Machine Design Project

Mechanism Analysis (54)

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1 Mechanism

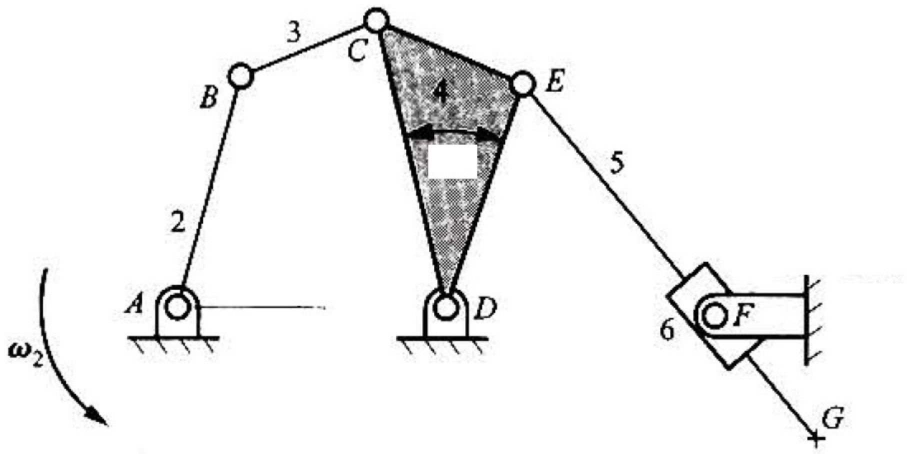

Figure 1: Slider crank mechanism connected with a 3 bar mechanism

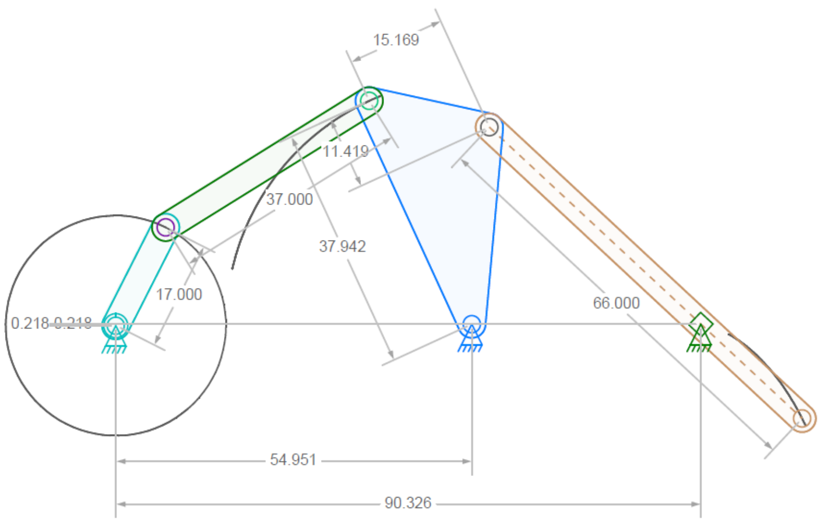

Figure 2: The mechanism's motion analysis using LINKAGE

- **Dimensions assumption:** $r_1 = 54.951$cm, $r_2 = 17$cm, $r_3 = 34.8$ cm , $r_4 = 37.942$ cm, $r_5 = 43.71$ cm, $r_6 = 34.8$ cm. $\omega_2 = 50$ rpm $= 5.23$ rad/s

2 Polar Analysis

The analysis is divided into two parts first part for the first mechanism and the second is related to the other one.

