Journal of Positive School Psychology
2022, Vol. 6, No. 2, 241 – 247 http://journalppw.com

Mathematical & Dimensional Based Data Model for Steering Mechanism of Face Shock up

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Abstract:

Transportation & Automobile sector is the key of market field. Automobile sector has biggest increasing due changes in customer desire, financial differences, market variation & strategies. Generally numbers of new vehicles have independent face variation, which resins that every face wheel of our vehicle in linked own way to the vehicle chassis. The face wheels must steer and results to the path cover for of vibration top & bottom when either wheel hit through the speed breaker. Vehicle will run bottom on the path in speciously & careful. The result of face spring arrangement of vehicle is depends on the steering construction of the shock up. The steering construction factors are 1] Kingpin θ, 2] Camber θ , 3] Caster θ, 4] Toe θ , 5] Toe in, 6] Toe out, 7] Scrub radius. Here dimensional equation are mathematically depends on the construction of steering can be decided & automobile results found.

Keywords: Steering construction, Formulation, Mathematical model, Vehicle, Face shock up.

[A] Introduction:

The face shock up containing of a rod which is a three Dimensional machine Revolute paired, Spherical, Spherical & Revolute. Steering result based on the exactness of spherical bush located at different points. Steering result based on the situation of kingpin center. Covering on the situation of kingpin center, kingpin θ, caster θ, camber θ, toe θ, & scrub radius of a automobile are fixed. In this article details the steering construction factors e. g. kingpin inclination θ, caster θ, camber θ, toe θ, are found by operating mathematical analysis solved by considering dimensional data.

B] Face Shock up System:

I] Performance of three dimensional Shock up:

Depending on 6 considering thetas of three shock up system, 1 at individual revolute points & 2 at individual spherical points of 4 rod chain, situation of kingpin center is found. Steering result based on the situation of kingpin center. Basing on the situation of kingpin center, caster θ, camber θ, kingpin θ, & toe θ of 4wheel automobile are considered. Situation of kingpin center is finding by mathematical system explain in the article by dimensionless factors available in practically is explain in “Fundamentals of Vehicle Dynamics”, by T. D. Gillespie.

II] Revolute paired, Spherical, Spherical & Revolute System:

Point O1 & O2 are revolute points & point A and B are Spherical points in diagram 1. Relative circulation of 2 rod jointed at point can be considered in factors of magnitudes of included θ which in incline can be counted with the help of potentiometer & operated by electronics equipment. 6 potentiometers are fixed at 4 points 2 spherical & 2 revolute of the Revolute paired Spherical, and Spherical & Revolute System. At revolute points O1 an O2 the 1 considered θ each of these points & at spherical points A and B the 2 considered θ at each of these points is discussed in, “Kinematics Design of Mechanisms”, Suh & Redcliff.

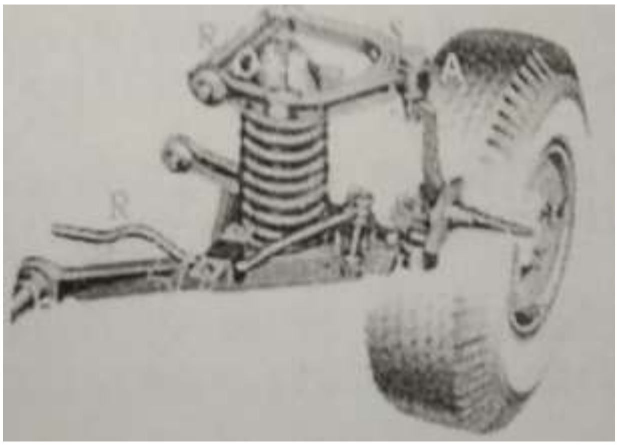

Diagram 1: Face Shock up System

[C] Design of Dimensional Process:

I] Searching of different dimensional quantities affecting on face shock up system.

Independent Variables:

1] Length of Upper Control arm

2] Length of Lower Control arm

3] Length of Knuckle arm

4] Length of Fixed arm

5] Diameter of wheel

6] Mass of wheel

7] Road surface roughness in terms of breaker height

8] Road surface roughness in terms of breaker height

9] Wheel linear velocity

10] Operational time

11] Acceleration due to gravity

12] Clearance at spherical joint

13] Clearance at spherical joint

14] Clearance at spherical joint

15] Clearance at spherical joint

16] Lateral displacement

17] Spindle length

Dependent Variables:

1] Kingpin angle

2] Camber angle

3] Caster angle

4] Toe angle

5] Toe in

6] Toe out

7] Scrub radius

Dimensional Analysis:

S. N.	Explanation	Abbreviation	Unit	Dimension
1	Length of Upper Control arm	Ua	M	L
2	Lower Control arm	La	M	L
3	Length of Knuckle arm	Ka	M	L
4	Length of Fixed arm	Fi	M	L

