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Design of Multi Link Structure for Rear Suspenion of a Heavy Vehicle

Posem Aravind, Tadiboina Bhargavi, Putrevu Suvankar,
Sucharitha Ayyalasomayajula

Department of Mechanical Engineering, GITAM University
Department of Mechanical Engineering, GITAM University
Department of Mechanical Engineering, GITAM University
Department of Industrial Engineering, GITAM University

---**ABSTRACT**---

Automobile systems today is going through major changes and as concert to comfort the suspension system and it's working is very important. The study of four link suspension system and dynamic analysis are discussed in this paper. This paper discusses the design problem of vehicles using four-link suspension systems with the aim of totally optimizing vehicle handling and stability. Since this problem includes many evaluation items, and Four-link suspension system has interconnected behaviour, the optimization is so complicated. An efficient and computable model is indispensable for compromising the total optimization. This paper investigates a structure of objectives, introduces appropriate simulation models for respective items; we apply multi body dynamic analysis to plot the varies terms such as wheel travel, camber angle, caster angle, toe-in, toe-out etc. The result of optimization calculation shows the validity of the optimization model.

Keywords: *Four link suspension system, Multi body dynamic analysis (MBD), Lower Centre Point(LCP), Instantaneous Centre Radius (ICR)*

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I. INTRODUCTION

Suspension used in an automobile is a system mediating the interface between the vehicle and the road, and their functions are related to a wide range of drivability such as handing ability, stability, comfort ability and so forth. Since the total optimization of such contents requires much of design freedom, a four-link suspension system, that is principally a parallel six-bar universal linkage, is getting installed to passenger cars, mainly to high-grade cars. On the other hands, such design freedom makes the design process for determining link geometry, etc. more complicated, and it is not so easy to design the suspension system with promising insights. This leads the necessity of a new generation of design methodology that can realize a potential of the complicated system toward total optimality. This paper discusses the total design method for both finding optimization possibilities within an established system structure and configuration and optimizing the system attributes that correspond to such possibilities, under the concerns with the total drivability optimization of a vehicle using multi-link suspension systems. For this direction, first we hierarchically structure design items from design variables that represent suspension geometry to evaluation criterion related to practical operation situations, and then organize an optimization problem by selecting a mathematically operational part from the whole design problem. Finally, we show that the optimal design solutions can be obtained by means of a genetic algorithm based optimization calculation, since the formulation results to a large-scale multi objective constrained optimization problem. Besides, a sequence of these procedures must be applicable to other design problems as an effective methodology as well as the design problem of a multi-link suspension system, when considering that various mechanical systems have become complicated to have high levels of functions. [2]

Multi-Link Suspension System And Its Design Problem

The reason why multi-link suspension systems are introduced mainly for high-grade cars is the high degree of design freedom for various function items. The essential difference between design problems for simple systems and ones for complicated systems is that in the former cases the mapping from design items to function items is relatively independent and it is possible to separately determine respective items, and that in the latter cases the interactions between all items are complicated as well as their structure and configuration and the trade-off among function items is not straightforward. This tendency seems to have become more obvious under the up-to-date technologies that try to condense more functions into a certain size of a system.

The above context can be found in the design problem of multi-link suspension systems used in automobiles. The fundamental functions of an automobile are to run straight, to turn and stop, and to run on both good and bad roads. That is, they consist of various operation modes. While there are a variety of suspension types, their performance depends on both the selection of their types and the judgment of their component link sizes. When focusing on a specific operation mode, the suspension geometry of simple types can be relatively easily determined to be ideal, since the relationship between link sizes and the specific function is straightforward. However, it is necessary to introduce complicated suspension types for realizing totally superior performance against all operation, and the corresponding design problem of suspension geometry is not so easy due to the aforementioned nature of complicated systems design. [4]
Under these points, the multi-link suspension system that this paper is going to discuss is principally a parallel four-bar universal linkage. It is generally impossible to understand the immediate relationships between link sizes and respective function items. So, the conventional design situation requires many times of try-and-errors for finding a superior design solution. If the design problem can be mathematically formulated and the optimization algorithm suitable for its characteristics is organized, such a design method can be effective.

