# Design and Development of Suspension of A Supra Vehicle

Tejas.A.Dhake[1], Sanket.S.Dhumal[2], Prathamesh Patil[3], Amit Mane[4], Prof. Sujit.S.Patil[5]
[1,2,3,4,5] *Zeal College of Engineering And Research, Narhe, Pune*

***Abstract-*** **In this paper, our main emphasis is on providing various aspects which are required in the design of suspension system. This paper consists of information about the evolution of suspension system. Basic terminologies required such as toe angle, camber angle, caster angle etc. This paper also includes kinematic and dynamic analysis of a suspension system with a detailed design procedure and analysis of the components using CAE software such as Ansys for further optimization.**

## I. INTRODUCTION

Suspension System is very important component of any vehicle as it should keep continuous contact between the tire with the road. Suspension system performs as dual purpose they especially provide to the vehicle's road handling and braking for proper safety. Different forms of vehicles applications involve different forms of suspensions system. For e.g., very heavy weight were required for early stage coaches of a simple form of suspension, as the core of the structure wrought iron beams were acting and the two wheels at any the front or the rear in need of on each other. However, recent passenger vehicles prefers independent suspension system for better drive comfort. The suspension systems can be categorized into:

A. Dependent Suspension Systems:
In this category of suspension system the lateral movement as well as the forces of any one wheel is transferred to the another wheel. Examples are Watt's Linkage, Leaf Spring Suspension, etc.

B. Independent Suspension Systems:
This category of suspension system there is no effect on other wheel lateral movement which is on similar axis, in the front or the rear. This increases resistance to vibrations and it also provides more space for the engine. This type of suspension system is mainly used in cars and light vehicles. Examples are MacPherson Strut, Double Wishbone and Trailing Arm etc.
In future, there are many new suspension technologies which can be actualized such as Dynamic bend tilting. Magnetic damper and Hydraulic move control.

## II. THEORY

"SUSPENSION DESIGN AND COMPONENTS"
This paper significance is on providing suspension terminologies and various suspension components which are used in the suspension system.
The basic terminologies used in suspension system are-
•Castor angle
Caster angle defined as the angle made by the steering's pivot point from the front to rear of the vehicle

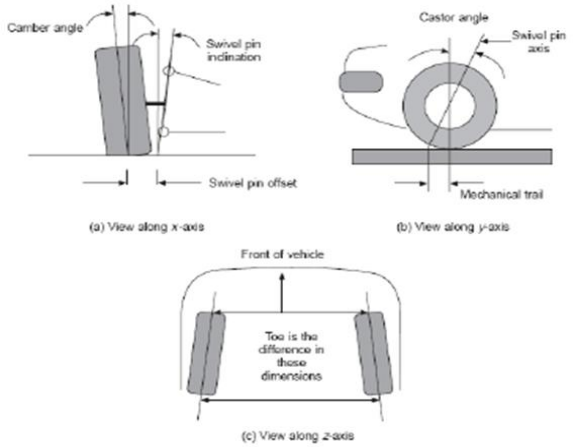
•Toe-in and Toe-out
Toe-in (Positive toe) is the front of the wheel point towards of the vehicle. Toe out (Negative toe), is the front of the wheel point away from center of automobile.

•Camber angle
Camber angle is the inclination between the vertical axis of the wheels and the vertical axis of the vehicle when it seen from the front or rear. It is known as camber angle.

•Swivel pin (kingpin) inclination
It is the inclination concerning the swivel pin axis to the vertical is known as kingpin inclination.

•Swivel pin (kingpin) offset

It is the distance between ground level and the intersection of the swivel pin axis to center of the tire contact spot.




Spring:

Spring is necessary component of all vehicles. The spring retaining the correct riding height while absorbing the shock forces. The increased effect of shock damage the vehicles handling the amount of deflection showed under a particular load.

Shock Absorber:

Shock absorber controls the movement in automobile. If not restrained, spring keeps escalating and shrinking after a shock until all the energy is engrossed. The Shock absorber can be inclined or vertically mounted.

