Analysis of Davis Steering Gear Mechanism for Four Wheels and Six Wheels

J. Pavan Kumar
Assistant Professor
Department of Mechanical Engineering
Mahatma Gandhi Institute of Technology, Hyderabad-500075

B. Rama Krishna
Assistant Professor
Department of Mechanical Engineering
Mahatma Gandhi Institute of Technology, Hyderabad-500075

J Venkatesh
Assistant Professor
Department of Mechanical Engineering
Sagar Institute of Technology, India

Abstract

Steering system is the system which provides directional change in the performance of an automobile. This system converts rotary movement of the steering wheel into angular movement of the front wheels. It multiplies driver’s effort by mechanical advantage, enabling him to turn the wheels easily. The Davis gear mechanism consists of a cross link sliding parallel to another link is connected to the stub axles of the two front wheels by means of two similar bell crank levers pivoted. The cross link slides in slides in the bearing and carries pins at its end. 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 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[1-2]. 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[3-5]. 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[6]. 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. A cross link AB, constrained to slide parallel to PQ, is pin jointed at its ends to two sliders. The sliders S1 and S2 are free to slide on the links PK and QL respectively.

II. FORMULAE FOR STEERING MECHANISM

\[ \text{Cot } \Phi - \text{Cot } \theta = \frac{c}{b} \]

This is the correct equation for steering.
Here
\( \theta \) = inner wheel angle  
\( \Phi \) = outer wheel angle  
\( b \) = wheel base  
\( c \) = distance between pivots

![Fig. 2: Instantaneous center](image1)

In order to avoid skidding, the two front wheels must turn about the same instantaneous centre(I) which lies on the axis of the back wheels. If the instantaneous centre of the two front wheels do not coincide with the instantaneous centre of the back wheel. The skidding on the front or back wheels will definitely take place.

![Fig. 3: Instantaneous center of rotation](image2)

### III. Methodology

When a figure is moving in a plane from position 1 to position 2 it is subject to a combination of rotation and translation. However, a point may be determined around which the figure has virtually rotated. That point, called instant centre of rotation, is not moving and exists for just one instant, for when the figure continues to move a new instant centre of rotation may be determined. To determine the instant centre of rotation one needs to choose only two points on the surface of the figure, in this case point A and point B. See sketch 1. The figure is defined in position 1 by \( A^1 \) and \( B^1 \) and in position 2 by \( A^2 \) and \( B^2 \). It may be observed from the sketch that the figure must have rotated and translated to move from position 1 to position 2. The next step requires bisecting the line \( A^1 - A^2 \). Any point on this bisection may be the centre of a circle where on its circumference the points \( A^1 \) and \( A^2 \) are located. Also any point on the bisection of the line \( B^1 - B^2 \) may be the centre of a circle where on its circumference the points \( B^1 \) and \( B^2 \) are located. Where these two bisections cross that is the one point that itself is not moving and that is the centre of two concentric circles on which these points are located. This one point is the instant centre of rotation \( P \) for these two positions. This is the correct equation for steering.

Here
\( \theta \) = inner wheel angle  
\( \Phi \) = outer wheel angle  
\( b \) = wheel base  
\( c \) = distance between pivots
Analysis of Davis Steering Gear Mechanism for Four Wheels and Six Wheels

Here
IP=b=wheel base
From triangle IPC
Cot θ=CP/IP
From triangle IAP
Cot d=AP/IP
AP/IP=[AC+CP]/IP=[[AC/IP]+[CP/IP]]
Cot d=[c/b]+Cot θ
Cot φ-Cot θ=c/b
The correct angle for steering is Cot φ-Cot θ=c/b
Formulae for Davis steering gear mechanism:

A. Four Wheels

Angle AEG= Angle BJI=α
Angle AEF=θ
Angle BIH=φ
IJ=EG=d
IH=FG=x
CD=c
AE=BJ=h
AC=BD=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+2d^2−dx)]
For correct steering
{[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 mechanism

Fig. 4: Instantaneous center
**B. Six Wheels**

Angle $\text{AEG}=\text{Angle BJI}=\alpha$

Angle $\text{AEF}=\theta$

Angle $\text{BIH}=\phi$

$IJ=\text{EG}=d$

$IH=\text{FG}=x$

$CD=c$

$AE=BJ=h$

$AC_1=BD_1=k+l=b$

From $\triangle BJH$

$\tan(\alpha+\phi)=\frac{JH}{BJ}=\frac{(d+x)}{h}$

From $\triangle BJI$

$\tan \alpha=\frac{IJ}{BJ}=\frac{d}{h}$

From $\triangle AEF$

$\tan(\alpha-\theta)=\frac{(d-x)}{h}$

$\tan(\alpha+\phi)=\frac{(\tan \alpha + \tan \phi)}{1-\tan \alpha \tan \phi}$

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

$\tan \theta=\frac{(hx)}{(h^2+d^2-dx)}$

For correct steering

$$\cot \phi - \cot \theta = \frac{c}{b}$$

$$\left\{ \frac{(h^2+d^2+dx)}{hx} - \frac{(h^2+d^2-dx)}{hx} \right\} = \frac{c}{b}$$

$2\tan \alpha=\frac{c}{b}$

$\tan \alpha=\frac{c}{2b}$

This is the steering formulae for davis steering mechanism
IV. LENGTH OF THE VEHICLE EFFECTING ON THE TURNING ANGLE

A. Four Wheels
Taking
\[
\text{Wheel base } b = 3335 \text{mm} \\
\text{Distance between pivots } c = 1600 \text{mm} \\
\tan \alpha = \frac{c}{2b} = \frac{1600}{2(3335)} \\
\alpha = 13.81^\circ
\]

B. Six Wheels
Wheel base \( b = 4400 \text{mm} \)
Distance between pivots \( c = 2000 \text{mm} \)
\[
\tan \alpha = \frac{c}{2b} = \frac{2000}{2(4400)} \\
\alpha = 13.14^\circ
\]

V. 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.

<table>
<thead>
<tr>
<th>S. No</th>
<th>No. of Wheels</th>
<th>Wheel Base(B)</th>
<th>Distance B/W Pivots(C)</th>
<th>Inclination Angle(( \alpha ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Four</td>
<td>3335</td>
<td>1640</td>
<td>13.81°</td>
</tr>
<tr>
<td>2</td>
<td>Six</td>
<td>4400</td>
<td>2000</td>
<td>13.14°</td>
</tr>
</tbody>
</table>

REFERENCES
[1] Arun Singh, Department of Mechanical Engineering, Delhi Technological University, Delhi, India “Study of Four Wheel steering to reduce turning radius and increase stability.”
[3] Dilip S. Choudhari, Assistant Professor, Department of Mechanical Engineering, Atmiya Institute of Technology and Science, Rajkot, Gujrat State, India “Four Wheel Steering System.”
[6] Sachin Saxena, Vinay Kumar, Sarabjeet Singh Luthra and Alok Kumar, National Conference on “Recent Advances in Mechanical Engineering” “4 Wheel Steering Systems (4was)”