Adaptive design on crank and slotted lever mechanism

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Abstract:One of the famous mechanisms for quick return motion to obtain reciprocating motion is crank and slotted lever mechanism. In this paper an adaptive design on this mechanism is briefly discussed. Certain changes have been made to the crank and the slotted lever mechanism to incorporate the class 1 lever instead of class 3 lever used in the mechanism. Moreover a possible approach for obtaining more than one reciprocating motion simultaneously from the same mechanism is discussed.

Keywords: Link, mechanism, lever, slotted bar.

1.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 & idle stroke. Since the time taken for return stroke is less than its working stroke, it is called as quick return mechanism. It is widely use in machine tool such as shaping machines, power-driven saws etc. In this mechanism class 3 lever is used which is basically a distance multiplier. The main purpose of this paper is to use class- 1 lever in the mechanism instead of class- 3 levers and to discuss few other possible arrangements in the design so obtained.

1.1Crank and slotted lever mechanism:

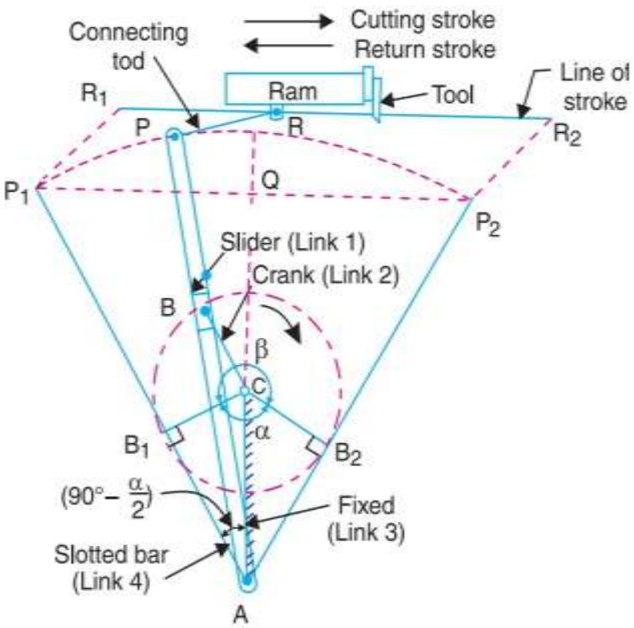

Fig1. Crank and slotted lever mechanism

In this mechanism, the slider 1 reciprocates in oscillating slotted lever 4 and link 2 rotates whole link 3 is fixed. Another link 5 (PR) connects the end of the link 4 to ram. The latter carries the cutting tool which reciprocates perpendicular to the fixed link3.

The ram and hence the cutting tool reverses its direction when the link 2 is perpendicular to link 4. The cutting stroke takes place during angle β whereas return stroke i.e. Idle stroke takes place during angle α which is equal to 360-β.
Thus

$$\frac{\text{time of cutting}}{\text{time of return}} = \frac{\beta}{\alpha} = \frac{\beta}{360-\beta}$$

The lever mechanism

A lever is one of the simplest mechanical devices. A lever consists of a beam or rod. It is pivoted to a part called the fulcrum. In crank and slotted lever mechanism “class 3- lever” i.e. the effort is placed between the load and the fulcrum is used.

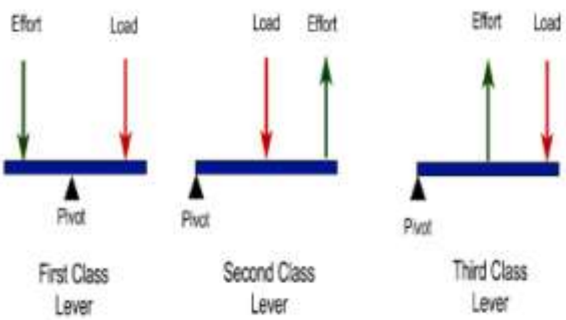

Fig2. The lever mechanism

Both first and second class levers are usually force multiplier whereas third one is the distance multiplier.

2. Description of the modified mechanism

In this modified mechanism the slider (link 1), crank (link 2) and fixed support (link 3) all are similar to earlier design except the slotted bar (link 4). Here slotted bar is supported by a hinge joint at the fulcrum (A) as shown in the figure. The extended part of the slotted bar on the other side of fulcrum from the crank and the slider is connected to link 5(PR) which transmits the motion from link 4 to the ram.

