Optimum Tolerance Scheme of Linkages for Quick Return Mechanism Based on Desired Output

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Abstract— The proposed research work gives the analysis of crank and slotted mechanism that converts rotary motion into reciprocating motion at different rate of its working stroke and return stroke. A CAD model of synthesized link lengths has been prepared to simulate the mechanism and to specify the accurate path of the mechanism which would provides the actual position of the slider against the crank rotation. Software is developed using programming language C-# which is very useful for synthesis and sensitivity analysis of crank and slotted mechanism. Software package will be helpful for manufacturing industries to get accurate performance in minimum manufacturing cost. Developed software is a tool that provides the optimized scheme of tolerance for desired permissible variation in output.

Index Terms— Generalised method, Performance, Mechanism, Sensitivity analysis etc

I. INTRODUCTION

A quick return mechanism is a mechanism that converts rotary motion into reciprocating motion at different rate of its working stroke and return stroke. Currently, it is widely used in machine tools, for instance, shaping machines, power-driven saws, and other applications requiring a working stroke with intensive loading, and a return stroke with non-intensive loading. Several quick return mechanisms can be found including the offset crank slider mechanism, the crank-shaper mechanisms, the double crank mechanisms, crank rocker mechanism and Whitworth mechanism. In mechanical design, the designer often has need of a linkage that provides a certain type of motion for the application in designing. Since linkages are the basic building blocks of almost all mechanisms, it is very important to understand how to design linkages for specific performance characteristics.

Therefore, the purpose of the paper is to provide optimum tolerance scheme by determining most sensitive link/s of the synthesize quick-return mechanism and reduce the cost of manufacturing by varying tolerance of individual link/s.

II. COMPUTER AIDED MODELING OF CRANK AND SLOTTED LEVER QUICK RETURN MECHANISM

Modeling is the process of producing a model. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoffs between realism and simplicity. An important issue in modeling is model validity. Model validation techniques include simulating the model under known input conditions and comparing model output with system output. For this purpose a CAD model of synthesized quick return mechanism is prepared with the help of modeling software CATIA V5R17

The synthesized link lengths for modeling are:

LINK 1(Fixed Link) = 250 mm

LINK 2(Crank) = 100 mm

LINK 3(Slotted Bar) = 650 mm

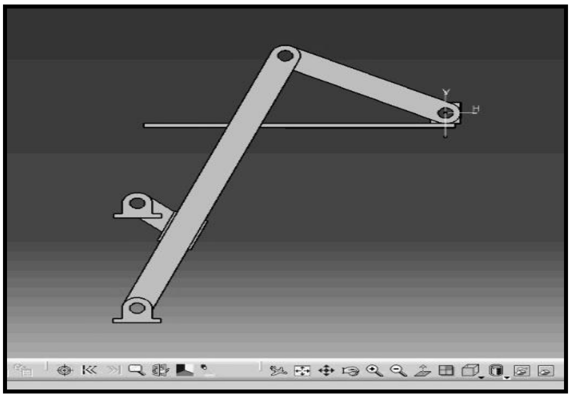


Figure 1: CAD Model of Crank and Slotted Lever Quick Return Mechanism

III. SOFTWARE DEVELOPMENT FOR TOLERANCE ANALYSIS

Computer plays an important role in all engineering disciplines, including design, synthesis and analysis. Analytical technique and graphical techniques are too cumbersome to carry out by hands. With the help of computer, it is now within grasp. For the above synthesis and analysis, software is developed which will be helpful for manufacturing industries to get accurate performance in minimum manufacturing cost. The language used for programming is ‘C-#’. L1 (Fixed Link), L2 (Crank) andL3 (Slotted Bar) denote the link lengths of the mechanism. And T1, T2 and T3 denote the permissible tolerance of corresponding link lengths. % Error denotes variation in performance. Figure 3 shows the Stroke Length Calculator for Quick Return Mechanism prepared for the program. This Stroke Length Calculator contains Input Lengths box, Input Length Tolerance box, % Error and Calculate Button. Initially we need to enter the Dimensions of Link Lengths and corresponding permissible tolerance, the value of percentage error above which the combinations of links are to be required. The ‘Calculate’ Button will compute stroke length and percentage error in the mechanism. The performance sheet can be saved in .pdf or excel format. Maximum and minimum percentage error in the stroke length is shown on the screen.

