# KINEMATIC ANALYSIS AND SYNTHEISIS OF AN ADJUSTABLE SIX BAR LINKAGE


Ashish Kumar (ME 05)

Ashish Kumar (ME 06)

Ayush Bhadauria (ME 08)

Thani Aswanth (ME 36)

Varun Suryan (ME 38)

Department Of Mechanical Engineering, IIT Jodhpur

## Draw backs of earlier adjustable six bar mechanisms

- Many variable speed transmission mechanisms incorporate cams and other higher pair mechanisms

- High complexity, high manufacturing cost, high maintenance cost .

- Loses due to shaking vibrations and slip.

# Existing six bar linkages

- Stephenson's III six bar linkages

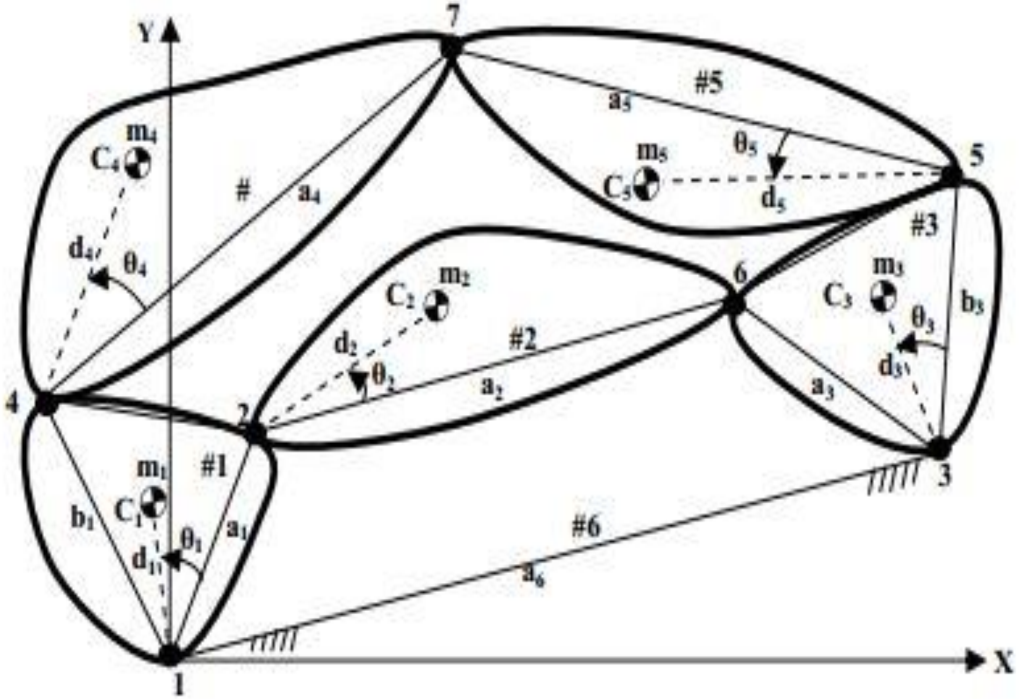
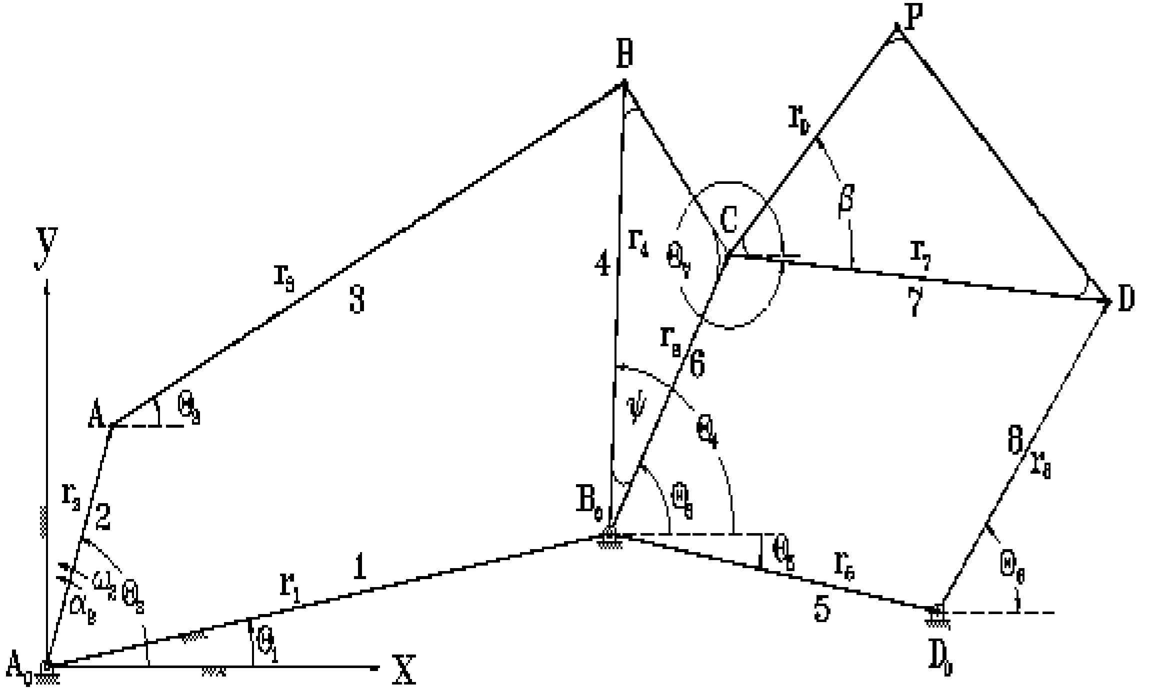



