Design optimization of double wishbone suspension system for motorcycle

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Abstract: Double wishbone is the best suspension System for Motorcycle. It can manage a broader grouping of an area. This sort of suspension is generally placed in four wheelers. Double Wishbone Suspension System (DWSS) can also be designed for bike and bicycles by an adjusted design streamlined. This venture improved the DWSS by displacing the current suspension. The traveller bike is amassed with a DWSS and consolidated by a single damper unit is associated with the higher and base burden. This damping structure get-together depicted immediately. This DWSS brings about wonderful camber caster control. The damping structure has got weight optimized tires. It can be handled for better grip wheels in contact with the street also it can take care of perpendicular and parallel burden. The variables are verified and then advancement of design and the outcomes have been taken for reduction of mass.

Keywords: Double Wishbone Suspension System, Finite Element Analysis, Design Optimisation

1. Introduction:

The Aesthetics of the bike is one of the important factors in the design and development of a bike. Normally bike structure follow up on appearance, dealing with and security in collected mechanism. Double Wishbone Suspension System (DWSS) is the exemplary suspension system. This DWSS can be utilized in forward and back tire for bike. DWSS have a powerful attributes and this DWSS is for the most part exclusive bikes. A DWSS is a gathering of controlling system and body. Shakes are eliminated to the passenger, bumps and so on. Kinds of suspension system utilized in bikes are adjustable DWSS associates by haggle independently from different sorts. Control arms are associated with haggle of the bike on closures. This DWSS aids in steering by ensuring that the tyre is continually in contact with the road, allowing for camber control. Tourist motorcycles are used to gather this DWSS. The Computer Aided Design Model of DWSS is given in Figure 1.
The streamlining method utilized for venture optimization design. Age configuration deary design measure program produces a particular number of results are indicated. Where design is chosen by various materials, anxiety, weight, volume, deformity and assembling strategy. DWSS contains safeguards, cushion, and links are associate clutches and an engine in two-wheeler. Significant boundaries stuns arriving at a significant part from Purchaser fulfilment 18, it will assist with disconnecting Cargo and travellers. During auto keeping away from activities that is moving it gives soundness. The two tires have been invigorated by it and directing backings camber points alongside the cow.

2. Material Selection:

The material Selection and material properties for Double Wishbone Suspension Systems are given in Table 1 and Table 2.

2.1.1 Aluminium A1Si10Mg

Table 1: Mechanical Properties of Aluminium A1Si10Mg

| Material Properties | Stainless Steel Type 316L |
|---------------------|----------------------------|
| Yield Point, MPa    | 332                        |
| Tensile strength, MPa | 673                       |
| Modulus of Elasticity, GPa | 165               |

2.1.2 Stainless steel:

Table 2: Mechanical Properties of Stainless steel

| Material Properties    | Type 316L Stainless Steel |
|------------------------|----------------------------|
| Yield Point, MPa       | 332                        |
| Tensile strength, MPa  | 673                        |
| Modulus of Elasticity, GPa | 165               |
| Strength at break, MPa | 586                        |
| Elongation at break, mm | 35.5                     |
3. Methodology:

The methodology of the design optimisation of Double Wishbone Suspension System is given in the Figure 2.

![Figure 2. Methodology](image)

3.1 Design Specification and Calculation:

3.1.1 DWSS Basic Principles:

The design specifications of DWSS are given in Table 3.

| Considerations                        | Values           |
|---------------------------------------|------------------|
| Fork Compression                      | 50 mm            |
| Existing Suspension System Weight     | 25 Kg            |
| Vibration                             | 4.51 Hz          |
| Shock Absorber Angle                  | 63.7             |
| C.G Hight                             | 650 Mm           |
| Steering Axis                         | 45 °             |
| Wheelbase                             | 1450 Mm          |
| Fork Angle                            | 24 °             |
| Slant Angle                           | 1°               |
| Kerb Weight                           | 157 Kg           |
| Caster Angle                          | 25°              |
| Tyre Radius                           | 300 Mm           |
| Swing Arm Reaction Force(Mean Value)  | 1207.066 N       |
3.1.2 Calculations in different load cases:

During turning:

Absolutely obtained seventy percentage (%) load inward and thirty percentage (%) external side

Max. Load = 2403.45N

Min. load = 1030.05N

3.1.3 Design calculations:

- Minimum force = 1030.05 N
- Kerb weight = 157 kg
- Maximum force = 2403.45 N
- Allowable shear stress = 470 MPa
- Design load = 3090.15 N
- Deflection = 90 mm
- Modulus of Rigidity = 7.2 x 10^4 MPa
- Spring constant k = w/δ = 34.335
- Spring Index (c) = 7

3.1.4 DWSS 3D CAD Model:

The Assembled parts of DWSS is represented in Figure 3.