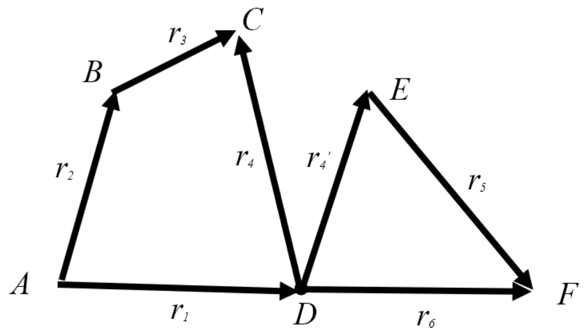

Figure 3: Mechanism analysis

2.1 Position Anaylsis

- $r_2+r_3 = r_1+r_4$

$$x : r_2cos\theta_2 + r_3cos\theta_3 = r_1 + r_4cos\theta_4 \tag{1}$$

$$y : r_2sin\theta_2 + r_3sin\theta_3 = r_4sin\theta_4 \tag{2}$$

$input : \theta_2 \ output : \theta_3, \ \theta_4$

- $r_4^{'}+r_5 = r_6$

$$x : r_4^{'}cos\theta_4^{'} + r_5cos\theta_5 = r_6 \tag{3}$$

$$y : r_4^{'}sin\theta_4^{'} + r_5sin\theta_5 = 0 \tag{4}$$

$input : \theta_4^{'} \ output : \theta_5, \ r_5$

2.2 Velocity Analysis

- $r_2+r_3 = r_1+r_4$

$$\dot{x} : -r_2sin\theta_2\omega_2 - r_3sin\theta_3\omega_3 = -r_4sin\theta_4\omega_4 \tag{5}$$

$$\dot{y} : r_2cos\theta_2\omega_2 + r_3cos\theta_3\omega_3 = r_4cos\theta_4\omega_4 \tag{6}$$

$input : \omega_2 \ output : \omega_3, \ \omega_4$

- $r_4^{'}+r_5 = r_6$

$$\dot{x} : -r_4^{'}sin\theta_4^{'}\omega_4 - r_5sin\theta_5\omega_5 + r_5cos\theta_5\dot{r_5} = 0 \quad (7)$$

$$\dot{y} : r_4^{'}cos\theta_4^{'}\omega_4 + r_5cos\theta_5\omega_5 + r_5sin\theta_5\dot{r_5} = 0 \quad (8)$$

$input : \omega_4 \ output : \omega_5, \ r_5$

2.3 Acceleration Analysis

- $r_2+r_3 = r_1+r_4$

$$\ddot{x} : -r_2cos\theta_2\omega_2^2 + r_3cos\theta_3\omega_3 = r_1 + r_4cos\theta_4\omega_4 \quad (9)$$

$$\ddot{y} : r_2sin\theta_2\omega_2 + r_3sin\theta_3\omega_3 = r_1 + r_4sin\theta_4\omega_4 \quad (10)$$

$input : \alpha_2 \ \omega_2 \ \omega_3 \ output : \alpha_4, \ \alpha_4$

- $r_4^{'}+r_5 = r_6$

$$\ddot{x} : -r_4^{'}cos\theta_4^{'}\omega_4^2 - r_4^{'}sin\theta_4^{'}\alpha_4 - r_5sin\theta_5\omega_5^2 - r_5sin\theta_5\alpha_5 - r_5sin\theta_5\omega_5\dot{r}_5 - r_5sin\theta_5\omega_5\dot{r}_5 + r_5cos\theta_5\ddot{r}_5 = 0 \quad (11)$$

$$\ddot{y} : r_4^{'}sin\theta_4^{'}\omega_4^2 + r_4^{'}cos\theta_4^{'}\alpha_4 - r_5sin\theta_5\omega_5^2 + r_5cos\theta_5\alpha_5 + r - 5cos\theta_{55}\dot{r}_5 + r_5cos\theta_5\dot{r}_{55} + r_5sin\theta_5\ddot{r}_5 = 0 \quad (12)$$