Fig. 1 Stephenson six-bar mechanism

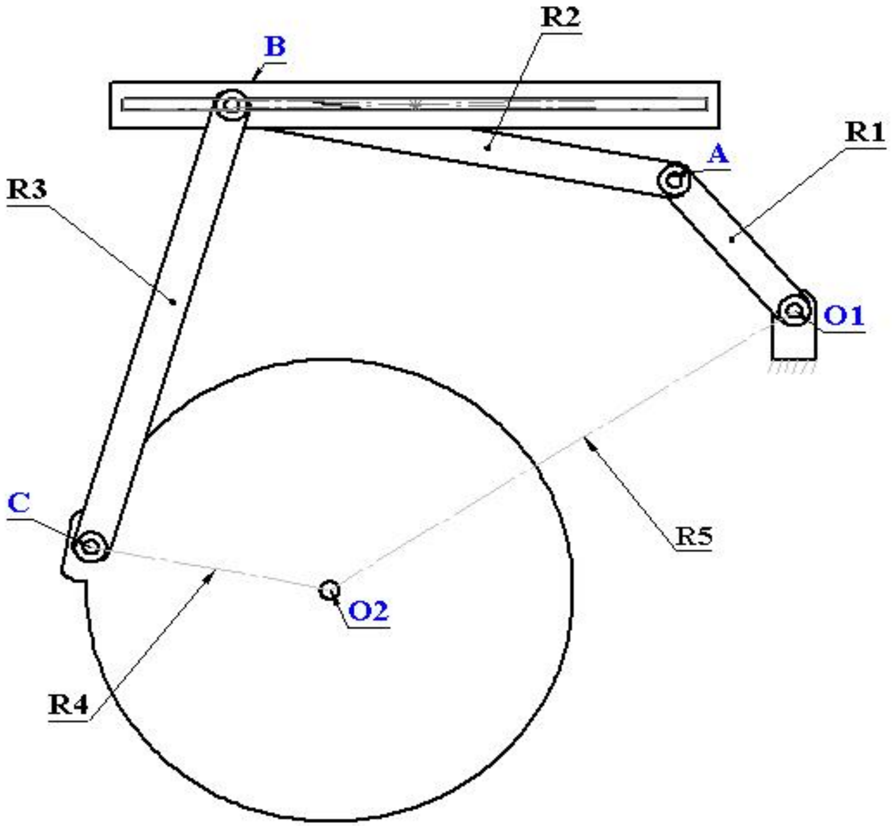
- Watts II six bar linkage



# Improvised model

- Use of slider crank mechanism.
- Adjustable pivots to obtain variable output to input speed ratio.

