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Method of assessing Bump steer and Brake steer, and Accomplishing Link with ADAMS

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Abstract: This paper proposes an effective method with simple technique, to evaluate bump steer and brake steer using ADAMS analysis, Vehicle drift has been reviewed. The Suspension and steering system is to be modelled using Kinematic software ADAMS and analysed for bump and brake steer. The Same characteristics are to be derived experimentally by testing on actual prototype. These characteristics are dependent on number of parameters, which can be optimized by ADAMS. It saves actual design, development, testing cost and time. The focus of project is to optimize only steering linkages and hard points to avoid major changes in adjacent Carryover aggregates such as suspension, axles etc. The New development of adjacent Aggregates is costly and time consuming. The different steering linkage concepts are to be proposed within available packaging Constraints and best suitable concept is to be optimized using ADAMS

Keywords: ADAMS, BUMP STEER, BRAKE STEER, FLOAT, DRIFT

I. INTRODUCTION

The vehicle should able to travel along a straight line with no external driver inputs is Importance for safe driving. The straight line path of vehicle should be maintained during bump, braking events. Deviation of vehicle from straight line during braking is known as Brake Steer while during bump is known as Bump Steer. Refer figure 1.1 for deviation of vehicle from straight line path. In such an event, driver needs to apply constant corrective steering to maintain straight-line path. It leads to driver fatigue Vehicle drifting during braking to one side is observed on one of off-road vehicle. It is related to steering characteristics such as bump and brake steer. The Vehicle needs to be analysed for same. Design optimization of steering system is to be done to reduce vehicleFLOAT[1]

II. OBJECTIVE

The Objective of the project is to find bump and brake steer present in the vehicle on which drifting concern is identified using ADAMS and correlate same with Experimental Results. Design optimization of steering system hard points id to be done in available packaging constraints using ADAMS to reduce bump and break steer which will reduce vehicle driftfrom the surface making the component redundant from the surface.

III.METHODOLOGY

The Literature available on steering system, bump and brake steer, Vehicle drift has beenreviewed. The Suspension and steering system is to be modelled using Kinematic software ADAMS and analysed for bump and brake steer. The Same characteristics areto be derived experimentally by testing on actual prototype. These characteristics are dependent on number of parameters, which can be optimized by ADAMS. It saves actual design, development, testing cost and time. The focus of project is to optimise only steering linkages and hard points to avoid major changes in adjacentCarryover aggregates such as suspension, axles etc. The New development of adjacent Aggregates is costly and time consuming. The different steering linkage concepts are to be proposed within available packagingConstraints and best suitable concept is to be optimised using ADAMSThe Literature available on steering system, bump and brake steer, Vehicle drift has beenreviewed. The Suspension and steering system is to be modelled using Kinematicsoftware ADAMS and analysed for bump and brake steer. The Same characteristics areto be derived experimentally by testing on actual prototype. These characteristics are dependent on number of parameters, which can be optimized by ADAMS. It saves actual design, development, testing cost and time. The focus of project is to optimise only steering linkages and hard points to avoid major changes in adjacentCarryover aggregates such as suspension, axles etc. The New development of adjacent Aggregates is costly and time consuming. The different steering linkage concepts are to be proposed within available packagingConstraints and best suitable concept is to be optimised using ADAMS

IV.MOTIVATION

The Vehicle handling plays an important role. It depends on number of parametersrelated to different aggregates. The finding exact root cause is always complex with lotsof iterations. The advent of Multi body system software's such as ADAMS can be used tosimulate actual vehicle virtual thus saving development time, cost. Reduced development time and cost always gives advantage in this

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competitive world.The vehicle under analysis can be modelled using ADAMS and optimised to reduceBump and Brake steer

Bump steer:

1. Occurs as pitman arm ball joint does not coincide Ideal center
2. Ideal center is center of arc of leaf spring as it deflects

