

Estimation of steering effort at parking condition using MATLAB

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Introduction

- At the parking condition, the driver has to overcome the static friction developed due to tire-rod contact
- The static steering effort to the driver at the steering wheel is function of tire-road contact friction and efficiency of mechanical linkages
- The initial design of steering system and component sizing is function of maximum steering torque observed at parking condition







Introduction



Objective:

- To develop parametric model for the prediction of the steering effort, tie-rod forces and rack forces at parking condition
- To estimate the required motor torque relative to the driver torque for PAS(Park Assisted Steering)
- To develop GUI for better visualisation with multiple options as per steering type





Input parameters

Below details of the steering geometry used in the calculation of the steering effort:

- Suspension parameters
 - Kingpin axis direction & location(coordinates of upper and ≻ lower point on kingpin axis)
- Steering parameters
 - IBJ & OBJ coordinates on tie rod
 - Rack gain/c-factor
 - Max. steering wheel angle
- Tire patch parameters
 - Coordinates of patch center Kingpin Upper Point Dimensions of patch Front axle load IBJ Ζ Friction coefficient OBI Rack Tie Rod Knuckle Kingpin Lower Point fathWorks® **Steering Geometry**

Calculation methodology

Calculation of effort at steering wheel

- Effort at wheel can be represented as sum of static steering torque and gravity aligning torque
- Gravity aligning torgue which is induced due to resistance from vertical tire force is the function of:
 - Kingpin inclination angle
 - Kingpin caster angle
 - > Tire angle
 - Kingpin offset
- Tire-patch friction torque can be given as integral function of :
 - Pressure distribution across the tire-road contact patch
 - Length of arm \geq
 - Coefficient of friction
- The final Steering effort is obtained by the relation:

 $M_{steering} = (M_{Friction} + M_{gravity}).\eta_{mech} .(d\theta_{sw}/d\theta_{tyre})$

Where,

- = Mechanical efficiency of linkages η_{mech}
- = Change in angle of steering wheel dθsw
- $d\theta_{tyre}$ = Change in angle of tyre
- M_{gravity} = Gravity aligning torque

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- The converted mathematical of steering effort calculation is embedded in MATLAB application.
- The embedded application GUI is created in app designer and compiled using MATLAB compiler to generate the .EXE for sharing with designers.

NPUT	
Select Input Excel File	Click Here
Sheet Name	input
Pressure Distribution	
Along Length Unifo	orm 🔻
Along Width Unifo	orm 🔹
Choose Rack Gear Type	Constant Variable
C-factor Sheet Name	C-factor
Steering Type	
Choose Steering Type	Normal Park Assisted

elect Input Excel File	Standard Input Template 4.
	Commenter and a rempirate_4.5
Sheet Name	input
Pressure Distribution	
Along Length	Uniform 🔹
Along Width	Uniform 🔻
C-factor Sheet Name	C-factor
Steering Type	·
Choose Steering Type	Normal Park Assisted
Td vs Tm Sheet Name	Td_Tm





 Steering geometry and tire details are taken as input from a standard EXCEL template.



Steering System Parameters						
Hard Points	X (mm)	Y (mm)	Z(mm)	Parameters	Dimension	Unit
OBJ				Gear Reduction ratio		null
IBJ				Rack Gain/C-Factor		mm/rev
				Maximum Steering Wheel Angle		deg
				Rack Efficiency		null
				thresholdAngle		deg
				Lh side		deg

Input template





- The pressure distribution selection for the modelling of the tire-patch parameters
- The user can select the dimensions across
 - Length & Width
- Pressure distribution type
 - Uniform
 - Linear
 - Square

Select Input Excel File	Standard Input Template_4.
Sheet Name	input
Pressure Distribution	
Along Length	Uniform 🔻
Along Width	Uniform
/ long / long	Linear
	Square
Choose Back Gear Type	
Choose Mack Ocar	Variable
C-factor Sheet Name	C-factor

Pressure distribution selection across length and width





- Selection of the rack gear type based on the steering ratio(c-factor) i.e.
 - Constant & variable
 - The status of the sheet name provided for each of the selection

Pressure Distribution		
Along Length	Uniform	
Along Width	Uniform	
Choose Rack Gear Type Ovariable		
C-factor Sheet Name	C-factor	

Rack gear type selection & name of the sheet name





- Selection of the steering type:
 - Normal
 - Park assisted

INPUT		
Select Input Excel File	Standard Input Template_4.	
Sheet Name	input	
Pressure Distribution		
Along Length	Iniform 👻	
Along Width	Iniform	
Choose Rack Gear Typ	e Constant Variable	
C-factor Sheet Name	C-factor	
Steering Type		
Choose Steering Type Normal Park Assisted 		
Td vs Tm Sheet Name	Td_Tm	

Steering gear type selection





Visualisation for the analysis of the results

- The results plotted in quick response time at the click
- The results plotted in "uixes" against the steering angles for:
 - Steering effort
 - Rack force
 - Motor torque



Steering effort vs Steering angle



Rack force vs Steering angle



Motor torque vs Steering angle





Additional features

Facility to export output excel file in form of excel standard template file

OUTPUT			
Max Algebric Sum of Tierod Force (N)	9950		
Generate Output Excel			
Select Output Excel File	Click Here		
Generate Output Excel			
Export output results			

The status bar to display the status of the calculation to the user

Status	Calculation Finished
	Calculation status

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- The Maximum tie-rod force is correlated with the mathematical results formulated in Matlab and found in good agreement with the test results
- From the below figure, the estimation of maximum steering effort and Rack force can performed





Conclusions



- This tool is useful for the concept level calculation for the maximum steering effort
- Gives the initial estimate at the design stage of steering system
- Useful for multiple projects





QUESTIONS?



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Thank you

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