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Performance Based Tolerance Scheme For Mechanism

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ABSTRACT

This paper deals with the analysis of crank and slotted mechanism that converts rotary motion into reciprocating motion at different rate for 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. Software also provides the optimized scheme of tolerance for desired permissible variation in output.

Keywords : Return Mechanism, Synthesis, Sensitivity Analysis, Tolerance scheme**.**

INTRODUCTION

A quick return mechanism is a mechanism that converts rotary motion into reciprocating motion at different rate for its two strokes, i.e. working stroke and return stroke. When the time required for the working stroke is greater than that of the return stroke, it is a quick return mechanism. It yields a significant improvement in machining productivity. 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 this paper is to that provide performance based tolerance scheme by determining most sensitive link/s of the synthesize quick-return mechanism and reduce the cost of manufacturing by providing selective tolerance of individual links.

Computer Aided Modelling Of Crank And Slotted Lever Quick Return Mechanism

Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest. 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 tradeoff between realism and simplicity. Simulation practitioners recommend increasing the complexity of a model iteratively. 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. A CAD model of synthesized quick return mechanism is prepared with the help of modeling software CATIAV5R17.

The synthesized link lengths for modeling are:

= 250 mm LINK 1(Fixed Link)
= 100 mm LINK 2(Crank)
= 650 mm LINK 3(Slotted Bar)

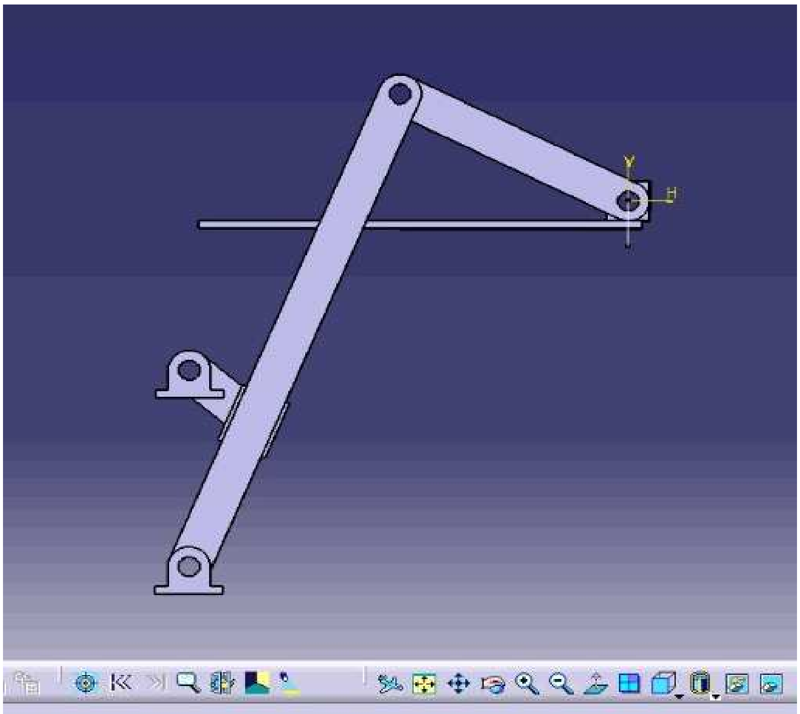


Figure 1: CAD Model of Crank and Slotted Lever Quick Return Mechanism

Development Of Software For Sensitivity 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-#'. L_1 (Fixed Link), L_2 (Crank) andL_3 (Slotted Bar) denote the link lengths of the mechanism. And T_1, T_2 and T_3 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.

