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Design and analysis of Inclination Angle on Davis steering gear mechanism

J Pavan kumar[1] B Ramakrishna[2] K Sudheer kumar[3]

[1,2]Assistant professor Mahatma Gandhi Institute of Technology Gandipet, HYD-500075, Telangana-India
[3]Assistant professor Vaageswari College of Engineering , Thimmapur, Karimnagar-505481,

Corresponding Author Email: pavanjoshi1007@gmail.com

ABSTRACT

The most conventional steering arrangement is to turn the front wheels using a hand operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints which may also be part of the collapsible steering column design, to allow it to deviate somewhat from a straight line. Other arrangements are sometimes found on different types of vehicles, for example, a tiller or rear–wheel steering. Tracked vehicles such as tanks usually employ differential steering that is, the tracks are made to move at differ speeds or even in opposite directions to bring about a change of course or direction. The slide blocks are pivoted on these pins and move with the turning of bell crank levers as the steering wheel is when the vehicle is running straight, the gear said to in its mid-position. The short arms are inclined an angle 90+α to their stub axles. The correct steering depends upon a suitable selection of cross-arm angle α.

Keywords: Steering, Wheel Base, Instantaneous Centre

I .INTRODUCTION

The basic aim of steering is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears. One of the fundamental concepts is that of caster angle- each wheel is steered with a pivot point ahead of the wheel; this makes the steering tend to be self-centering towards the direction travel[1]. The steering linkages connecting the steering box and the wheels usually conforms to a variation of steering geometry, to account for the fact that in a turn, the inner wheel is actually travelling a path of smaller radius than the outer wheel, so that the degree of toe suitable for driving in a straight path is not suitable for turns. The basic geometry of steering is shown in fig 1.

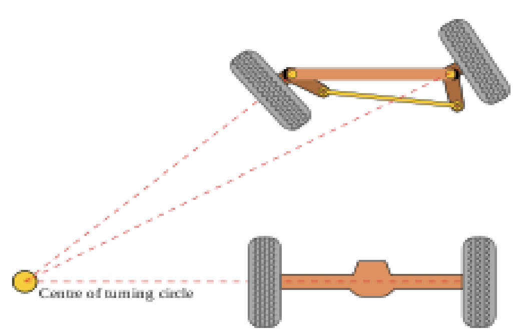

Fig 1. Basic geometry of steering

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A Davis steering gear has sliding pairs which means more friction and easy wearing. The gear fulfils the fundamental equation of gearing in all the positions. However, due to easy wearing it becomes inaccurate after some time. A davis steering shown in fig. consists of two arms PK and QL fixed to the stub axles PC and QD to form two similar bell crank levers CPK and DQL pivoted at P and Q respectively[2-3]. A cross link AB, constrained to slide parallel to PQ, is pin jointed at its ends to two sliders. The sliders S 1 and S2 are free to slide on the links PK and QL respectively. During the straight motion of the vehicle, the gear is in the mid-position with equal inclination of the arms PK and QL with PQ.

