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Suspension Damper Light Weighting by Optimizing Suspension Hard Points

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***Abstract*—Now-a-days weight reduction is one of the most important topics in automotive industry due to stringent emission norms. Also, by optimizing design, weight reduction can be achieved along with reduction in cost and without affecting performance. In this paper weight reduction using hard point optimization is worked for suspension systems.**

Weight reduction is divided in two approaches. First approach elaborates on methods to identify the proper load paths for load transfers. Second approach elaborates on optimization of hard points to reduce loads transfer from wheel to tire.

Finally optimized hard points is proposed which summarizes on % side load reduction, also this reduces the weight of knuckle a-arm.

***Index Terms*—Side load, VAVE, Knuckle optimization, cost reduction, weight optimization.**

I. INTRODUCTION

Automobiles today are concentrating on safety, fuel economy, design, comfort, zero emission, dynamics, connected and autonomous cars. Because of which active safety is now becoming the major priority for all the OEMs which increases the strength of chassis hence weight of the overall vehicle increases.

This offers new challenge for designer to optimized the components which can withstand this higher loads and at the same time should it be light weight. Various ways are iterated to optimized the weight of struts, however very few effective solution can be able to meet cost, weights and durability targets.

This research paper explains about the methodology through which weight of the front struts can be reduced by optimizing the hardpoints of the suspension geometry.

First approach, in this paper, we refer identification of load paths. In which we have evaluated the loads coming from road surfaces to strut top point. Second approach, in this paper, refer as hard point optimization. Which explains the opportunity to reduce the side loads using load paths optimization.

Scope of this paper is lightweight of struts assembly and its child parts. Case study is presented for strut.

II. RESEARCH METHODOLOGY

Below are the components considered for light weighing the strut.

- Hard points
- Load paths
- Side loads
- Knuckle

Hard points are sensitive to the suspension parameters. Those are the junction points of all the linkages at which forces and moments are evaluated. Based on the suspension architecture, packaging requirement and component placements hard points are placed.

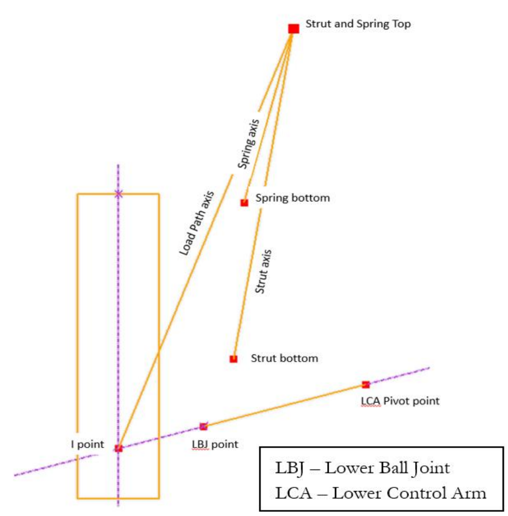

Figure 1: Load path diagram

It contributes mainly into the kinematics and wheel transverse motion. With this we can analyze the various factors like toe change, camber change to optimized the suspension geometry. Load paths are the output of hard points. During the virtual simulation, load coming from the road surfaces are transfers via the load paths and recorded at the hard points. Basis the component design is carried out. This paper mainly focuses on to reduce the loads coming on the various points of strut for which hard point optimization study carried out.

To understand the detail theory of the loads coming from road surfaces during vehicle running condition those are transfer via load paths. To understand the load paths, following diagram is made. This diagram consists of wheel, front strut, and lower control arm.

The Loads and angles on damper are shown in below image.

A. Data Aquiations

At frist, side loads coming on the struts were measured at standard track recipes. Both static and dynamic conditions were examined with current suspension hardpoints setups.

Set of strain gauged mounted and calibrated dampers were used in conjuction with various accelerometers and sensors to collect the side load data.

B. Calibration and Optimization

Collected data then calibrated with numerical calculations and co-relation was established (refer Table: 1).

Calculated Side load (kg)	Measured Side load (kg)
261	247

Table 1: Sideload values.

For optimizations suspension hardpoints changed and side loads recorded at each iterations. It is observed that strut hardpoints were sensitive to the amount of side loads.

C. Validation

Based on the optimized hardpoints, samples were prepared and side load measurement activity conducted. It is observed that calculated and experimentally measured side loads were following the co-relation which was established earlier.

III. CALCULATION AND OPTIMIZATIONS

To calculate the side loads, below equation referred.

$$A=[(\cos p/\cos q)*(x/y)]$$

$$B=\{[\sin(q-p))/\cos q]*[(z/y)+1]\}$$

$$P_{rg}= Ps*A*B$$

Where:

Prg referred as side load coming on rod guide point of strut.

Spring angle is denoted by q

Load axis angle denoted by p

Z and Y are the distance from strut top to rod guide center and rod guide center to piston center respectively.

Because of the strut inclination angle, suspension architecture and wheel motion, spring absorbs some loads and remaining loads converted as side loads. And these loads create bending moment on piston rod. To reduce the side loads generated on piston rod, spring need to absorb maximum amount of force which will reduce the amount of side load generated. To achieve this side geometry has been optimized.

IV. RESULTS AND DISCUSSION

Detail comparison side loads coming on rod guide before and after hard point optimization are shown in (Table 2).

Case	Before hard point optimization	After hard point optimization
Side load (kg)	247	111
Weight (kg)	7.4	6.9

Table 2: Sideload values before and after optimization.

V. CONCLUSION

Hard points are the sensitive parameters for side load reductions. In this research paper the attempt is made to reduce the side load by optimizing hard point and based on that theory has been developed. *

* Detail theory of this paper cannot be published due to confidential reasons.

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