5	Diameter of wheel	Dw	M	L
6	Mass of wheel	Wt	Kg M/s^2	MLT^{-2}
7	Breaker height	Bh	M	L
8	Breaker height	Bw	M	L
9	Wheel linear velocity	Vt	m/s	LT^{-1}
10	Operational time	T	Sec	T
11	Acceleration due to gravity	g	m/s^2	LT^{-1}
12	Clearance at spherical joint A	Ca	M	L
13	Clearance at spherical joint B	Cb	M	L
14	Clearance at spherical joint O 1	Co1	M	L
15	Clearance at spherical joint O2	Co2	M	L
16	Lateral Displacement	Ld	M	L
17	Spindle length	Sl	M	L
18	Kingpin angle	Kga	Degree	-
19	Camber angle	Cm	Degree	-
20	Caster angle	Ca	Degree	-
21	Toe angle	Ta	Degree	-
22	Toe in	Ti	M	L
23	Toe out	To	M	L
24	Scrub radius	Sr	M	L

Total Independent Variables: 17

Total Dependent Variables: 7

fd_1= f (f_1, f_2, f_3, --f_{17})

fd_2= f (f_1, f_2, f_3, --f_{17})

fd_3= f (f_1, f_2, f_3, --f_{17})

fd_4= f (f_1, f_2, f_3, --f_{17})

fd_5= f (f_1, f_2, f_3, --f_{17})

fd_6= f (f_1, f_2, f_3, --f_{17})

fd_7= f (f_1, f_2, f_3, --f_{17})

Repeating Independent Variables = 17-14=3

S. N.	Repeating Independent Variables	Dimension
1	Ua	L
2	Wt	MLT^{-2}
3	Vt	LT^{-1}

Repeating Variables is 3 in LMT form

Work for Independent:

π 1 term independent variable La

$\pi\ 1 = (Ua)^{a1}(Vt)^{b1}(Wt)^{c1}La$

$M^0L^0T^0 = (L)^{a1}(LT^{-1})^{b1}(MLT^{-2})^{C1}L$

L	M	T
$0=a_1+b_1+c_1+1$	$0=0+0+c_1+0$	$0=0-b_1-2c_1+0$
$a_1=-1$	$c_1=0$	$b_1=0$

$\pi\ 1 = (Ua)^{-1}(Vt)^0(Wt)^0La$

$\pi\ 1 = La/Ua$---(1)

$\pi\ 2 = (Ua)^{a2}(Vt)^{b2}(Wt)^{c2}Ka$

$M^0L^0T^0 = (L)^{a2}(LT^{-1})^{b2}(MLT^{-2})^{C2}L$

L	M	T
$0=a_2+b_2+c_2+1$	$0=0+0+c_2+0$	$0=0-b_2-2c_2+0$
$a_2=-1$	$c_2=0$	$b_2=0$

$\pi\ 2 = (Ua)^{-1}(Vt)^0(Wt)^0Ka$

$\pi\ 2 = Ka/Ua$---(2)

in this way up to π 14 equation generated.

$\pi\ 3 = Fi/Ua$---(3)

$\pi\ 4 = Dw/Ua$---(4)

$\pi\ 5 = Bh/Ua$---(5)

$\pi\ 6 = Bw/Ua$---(6)

$\pi\ 7 = (Vt)t\ /Ua$---(7)

$\pi\ 8 = (Ua)g\ /(Vt)^2$---(8)

$\pi\ 9 = Ca/Ua$---(9)

$\pi\ 10 = Cb/Ua$---(10)

$\pi\ 11 = Co1/Ua$---(11)

$\pi\ 12 = Co2/Ua$---(12)

$\pi\ 13 = Ld/Ua$---(13)

$\pi\ 14 = Sl/Ua$---(14)

Work for Dependent:

πD 1 term independent variable Kga

$\pi D\ 1 = (Ua)^{a1}(Vt)^{b1}(Wt)^{c1}Kga$

$M^0L^0T^0 = (L)^{a1}(LT^{-1})^{b1}(MLT^{-2})^{C1}$

L	M	T
$0=a_1+b_1+c_1+o$	$0=0+0+c_1+0$	$0=0-b_1-2c_1+0$
$a_1=0$	$c_1=0$	$b_1=0$

$\pi D\ 1 = (Ua)^0(Vt)^0(Wt)^0Kga$

$\pi D\ 1 = Kga$---(1a)

Same way solved πD 2, πD 3, πD 4, πD 5, πD 6, πD 7

$\pi D\ 2 = Cm$---(2a)

$\pi D\ 3 = Cs$---(3a)

$\pi D\ 4 = Ta$---(4a)

$\pi D\ 5 = Ti\ /Ua$---(5a)

$\pi D\ 6 = To\ /Ua$---(6a)

$\pi D\ 7 = Sl\ /Ua$---(7a)

II] Reduction of Dimensional Data Based Models:

Therefore, $\pi 1 = [(La*Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]$---------------(15)

$\pi 2 = [(Ua)g/(Vt)^2]$---(16)