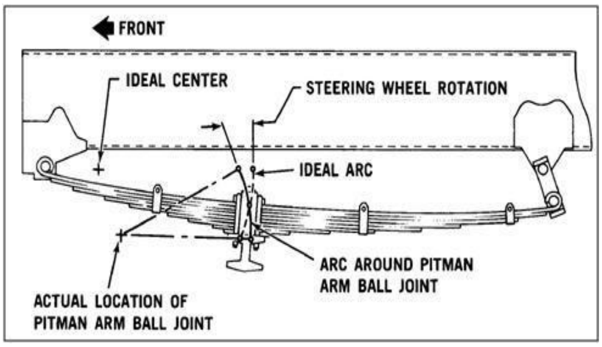

Fig.1 Bump steer phenomenon[3]

Brake Steer

1. Occurs during braking event
2. Springs winds up due to braking torque
3. Occurs as steering arm ball joint does not coincide with center of rotation

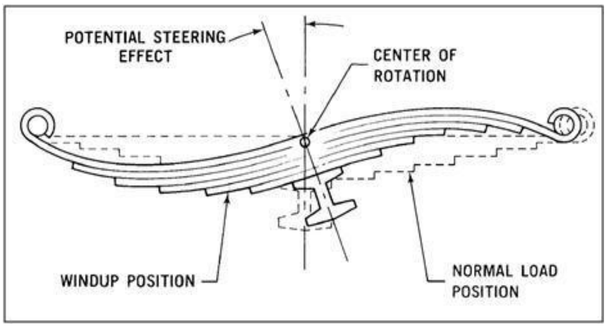

Fig.2 Brake steer phenomenon[3]

V. MODELLING AND ANALYSIS OF VECHICLE

The Vehicle front end which consists of aggregates such as steering, suspension, tires, axles is modeled in ADAMS.

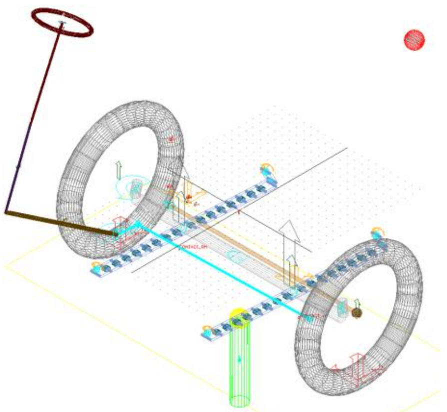

Fig 3 – ADAMS model for Optimized Steering Linkages

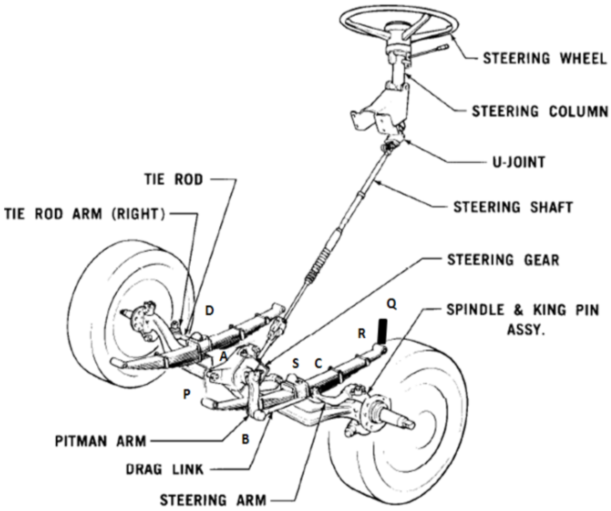

Fig.4 Typical Steering system and hard points [3]

A. The brief Vehicle specifications

Parameter	Details
GVW, Kg	4600
Front Axle Weight, kg	2200
Front Track, m	1.8
Wheel Base, m	3
Steering	Recirculation ball type
	Inner: 36º , Outer:25º
Suspension	Leaf Spring suspension
Tire	Radial Tire
SLR	430
Axel	Rigid axle
Brakes	Disc Brakes at front and rear

Table I Brief Vehicle Specifications

Hard points with description,
A = Pitman arm gear box
B = Pitman arm drag link Ball Joint
C = Drag link Steering arm Ball Joint
D = Tie Rod arm Tie rod Ball Joint

