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EVALUATION OF STEERING ANGLES THROUGH FOUR BAR LINK MECHANISM

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ABSTRACT;It would take a long time to find steering angles through theoretical method or by drawing four bar mechanism in a CAD software and to find steering angles through them. The present solution for this problem is to develop a programme, so that by giving basic inputs we would get the result of steering angles. The main objective of this paper is to explain how to develop a programming code for finding steering angles and comparing the results with theoretical and CAD model solution.

KEYWORDS ; steering arm , trackrod, c to c distance, input angle, out put angle, Ackermann angle, steering angle

1. INTRODUCTION

There is been well known theoretical method to find the steering angles, in which some formulae is used for finding the angles. Further method to find the steering angles is by using cad model. which is done as following, In basic every steering mechanism (either Ackermann or Devis) is inversion of four bar or six bar mechanism. Now let us define constraints of steering to basic four bar link mechanism and develop a CAD model to it . An another method is developed from the cad model in which a programming code is developed to find the steering angles. The programming code can be developed easily once model is developed.

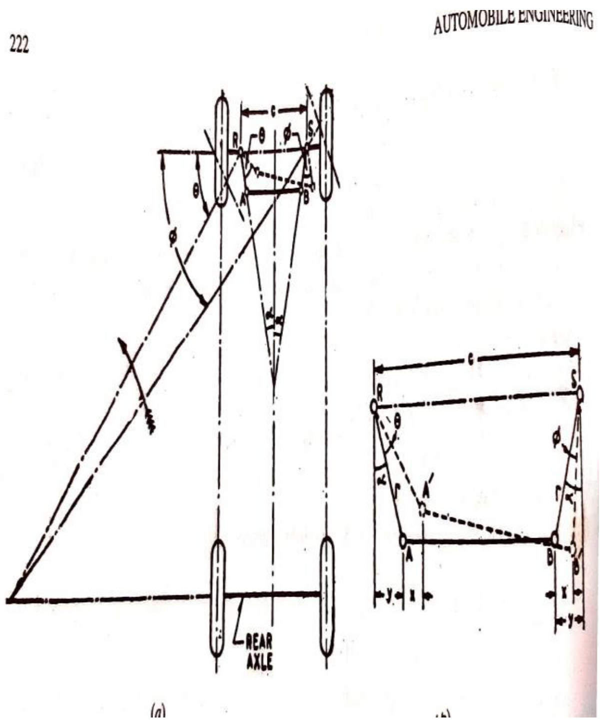
2. THEORETICAL METHOD

Theoretical method for finding steering angles includes developing of formulae using instantaneous centre method as shown in below figure.

The distance b/w c bracket to c bracket is assumed as c , trackrod length is assumed as l and steering arm length is assumed as k and θ is inner angle and ϕ is outer angle and α is Ackermann angle

From figure it is clear that sin(α)=(c-l)/2r=y/r

And also sin(θ + α) + sin(α – ϕ)=2y/r=2sin(α)



Now let us assume

Length of front axle=300cm (c to c distance)

Length of steering arm =120cm

Length of track rod =250cm

Now we will find the output angles from each input angle (varying from I to n)

Sol

Sin(α)=(300-250)/2*120=12.02 degrees

Now a table is drawn for showing results of output angles for each input angle

By using formulae sin(θ + α) + sin(α – ϕ)=2sin(α)

θ	Input angle (θ + α)	Output angle(α – ϕ)	ϕ
0	12.02	12.02	0
1	13.02	11.0237	1.0037
3	15.02	9.0531	2.966
5	17.02	7.111	4.908
10	22.02	2.3828	9.6372
15	27.02	92.166	80.146

3. CAD MODEL

It is very simple to draw a 4 bar link mechanism sketch in any cad software .Since it is easy for me to use catia software I adapted it.

Now let us assume

1. fixed link as distance b/w c bracket to c bracket(front axle)
2. the crank as steering arm
3. connecting rod as track rod

if these inputs were given and by giving input angle we would get output angle. The resultant Ackermann angle is angle for which the difference b/w input and output angle is nearly equals to zero.

The below mentioned figure can be assumed as follows

Dotted line; It is assumed as the distance b/w the C bracket to C bracket(front axle).

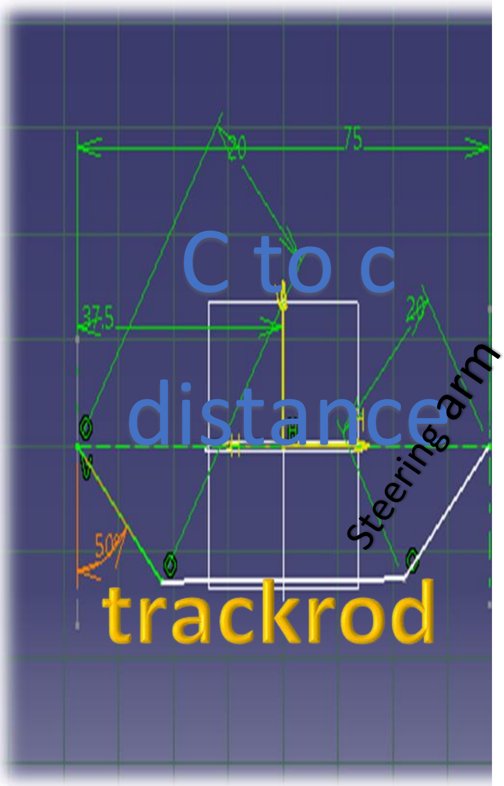
Inclined line; It is assumed as the length of steering arm.

