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# A Generalized Approach For Providing Effective Tolerance On A Link In Planer Mechanism Considering Pin-joint Tolerances

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**Abstract:-** *Mechanisms are designed for desired output or required performance for specified input. Error in link length and joint clearance results in variation in the performance of mechanism. Machines are consisting of mechanism for their successful operations. The link length inaccuracies are due to no. of factors like machining errors deflection of link, clearances in joint etc. Due to manufacturing defects & clearances, the link length varies. This variation in link length causes variations in designed performance of mechanism. In this paper a simple class I four bar mechanism is analyzed, assuming that links are rigid. Design engineer wants tight tolerances for accurate performance; while on other hand manufacturing engineer prefer loose tolerances. This paper proposes an approach to identify the effect of change in link length on the performance of the mechanism, using relative velocity method.*

**Keywords:** Mechanism, Joint Clearance, Tolerance, Performance.

## 1. INTRODUCTION:

If a number of links are assembled in such a way that motion of one cause constrained and predictable motion to other it is called as mechanism. A mechanism transmits a motion, force, torque etc. A machine is a mechanism or combination of mechanisms, which apart from imparting definite motion to the parts, also transmit available mechanical energy into some kind of desired work. Thus mechanism is a fundamental unit for motion transmition. Generally mechanism used in machine is responsible for the performance of machine and required output. A mechanism with four links is called as simple four bar chain mechanism. Many researches have been carried out on performance evaluation of mechanism due to inadequate tolerance on link length and clearance in joint. In this links are assumed as rigid. For these purposes, graphical approach is used, but analytical approach is also an alternate method.

## 2.JOINT TOLERANCE

In this paper we calculate performance of a plainer mechanism by giving a tolerance +ve link & pin joint

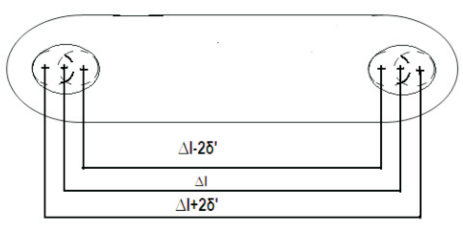


**Fig 1: Joint Tolerance**

Let, L=L1 ±?L Where ±?L=± ?l ± δ ,
Also ±δ = ± 2δ'

In word we can conclude that total tolerance should be equal to arithmetic sum of link hole tolerance & difference between pin center & link hole center .Here we are trying to determine effective tolerance for pin joint clearance in planar mechanism.

**Calculating output angle:**

Output angle can the calculated using relation,

$$\Phi 1,2 = 2\tan^{-1}\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

Where, θ= Input angle

$A = (1-K_2)\cos\theta - K_1 + K_3$

$B = -2\sin\theta$

$C = K_1 - (1+K_2)\cos\theta + K_3$

$K_1 = d/a$

$K_2 = d/c$

$K_3 = (a^2-b^2+c^2+d^2)/2ac$

a, b, c, d, are length of links respectively.

**b) Velocity analysis:**

Graphical approach is used for velocity analysis of four bar mechanism.

$\omega_2 = 2p\,N_2/60$ (rad/sec)

Where,

$\omega_2$= angular velocity of crank

$N_2$= angular speed of crank

$V_2$= length of crank x $W_2$
$V_2$= velocity of crank (m/s)

Using velocity of crank drawing velocity diagram & measuring velocity of coupler (V3) & follower (V4) resp. To calculate angular velocity of follower or output link.

$V_4$= length of follower x $W_4$
$W_4$= $V_4$/ (Length of follower)
$W_4$= angular velocity of follower

**c) Performance analysis:**
Rv = $\omega_4 / \omega_2$
= (ang.Velocity of o/p link) / (ang.Velocity of i/p link)
M.A = (Torque on o/p link) / (torque on i/p link)

M.A =$T_4/T_2$
$T_4/T_2 = W_2/W_4$

**5. MATHEMATICAL CALCULATION:**

The four bar mechanism which is selecting for analysis purpose it's dimension are as follows

| Links | Nomenclature | Dimensions |
|---|---|---|
| AB(Link 2) | Crank | 40 |
| BC(Link 3) | Coupler | 150 |
| CD(Link 4) | Follower | 80 |
| AD(Link 1) | Frame | 150 |

**Table 1:Link Dimension**

Input angle (θ) = 60°
Input Torque $T_2$= 50Nm

**POSITION ANALYSIS**

Position analysis is divided in to two stages - Check the Grashof Condition:

Grash of condition is useful to determine the class of the mechanism whether it is Class I or Class II mechanism. It is given by,

$Lmax+Lmin \leq P + Q$

Where,
Lmax= maximum length of link
Lmin= minimum length of link
P & Q = Remaining two links
Above condition is satisfied. Thus, given mechanism is Class I mechanism.