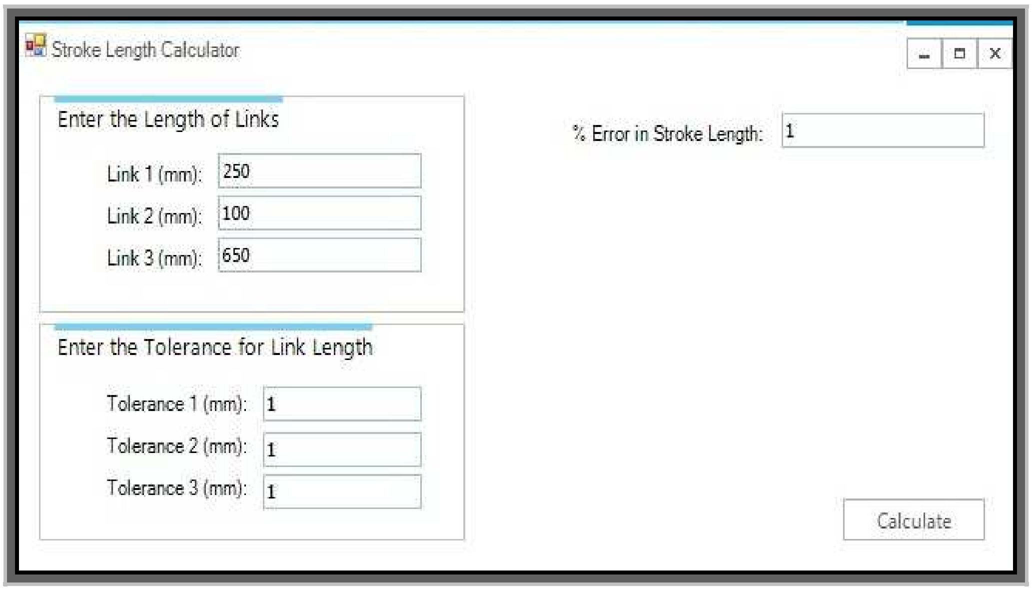


Figure 3: Screen of Stroke Length Calculator

RESULT AND DISCUSSION

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 constant. Allowable performance variation was kept ±1 %.

The results obtained by the experiments as tabulated below,

Keep LINK 1(Fixed Link) constant and providing ±1mm tolerance other two links

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

SN	LINK 1 (mm)	LINK 2 (mm)	LINK 3 (mm)	STROKE LENGTH (mm)	% ERROR
1	250	99	649	514.007	1.15 %
2	250	100	650	520	0 %
3	250	101	651	526.001	-1.15 %
4	250	99	650	514.799	1 %
5	250	100	651	520.79	-0.1538 %
6	250	101	649	524.39	-0.84 %
7	250	99	651	515.591	0.84 %
8	250	100	649	519.19	0.1538 %
9	250	101	650	525.20	-1 %

Keep LINK 2 (Crank) constant and providing ±1mm tolerance other two links

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

SN	LINK 1 (mm)	LINK 2 (mm)	LINK 3 (mm)	STROKE LENGTH (mm)	% ERROR
1	249	100	649	521.285	-0.24 %
2	250	100	650	520	0 %
3	251	100	651	518.72	0.24 %
4	249	100	650	522.08	-0.4016 %
5	250	100	651	520.799	-0.1538 %

6	251	100	649	517.13	0.5516 %
7	249	100	651	522.89	-0.5516 %
8	250	100	649	519.19	0.1538 %
9	251	100	650	517.92	0.3984 %

Keep LINK 3 (Slotted Bar) constant and providing ±1mm tolerance other two links

Table 3: Effect on Performance of Mechanism by Keeping Link 3 Constant and Providing ±1 mm Tolerance To Other Two Links

SN	**LINK 1 (mm)**	**LINK 2 (mm)**	**LINK 3 (mm)**	**STROKE LENGTH (mm)**	**% ERROR**
1	249	99	650	516.867	0.6029 %
2	250	100	650	520	0 %
3	251	101	650	523.10	-0.5976 %
4	249	100	650	522.08	-0.4016 %
5	250	101	650	525.20	-1 %
6	251	99	650	512.74	1.3944 %
7	249	101	650	527.30	-1.40 %
8	250	99	650	514.79	1 %
9	251	100	650	517.92	0.3984 %

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 %.

The result obtained by experimentation as shown below

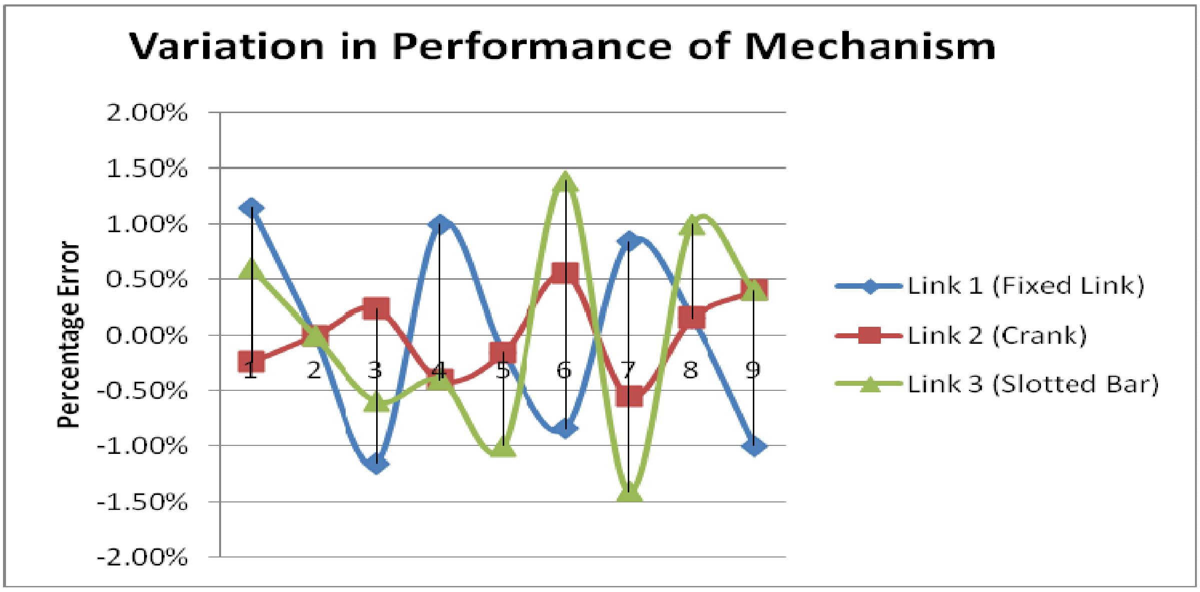
Table 4: % Acceptance and % Rejection by variying tolerance to various links