# Redesigned Mechanism



# Mathematical analysis



Linkage can be represented by two independent vector loop equations. The first vector loop equation can be written as $(O_1ABCO_2)$

$$\vec{R_1} + \vec{R_2} + \vec{R_3} + \vec{R_4} + \vec{R_5} = 0 \quad \text{——} \quad (1A)$$

$$R_1 e^{j\theta_1} + R_2 e^{j\theta_2} + R_3 e^{j\theta_3} + R_4 e^{j\theta_4} + R_5 e^{j\theta_5} = 0 \quad \text{—} (1B)$$

Seperating real and Imaginary parts,

$$R_1 \cos\theta_1 + R_2 \cos\theta_2 + R_3 \cos\theta_3 + R_4 \cos\theta_4 + R_5 \cos\theta_5 = 0 \quad (2A)$$

$$R_1 \sin\theta_1 + R_2 \sin\theta_2 + R_3 \sin\theta_3 + R_4 \sin\theta_4 + R_5 \sin\theta_5 = 0 \quad (2B)$$

Known values in this equation are

$|R_1| = 15$ mm $\quad |R_2| = 37$ mm $\quad |R_3| = 40$ mm

$|R_4| = 20.14$ mm $\quad |R_5| = 45.35$ mm , $\theta_5 = 32.35$

Maximum angle for the clutch obtained through simulation is $171.2^\circ$

Other angles accordingly are :

$\theta_1 = 160^\circ$ , $\theta_2 = 160^\circ$, $\theta_5 = 32.35^\circ$, $\theta_3 = ?$, $\theta_4 = ?$

From equations (2A) and (2B)

$$15\cos(160^\circ) + 37\cos(160^\circ) + 40\cos\theta_3 + 20.14\cos\theta_4 + (45.35)\cos(32.35) = 0$$

$$40\cos\theta_3 + 20.14\cos\theta_4 = 36.56 \quad \text{—} \quad (3A)$$

$$15\sin(160^\circ) + 37\sin 160^\circ + 40\sin\theta_3 + 20.14\sin\theta_4 + (45.35)\sin(32.35) = 0$$

$$40\sin\theta_3 + (20.14)\sin\theta_4 = -42 \quad (3B)$$

Solving (3A) and (3B),

$$40\cos\theta_3 + 20.14\cos\theta_4 = 36.56 \qquad (3A)$$

$$40\sin\theta_3 + 20.14\sin\theta_4 = -42 \qquad (3B)$$

Squaring and adding (3A) and (3B) we obtained, $\theta_4 = -8.8°$.

Minimum angle for the clutch obtained through simulation is $126°$

Other angles accordingly are

$\theta_1 = -53.91°$, $\theta_2 = 126°$, $\theta_5 = 32.35°$

From equations (2A) and (2B)

$$15\cos(-53.91°) + 37\cos(126°) + 40\cos\theta_3 + 20.14\cos\theta_4 + (45.35)\cos 32.35 = 0$$

$$40\cos\theta_3 + 20.14\cos\theta_4 = 25.44 \qquad (4A)$$

$$15\sin(-53.91°) + 37\sin(126°) + 40\sin\theta_3 + 20.14\sin\theta_4 + (45.35)\sin 32.35 =$$

$$40\sin\theta_3 + 20.14\sin\theta_4 = -41.97 \qquad (4B)$$

Squaring and Adding (4A) and (4B) we obtained $\theta_4 = -69.08°$.

