iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VI Month of publication: June 2023

DOI: https://doi.org/10.22214/ijraset.2023.53849

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Design and Analysis of Driver Seat Suspension System

Prathmesh Pawar[1], Prof. Gayatri S. Patil[2]
[1]Student, Masters of Mechanical Engineering, KJ College of Engineering and Research Management, Pune, Maharashtra, India
[2]Asst. Professor, Department of Mechanical Engineering, KJ College of Engineering and Research Management, Pune, Maharashtra, India

Abstract: Over the years, the vehicle driver has endured a great deal of agony and anguish as a result of poor road conditions or lengthier travel lengths that they must complete within a certain time limit. It is a misery to them that the standard or budget vehicles do not feature a good suspension system for their wellbeing. This research article demonstrates a unique design of scissor seat suspension for vehicles, as well as models for manufacturing and testing the system to eliminate low-frequency and high-amplitude vibrations that might cause health problems for vehicle drivers or passengers. Although scissor seat suspension is frequently utilized in commercial vehicles to reduce interior vibrations, a common optimization difficulty emerges because designs often involve a compromise between seat acceleration and suspension travel. The stiffness and damping characteristics of the scissor seat suspension are also investigated, and a simplified model of the scissor seat suspension is presented. The effect of damping force and mass on a human is investigated in preparation for future design and testing. The ideal vertical stiffness damping response is then cascaded into a performance-oriented model, and the design parameters are optimized with a multi-body kinematics model focused on the scissor seat suspension structure.
Keywords: Scissor Seat Suspension, Low Frequency, High-Amplitude, Vibrations, etc.

I. INTRODUCTION

Seat suspension system is a necessity in all vehicles including commercial vehicles. In commercial vehicles the secondary suspension (seat, driver's cabin) is responsible for the driver's comfort. The fatigue caused by long termed vibrations to which the vehicle drivers are exposed, can be very severe spinal hernia, dislocation of the spinal disks, etc. In today's world, considering the new technologies, Vehicle manufacturers have to focus on the safety and comfort of the vehicle drivers. After N-number of investigations it is observed that the driver is facing a lot of vibrations and discomfort while driving as they get tired out very quickly. The challenging task for us is the design of the suspension system. It is very essential to design reliable, safe, and convenient seats to eliminate road excitation, as it transmits vibrations to the Vehicle driver's body, and it may cause some damaging effects on their health and efficiency. Vehicle drivers have faced a lot of vibrations from road surface unevenness. The outcomes for vehicle drivers are the following reasons such as lack of concentration, they may feel tiredness and reduction of the effectiveness of the work being conducted.

II. LITERATURE SURVEY

Jianqiang Yu et al. [1] proposed that under sinusoidal excitations, the MTS machine is utilized to measure dynamic damping characteristics. The backbone curve-based hysteretic model is chosen.

Xiu-Mei Du et al. [2] proposed that designs a simplified model of the semi-active scissors linkage seat suspension by analyzing its characteristics. And a robust state-feedback $H\infty$ control is established by considering the system uncertainties. which helps in reduction of vibration.

Donghong Ning et al. [3] Member proposed that A continuously controllable electromagnetic damper (EMD) system, consisting of a permanent magnet synchronous motor (PMSM), a three-phase rectifier, a metal-oxide-semiconductor field-effect transistor (MOSFET) switch, and an external resistor, was employed in this study. To create a variable damping seat suspension, a commercial passive seat suspension was modified by removing the original damper and placing the variable damper in the center of the scissors structure.

Xinjie Zhang et al. [4] proposed that the foundation of scissor seat suspension optimization, control, and development is precisely obtaining the dynamics characteristics. The author went over the steps required in performing an analytical computation for the suspension system in detail.

The suggested scissor seat suspension multi-body dynamics model gives a precise dynamics characteristics description, which can be used for scissor seat suspension structure optimization and virtual product development, as demonstrated in this work.

Jianqiang Yu et al. [5] proposed the scissor suspension system should be self-powered, self-sensing, adaptable, and long-lasting. Magnetorheological fluid is employed in a damper controlled by an electromagnet to achieve this purpose.

Chunlei Wang et al. [6] proposed the hierarchical optimization on scissor seat suspension characteristic and its structure, providing a top-down methodology with the globally optimal and fast convergent solutions to compromise these design contradictions. In detail, a characteristic-oriented non-parametric dynamics model of the scissor seat suspension is formulated firstly via databases, describing its vertical dynamics accurately. Then, the ideal vertical stiffness-damping characteristic is cascaded via the characteristic-oriented model, and the structure parameters are optimized in accordance with a structure-oriented multi-body dynamic model of the scissor seat suspension. Eventually, the seat effective amplitude transmissibility factor, suspension travel and the CPU time for solving are evaluated.