II. DESIGN CONSIDERATIONS

The first problem with building a four-link is that how long they should be and where they should be attached to the frame and axle. Material was an important factor and concern for strength and safety.

2.1 Stepwise Multi link Mounting Arrangement diagram
2.1.1 Step-1

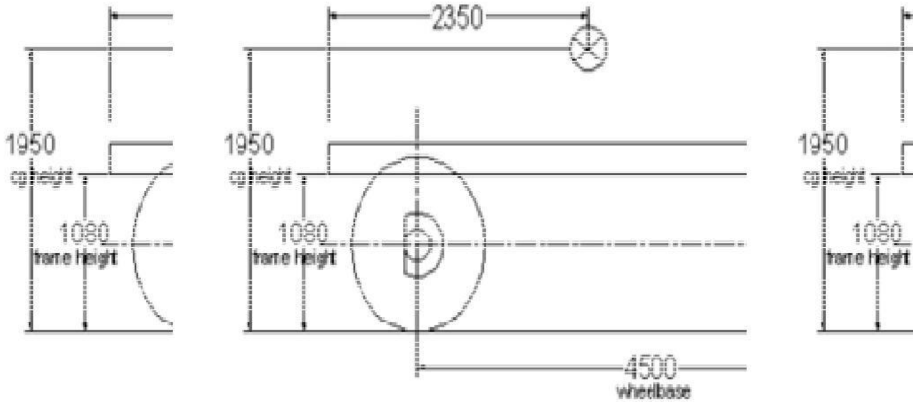

Fig.1 –Diagram for basic chassis dimensions

The first step in building a four-link consist of taking dimensions from Workshop Maintenance manual for "stallion 4x4 mark ш" and constructing diagram in CAD. By using this figured out, the axle centre line points on the bottom half were located, where the frame should sit above the axle. The centre of gravity of the sprung weight was located. [1]

2.1.2 Step-2

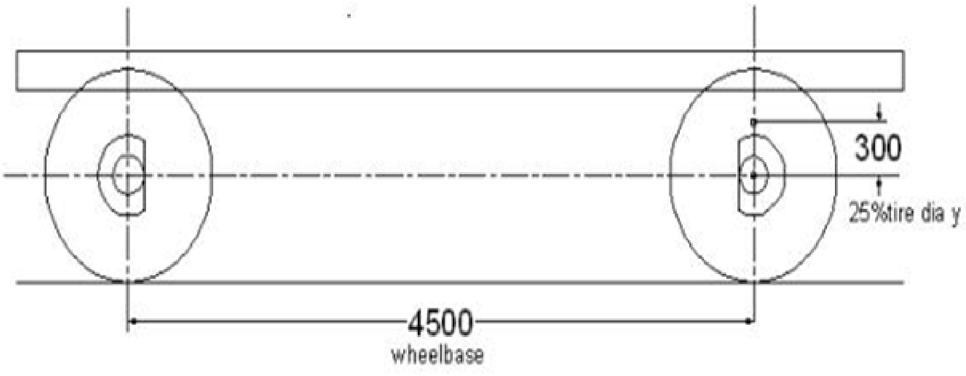

Fig .2 –locating point for upper link axle

The second step is locating point above the front centre of the rear axle-tube at 25% of tire diameter this point is known as upper link axle. [1]