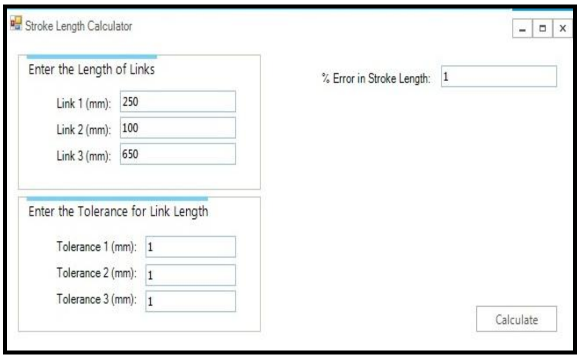


Figure 2: Screen of Stroke Length Calculator

IV. RESULT AND ITS ANALYSIS

To find out most sensitive link which will affect the performance of the mechanism, various experiments are carried out.

In first type of experiment, ±1mm tolerance was provided to one of the link and other two links lengths were kept unchanged. Allowable performance variation was kept ±1 %.

A. Providing ±1mm tolerance to LINK 1 and other two links keep constant (Sr.No. 1 to 3),

Providing ±1mm tolerance to LINK 2 and other two links keep constant(Sr.No. 4 to 6) &

Providing ±1mm tolerance to LINK 3 and other two links keep constant (Sr.No. 7 to 9)

Table 1: Effect on Performance of Mechanism by providing ±1mm Tolerance to one of the Link and Other Two Links Keep Constant

S.N	Stroke Length (mm)	% Error
1	522.08	-0.40 %
2	520.00	0 %
3	517.13	0.55 %
4	514.79	1 %
5	520.00	0 %
6	525.20	-1 %
7	519.19	0.15 %
8	520.00	0 %
9	520.80	-0.15 %

In second type of experiment, one of the link kept unchanged and ±1mm tolerance were provided to other two links. Allowable performance variation was kept ±1 %.

B. Keep LINK 1 constant and providing ±1mm tolerance other two links(Sr.No. 1 to 9),

Keep LINK 2 constant and providing ±1mm tolerance other two links(Sr.No. 10 to 18) &

Keep LINK 3 constant and providing ±1mm tolerance other two links (Sr.No.19 to 27)

Table 2: Effect on Performance of Mechanism by Keeping One of the Link Constant and Providing ±1 Mm Tolerance to Other Two Links

S.N	Stroke Length (mm)	% Error
1	514.00	1.15 %
2	520.00	0 %
3	526.00	-1.15 %
4	514.80	1 %
5	520.79	-0.15 %
6	524.39	-0.84 %
7	515.59	0.84 %
8	519.19	0.15 %
9	525.20	-1 %
10	521.28	-0.24 %
11	520.00	0 %
12	518.72	0.24 %
13	522.08	-0.40 %
14	520.80	-0.15 %
15	517.13	0.55 %
16	522.89	-0.55 %
17	519.19	0.15 %
18	517.92	0.40 %
19	516.87	0.60 %

20	520.00	0 %
21	523.10	-0. 60 %
22	522.08	-0.40 %
23	525.20	-1 %
24	512.74	1.39 %
25	527.30	-1.40 %
26	514.79	1 %
27	517.92	0.40 %

Above calculations shows, Variation in the crank i.e LINK-2 dimension affects more on the performance of the mechanism, so providing closure tolerance to Crank i.e. ranging from 0.1 mm to 0.5 mm and larger tolerance to other two links i.e. ±2 mm or ±1.5 mm or ±1.5 mm & ±2 mm at a time. Allowable variation of the performance was kept 1 %.