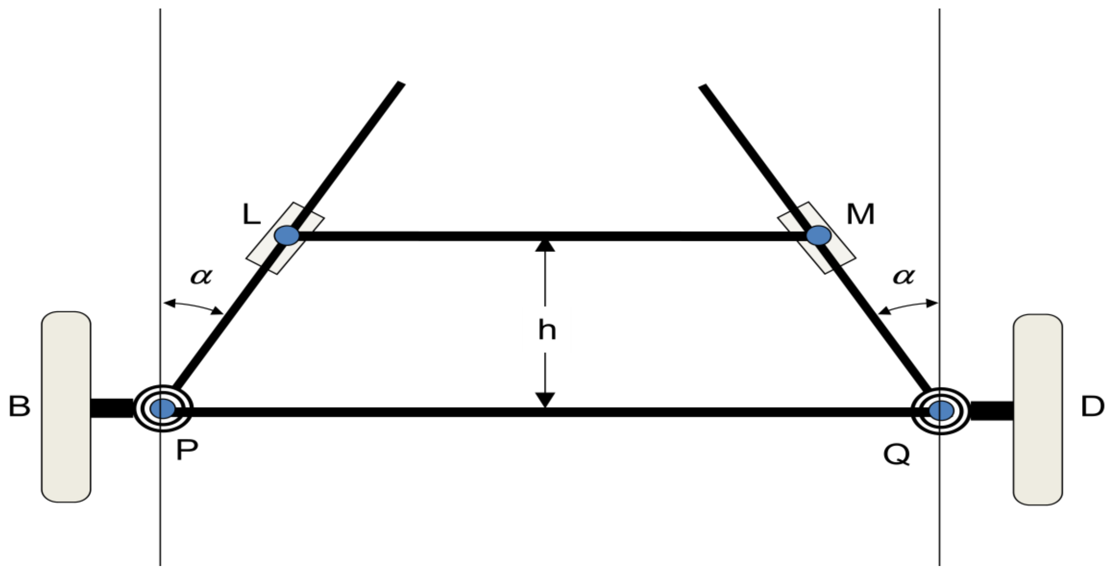

Fig 2. Davis steering gear mechanism

II . METHODOLOGY

The instant centre of rotation, also called instantaneous centre, for a plane figure moving in a two dimensional plane is a point in its plane around which all other points on the figure, for one instant, are rotating. This point itself is the only point that is not moving at that instant. According to the Euler's rotation theorem any 3D rotation that has a fixed point also has a fixed axis [4-5]. Therefore in 3D rotations it is more common to speak of the instant axis of rotation.

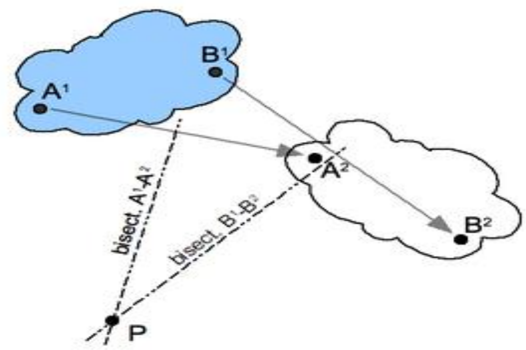

Fig 3. Instantaneous center of rotation

The correct equation for steering is

Cot Φ– Cot θ = c/b

Here
θ =inner wheel angle
Φ=outer wheel angle
b=wheel base
c=distance between pivots

