

Design and Analysis Double Wishbone Suspension System using Finite Element Analysis

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Abstract— Double wishbone designs allow the engineer to carefully control the motion of the wheel throughout suspension travel. 3-D model of the Lower Wishbone Arm is prepared by using CAD software for modal and stress analysis. The forces and moments are used as the boundary conditions for finite element model of the wishbone arm. By using these boundary conditions static analysis is carried out. Then making the load as a function of time; quasi-static analysis of the wishbone arm is carried out. A finite element based optimization is used to optimize the design of lower wishbone arm. Topology optimization and material optimization techniques are used to optimize lower wishbone arm design.

Key words: Double wishbone suspension, ANSYS, durability Analysis

Wishbone or A-arm can also be used in various other suspension types, such as variations MacPherson. The upper arm is usually shorter to induce negative camber as the suspension jounces (rises), and often this arrangement is titled an "SLA" or Short Long Arms suspension. When the vehicle is in a turn, body roll results in positive camber gain on the lightly loaded inside wheel, while the heavily loaded outer wheel gains negative camber.

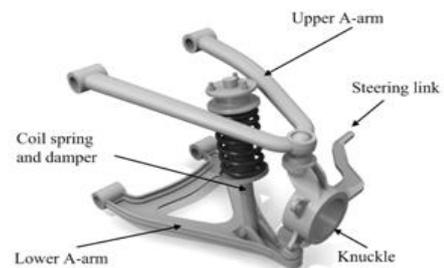


Fig: Double wishbone Suspension system

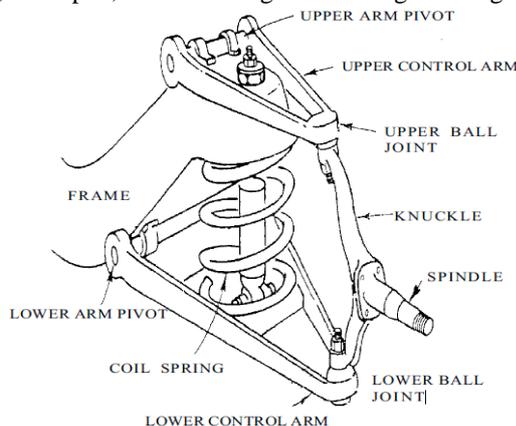
The Four bar link mechanism formed by the unequal arm lengths causes a change in the camber of the vehicle as it rolls, which helps to keep the contact patch square on the ground, increasing the ultimate cornering capacity of the vehicle. It also reduces the wear of the outer edge of the tire.

NOMENCLATURE OF DOUBLE WISHBONE:

- Offset of upper arm (d)
- Offset of lower arm (e)
- Distance of upper ball joint from ground (H)
- Distance between upper ball joint and lower ball joint (h)
- Lift of the wheel centre (Z)
- Lift of upper arm (Z1)
- Lift of lower arm (Z2)
- Lateral displacement of upper ball joint (Y1)
- Lateral displacement of lower ball joint (Y2)
- Length of upper arm (R1)
- Length of lower arm (R2)
- Vertical distance of upper ball joint wrt inboard
- Point (a)
- Vertical distance of lower ball joint wrt inboard
- Point (b)

I. INTRODUCTION

The double-wishbone suspension can also be referred to as "double A-arms", though the arms themselves can be A-shaped, L-shaped, or even a single bar linkage. A single



II. LITERATURE REVIEW

Adel Mahmoud Bash.[1] In this project robust design technique could be applied in the design stage of the product optimum process so as to maximize product reliability. A detailed model of suspension arm has been developed using finite element techniques. The tetrahedral elements (TET10) is used for the initial analysis then used for the solid mesh. Sensitivity analysis was performed to determine the optimum element size. It can be seen that the TET10 at mesh size 0.1 capture highest moment levels von Mises stress for this reason used to dynamic analysis. The results of the frequency are shown 10 modes and several deformation shapes and from the results proved that the control suspension arm model has been predicted the dynamic behavior.

Aditya Arikere, Gurunathan Saravana Kumar, and Sandipan Bandyopadhyay [2] the paper proposes a framework for optimizing the design of double wishbone suspension systems. Pareto-optimal solutions to the mechanism synthesis problem are generated so that the designer can choose from the set of solutions under contradicting objectives of minimizing camber as well as toe – the two important performance parameters leading to better vehicle handling characteristics. The results show that the method based on NSGA-II converges to solutions better than that based on classical methods.