2.1.3 Step-3

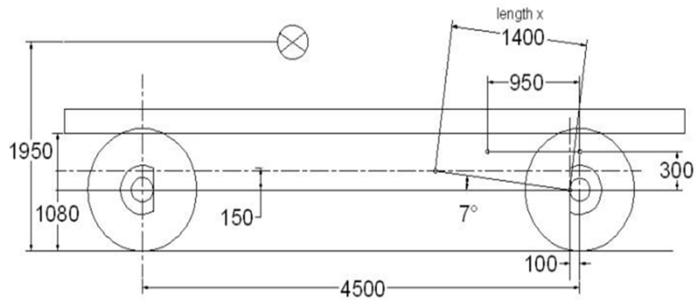

Fig.3 – Locating upper link and lower link

The third step in the process is marking a horizontal line at a distance of 50% of tire diameter (y). Now, considering lower link axle as center, an arc is drawn at a distance of lower link length. The intersection point of horizontal line and arc is called as lower link frame. Now the lower link is constructed between lower link axle and lower link frame. Now draw a horizontal upper link of length which is 70% of lower link length. It is drawn from the point upper link axle. [1]

2.1.4 Step-4

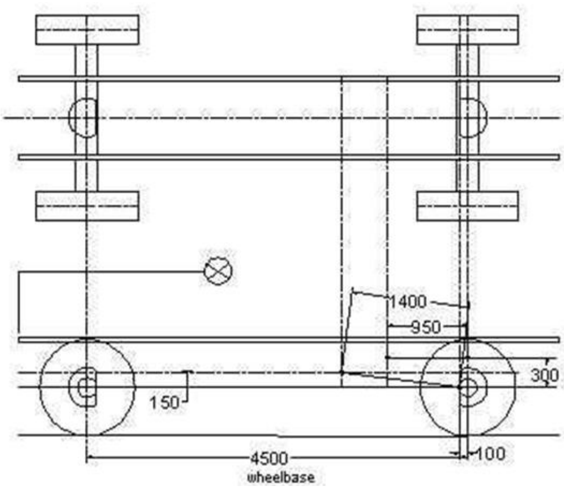

Fig. 4 – Projecting upper link and lower link in top view

Now the ends of the links are projected in top view from the side view. This is the fourth step.[1]

2.1.5 Step-5

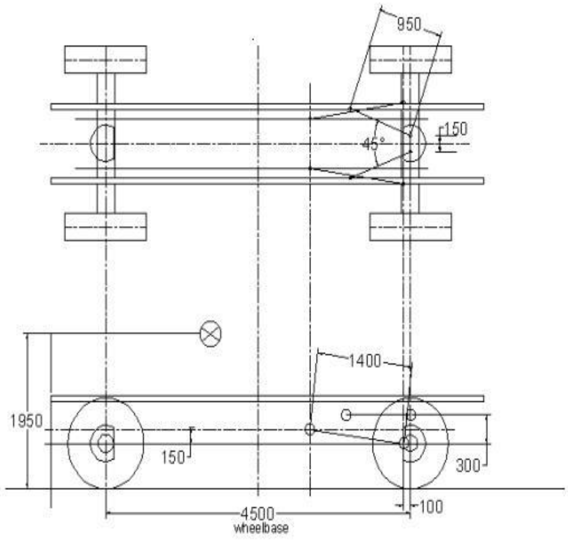

Fig. 5 –Locating angle between two upper links

Locating the upper links first, the angle between two upper links is 45 degrees. This angle locates axle, laterally or side to side. [1]

