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Design, Analysis and Manufacturing of Dual Purpose Mono-Shock Suspension System

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ABSTRACT

In suspension framework spring configuration is exceptionally paramount as it impacts the riding consolation in a time of distress and in the general weight of the vehicle. The present work focuses mainly on using suspension system as the primary member to fully support the load and help the foldable electric bike its folding attribute. One end of the suspension system will act as a fixed end while the other end will act as fixed (in motion) Free (At rest). This research will help manufactures to reduce the overall weight while keeping comfort and aesthetics unaffected. To meet the above objective first, designing the shock absorber in Creo Parametric software based on load/stress acting on it when a person sits on the seat. Then the design will be further analysed for FEA, static analysis to find if the theoretically calculate estimation meets the current scenario and finally manufacturing the mono-shock and tested it in real conditions on a foldable electric bike electric bike

KEYWORDS: mono-shock suspension, Creo parametric, FEA, Static Analysis, Manufacturing.

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INTRODUCTION

In the current scenario, a primary member (metal-alloy) is used to withstand the load of the rider and if the load/stress exceeds, the suspension system compresses and provides compressing action to provide maximum comfort. This mechanism not only increases the weight of the bike but also increases the overall cost. To make the electric bike foldable, weight is a major constraint. Thus this designed mono-shock suspension system will help in providing the suspension effect as well as its one end will act as a hinge to help the electric bike fold. Thus eliminating the need of any metal-alloy member to support. By considering a person's weight this research is done to manufacture a suspension system to best fit a human ergonomically. This suspension system uses a specially fabricated brass alloy coil with calculated design constraints.

CURRENT PROBLEMS

Current Motor-bikes, E-bikes or cycle are using an alloy member to handle variable weight of the rider. This results in increase in weight of the bike frame as well as increase in cost. In this electric mobility era need of foldable electric bikes is increasing exponentially. The user-based problems like traffic, parking, and fuel as well as few global problems can be solved with the aid of this folding mechanism.

Theoretical calculation

Material of mono-shock suspension - Spring Brass alloy

Weight of the person-70kg, -80kg, -100 kg

Weight of Foldable E-bike – 8kg

Permissible shear stress – 49.14Mpa

Modulus of rigidity – 328.17KN/mm2

Load1 = -686.7N

Load2 = -784.8N

Load3 = -981N

I. Design[1]

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

C=3 therefore, K=1.58

Permissible Shear stress= $K \times \frac{8\,W.C}{\pi\, d^2}$

Therefore d=15mm and D = Cd = 45mm and Do = D+d = 60mm

2) Number of coils required

Deflection of spring = $\frac{8W.C^3.n}{G.d}$

Therefore number of coils = 13.99 ~ 14

3) Pitch of the spring = Free length/n'-1

Free length = 210.15 and pitch= 16.165mm

II. MODELLING.

Creo is a family or suite of design software supporting product design for discrete manufacturers and is developed by PTC. The suite consists of apps, each delivering a distinct set of capabilities for a user role within product development.

Creo runs on Microsoft Windows and provides apps for 3D CAD parametric feature solid modelling, 3D direct modelling, 2D orthographic views, Finite Element Analysis and simulation, schematic design, technical illustrations, and viewing and visualization.

Modelling helps you which pattern you want touse toget your project completed. Modelling of this suspension(fig 1) was done in Creo Parametric software considering the design values which includes diameter of coil, free length of suspension system, Pitch of coil.

Modelling is necessary to visualize the figure 1 suspension system's working and perform analysis based on stress it can handle practically.

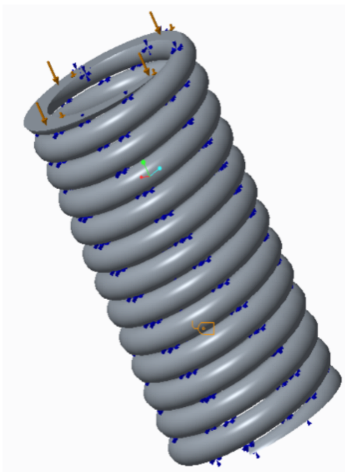

Figure 1: 3D Model of spring

The upper and lower ends of the suspension are sharpened to help in mounting of the suspension to the bike frame Meshing of the suspension (fig 2) is done to break up the domain into pieces, each piece representing an element. Finite element analysis is performed where analysis of element by element is done based on how each particular element will react based on load given. In this research analysis of how each element of the spring will react to the stresses is shown and then integrated it as a whole.