$input : \omega_4 \ \alpha_4 \ \omega_5 \ output : \alpha_5, \ \ddot{r}_5$

3 Analytical Solution

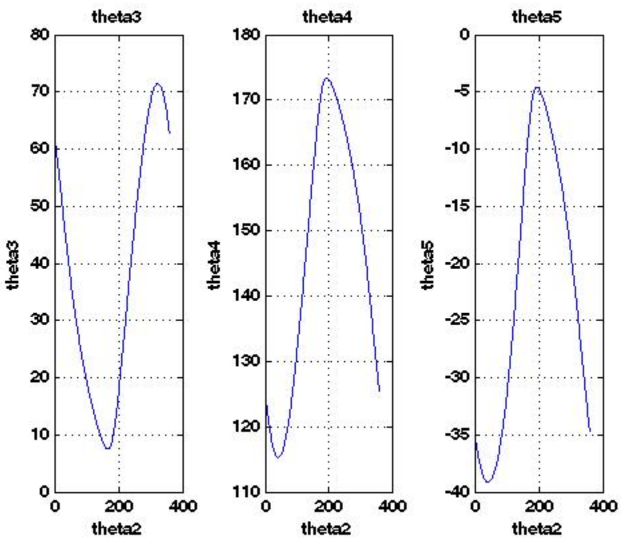

Figure 4: Position Graphs

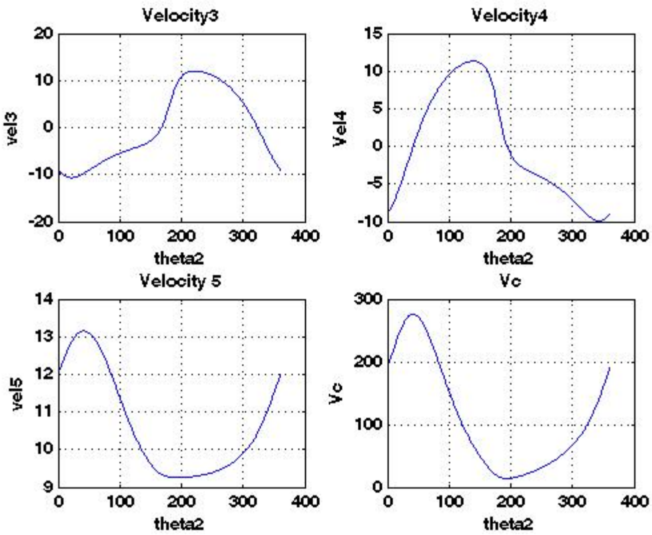

Figure 5: Velocity Graphs

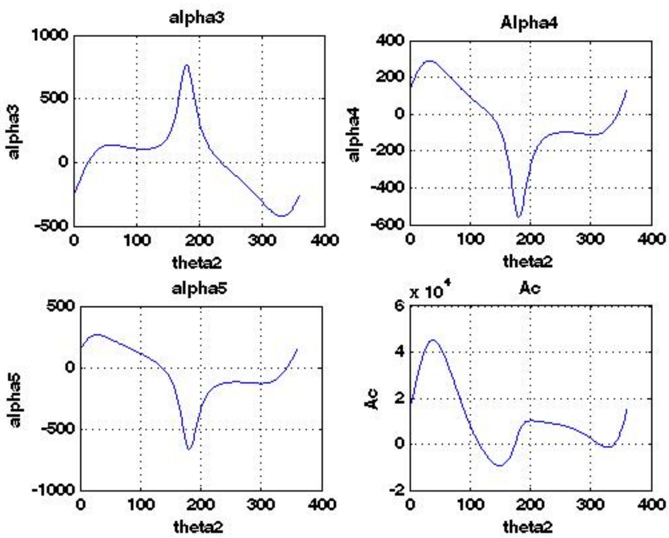

Figure 6: Acceleration Graphs

4 MATLAB codes

4.1 Position 1

```
function w=Position1(output, input)
r1 = 54.951;
r2 = 17;
r3 = 34.8;
r4 = 37.942;
w=[(r2*(cosd(input)))-r1+(r3*cosd(output(1)))-(r4*cosd(output(2)))
```

```
;
(r2*sind(input))+(r3*sind(output(1)))-(r4*sind(output(2)))];
end
```

4.2 Position 2

```
function w=Position2(output, input)

r4_2 =30.5 ;
r5 = 43.71 ;
theta5=output(1);
r6 = output(2) ;
w=[(r4_2*(cosd(input)))+(r5*cosd(theta5))-r6;
(r4_2*sind(input))+(r5*sind(theta5))];
end
```