Seung-Bokchoi et al. [7] proposed a magneto-rheological (MR) fluid damper was used to control the vibration of a semi-active seat suspension. which is built around the Bingham model of the MR fluid whose field-dependent damping force characteristics have been experimentally evaluated, and whose vibration control performances have been evaluated using hardware-in the-loop simulation.

Kiana Kia et al. [8] proposed that an active suspension seat may have the potential to reduce vertical and total WBV exposures in the future. However, none of the, including a vertical active suspension, multi-axial active suspension, and a static suspension-less seat, demonstrated any significant benefits on non-driving task performance, muscle activity, self-reported discomfort, or motion sickness measures in a simulated vehicle environment.

I.Maciejewski et al. [9] proposed an active vibration reduction system with a seated human body. A permanent magnet synchronous motor is developed to improve the vibration isolation properties of the horizontal seat suspension.

Jeong Ho Kim et al. [10] proposed that a new hybrid controller that combines three control schemes: fuzzy neural control, PI control, and sliding mode control Following the development of the mathematical model, the proposed controller is used to control the vibration of a vehicle seat suspension with a magneto-rheological (MR) damper. Both simulation and experiment show that the proposed controller can provide much better vibration control performance than conventional controllers with more robust stability.

Lixin Tu et al. [11] proposed that a magnetic spring with a negative stiffness is created by combining two columnar magnets in a specific arrangement. It can be used in semi-active seat suspension to reduce vibration on vehicle drivers. It reduces resonance frequency vibration during vertical excitation without compromising loading capacity and achieves excellent lowfrequency vibration suppression performance.

III. LITERATURE GAP

Referring to the studies conducted by the researchers around the globe, it was concluded that the need of a low-cost, highly effective seat suspension system is essential. In-depth investigation revealed that the components used to produce the desired operation in the case studies were sophisticated assemblies, rather than straightforward mechanical parts. Therefore, none of the other case studies that were presented shared the idea of using a simplified method to obtain the intended output.

IV. PROBLEM STATEMENT

Most of the vehicles have normal seats that are not able to isolate the low-frequency vibrations. It is fully identified that vertical vibration at lower frequencies is the most harmful vibration to the human body. However, in order to lower the vertical vibration acceleration, felt by the human body, a seat suspension system is required. Vehicle driver fatigue is typically caused by inadequate sleep, by working too many hours, or by driving while sick. This is one of the most dangerous impairments a vehicle driver can experience. Considering all these terms and factors the focus should be on the driver's comfort so that the driver doesn't feel restless very early. Passive vibration control system where mechanical parts are utilized to damp undesired vibrations. The mechanical parts include spring, shock absorber, damper, etc. However, in order to lower the vertical vibration acceleration, felt by the human body, a seat suspension system is required. Vehicles are designed to carry a lot of weight on their axles, which effectively means that they need to have very stiff springs in their suspension. This makes for a very bouncy, harsh, uncomfortable ride, which can be fatiguing for a driver who has to deal with it all day long. "Chronic back pain" is often the result of a vehicle driver. Nearly, 59% of vehicle drivers experience low back pain.

To overcome these major problems, the need of a suspension seats system arises as the driver sit on a scissor-type frame that provides up-and-down travel to cushion the driver over speed breaker and also in uneven roads.

V. MATERIAL SELECTION

A. For Bell Cranks

Aluminium 6061 T6

T6 temper 6061 has -

- Ultimate tensile strength of at least 290 MPa (42,000 psi)
- Yield strength of at least 240 MPa (35,000 psi).
- More typical values are 310 MPa (45 ksi) and 270 MPa(39 ksi), respectively.
- Young's modulus (E): 68.9 GPa (9,990 ksi)
- Elongation (ε) at break: 12–25%
- Density (ρ): 2.70 g/cm3
- Thermal conductivity (k): 151–202 W/(m•K).