$\pi D1 = f(\pi 1, \pi 2)$

III] Formulation of Dimensional Data Based Model:

Kga=f [[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}], [(Ua)g/(Vt)^{2}]]=0

Kga= [[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]* [(Ua)g/(Vt)^{2}]]=0

Cm=[[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]* [(Ua)g/(Vt)^{2}]]=0

Cs= [[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]* [(Ua)g/(Vt)^{2}]]=0

Ta= [[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]* [(Ua)g/(Vt)^{2}]]=0

Ti =Ua [[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]* [(Ua)g/(Vt)^{2}]]=0

To=Ua [[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]* [(Ua)g/(Vt)^{2}]]=0

Sl=Ua [[(La* Ka*Fi*Dw*Bh*Bw*(Vt)t*Ca*Cb*Co1*Co2*Lb*Sl)/Ua^{13}]* [(Ua)g/(Vt)^{2}]]=0

IV] Formulation of Mathematical Model:

$\pi D1=K1*(\pi_1)^{a1}*(\pi_2)^{a2}*(\pi_3)^{a3}$ ----------------------(16a)

$\log_e \pi D1= \log_e K1+a1 \log_e \pi_1+a1 \log_e \pi_2+c1 \log_e \pi_3$

$Z_1=K_1+a_1*A+b_1*B+c_1*C$

$\sum Z_1=nK_1+a_1*\sum A+b_1*\sum B+c_1*\sum C$ -- (17)

$\sum Z_1*A=nK_1\sum A+a_1*\sum A*A+b_1*\sum B*A+c_1*\sum C*A$--- (18)

$\sum Z_1*B=nK_1\sum B+a_1*\sum A*B+b_1*\sum B*B+c_1*\sum C*B$ --- (19)

$\sum Z_1*C=nK_1\sum C+a_1*\sum A*C+b_1*\sum B*C+c_1*\sum C*C$------------------------------------- ----- (20)

$$\begin{pmatrix} Z_1 \\ Z_1A \\ Z_1B \\ Z_1C \end{pmatrix} = \begin{pmatrix} n & A & B & C \\ A & AA & BA & CA \\ B & AB & BB & CB \\ C & AC & BC & CC \end{pmatrix} \begin{pmatrix} K_1 \\ a_1 \\ b_1 \\ c_1 \end{pmatrix}$$

Where, n is the numbers of reading.

[D] Experimental Readings:

S. N.	Explanation	Abbreviation	Experimental Readings
1	Length of Upper Control arm	Ua	
2	Lower Control arm	La	
3	Length of Knuckle arm	Ka	
4	Length of Fixed arm	Fi	
5	Diameter of wheel	Dw	
6	Mass of wheel	Wt	
7	Breaker height	Bh	
8	Breaker height	Bw	
9	Wheel linear velocity	Vt	
10	Operational time	T	
11	Acceleration due to gravity	g	
12	Clearance at spherical joint A	Ca	
13	Clearance at spherical joint B	Cb	

14	Clearance at spherical joint O 1	Co1	
15	Clearance at spherical joint O2	Co2	
16	Lateral Displacement	Ld	
17	Spindle length	Sl	

Sensitivity Analysis: Finding the sensitivity analysis with varying 10 % difference in π_1, π_2

S. N.	Resulted Equation	Dependent Output	S. N.	Resulted Equation	Dependent Output
1	π_1	πD 1	2	π_2	πD 1
		πD 2			πD 2
		πD 3			πD 3
		πD 4			πD 4
		πD 5			πD 5
		πD 6			πD 6
		πD 7			πD 7

[E] Results of Data:

The mathematical dimensional model is formulated. The practically mathematical dimensional modes evaluated for deciding the steering activity. In this activity may not be decided to all the parameters that impact on validation. But decision that they & particular dimensional formula have clear in system may be or not apparent. In the model Indies is showing how system is vibrating due to contact of different independent π equation. Impact of independent parameters over the dependent parameter with the help of dimensional equation is discussed in (16a).

[F] Conclusion:

After solving the matrix in manual or MATLAB software with adding experimental reading, the influence parameter will be obtained. Through the mathematical model dependent π equations is decided. The practically & calculated dependent π equation are clarified by computing mean quantities. One by one inspect the correctness of the dimensional quantities of the dependent π equations, some differences is tasked.

CrediT authorship contribution statement

M. S. Dhande: Formal analysis, Investigation, Writing - review & editing, Supervision. K.S. Zakiuddin: Research work administration, funding information, Resource, Material collection, Concept developing, Methodology, Formal analysis, Main foundation, Invention, Benchmark, Supervise.

Declaration of Competing Interest

The authors declare that they have no computations with other investigator visualizing competing financial interests or personal contact that could have appeared to influence the work informed in this paper.

Acknowledgment

I would like to acknowledge Lokmanya Tilak

Janklyan Shikshan Sanstha for this research work and would like to extend my sincere heart fail gratitude.

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