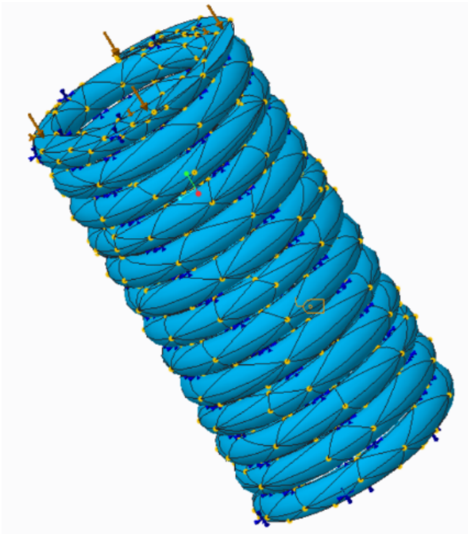

Figure 2:meshing of spring

III. ANALYSIS.

Analysis helps you to gather the loopholes of the system before the development process. Analysis of the mono-shock was done in Creo parametric software as static analysis.

Generally, a finite-element solution may be broken into the accompanying three stages.

1. Pre-processing: defining the problem,
2. Solution: assigning loads, constraints, and solving
3. Post processing: further processing and viewing of the results

In this stage one may wish to see

(I) Arrangements of nodal relocations,

(ii) Component strengths and moments,

(iii) Diversion plots, and

(iv) Stress shape outlines

The analysis showed in figure (3) is static stress for load of -686.7N

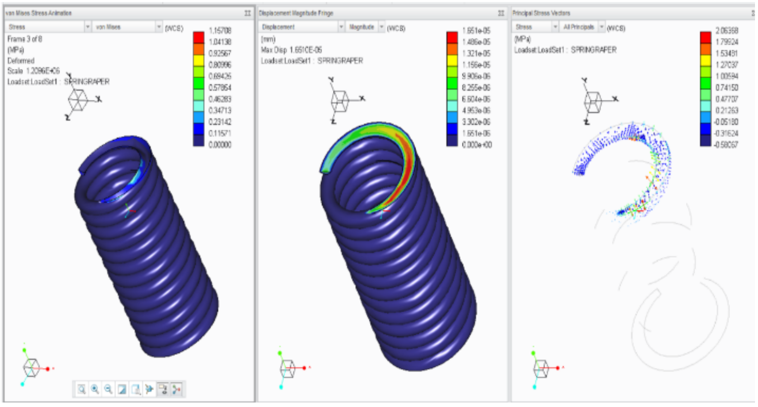

Figure 3: static analysis for load 1

Similarly the analysis showed in figure (4) is showing analysis for static load of -784.8N

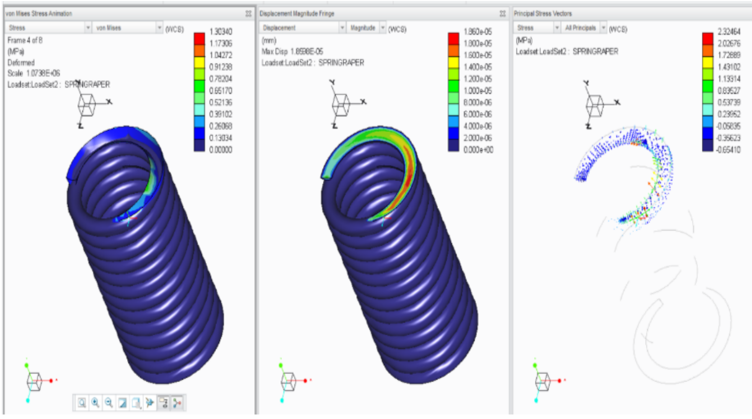

Figure 4:static analysis for load 2

Thus, up till the stress induced by the person, the suspension system will not deflect.