2.1.6 Step-6

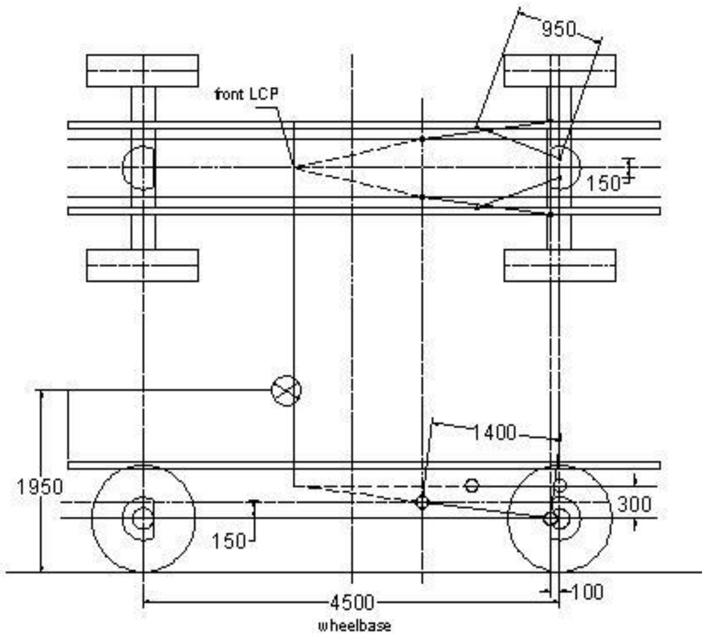

Fig. 6 – Locating lateral constraint point in top view

Extending lines from the links they converge, when viewed from the top of the vehicle. These convergence points are known as the lateral constraint points (LCP). This is the sixth step. [1]

2.1.7 Step-7

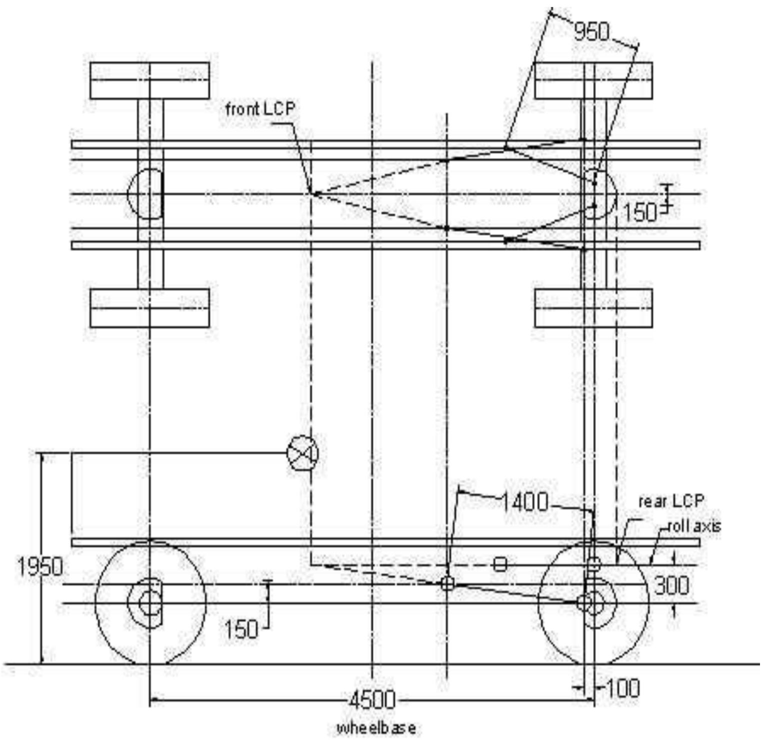

Fig. 7 – Locating the roll axis

A vertical line is projected down from the LCPs to the side view drawing. The links are extended so as to get an intersection point. This intersection point is joined with the LCPs. Now this line is called as roll axis. [1]