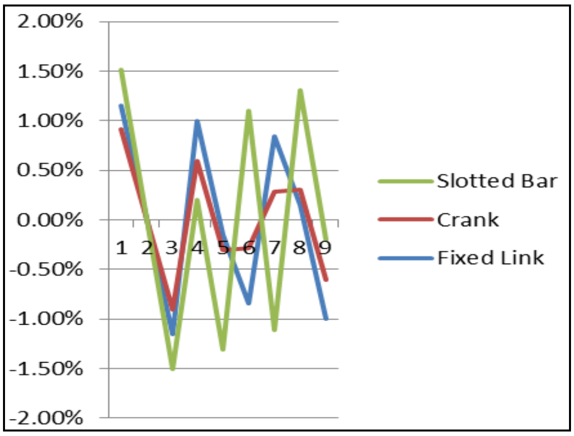
Table 3: Results of Experimentation on Stroke Length Calculator

S.N	Permissible Tolerance for Links (A)			Accepted Combination of Links (Numbers)	% Acceptance	Rejected Combination of Links	% Rejection
	Link 2 (mm)	Link 1 (mm)	Link 3 (mm)				
1	0.1	1.5	1.5	27	100.0	0	0
2	0.1	2.0	2.0	22	81.50	5	18.50
3	0.1	1.5	2.0	25	92.59	2	07.41
4	0.2	1.5	1.5	25	92.59	2	07.41
5	0.2	2.0	2.0	22	81.50	5	18.50
6	0.2	1.5	2.0	25	92.59	2	07.41
7	0.3	1.5	1.5	25	92.59	2	07.41
8	0.3	2.0	2.0	21	77.77	6	23.23
9	0.3	1.5	2.0	25	92.59	2	07.41
10	0.4	1.5	1.5	24	88.88	3	12.12
11	0.4	2.0	2.0	21	77.77	6	23.23
12	0.4	1.5	2.0	24	88.88	3	12.12
13	0.5	1.5	1.5	23	85.18	4	14.82
14	0.5	2.0	2.0	21	77.77	6	23.23
15	0.5	1.5	2.0	23	85.18	4	14.82

V. GRAPHS

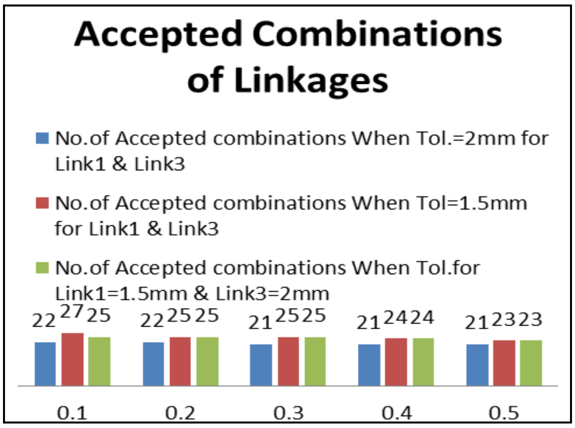
Graph 1 shows the effect on performance of the mechanism when one of the Link was kept constant and ±1mm tolerance were provided to other two links. Allowable performance variation was kept ±1 %.

Graph: 1



Graph 2 shows the no. of Accepted no. combinations when the tolerance of Link 2 i.e Crank length is 0.1, 0.2, 0.3, 0.4, 0.5 mm and tolerance of Link 1, Link 3 are 2mm, 1.5 mm and 1.5 mm & 2 mm at a time.

Graph: 2



VI. CONCLUSION

On the basis of the results and its analysis, some of the following conclusion can be drawn:

1. Link no. 2 i.e. Crank is the most sensitive link

2. Zero rejection can be achieved by using optimum combinations of linkages,

i.e L1= 1.5 mm, L2 = 0.1 mm, L3 = 1.5 mm

3. Instead of providing same tolerance to all the links of the mechanism, only provide closure tolerance to Link 2 i.e Crank to obtain desired output

4. An optimum combination of linkages helps to decide particular type of machine to control the definite tolerance of the linkages

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