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	2	22	81.50	5	18.50
3	0.1	1.5	2	25	92.59	2	07.41
4	0.2	1.5	1.5	25	92.59	2	07.41
5	0.2	2	2	22	81.50	5	18.50
6	0.2	1.5	2	25	92.59	2	07.41
7	0.3	1.5	1.5	25	92.59	2	07.41
8	0.3	2	2	21	77.77	6	23.23
9	0.3	1.5	2	25	92.59	2	07.41
10	0.4	1.5	1.5	24	88.88	3	12.12
11	0.4	2	2	21	77.77	6	23.23
12	0.4	1.5	2	24	88.88	3	12.12

13	0.5	1.5	1.5	23	85.18	4	14.82
14	0.5	2	2	21	77.77	6	23.23
15	0.5	1.5	2	23	85.18	4	14.82

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: Effect on performance by providing ±1mm tolerance to two links at a time

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.

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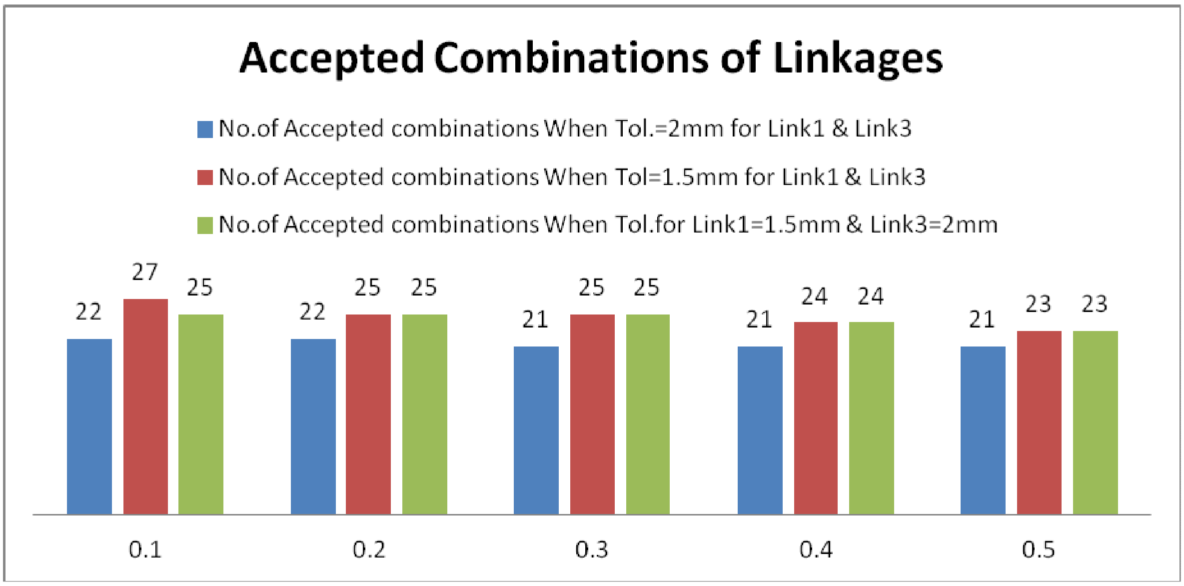
Analysis

1. Table no. 1, 2 and 3 shows that for ± 1 mm tolerance to two links at a time of link $Link_1$, $Link_2$, $Link_3$ and rest one keep constant. The maximum error occurs when there is a change in both $Link_1$ and $Link_2$, Comparatively less in case of change in $Link_2$ and $Link_3$, and very smaller in case of change in $Link_1$ and $Link_3$

2. Percentage rejection is same i.e 23.23 % for tolerance of link $Link_1$ = $Link_3$ = ±2 mm and $Link_2$=0.3/0.4/0.5 mm

3. For optimum combination of linkages i.e $Link_1$ = 1.5 mm, $Link_2$ = 0.1 mm, $Link_3$ = 1.5 mm percentage rejection is zero.

4. For another optimum combination of linkages i.e $Link_1$ = 1.5 mm, $Link_2$ = 0.2/0.3 mm, $Link_3$ = 1.5/2 mm percentage rejection is very less i.e 7.41 %



Graph 2: No. of Accepted combinations of Linkages

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. 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
3. Zero rejection can be achieved by using optimum combinations of linkages i.e L_1= 1.5 mm, L_2 = 0.1 mm, L_3 = 1.5 mm
4. An optimum combination of linkages helps to decide particular type of machine to control the definite tolerance of the linkages
5. This approach will also help in reducing the cost of manufacturing by providing selective tolerance of individual link/s.

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