1) Properties

a) Resistance to corrosion
b) A high value of hardness
c) Easy machinability
d) Rigidity and toughness
e) Light Weight with high yield strength
f) Good weld ability

B. For Pushrods and Mountings

AISI 4130 ChromolySteel 19*1 mm

1) Mechanical Properties

PROPERTIES	METRIC
Tensile strength, ultimate	560 MPa
Tensile strength, yield	460 MPa
Modulus of elasticity	190-210 GPa
Bulk modulus (Typical for steel)	140 GPa
Shear modulus (Typical forsteel)	80 GPa
Poissons ratio	0.27-0.30
Elongation at break (in 50 mm)	21.50%
Reduction of area	59.6
Hardness, Brinell	217
Hardness, Knoop (Converted from Brinell hardness)	240
Hardness, Rockwell B (Converted from Brinell hardness)	95
Hardness, Rockwell C (Converted from Brinell hardness, value below normal HRC range, for comparison purposes only.)	17
Hardness, Vickers (Convertedfrom Brinell hardness)	228
Machinability (Annealed andcold drawn. Based on 100% machinability for AISI 1212 steel.)	70

2) Thermal Properties

Thermal conductivity (100°C) - 42.7 W/mk

Properties

a) Easy machinability
b) Good atmospheric corrosion resistance
c) Reasonable strength
d) High Strength to weight ratio

The spring damper system is an OEM part from DNM springs. The model used is Burner RCP- 2S with a stiffness(k)=140 pounds/inch.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

VI. SYSTEM DESIGN

1) A standard seat model was taken.
2) The suspension geometry was decided.
3) A spring-damper system was selected instead ofregular springs to dampen the active vibrations.
4) All the calculations for the forces were done.

A. Design Of Components And Assembly

1) *Base Plate:* The base plate is created by drawing a 2d rectangle with dimensions equal to the seat specifications and then drawing the shape that will be cut out during the extrusion process. Once the 2D sketch is finished, the extrude command to extrude the 2D sketch while removing the unwanted potions/contours was used.

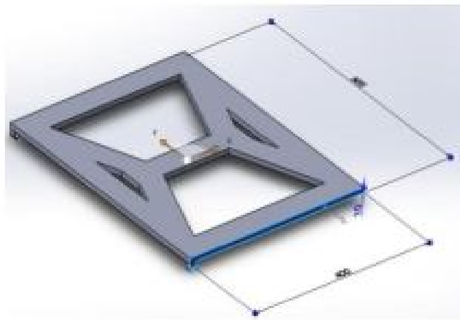

Fig 1. CAD Model of Base Plate

2) *Roller:* For the roller, two concentric circles of appropriate diameter were constructed then extrude command was executed and the area between two circles is extruded.

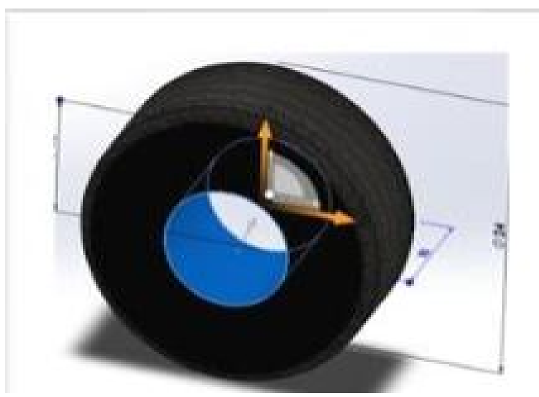

Fig 2. CAD Model of Roller

3) *Sleeve:* To create the seat suspension system's sleeve, 2-D sketch of the sleeve using the slot command in the sketch menu was constructed with specified length and diameter of the semi circles at the end. Following that, extrude command was executed to give the sleeve the required thickness, and then extrude cut command was executed to make the necessary holes.

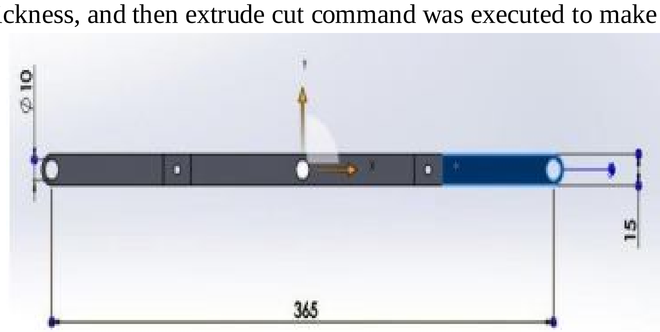

Fig 3. CAD Model of Sleeve

4) *Dynamic Spring:* To make the spring, first draw a circle for the spring and then a helix. Choose desired pitch and height from the drop-down menus. Pierce the two sketches and then go to sweep path selection. Extrude cut the ends to increase the contact area with the attachments. Hooks are created by extruding a 2-D figure in a certain design and generating a gap in the features tab by extruding a cut feature.