Takashi Yamanaka * Hiroaki Hoshino Keiichi Motoyama [3] In this project Prototype of optimization

system for suspension systems based on Genetic Algorithms was developed. In this system, the suspension system was analyzed and evaluated by Mechanical System Simulation Software ADAMS. The validity of the optimization system was clarified through the two case studies focusing on toe curve and lateral stiffness. Typical double wishbone type rear suspension with twenty design variables was analyzed and optimized by the optimization system.

N.Vivekanandan¹, Abhilash Gunaki², Chinmaya Acharya³, Savio Gilbert⁴ and Rushikesh Bodake⁵ [5] The main objective of the paper is to design and analyze the entire double wishbone suspension system for an All-Terrain Vehicle for improving the stability and handling of the vehicle. Stability of the vehicle and the ride comfort is given a prominent importance in this project. They Designed simulated it in the LOTUS software. Objectives namely providing greater suspension travel, reducing the unsprung mass of the vehicle, maximizing the performance of the suspension system of the vehicle and better handling of vehicle while cornering; have been achieved.

Prof. A. M. Patil¹, Prof. A.S. Todkar², Prof. R. S .Mithari³, Prof. V. V. Patil⁴ [6] In this paper a Under the static load conditions deflection and stresses of steel lower wishbone arm and composite lower wishbone arm are found with the great difference. Carbon fiber suspension control Arms that meet the same static requirements of the steel ones they replace. Deflection of Composite lower wishbone arm is high as compared to steel lower wishbone arm with the same loading condition. The redesigned suspension arms achieve an average weight saving of 27% with respect to the baseline steel arms. The natural frequency of composite material lower wishbone arm is higher than steel wishbone arm.

Vinayak Kulkarni¹, Anil Jadhav², P. Basker³ [7] This paper deals with calculating the forces acting on lower wishbone arm while vehicle subjected to critical loading conditions (Braking, Cornering and Descending though slope). Suspension geometry and suitable materials for the suspension arm has been identified. Lower arm suspension has been modeled using Pro-Engineer. Von mises stress – strain is carried out in order to find out maximum induced stress and strain, while modal analysis is done for finding out natural frequencies and mode shapes of component. These analyses were carried using Altair Hyper works and solver used is Radios. From the analyzed results, design parameters were compared for two different materials and best on was taken out. From result obtained it was found that current design is safe and is somewhat overdesign. So in order to save material and reduce weight of component, Topology optimization analysis is carried out in Hyper works which yielded in optimized shape. They conclude that on strength basis, aluminum alloy is good material than Mild Steel whereas on strain basis, Mild Steel is good material than aluminum alloy. Modes and mode shapes of lower control arm contingent on material properties. Hence change in material leads to change in resonance condition. Modes are used as a simple and efficient means of characterizing resonant vibration. The higher factor of safety leads to optimization of component. Topology optimization generates an optimized material distribution for a set of loads and constraints within a given design space. Optimization reduces weight, product design cycle time and

cost.

[8], Shilpa.B4 An attempt has been made to analyze and obtain the idealized operating conditions of the human body. The analysis has shown that for the given vehicle and human body, the idealized operating speed for HERO HONDA SPLENDOR vehicle on the terrain of specified amplitude at given input is found to be 49.66 km/hr on the frequency of 8 HZ

T. Siva Prasad, T. Krishnaiah, J. Md. Iliyas, M.Jayapal Reddy [9] static analysis work was carried out by considered two different materials namely aluminum and forged steel and their relative performances have been observed respectively. In addition to wheel rim is subjected to modal analysis, a part of dynamic analysis is carried out its performance is observed. In This paper by observing the results of both static and dynamic analysis obtained forged steel is suggested as best material.

Rajkumar Kewat, Anil Kumar Kundu, Kuldeep Kumar, Rohit Lather, Mohit Tomar [10] This paper studies about the model of double wishbone used in off-road racing cars. Dynamic analysis of Wishbones is done in „LOTUS-Shark V 5.01“. Analysis is also done by changing the design of double wishbone. By applying an extra link named toe link and S link for providing two mounting points. It is clear from the graphs there is a small or negligible change in the toe angle when vehicle faces the condition of bump and rebound. Moreover, the height of the rack mounting is also low with double wishbone +slink +toe link. Therefore in condition of simple Ackermann if rack is placed behind the pedals (especially in off-road vehicles) Comfort ability increases to large extend for driver because pedals can be operated without facing any obstacles.