The analysis showed in figure (5) is showing static analysis for the load of -981N

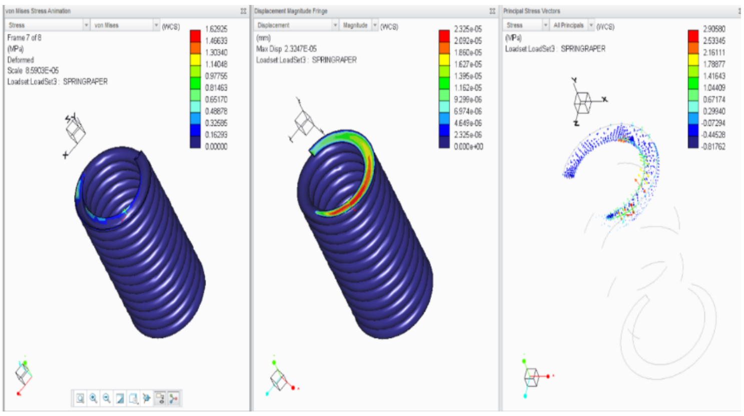

Figure 5: static analysis for load 3

IV. MANUFACTURING AND PLACEMENT

Preparation of the spring made of alloy of brass was done by the following steps

1) Long stock wire was purchased based on material required

2) Coils made with the help of auto-coiler based on design measurements.
3) Ends of the spring sharpened for the placements of support mountings
4) Shock-absorber placed to allow spring regain its original position without affecting human comfort.
5) Support mounting member placed above and below suspension system.

The support mounting where made in a round shape with aluminum 6000 grade. The suspension system was mounted in clamp to hold it from falling. The angle of the suspension system mounted was based on the moment of swing of the seat on which a person will sit.

Figure 7 shows the suspension system actual prepared based on design calculations and certain constraints for mounting.

Figure 6: Mono-shock Suspension

V. WORKING

The working of this suspension system is shown in figure 7

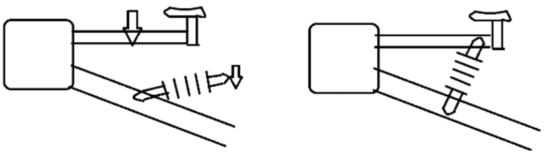

Figure 7 Folding mechanism of bike

One end of the suspension is fixed on the other hand, the other end is attached to the frame with the aid of a pin. During folding of the Electric bike, the pin is removed and the fixed end works as a hinge and the other hand acts as free to fall. Thus this mechanism helps in providing dual function

1. Acts as an actual suspension system when in motion

2. Acts as a folding mechanism in static position.

VI. RESULTS AND DISCUSSIONS

The analysis showed in figure (3) is for -686.7N. The stress is induced on the sharp-Edge of the spring and is not extreme for breakage (1.15Mpa < 49.14Mpa). The maximum displacement is shown which happens on the upper face of the spring where the part will interface with the mountings without letting the other coils to deflect. Thus, the analysis proves that the suspension system will only deflect when force is greater than the person's weight

Similarly the analysis showed in figure 4 is for load of -784.8N

The analysis showed in figure (5) is for -981N

Limitation

The suspension system is particularly designed for foldable electric bike where suspension system is used as primary or secondary folding mechanism. Thus, this suspension system cannot be replaced by other suspension.

Potential direction

Due to exponential increment of population, foldable electric bikes will be emerge as more convenient mode of transport. This suspension system is the best way to make e-bikes more compact.

VII. CONCLUSION.

Overall, after the research, with the aid of designing, modelling, static analysis and FEA and practically applying the suspension system, the research is able to successfully design a suspension system which can withstand the weight of the person with negligible deflection further deflection of the suspension system is only possible when the reaction due to obstacles on the road surface occurs. Thus, the suspension system in motion acts as a main supporting member as well as provide suspension effect. For folding of electric bike, the suspension system acts as a folding mechanism. This mechanism helps foldable electric bikes to get more compact and portable so that the user can travel on the electric bike as well as fold it according to situations and requirements.

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