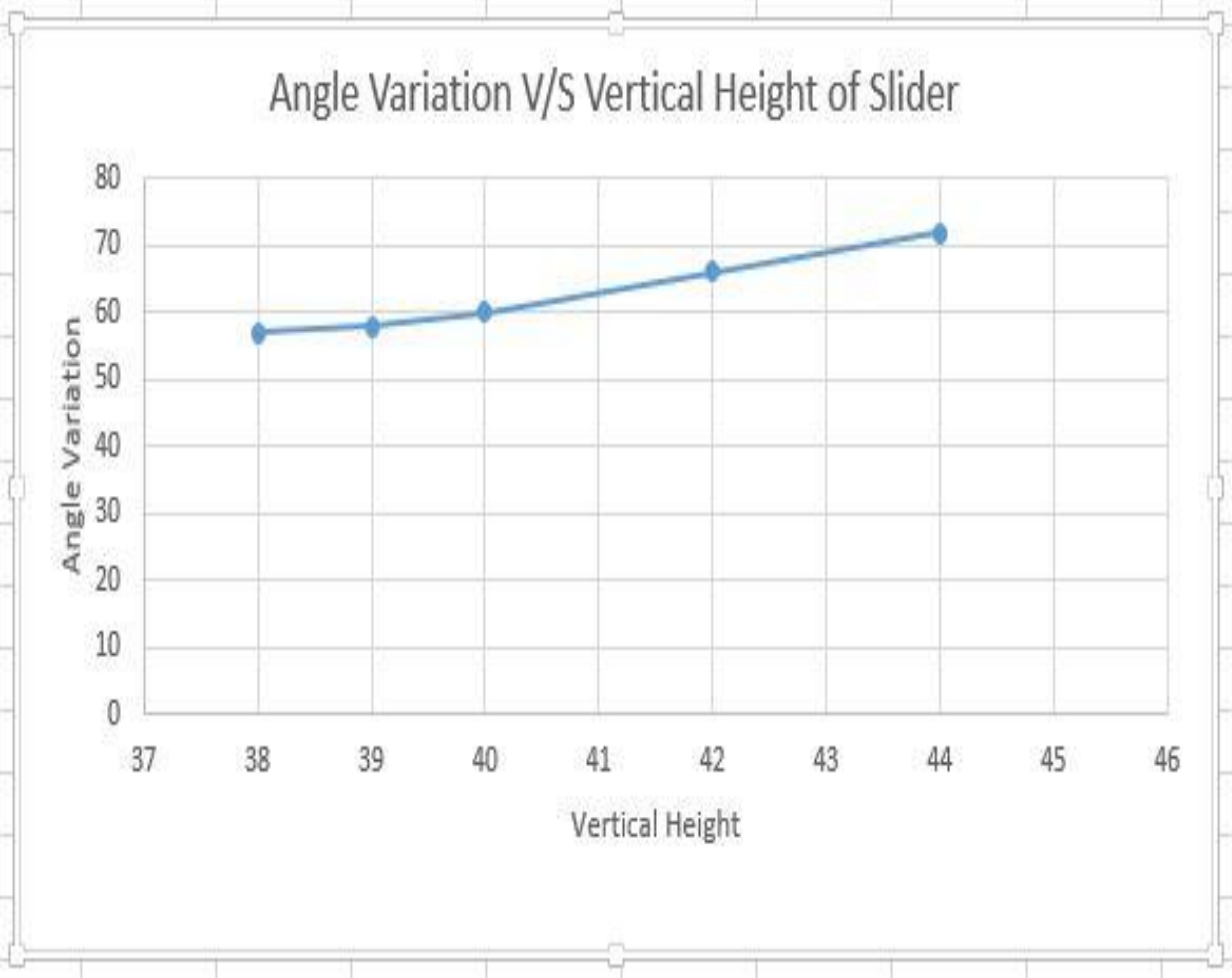
Results obtained for maximum and minimum clutch angles by simulation and analytical equation are approximately same.

Total angular variation ($\Delta\theta_4$) for clutch in paper was $= 56.5°$.

Finally obtained angular variation from our work $= 60°$.

# Uses of the improvised model

- Car wiper mechanism
- Refrigeration compressor system
- Pendulums
- Gasoline driven rail road section cars
- others


Angle Variation V/S Vertical Height of Slider
Angle Variation
80
70
60
50
40
30
20
10
0
37
38
39
40
41
42
43
44
45
46
Vertical Height

# Conlcusion

- Variable speed transmission mechanism is achieved.

- The rotation of the input crank is converted into oscillation of the overrunning shaft through slider crank.
- Final obtained result for our mechanism is 60 degrees (angular variation) which is slightly greater than 56.5 degrees of the original model for complete rotation of the crank.