Horizontal line; It is assumed as the track rod length.

Input angle ; It is assumed as the angle b/w the inclined line located at left side with vertical.

output angle ; It is assumed as the angle b/w the inclined line located at rigth side with vertical.

While construction it is checked carefully that length and position of front axle is fully constrained, length of steering arm and length of track rod are constrained .
And also it is essential to make those vertical lines as axis.



Now by giving different input angles we would get different output angles since position of track rod is not constrained. Each input angle, output angle and also the difference b/w them is noted.

The input angle for which least difference is obtained is chosen as the Ackermann angle.

The following is the table containing some of the input , output angles and difference b/w them ,if the following constrains are assumed

Length of front axle=300cm

Length of steering arm =120cm

Length of track rod =250cm

INPUT ANGLE	OUTPUT ANGLE	DIFFERENCE
0	24.752	-24.752
5	19.279	-14.279
10	14.068	-4.068
12	12.049	0.049
15	9.088	6.088
20	4.326	16.326
22	2.182	20.182
50	109.108	59.108

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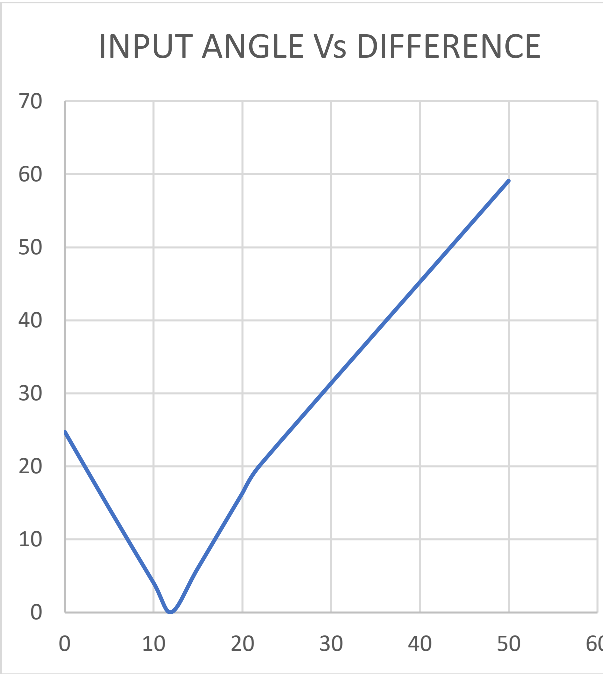
Now if we observe the table, difference is being decreased initially as the input angle increases and at certain point it becomes nearly equals to zero and increases if further increase in input angle.

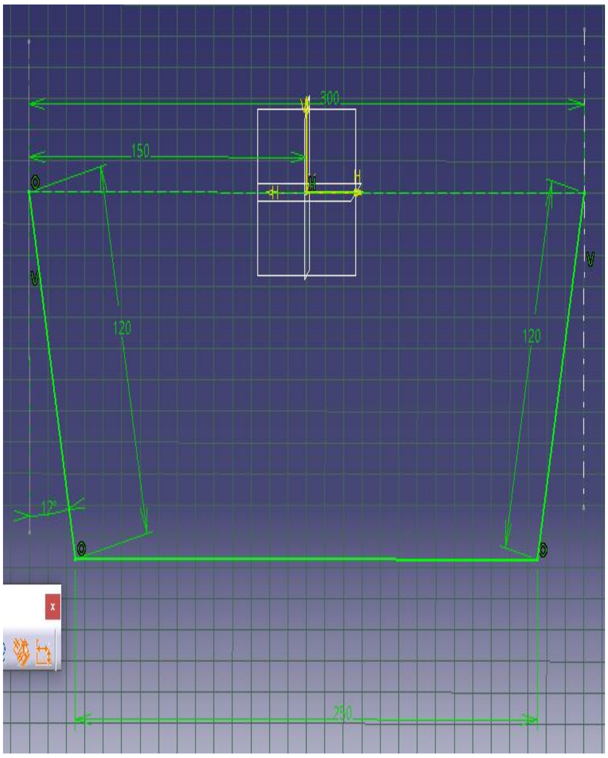
The input angle for which difference is nearly equals to zero is chosen as Ackermann angle and knuckle is so manufactured according to this angle.

In the above table at angle 12 degrees difference is nearly equals to zero so it is chosen as Ackermann angle.



Note: while plotting graph only magnitude of difference is considered neglecting its sign.

The resultant four bar link mechanism figure for above problem is as follows



This process would definetly takes very long time, so we will develop an programming code following above process so that problem becomes easier.