Ball Joint:

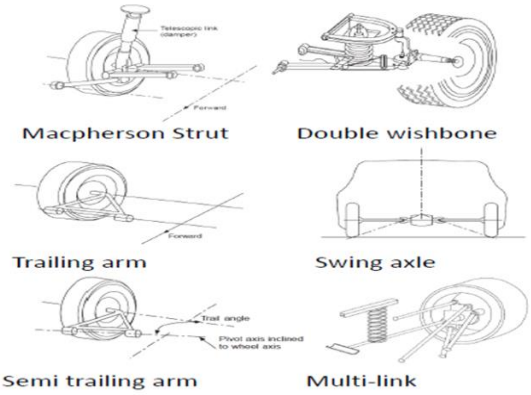
Ball joints that connecting the steering knuckles to the control arms, during steering it permits swivelling on the control arm. The ball joint is a pivot between the wheels and the suspension system of a vehicle. In most vehicles, in the front suspension, there are upper and lower ball joints on both sides. It also allows turbulent motion of control arm as the suspension interrelate to road environments.

Bump Stop:

The Bump stop is situated on the lower arm and it keeps away the contact of the arm with the framework while the vehicle moves upward (jounce) and downward (rebound) direction.

This paper also includes information about various types of independent suspension as follows-

1. Macpherson Strut
2. Double wishbone
3. Trailing Arm
4. Multi-link




## III. DESIGN

For selecting the suspension system the design procedure is as follow:

- Design and Improvement of several modules of the suspension
- Study dynamic aspect
- Adjust design constraints
- Statistical testing
- Dynamic testing
- Adjusting the design of component grounded on Dynamic Testing outcomes

The part for designing are-

- A-arms or wishbones
- Spring

There is a primary deliberation required for scheming of different modules of suspension system of vehicle, parameters specified by SAE Rulebook.[1]

Design of independent suspension system of non equal, non-parallel, double wishbone upper H arm suspension, with bell crank lever and pull rod connected to damper to the chassis in the front suspension and a pushrod connected to the damper for rear suspension and double wishbone with bell crank lever. [3][4]

Design of front suspension

In the design of front suspension were used of unequal Double Wishbone of A-arms with Pushrod suspension system. Bell crank Assembly type of suspension was used with the modified rocker arm.

The kinematic design procedure followed by vibration analysis.[8]

Design of Rear Suspension

For designing of the rear suspension it should be rigid enough to provide a greater amount of stiffness to wheel travel otherwise it may generate problems for transmitting power to the wheel from the gearbox. To join all these necessary requirements for the suspension was directly join to the upper A-arm.

The stiffness of spring is calculated by dynamic analysis and the quarter car model provides the damping ratio.

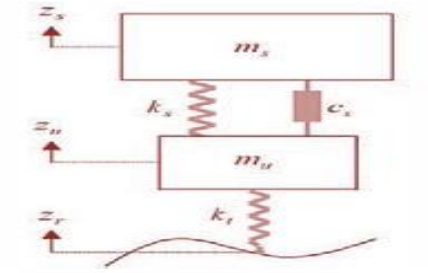
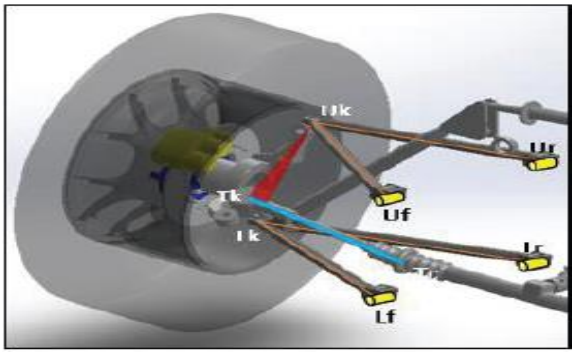



Fig –Quarter car model

In the first phase of the design, the procedure consists of finding the mounting point coordinates and measurements of arms.

The maximum loads and spring stiffness were calculated by performing dynamic analysis of wheel and A-arm.




Design of Spring

The above calculated stiffness was further used in the design of spring which consist of the following formulas.

| |
|---|
| Pm=1/2(Pmx + Pmn) |
| Pa=1/2(Pmx – Pmn) |
| τm=ksc(8PmDo/πd3) |
| τa=k(8PaDo/πd3) |
| Cs = Do/Di |
| ksc = 1+ 0.5/Cs |
| k=(4Cs−1/4Cs−4)+(0.615/Cs) |
| Sse′= 0.22Sut |
| Ssy = 0.45Sut. |
| Ta/[(Ssy/fs)−τm]=Sse′/(2Ssy−Sse′) |
| $N=Gd^4/8D^3K$ |

Where, Pmx=Maximum Force and Pmn=Minimum forces k and ksc are constants, Cs is spring index

Do and Di are outer and inner diameters.