2.1.8 Step-8

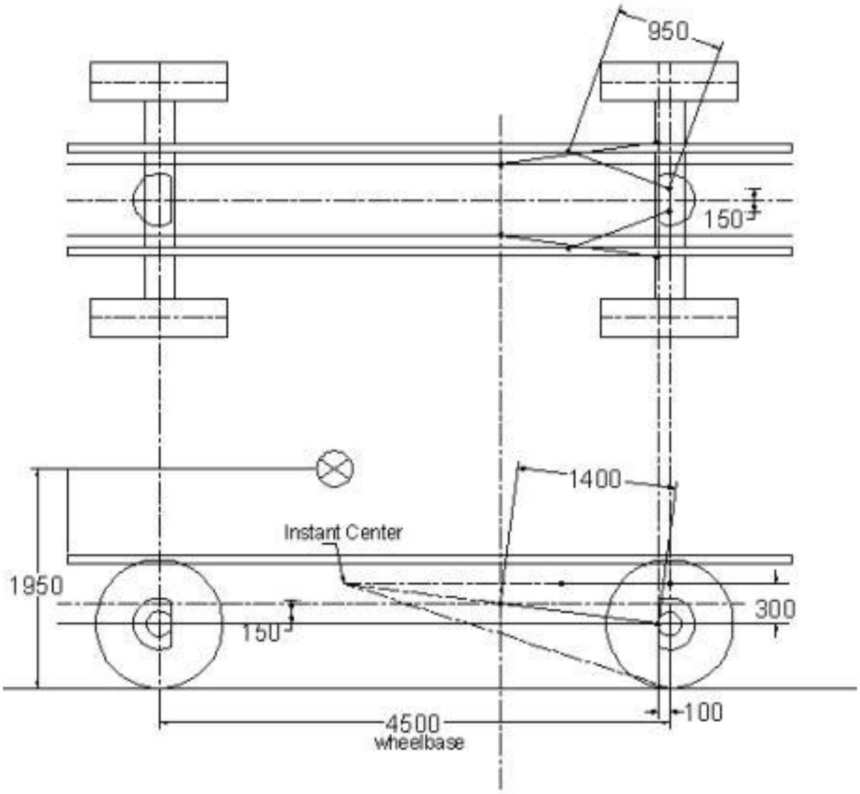

Fig. 8– Locating point for instant centre

Extend line from upper link frame and lower link frame. These lines meet at a point called instant centre. [1]

III. MATERIAL SELECTION

There are various tubing materials like A-53 pipe, Chromium- molybdenum steel and aluminium. The below given table gives the material list required to design the proposed system.

Table 1-Material List

	Carbon Steels
10xx	Plain Carbon (Mn 1.00% max)
11xx	Resulfurized
12xx	Resulfurized and Rephosphorized
15xx	Plain Carbon (Mn 1.00% to 1.65%)
	Manganese Steels
13xx	Mn 1.75%
	Nickel Steels
23xx	Ni 3.50%
25xx	Ni 5.00%
	Nickel-Chromium Steels
31xx	Ni 1.25%, Cr 0.65% or 0.80%
32xx	Ni 1.25%, Cr 1.07%
33xx	Ni 3.50%, Cr 1.50% or 1.57%
34xx	Ni 3.00%, Cr 0.77%
	Molybdenum Steels
40xx	Mo 0.20% or 0.25%
44xx	Mo 0.40% or 0.52%
	Chromium-Molybdenum (Chromoly) Steels
41xx	**Cr 0.50% or 0.80% or 0.95%, Mo 0.12% or 0.20% or 0.25 % or**
	Nickel-Chromium-Molybdenum Steels
43xx	Ni 1.82%, Cr 0.50% or 0.80%, Mo 0.25%

From the above material list the Chromium-Molybdenum steel is selected. Because, it is high tensile strength 620-650 MPa in the normalized condition and malleability. It is also easily welded and is considerably stronger and more durable than standard steel.

IV. EQUATIONS AND CALCULATIONS

4.1 Input

Table 2 –Input Dimensions

S. No	Description	Symbol	Value
1	Rear axle weight	W	3102.5 Kg
2	Length of link	L	1150mm
3	Outside diameter	OD	63.5mm
4	Thickness	Th	12.7mm
5	Inside Diameter	ID	38.1mm

CALCULATIONS

4.2 MOMENT OF INERTIA

$$M.I = \frac{\pi}{64} \times (D^4 - d^4)$$
$$= \frac{\pi}{64} \times (63.5^4 - 38.1^4)$$
$$= 804.887 \times 10^3 \, mm^4$$

4.3 SECTION MODULUS

$$Z = \frac{\pi}{32} \times \frac{(D^4 - d^4)}{D}$$
$$= \frac{\pi}{32} \times \frac{(63.5^4 - 38.1^4)}{63.5}$$
$$= 2.1868 \times 10^4 \, mm^3$$

4.4 STRESS

$$Stress = \frac{WL}{4Z}$$
$$= \frac{310.25 \times 1150 \times 9.81}{4 \times 21868.54}$$
$$= 400.128 \, N/mm^2$$

From the above calculations the following parameters are selected.