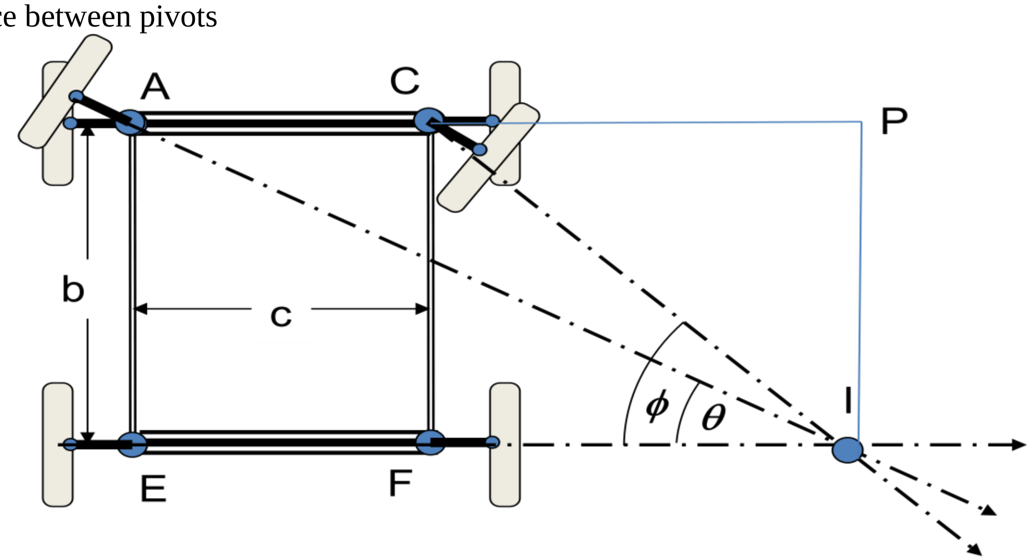

Fig. 4: Instantaneous center

Here
IP=b=wheel base
From triangle IPC
Cot θ=CP/IP
From triangle IAP

Cot ϕ=AP/IP
AP/IP=[AC+CP]/IP ={[AC/IP]+[CP/IP]}
Cot ϕ=[c/b]+Cot θ
Cot ϕ-Cot θ=c/b
The correct angle for steering is Cot ϕ-Cot θ=c/b