Height of CG from ground, mm =900
Deceleration value, g =0.7
Static loaded radius, mm =420
Weight transfer to front axle,
Weight transfer to front axle

$$= \frac{Deceleration * Height\ of\ CG * GVW}{Wheelbase}$$

$$= \frac{0.7 * 900 * 4600}{2900}$$

=999.3 Kg

Weight transfer to each tyr

$$= \frac{Weight\ transfer\ to\ front\ axle}{2}$$

=499.6 Kg

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Now,
Total Weight on each front tyre=
Weight transfer to each tyre+ FAW/2

=499.6 + 2150\2

=1574.6Kg
Brake Torque per wheel = Decelleration ∗ Total Weight on each front tyre∗ SLR/1000
=0.7∗1574.6∗430/1000
=473.9 Kg

VI. SIMULATION OF VECHICLE IN ADAMS

The vehicle is then simulated to find brake and bump steer. Typical bump and brake steer graph is as shown in below figure

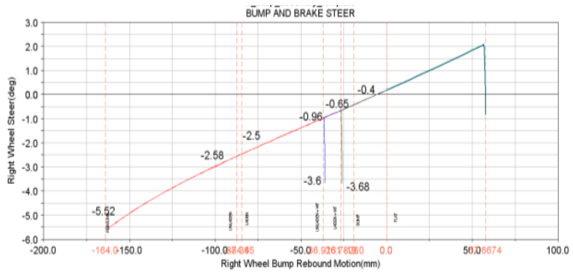

Fig.5 Brake and Bump steer graph

Bump Steer in Laden

$$= \frac{\text{Wheel steer angle in laden} - \text{Wheel steer angle in bump}}{\text{Wheel travel from laden to bump}}$$

$$\text{Bump Steer in Laden} = \frac{-2.5-(-0.4)}{66.7}$$

Bump Steer in Laden=-0.031 min/mm
From Vertical line ordinates,

Brake Steer in Laden=−3.6− (−0.65)
= −3.03 deg

Thus, it is found out that brake steer value is -3.03 deg. Negative sign indicates left side which is too high and not acceptable. Hence new steering linkage concept needs to be optimized.

VII. CONCEPT DESIGN REDUCTION

There are many parameters that affect brake and bump and brake steer. Only steering parameters i.e. hard points which affects are considered. The Steering arm, pitman arm hard point has been varied within vehicle packaging constraints Packaging constraints
As Axle is under slung, it is not possible to take steering arm BJ down towards centre of leaf spring.

All adjacent parts of steering linkages are carryover and developed. Major modification of same will lead to large development cost as well as time which were not accepted. Considering these constraints different concepts has been proposed to reduce brake and bump steer and evaluated using Pugh concept selection technique as below
B. Different concepts of steering linkages proposed
Concept 1: Datum concept
Concept 2: Stg Arm BJ down by 30mm, Pitman arm BJ to front by 30 mm