Sr.No.	Description	Symbol	Value
1	Outside diameter	OD	63.5 mm
2	Thickness	Th	12.7 mm
3	Inside diameter	ID	38.1 mm
4	Weight	W	31025 kg
5	Length	L	1150 mm
6	Moment of inertia	M.I.	804887.5 mm^4
7	Section modulus	Z	21868.54 mm^3
8	Stress	σ	400.128 N/ mm^2

V. CONCLUSIONS

High performance on rough terrain can be provided using this configuration. In spite of the demand of increased driver comfort and better vehicle performance, so far, independent suspension system has not been used for heavy vehicle. The objective of this master's thesis is to develop a new multi-link suspension suitable for the heavy vehicle. Four research areas mounting point of multi-link are addressed in the thesis: when calculating mounting point angle between the link is to be considered and roll center play very important roll to find out the arrangement in this paper calculating the arrangement of multi-link on basis on schematic dig, and also calculate the stress, moment of inertia, section modules on the basis of input dimension. New design tools are developed to design the suspension kinematics. The use of numerical optimization techniques makes it possible to design superior kinematics even with the tight space boundaries, especially on the rear.

REFERENCES

[1]. VRDE/WV/RSS/DR/807-design report on four link suspension
[2]. Timoney, E.P., Timoney, S.S., Timoney, S.G., "Heavy vehicle independent suspension", Proceedings of the IMechE, "Advanced suspensions", C434/88, 1988-9, p 125-133.
[3]. Jagirdar, V.V., Pandurengan, D., "Development of Double wishbone independent suspension system for a military truck", Symposium on International Automotive Technology SIAT-2009 Reference Technical Bulletin.Prior, Gary M., "The use of multi-body systems analysis in the design and analysis of vehicle suspension systems", SAE 921463, 1992.
[4]. Dynamic Analysis of Four link Suspension by Duygu GÜLER inJuly 2006
[5]. Kami, Y., Minikawa, M., "four link suspension for Honda Prelude", SAE 841186, 1984.
[6]. Murakami, T., Uno, T., Iwasaki, H., Naguchi, H., "Development of a new multi-link front suspension", SAE 890179, 1989.
[7]. Shim, T and Velusamy, P. C., Suspension Design and Dynamic Analysis of a Lightweight Vehicle, Int. J. Vehicle Design, Vol. 43, Nos 1-4, 2007.
[8]. Gillespie, T. D., Fundamentals of Vehicle Dynamics, SAE, 1992.
[9]. J.Reimpell, H.Stoll, J.W. Betzler "Automotive Chasis".
[10]. SAE spring design manual.
[11]. IS Standard of spring.
[12]. Workshop maintenance manual of "Stallion 4x4 Mark III (Ashok Leyland)".
[13]. R. B. Patil "Design of M/C Elements".
[14]. Kripalsingvol-I & II.
[15]. Adanms car reference guide.
[16]. Chaitanya Kuber, "Modelling Simulation and Control of An Active Suspension System" International Journal of Mechanical Engineering & Technology (IJMET), Volume 5, Issue 11, 2014, pp. 66 - 75, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.
[17]. Alok Kumar Pandey and Dr R. P. Sharma, "Simulation of Eight Wheeled Rocker Bogie Suspension System Using Matlab" International Journal of Mechanical Engineering & Technology (IJMET), Volume 4, Issue 2, 2013, pp. 436 - 443, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.
[18]. Nitin H. Ambhore, Shyamsundar D. Hivarale and Dr. D. R. Pangavhane, "A Comparative Study of Parametric Models of Magnetorheological Fluid Suspension Dampers" International Journal of Mechanical Engineering & Technology (IJMET), Volume 4, Issue 1, 2013, pp. 222 - 232, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.