = 290.74\ Mpa$

Factor of safety at W1= $\frac{505}{143.06}$= 3.59

Factor of safety at W2= $\frac{505}{214.57}$= 2.41

Factor of safety at W3= $\frac{505}{290.74}$= 1.75

Twin Suspension (Aluminium Alloy)

Mean coil diameter(D)= $\frac{Di+Do}{2}$= 60mm

Spring index (C)= $\frac{D}{d}$ = 7.69

Wahl's stress factor (K)= $\frac{4C-1}{4C+1}+\frac{0.615}{C}$= 1.19

Maximum shear stress (τ) at W1= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*701*60}{\pi*7.8^3} = 265.48\ Mpa$

Maximum shear stress (τ) at W2= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*1119.3*60}{\pi*7.8^3} = 423.48\ Mpa$

Maximum shear stress (τ) at W3= $\frac{K8PD}{\pi d^3} = \frac{1.51*8*36*1537.2*60}{\pi*7.8^3} = 581.59\ Mpa$

Factor of safety at W1= $\frac{310}{265.48}$= 1.16

Factor of safety at W2= $\frac{310}{423.48}$= 0.73

Factor of safety at W3= $\frac{310}{581.59}$= 0.53

Twin Suspension (Stainless steel)

Mean coil diameter(D)= $\frac{Di+Do}{2}$= 60mm

Spring index (C)= $\frac{D}{d}$ = 7.69

Wahl's stress factor (K)= $\frac{4C-1}{4C+1}$+$\frac{0.615}{C}$= 1.19

Maximum shear stress (τ) at W1= $\frac{K8PD}{\pi d^3}$ =$\frac{1.51*8*36*682.7*60}{\pi*7.8^3}$ = 268.57 Mpa

Maximum shear stress (τ) at W2= $\frac{K8PD}{\pi d^3}$ =$\frac{1.51*8*36*1044.85*60}{\pi*7.8^3}$ = 428.84 Mpa

Maximum shear stress (τ) at W3= $\frac{K8PD}{\pi d^3}$ =$\frac{1.51*8*36*1434.75*60}{\pi*7.8^3}$ = 588.59 Mpa

Factor of safety at W1= $\frac{505}{268.57}$= 1.84

Factor of safety at W2= $\frac{310}{428.84}$= 1.15

Factor of safety at W3= $\frac{310}{588.59}$= 0.8

MODELLING

Modelling can be drained various methods such as wireframe demonstrating, surface modelling, solid displaying, etc. the most straightforward way is chosen for modelling. Here we have chosen strong displaying strategy of making a strong. There are many packages for displaying, out of which CATIA V5 has been chosen for its ease of accessibility and because it is client neighbourly.

Mono suspension Assembly:

Step 1: Press on Gathering plan module in mechanical plan. Right tap on item and select component and include the existing components into the get together plan.

Step 2: After adding all the components required for mono suspension framework into the get together module, press on the manipulation command and isolated each portion to put it within the redress position.

Step 3: Presently utilize imperatives instrument bar for performing required constraint operations like coincidence, off-set, contact imperative, point limitation etc.

Step 4: After performing all the limitation operations to induce the required get together, at that point at last tap on the overhaul all command to complete the get together plan. Now this assembly plan can be imported to simulation software for performing investigation.

Twin suspension Assembly:

Step 1: Tap on Assembly design module in mechanical plan. Right click on item and select component and add the existing components into the assembly design.

Step 2: After including all the components required for twin suspension system into the gathering module, press on the control command and separate each part to put it in the right position.

Step 3: Presently utilize limitations device bar for performing required imperative operations like coincidence, off-set, contact imperative, point imperative etc.

Step 4: After performing all the imperative operations to induce the required gathering, at that point at long last press on the upgrade all command to total the get together design.

After performing the theoretical calculations on both suspension systems when the suspensions are in compressed position, to support the calculations an analysis using Ansys simulation has been performed on both suspension system. The respective Maximum shear stress and factor of safety were determined and then compared.

The resultant stress obtained through calculations of suspension systems of different materials at different loading conditions are tabulated in the following table.

RESULTS

Maximum shear stress:

Mono suspension:

Type of material	**Load appliedin N**	**Maximum shear stress (theoretical) MPa**	**Maximum shear stress (Ansys Simulation) MPa**
Aluminium alloy			
	W1=1402N	143.06	148.6
	W2=2238.6N	214.57	210.50
	W3=3074.4N	290.74	285.44
Stainless steel			
	W1=1402N	140.02	140.36
	W2=2238.6N	208.97	209.4
	W3=3074.4N	286.74	287.68

Table 6.1 Max. Shear stress (mono)

Twin suspension:

Type of material	**Load appliedin N**	**Maximum shear stress (Theoretical) MPa**	**Maximum shear stress (Ansys Simulation)in MPa**
Aluminium alloy			
	W1=701N	268.57	270.02
	W2=1119.3N	428.84	430.22
	W3=1537.2N	588.59	592.33
Stainless steel			
	W1=701N	265.22	274.35
	W2=1119.3N	423.48	438.06
	W3=1537.2N	581.59	601.61

Table 6.2 Max. Shear stress (twin)

Factor of safety:

Mono suspension:

Type of material	Load applied in N	Factor of safety (Theoretical)	Factor of safety (simulation)
Aluminium alloy			
	W1=1402N	2.213	2.33
	W2=2238.6N	1.48	1.76
	W3=3074.4N	1.08	1.35
Stainless steel			
	W1=1402N	3.59	3.66
	W2=2238.6N	2.41	2.6
	W3=3074.4N	1.75	1.88

Table 6.3 Factor of safety (mono)

Twin suspension:

Type of material	Load applied in N	Factor of safety (Theoretical)	Factor of safety (Simulation)
Aluminium alloy			
	W1=701N	1.16	1.3
	W2=1119.3N	0.73	1.12
	W3=1537.2N	0.53	0.98
Stainless steel			
	W1=701N	1.84	2.07
	W2=1119.3N	1.15	1.53
	W3=1537.2N	0.83	1.12

Table 6.4 Factor of safety (twin)

Total deformation:

Mono Suspension:

Type of material	Total Deformation in mm		
	W1 = 1402 N	**W2=2238.6 N**	**W3 = 3074.4 N**
Aluminium alloy	2.09 mm	3.12 mm	4.288 mm
Stainless steel	0.761 mm	1.135 mm	1.559 mm

Table 6.5 Total deformation (mono)

Twin Suspension:

Type of material	Total Deformation in mm		
	W1 = 701 N	**W2=1119.3 N**	**W3 = 1537.2 N**
Aluminium alloy	4.99 mm	7.97 mm	10.94 mm
Stainless steel	1.81 mm	2.90 mm	3.98 mm

Table 6.6 Total deformation (twin)

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