Mohammad Iman Mokhlespour Esfahani, Masoud Mosayebi, Mohammad Pourshams, Ahmad Keshavarzi [11] The quarter car with the double wishbone suspension system has been modeled for two different approaches to the Suspension links to be rigid and flexible. Therefore, the dynamic analyses of these models have been investigated by The finite element method Analysis of the results showed that the agreement between the simple model and flexible Model without unloaded links is excellent for both natural frequencies and the time responses. Therefore, the simple Model is adequate for the first design step

1. Shpetim LAJQI, 2. Stanislav PEHAN, 3. Naser LAJQI, 4. Afrim GJELAJ, 5. Jože PŠENIČNIK, 6. Sašo EMIN [12] this paper present design of the suspension mechanism intended to use in a terrain vehicle with four wheels steer and four wheels drives. The main aims are concentrated to design an independent suspension system to provide better contact of tire with road surface and less lateral displacement of the tire. Following are derived some important conclusions, such as: Designed suspension system provides 45% less displacement of the wheel in lateral motion. When wheel is pushed upward situation is better and provides 72.6% less displacement compared with same double wishbone suspension system, Designed suspension system provides relatively small values of camber angel nearly to zero which influence to have better contact of the tire with road surface. This improve, is a result that suspension mechanism allow wheel respectively tire to acts perpendicular in road surface. The large vertical motion of the wheels (– 250 ... 250 mm) will be caused a lot of

problems in steering mechanism. The large vertical motion should be not influence on the contra torque on the steering wheel, but have ability to rotate the wheel around the kingpin axes for minor angle thus causing the vehicle to decrease stability. To avoid this problem completely new design of steering mechanism should be done. Achieved results that are presented here in general will help the designer of vehicles to equip his vehicle with such suspension system

Sagar Darge*, S.C. Shilwant**, S. R. Patil*** [13] in this paper it has been seen that the maximum value of force transmitted by tyre to the body of vehicle through lower suspension arm. During braking and cornering lower suspension arm is subjected to high stresses because of that Failure of lower suspension arm of vehicle was reported. Plastic deformation and cracks were observed frequently during on road running of vehicle. Stress analysis was performed using finite element method. Reinforced models were proposed on the basis of result data. The finite element analysis of component leads to a reduction of physical and expensive tests. Consequently, it was not necessary for the production of several prototypes. Further corrective actions that are modifications in design will be carried on the basis of results analysis. First stage results show higher stress effects on the component. There were two approaches to solve this problem first topology which is concerned with material density distribution in which optimization is performed on a model to create a new topology for the structure, removing any unnecessary material and second Topography which is concerned with optimization is an advanced form of shape optimization in which a design region for a given part is defined and a pattern of shape variable-based reinforcements within that region is generated. They used specific size of bead to subdivide the area into a large number of separate variables whose influence on the structure is calculated and optimized over a series of iterations.

III. CONCLUSION

From review of above literature we can conclude the following points:

- 1) Static load conditions deflection and stresses of steel lower wishbone arm and composite lower wishbone arm are found with the great difference. Carbon fiber suspension control arms that meet the same static requirements of the steel ones they replace. Deflection of Composite lower wishbone arm is high as compared to steel lower wishbone arm with the same loading condition.
- 2) This mechanism can change camber angle from - 5.5 degree to 5.5 degree, piston rod movement about 60 mm and crankshaft about 650 degree. Mechanism has very short response time that can be a major advantage for the vehicle stability
- 3) Framework for optimizing the design of double wishbone suspension systems. *Pareto*-optimal solutions to the mechanism synthesis problem are generated so that the designer can choose from the set of solutions under contradicting objectives of minimizing camber as well as toe – the two important performance parameters leading to better vehicle handling characteristics

- 4) Robust design technique could be applied in the design stage of the product optimum process so as to maximize product reliability
- 5) Double wishbone suspension system and then simulated it in the LOTUS software. This was providing greater suspension travel, reducing the unsprung mass of the vehicle, maximizing the performance of the suspension system of the vehicle and better handling of vehicle while cornering; have been achieved. The suspension system can be further modified for decreasing the weight and cost

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