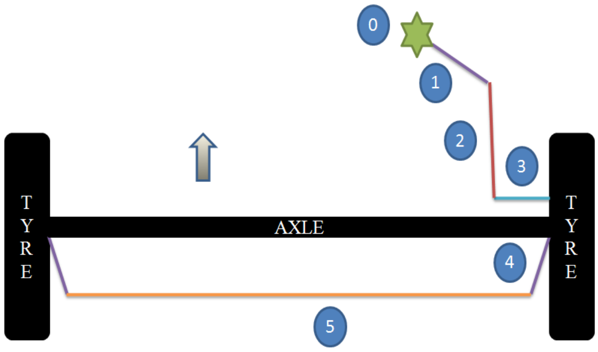

Fig 6 - Concept 1, 2 Steering Linkages

Concept 3: Drag link on tie rod at front

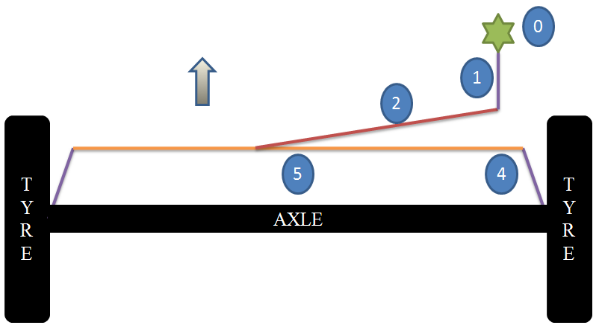

Fig.7 - Concept 3 Steering Linkages

Concept 4: Drag link on left stub axle, Tie rod behind axle

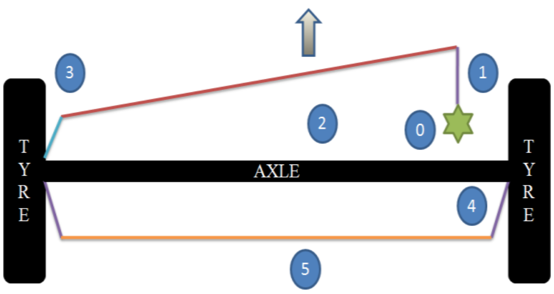

Fig 8 - Concept 4 Steering Linkages

Where,
1: Pitman arm
2: Drag Link
3: Steering Arm
4: Tie Rod Arm
5: Tie Rod & arrow indicates vehicle front.
These different concepts are evaluated using Pugh concept selection matrix as shown in Table III.

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"S" indicates it is same as in Datum concept.
"+" indicates it is better than Datum concept.
"-"indicates it is below the Datum concept.
The Concept 4 i.e. Drag link on left stub axle, Tie rod behind axle is having more overall score hence it is selected for further optimization.

	Parameter	Concept 1	Concept 2	Concept 3	Concept 4
Criteria	Bump Steer	Baseline	S	+	+
	Brake Steer		+	+	+
	Net Effect		+	+	+
	Packaging feasibility		-	+	+
	Carryover components		S	-	S
	Development time		S	-	S
	∑ +		2	4	4
	∑ -		1	2	0
	∑ S		3	0	2

Table II: Pugh concept selection matrix

VIII. OPTIMISATION OF CONCEPT

Concept 4 hard points are optimised to reduce bump and brake steer. The hard points varied are Drag link pitman arm hard point, Drag link stub axle hardpoint. The Final optimised layout is shown in below figure

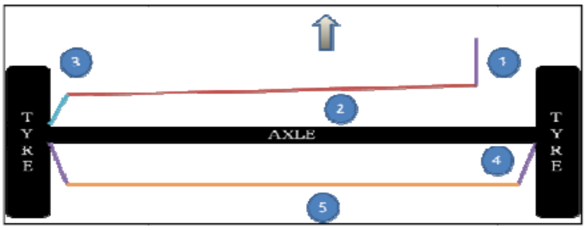

Fig. 9: Optimized Steering Linkages

Different iteration are performed on concept 4 to optimize are Table 4

Parameter	Brake Steer	Bump Steer	Bump Steer (During Braking Event)	Net Effect
Unit	Deg	min / mm	Deg	Deg
Base	0.96	0.07	0.16	1.05
Iteration 1	0.47	0.44	0.78	0.94
Iteration 2	0.23	0.40	0.75	0.77

Table III Steering hard points changes for different iterations

IX. RESULT AND DISCUSSION

The Current vehicle has been modeled in ADAMS for Bump and Brake steer calculation. The net effect of bump and brake steer indicates the vehicle drifting to left side. The subjective assessment of same vehicle is done which also indicates left side pulling. Thus values obtained by ADAMS are in good agreement with subjective assessment of vehicle. As these values were high, which is safety concern, different concepts of steering linkages are prepared. Using Pugh concept selection matrix the best concept considering packaging constraints, maximum carryover parts, brake, bump steer values and development time is selected. The selected steering system linkage concept has been optimized by varying different drag link ball joints. The comparison of existing and optimized steering system design is shown in table IV.

Parameter	Brake Steer	Bump steer	Bump steer (During braking event)	Net Effect
Unit	Deg	min/mm	Deg	Deg
Existing	-3.06	0.93	0.55	-2.40
Optimised	0.33	0.75	0.45	0.72

Table IV: Results Comparison

It can be seen from above table that Bump steer is improved by 25% while Brake steer is improved by 90%. The net effect indicates marginal pulling of vehicle to right side which is acceptable

X. CONCLUSION

In present paper current vehicle steering system has been analysed for bump & brake. The different hard points which affects bump and brake steer have beenstudied. It is found that steering arm and pitman draglink ball joint affects these parameters.

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