4.3 Velocity 1

```
function w=velocity1(output, input)
omega2=20;
r2 = 17;
r3 = 34.8;
r4 = 37.942;
theta2=input(1);
theta3=input(2);
theta4=input(3);
omega3=output(1);
omega4=output(2);
w=[omega2*r2*sind(theta2)+omega3*r3*sind(theta3)-omega4*r4*sind(
    theta4);
omega2*r2*cosd(theta2)+omega3*r3*cosd(theta3)-omega4*r4*cosd(
    theta4)];
end
```

4.4 Velocity 2

```
function w=velocity2(output, input)
r4_2 =30.5 ;
r5 = 43.71 ;
r6 = 34.8 ;
theta4_2=input(1);
theta5=input(2);
omega4=input(3);
omega5=output(1);
Vc=output(2);
w=[omega4*r4_2*sind(theta4_2)+omega5*r5*sind(theta5)-Vc*cosd(
    theta5);
```

```
omega4*r4_2*cosd(theta4_2)+omega5*r5*cosd(theta5)+Vc*sind(theta5)
    ];
end
```

4.5 Acceleration1

```
function w=Acceleration1(output, input)
r4_2 =168 ;
r5 = 141 ;
theta4_2=input(1);
theta5=input(2);
omega4 =input(4);
omega5 = input(5);
Vc=input(6);
alpha4 = input(7);
alpha5 = output(1);
Ac = output(2);
w=[((-(alpha4)*r4_2*sind(theta4_2))-((omega4^2)*cosd(theta4_2)*
    r4_2)+(Ac*cosd(theta5))-((omega5)*sind(theta5)*Vc)-((omega5)*
    sind(theta5)*Vc)-((omega5^2)*cosd(theta5)*r5)-((alpha5)*sind(
    theta5)*r5));
 (((r4_2)*cosd(theta4_2)*alpha4)-(r4_2*sind(theta4_2)*(omega4^2))+(
    Ac*sind(theta5))+(Vc*cosd(theta5)*omega5)+(Vc*cosd(theta5)*
    omega5)-(r5*sind(theta5)*(omega5^2))+(r5*cosd(theta5)*alpha5))
    ];
end
```

4.6 Acceleration 2

```
function w=Acceleration1(output, input)
r4_2 =168 ;
r5 = 141 ;
theta4_2=input(1);
theta5=input(2);
omega4 =input(4);
omega5 = input(5);
Vc=input(6);
alpha4 = input(7);
alpha5 = output(1);
Ac = output(2);
w=[((-(alpha4)*r4_2*sind(theta4_2))-((omega4^2)*cosd(theta4_2)*
    r4_2)+(Ac*cosd(theta5))-((omega5)*sind(theta5)*Vc)-((omega5)*
    sind(theta5)*Vc)-((omega5^2)*cosd(theta5)*r5)-((alpha5)*sind(
    theta5)*r5));
 (((r4_2)*cosd(theta4_2)*alpha4)-(r4_2*sind(theta4_2)*(omega4^2))+(
    Ac*sind(theta5))+(Vc*cosd(theta5)*omega5)+(Vc*cosd(theta5)*
```

```
omega5)-(r5*sind(theta5)*(omega5^2))+(r5*cosd(theta5)*alpha5))
];
end
```

5 Graphical Verification

References

1. C. E. Wilson J. P. Sadler "Kinematics and Dynamics of Machinery" third Edition (2005) Pearson Education, Prentice Hall, ISBN 0-13-186-642-9

2. Robert L. Norton " Design of Machinery", fourth Edition (2008) McGraw Hill Publishing Co., New York, NY, ISBN 978-0-07-312158-1

3. David H. Myszka "Machines and Mechanisms – Applied Kinematic Analysis" third edition (2005) Pearson Education, Prentice Hall, ISBN 0-13-183-776-1