Fig 4. CAD Model of Dynamic Spring

5) *Damper:* To make a damper, a cylinder with dimensions is made. The rotate command from the features manager is used to produce the rod. To allow the piston rod to glide inside the damper cylinder, advanced mate is provided. The piston head has a circular pattern of holes to allow oil to flow solely in one direction.

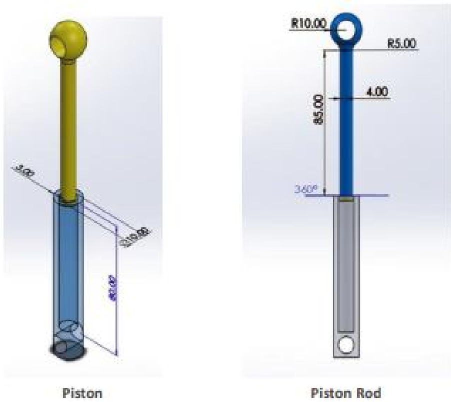

Fig 5. CAD Model of Damper

6) *Full Assembly:* The Assembly is designed such that most of the load is taken by the damper and restoration force is applied by the spring on the seat to restore the original position using the potential energy stored in the spring. The spring is stiff enough to regain the initial position after removal of sudden load.

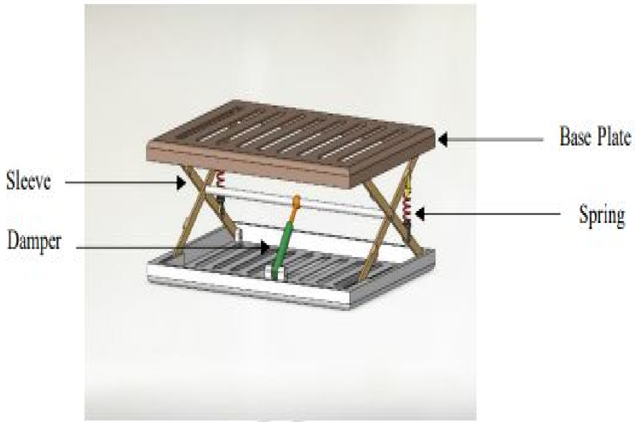

Fig 6. CAD Model of full assembly

VII. CALCULATION

Weight of an average Driver = 78 kg
Weight of the cushioned seat = 2 kg
Total Weight = 80 kg
In a seating position the total weight of the driver is taken as73% of the total weight,
Driver Weight = 57 kg
Now,
total weight acting on the setup = 59 kg
Vertical Load (P1) = (59*9.8)/2 = 289.1 N
Load on Pushrod (Fp) = 289.1* Cos (15.82) = 278.14 N,

Now to find the spring force (Fs) we have to balance themoments about the pivot point of the bell crank,
Fs * 11.44 = Fp * 17, Fs = (278.14*17)/11.44,Fs = 413.31 N
K = 140Psi = 25 N/m
Wn = √ (K/m) =√ (25/80) =0.55
Cc = 2mWn =88 Ns/mm

We have to keep the damping condition as C < Cc, for Underdamping condition.
K = Gd4/8D3
[K = 25N/mm (given), G = 2.1*105 MPa, C = d/D = 6(assume), n = 6 (assume)]
25 = 2.1*105d4/8*216*6

- d = 5mm
- D=30mm

Free length of spring,
Lf = nd+ (n-1)
Lf = 6*5 + 5 = 35mm

X_{st} = Compression in the spring in static condition
X_{st} = Fs/K =413.31/25= 16.53 mm

VIII. RESULTS AND DISCUSSIONS

Result of analysis of Seat Suspension System:
The Ansys workbench solution tab is a tool that provides users with visual and numerical solutions using contours. It is the average of all the input criteria, which include load, displacement model, degree of freedom, stiffness, and so on.
The figure below depicts the total deformation caused by dynamic loading in the model.

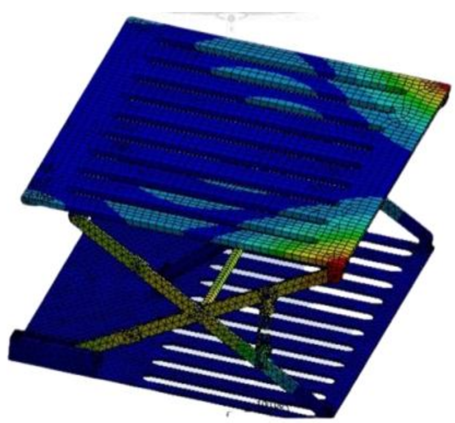

Fig 7. Deformation schematic of seat suspension system

IX. CONCLUSIONS

A seat suspension system is designed and analyzed to provide maximize seat quality and performance which reduce the driver's stress during long operating drives A different topology is approached in this report to make the system more economically feasible and reliable at same time.