A. Eight Wheels

Angle AEG= Angle BJI=α

Angle AEF=θ

Angle BIH=ϕ

IJ=EG=d

IH=FG=x

CD=c

AE=BJ=h

AC2=BD2=k+l+m=b

From Δ BJH

Tan(α+ϕ)= JH/BJ=(d+x)/h

From Δ BJI

Tanα=IJ/BJ=d/h

From Δ AEF

Tan(α –θ)=(d-x)/h

Tan(α +ϕ)=(tanα+tanϕ)/1-tanα tanϕ

Tanϕ={(hx)/(h^2+d^2+dx)}

Tanθ={ (hx)/(h^2+d^2-dx)}

For correct steering

Cot ϕ-Cot θ=c/b

{{h^2+d^2+dx}/hx}-(h^2+d^2-dx)}/hx=c/b

2tanα=c/b

Tanα=c/2b

This is the steering formulae for davis steering mechanisms

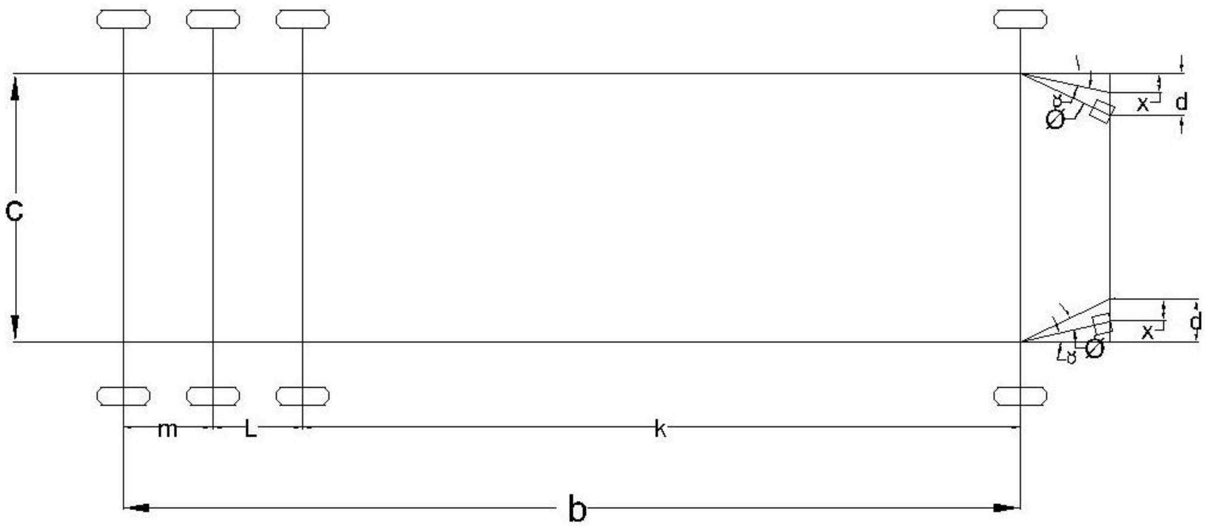

Fig 5. Eight Wheels

B. Ten wheels

Angle AEG= Angle BJI=α

Angle AEF=θ

Angle BIH=ϕ

IJ=EG=d

IH=FG=x

CD=c

AE=BJ=h

AC3=BD3=k+l+m+n=b

From Δ BJH

$\tan(\alpha+\phi)$= JH/BJ=(d+x)/h

From Δ BJI

$\tan\alpha$=IJ/BJ=d/h

From Δ AEF

$\tan(\alpha-\theta)=(d-x)/h$

$\tan(\alpha+\phi)=(\tan\alpha+\tan\phi)/1-\tan\alpha\tan\phi$

$\tan\phi=\{(hx)/(h^2+d^2+dx)\}$

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Tanθ={ (hx)/(h^2+d^2-dx)}

For correct steering

Cot ϕ-Cot θ=c/b

{{h^2+d^2+dx}/hx}-(h^2+d^2-dx)}/hx=c/b

2tanα=c/b

Tanα=c/2b

This is the steering formulae for davis steering mechanisms

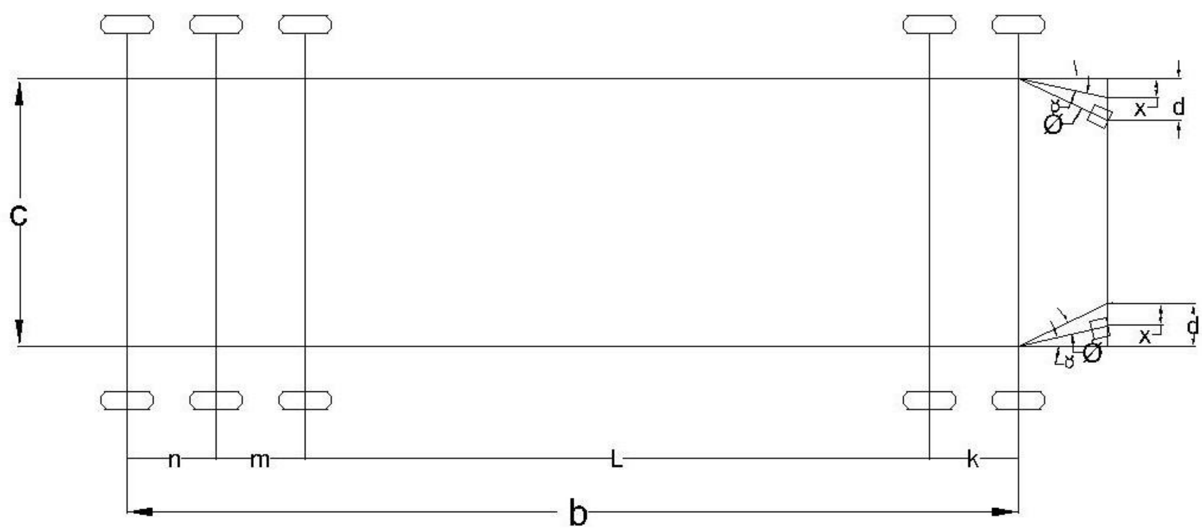

Fig 6. Ten wheels

III. LENGTH OF THE VEHICLE EFFECTING ON THE TURNING ANGLE

A. Eight wheels

Wheel base b=5100mm

Distance between pivots c=2200mm

Tanα= c/2b

=2200/(2)(5100)

α=12.17°

B. Ten wheels

Wheel base b=6200m

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Distance between pivots c=2500mm

Tanα= c/2b

=2500/(2)(6200)-=

α=11.39°

IV. CONCLUSION

It is observed that the length of the wheel base is affecting the turning angle, and If wheels are increased the turning angle will be decreased. Large vehicles have small angle and small vehicles have big angle. The small vehicles take easy turning compared to big vehicles. The results are shown in table.

No. of Wheels	Wheel Base(B)	Distance B/W Pivots(C)	Inclination Angle(A)
Eight	5100	2200	12.17°
Ten	6200	2500	11.39°

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