**Output Angle Calculations:**

Output angle of four bar mechanism can be calculated using the equation,

$$\Phi 1,2 = 2\tan^{-1}\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

Where,

A = $(1-K_2)\cos\theta - K_1 + K_3$
B = -2 sin θ
C = $K_1 - (1 + K_2)\cos\theta + K_3$
Where,
$K_1$= 3.75
$K_2$= 1.875
$K_3$= 1.25
A = (1-1.875) cos 60 – 3.75 + 1.25
A = -2.937

B = -1.732
C = 3.75 – (1+ 1.875) cos 60 + 1.25
C = 3.562
$\Phi_1$= -110.24°
$\Phi_2$= 80.40°

Velocity analysis:

We use graphical approach for velocity analysis of the four bar mechanism which is more accurate.

$\omega_2$= 2p $N_2$/ 60 (rad/sec)
Where,
$\omega_2$= angular velocity of crank
$N_2$= angular speed of crank
$\omega_2$= (2*π*120) / 60
$\omega_2$= 12.566 rad/sec
We have,
$V_2$= l(AB) * ω2
Where,
$V_2$is the velocity of link 2
l(AB) = r, radius of the crank
$V_2$= r * ω2
$V_2$= 0.502 m/s

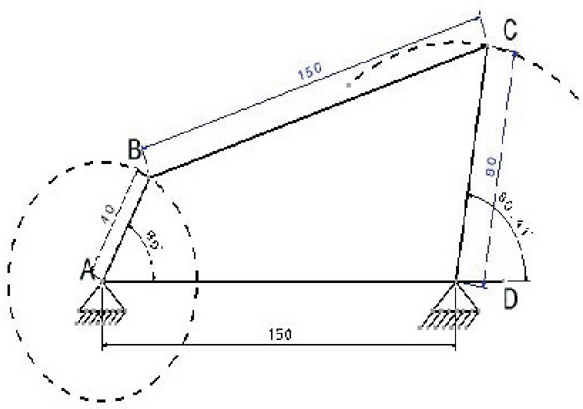


**Fig. 2a) Four Bar Mechanism**

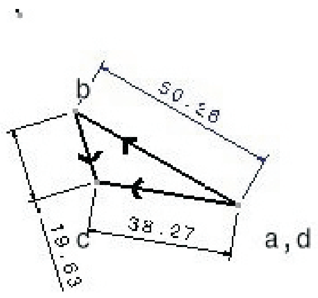


**Fig. 2b) Velocity diagram**

Figure shows a Crank Rocker Four Bar Mechanism along with Its Velocity Diagram Measure from the velocity diagram.

$V_3 = 0.198$ m/s

$= 0.382$ m/s

To calculate angular velocity of output link

Where V4 is the velocity of link CD

$\omega_4 = V_4 / l(CD)$

$\omega_4 = 4.755$

**PERFORMANCE ANALYSIS:**

Angular Velocity Ratio = $\omega_4 / \omega_2$

Rv = 4.775/12.566

Rv =0.3799

Mechanical Advantage = $T_4 / T_2$

M.A = $T_4 / T_2$

Output Torque $T_4$, $T_4 / T_2 = \omega_4 / \omega_2$

$T_4 = 131.58$ Nm

| Links (2) Crank mm (a) | Links (3) Coupler mm (b) | Links (4) Follower mm (c) | Links (1)Frame mm (d) | Input angle | Input torque T2 Nm | Joint Clearance | Angular Velocity Ratio Rv | MechanicalAdvantage M.A | Output Torque T4 Nm | % Variation |
|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 150 | 80 | 150 | 60 | 50 | +0.5 | 0.3709 | 2.6454 | 132.27 | 5.26 |
| | | | | | | -0.5 | 0.3680 | 2.7169 | 135.84 | 8.10 |
| 40 | 150 | 80 | 150 | 60 | 50 | 0.5 | 0.3799 | 2.6316 | 131.58 | 0.00 |
| 41 | 150 | 80 | 150 | 60 | 50 | +0.5 | 0.3879 | 2.5776 | 128.88 | 2.56 |
| | | | | | | -0.5 | 0.3978 | 2.5132 | 125.66 | 0.00 |

**Table 2: Performance Ratio Calculation**

**RESULT:**

Table shows the values obtained of Angular velocity ratio, Mechanical advantage and percentage variation in the performance from standard performance for crank length 40±1±0.5 mm.

**CONCLUSION:**

The proposed analytical method is useful in determining performance variation of any planar four bar mechanism cause due to dimensional inaccuracies. Computer aid can help in easy workout of possible variation in link dimension.

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