4. Solution

From the cad model result, it is observed that at resultant Ackermann angle, track rod is located in b/w c brackets.

From the graph obtained it is clear that the curve is being decreasing in nature upto the Ackermann angle .

Let us assume;

1. C to c distance as d
2. Steering arm length as h
3. Trackrod length as k
4. Input angle=r, output angle=s, difference=t

Let us assume k1 and k2 such that k1+k2=k (k1 is distance from central axis to left side of trackrod and k2 is distance from central axis to right side of trackrod).

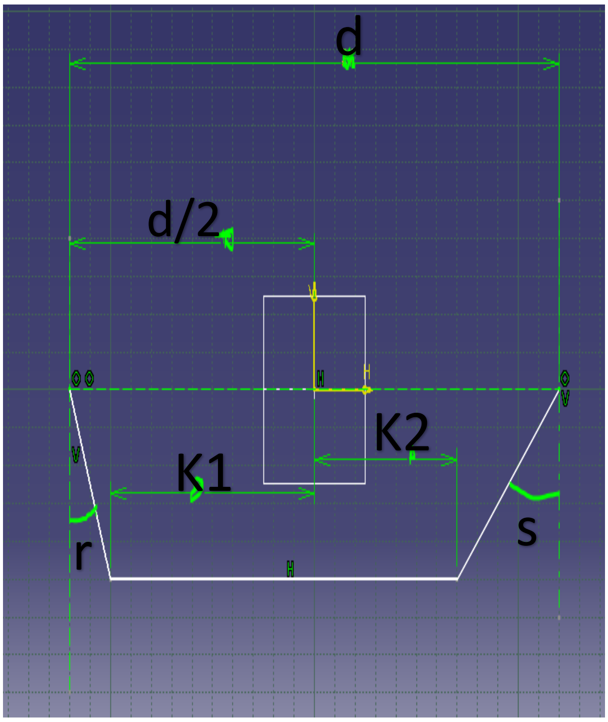
From cad model it is concluded that; Sine ratio of input and output angles can be calculated from length k1 and k2 as mentioned in below formulae

Sin(r)= ((d/2)-k1)/h

Sin(s)= ((d/2)-k2)/h

Only if below condition is satisfied

(d/2)-k1>0 && (d/2)-k2>0.



(d/2)-k2<0 then input and output angles are taken as

Sin(r)= ((d/2)-k1)/h

Sin(s)=90 – (((d/2)-k2)/h)

Now by varying k1 from 0 t0 k by satisfying above condition different input angles(r) and output angles(s) can be calculated.

Difference b/w the r and s is also calculated and stored in value t.

All the results of r s and t are printed. Now result is checked and the value of r for which t is nearly equals to zero is chosen as Ackermann angle.

PROGRAMMING CODE

```
#include<stdio.h>

#include<conio.h>

#include<math.h>

void main()

{

        int i;

        float r,s,t;

        float k,h,d;

        float n,m,k1,k2;

        printf("enter c to c distance==");

        scanf("%f",&d);

        printf("\nenter steering arm length==");

        scanf("%f",&h);

        printf("\nenter track rod lenth==");

        scanf("%f",&k);

        for(i=0;i<=k;i++)

        {

        k1=k-k2;

        k2=i;

        n=(((d/2)-k1)/h);

        m=(((d/2)-k2)/h);

        if(m>=0&&n>=0)

        {

        r=asin(n)*180/3.14;

        s=asin(m)*180/3.14;

        t=r-s;

        }

        Else if(m<0)

         {

         r=asin(n)*180/3.14;
```

```
        s=90-(asin(m)*180/3.14);
      }
     printf("\nr=%f  s=%f  t=%f\n",r,s,t);

     }
     getch();
}
```

5. RESULT AND COMPARISION;

If the above code is compiled and run . firstly system asks for inputs . if we give inputs all possible angles satisfying all above conditions are displayed from which resultant Ackermann angle is chosen.

Suppose if we give inputs as

Length of front axle=300cm

Length of steering arm =120cm

Length of track rod =250cm (same inputs in cadd model solution)

The different r,s,t values are printed as output, some of them are mentioned in below table

r	s	t
0	24.112	-24.112
1.433270	22.551743	-21.118473
2.389227	21.521099	-19.131872
3.3458	20.4977	-17.1578
6.7031	16.9663	-10.2632
12.030798	11.542811	0.487987
13.009473	10.569336	2.440137
15.473855	8.148432	7.325423
20.49775	3.345848	17.151857

At r=12.030798 t is nearly equals to zero so it is chosen as resultant Ackermann angle.

By observing all three tables we can observe that

From theoretical method Ackermann angle=12.02 degrees

From cadd model Ackermann angle =12.0 degrees

From programming code Ackermann angle =12.030798 degrees

And also the input and output angles in all three cases are also accurately equal

6. CONCLUSION

The Ackermann angle from the programming code is also nearly equals to Ackermann angle from the cadd model. Hence other input and output angles are also nearly equal in both cases.so this method can also be adapted for calculating steering angles through four bar link mechanism which saves a lot of time.

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