X. ACKNOWLEDGMENT

We would also like to show our gratitude to, *Prof. Ms. Gayatri S. Patil (Asst. professor, department of Mechanical Engineering, KJ College of Engineering and Research Management, Pune, Maharashtra, India.)* for sharing their pearls of wisdom with us during the course of this research. We are also immensely grateful to him for his comments on an earlier version of the manuscript, although any errors are our own and should not tarnish the reputations of these esteemed persons.

REFERENCES

[1] Yu, J., Dong, X., Wang, X., Li, J., & Li, B. (2020). Design, modeling, and control of a magnetorheological rotary damper for scissor seat suspension. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, 234(9), 2402-2416.
[2] Du, X. M., Yu, M., Fu, J., Peng, Y. X., Shi, H. F., & Zhang, H. (2019). H∞ control for a semiactive scissor's linkage seat suspension with magnetorheological damper. Journal of Intelligent Material Systems and Structures, 30(5), 708-721.
[3] Ning, D., Du, H., Sun, S., Li, W., & Li, W. (2018). An energy saving variable damping seat suspension system with regeneration capability. IEEE Transactions on Industrial Electronics, 65(10), 8080-8091.
[4] Zhang, X., Wang, C., Guo, K., Sun, M., & Yao, Q. (2017). Dynamics modeling and characteristics analysis of scissor seat suspension. Journal of vibration and control, 23(17), 2819-2829.
[5] Yu, J., Dong, X., Zhang, Z., & Chen, P. (2019). A novel scissor-type magnetorheological seat suspension system with self-sustainability. Journal of Intelligent Material Systems and Structures, 30(5), 665-676.
[6] Wang, C., Zhang, X., Guo, K., Lv, J., & Yang, Y. (2016). Hierarchical optimisation on scissor seat suspension characteristic and structure. Vehicle System Dynamics, 54(11), 1538-1553.
[7] Choi, S. B., Nam, M. H., & Lee, B. K. (2000). Vibration control of a MR seat damper for commercial vehicles. Journal of intelligent material systems and structures, 11(12), 936-944.
[8] Kia, K., Bae, H. T., Johnson, P. W., Dennerlein, J. T., & Kim, J. H. (2022). Evaluation of vertical and multi-axial suspension seats for reducing vertical-dominant and multi-axial whole body vibration and associated neck and low back joint torque and muscle activity. Ergonomics, 1-15.
[9] Maciejewski, I., Zlobinski, M., Krzyzynski, T., & Glowinski, S. (2020). Vibration control of an active horizontal seat suspension with a permanent magnet synchronous motor. Journal of Sound and Vibration, 488, 115655.
[10] Kim, J. H., Marin, L. S., & Dennerlein, J. T. (2018). Evaluation of commercially available seat suspensions to reduce whole body vibration exposures in mining heavy equipment vehicle operators. Applied ergonomics, 71, 78-86.
[11] Tu, L., Ning, D., Sun, S., Li, W., Huang, H., Dong, M., & Du, H. (2020). A novel negative stiffness magnetic spring design for vehicle seat suspension system. Mechatronics, 68, 102370.
[12] Choi, S. B., & Han, Y. M. (2007). Vibration control of electrorheological seat suspension with human-body model using sliding mode control. Journal of Sound and Vibration, 303(1-2), 391-404.
[13] Maciejewski, I., Meyer, L., & Krzyzynski, T. (2009). Modelling and multi-criteria optimisation of passive seat suspension vibro-isolating properties. Journal of sound and Vibration, 324(3-5), 520-538.
[14] Types Of Drilling Operations Performed in Drilling Machine available at https://www.mechanicalbooster.com/2019/09/drilling-operations.html
[15] Density of Mild Steel available at https://material-properties.org/mild-steel-density-strengthhardness-melting-point/
[16] Dampers available at https://www.stabilusindustryline.com/products/oil-dampers/
[17] General Types of Rivets & Their Applications available at https://www.goebelfasteners.com/general-types-of-rivets-their-applications/
[18] Fastening and Joining available at https://www.globalspec.com/learnmore/mechanical_components/mechanical_fasteners_hardw are/studs/
[19] Types off Stud Fastener https://engineeringlearn.com/types-of-stud-fastener-threaded-studbolt-undercut-studs-wall-studs-with-pictures/
[20] Different Types of Springs and Their Application https://www.rapiddirect.com/blog/typesof-springs-and-applications/