![Figure 3: Assembled parts of DWSS (DWSS)](image)

Parts Of DWSS: (i) Bearing, (ii) Axle Head (iii) Outermost Link, (iv) Outermost Shackle (v) Intermediate Linkage, (vi) Underside Axle Adjustable Bar (1) for Outermost Linkage, (vii) Cushion, (viii) Adjustable Bar (2), (ix) Monoshock (x) Fork, (xi) Wing Fork, (xii) Fork Bar Cover, (xiii) Fork Linkage, (xiv) Threaded inserts
3.1.5 Modelling of DWSS:

The coefficients of the springs and dampers were determined by ongoing bicycle DWSS. The diversion is utilized to change the movement resulted the regulating a specific heap. Heap following up with damper inverse on augmentation of the forks, as it has a 2403.45 N heap and a movement redirection 40 mm the stroke which is resolved relating till the end of the spring. The fork cushion has a 150 mm travel length. Here, the spring's capacity is put to good use with the expectation of complimentary joint movement between the upper and lower arm joins. Figure 4 shows the forces act on wishbone by mounting parts.

![Figure 4: Forces on wishbone by mounting parts](image)

Estimated comparative with completely broadened length of the fork. The load following up the static force on front wheel of the model is 2403.45 N for the suspension point of 24 degree which corresponds to a heap of 1030.05 N in the direction of the fork. Suspension attributes of the fork leg and wishbone are exhibited by a single spring but a joint that functions as both a spring and a damper. This heap brought about underlying fork pressure around 60 mm. inside the fork the spring in the fork model and pressing factor mimicked.

Generation designing is a tedious design procedure in which a programme delivers a particular amount of solutions in accordance with the requirements. In this research, bulk improvements are made to the damper forks and wishbone of the DWSS. In which the material defines the design. Safety factor, anxiety, weight, volume, deformity and assembling technique. Several components are dependent on agreed design portion to conduct this interaction in generative design measure. The component should be set up using a predetermined model first. Position the grippers in the model such that the heaps are in place.

3.1.6 Fork Generative Design

In the DWSS, the suspension fork is gathered using pressure-driven safeguards fastened to the casing over the front axle. The dynamic development assimilates the jerks and different effects extreme territory; the rider will have a pleasant ride as a result of the design. Figure 5 represents the suspension fork setup. Figure 6 represented the various factors considered. Also figure 7 represents the final optimised design results of fork.
3.1.7 Wishbone Generative Design

This suspension system's wishbone is an important component. It is able to regulate the journey of the wheel and to transmit the heap to the wheel. At one point when the bicycle is in movement, this wishbone is goes through to muddled burdens as per time and other different limit condition. The elements of wishbone are to assimilate the street stuns and give the rider a happy with riding experience. It assists bicycle with being in stable conditions during numerous situations like slowing down, pitching, turning, and rolling. It also eliminates the impact of stress on the bicycle mechanical components from stun loads and has a cushioning effect.
Figure 8: Set-up for generative design suspension Wishbone

Figure 9: Stress, mass, FOS, material, manufacturing cost etc. are the factors consider during design outcome selection for wishbone

Figure 10: After the different iterations have been resolved, the result view shows the form and stresses for the selection of design results for wishbone
4. Results and Discussion

4.1 FEA for fork before optimisation:
The results of this analysis are given in Table 4.

Table 4: FEA results of fork before optimisation.

| Suspension Part | Analysis Type                  | Results |
|-----------------|--------------------------------|---------|
| Fork            | Von Mises Stress: 122.1 MPa    |         |
|                 | Displacement: 0.002442 mm      |         |

4.2 FEA for fork after optimisation:

Table 5. FEA results of the fork after optimisation.

| Suspension Part | Analysis Type                  | Results |
|-----------------|--------------------------------|---------|
| Fork            | Von Mises Stress: 87.83 MPa    |         |
|                 | Displacement: 4.44*10^-4 mm    |         |
4.3 FEA for wishbone before optimisation:

Table 6: FEA results of wishbone before optimisation

| Suspension Part | Analysis Type                  | Results |
|-----------------|--------------------------------|---------|
| Wishbone        | Von Mises Stress: 48.46 MPa    |         |
|                 | Displacement: 0.0644 mm        |         |

4.4 FEA for wishbone after optimisation:

Table 7. FEA results of wishbone after optimisation.

| Suspension Part | Analysis Type                  | Results |
|-----------------|--------------------------------|---------|
| Wishbone        | Von Mises Stress: 39.23 MPa    |         |
|                 | Displacement: 0.2211 mm        |         |

4.5 DWSS Comparison Study for Parts:

The stress, Strain and Factor of Safety FEA results before optimisation and after optimisation are given in the Table 8.

We need to know the parts of the case, the rack point, wheel base, cornering speed, weight management and so on in order to create this suspension system, to achieve an optimum design and restrict jerks, drag, and persistent track surface contact when hustling.
Thereafter, when we designed suspension systems, we looked at the parts, the updated fork and wishbone exhibited superior results following investigation, but yet its design is complicated. The design of the processed double wishbone exhibits excellent results for the bike, and AlSi10Mg aluminium alloy is used to light up the suspension system.

5. Conclusion

In this paper, we observed that the enhanced design exhibits significant achievements for the Fork and Wishbone through the FEA Investigation. Following the design and recreating process, bulk and FOS are also provided with optimal Fork and Wishbone calculations using Autodesk Fusion 360° software. It also has the right methods for designing the suspension. The force and distortion outcomes for the improved DWSS elements are conducted within a sufficient well-being limit factor limit, which confirms the design and evaluation of the suspension parts. Generative design may ultimately be beneficial for reducing weight by up to 8% of the DWSS.

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