## IV. ANALYSIS RESULTS

A Dual Wishbone Pushrod Actuation Suspension System

The dual wishbone pushrod actuation suspension system of supra SAE India of the vehicle was optimized through FEA by using ANSYS software as an analysis tool. [9] The objective of this research was to analyze the vehicle in terms of component load and stress.

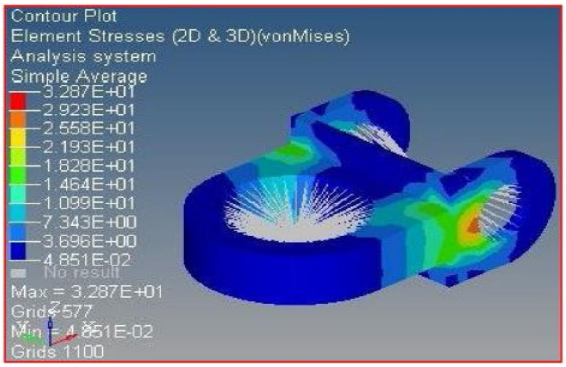



Fig –Wishbone mounting analyses result

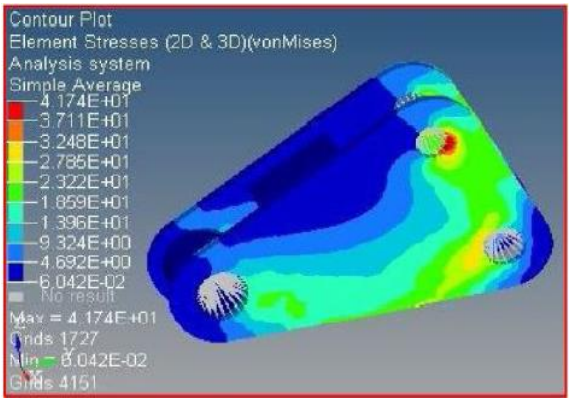



Fig –Rocker arm analyses result

A quarter vehicle using a front wheel drive for typical double wishbone suspension systemusing multi-body simulation system (MBS) also with computer-aided design and analysis environment (CAD &CAE).

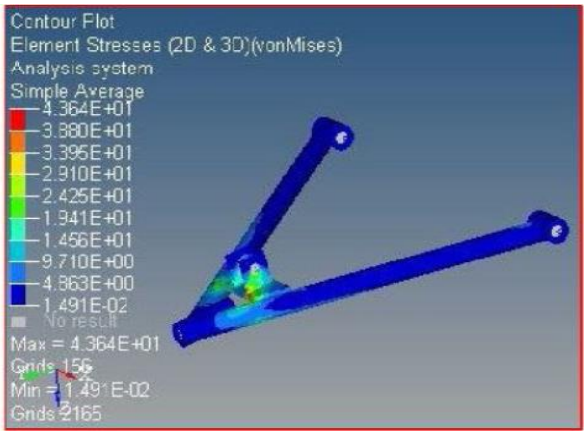



Fig –Double wishbone analysis result

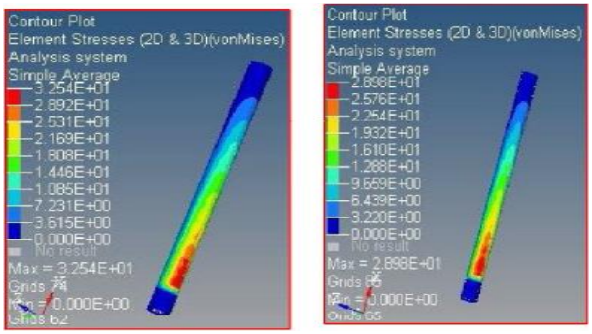



Fig –Push rod analysis result

The results of the stress analysis allows further improvement in design of the individual components.

## V. CONCLUSION

In this paper, we have covered basic aspects required in designing a suspension system of a supra SAE vehicle such as the evolution of suspension, its basic terminologies and components, design procedure and analysis using the software

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