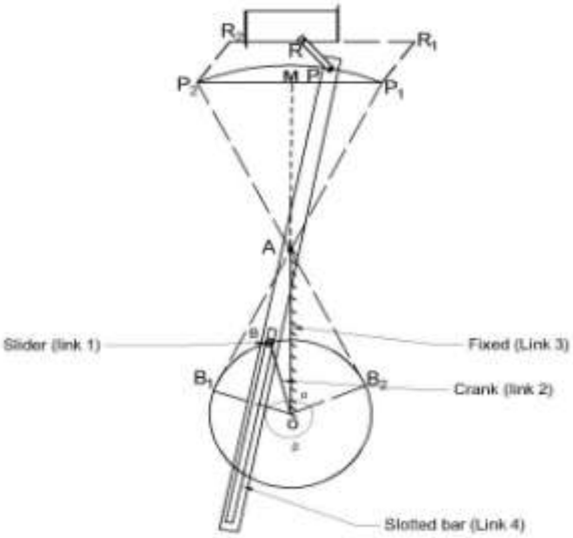

Fig3: Modified mechanism

2.1Length of stroke and time ratio

Let $\angle OAB_1$=Inclination of the slotted bar with the vertical=90-α/2

$\angle OAB_1=\angle P_2AM$(opposite angles) Now, length of stroke=$R_1R_2=P_1P_2=2P_2M$ $=2AP_2\text{Sin}(90-\alpha/2)$

Time Ratio$=\frac{Time\ of\ cutting\ stroke}{Time\ of\ return\ stroke}=\frac{\beta}{\alpha}$

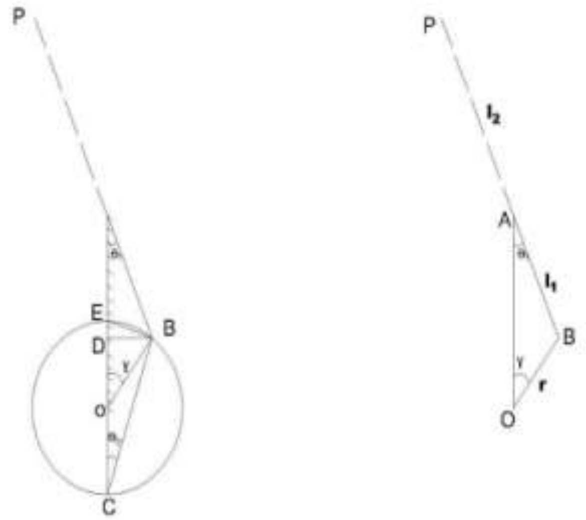

Fig4: Angular relationship diagram

2.2Forces and angular relationship

Let Θ_1 = inclination of the slotted bar with the vertical

γ = inclination of the crank with the vertical

From ΔOBC,$\angle OBC=\angle BCO$

$=\Theta_2$ (since, OC=OB= crank length, r)

Also, $\gamma = 2\Theta_2$ (from triangle's law)

Now from ΔCBE, $\angle B$=90 (angle in a semicircle)

$CB=CE\cos\Theta_2$

And $CD=CB\cos\Theta_2$

$=CE\cos^2\Theta_2$

Now, $\tan\Theta_1=\frac{BD}{AD}$, $BD=CD\tan\Theta_2$

$=\frac{CD\tan\Theta2}{AD}$

$=\frac{CE\cos^2\Theta2\tan\Theta2}{AC-CE\cos^2\Theta2}$

$=\frac{CE\sin\Theta2\cos\Theta2}{AC-CE\cos^2\Theta2}=\frac{CE\sin2\Theta2}{2(AC-CE\cos^2\Theta2)}$

$\Rightarrow\Theta_1=\tan^{-1}\left(\frac{CE\sin2\Theta2}{2(AC-CE\cos^2\Theta2)}\right)$

Let F_1= effort applied

F_2= force developed at the junction of link 4 and5 L_1= effort length from the fulcrum

L_2= distance of the developed force F2 from the fulcrum

By applying moment equation at the fulcrum, A We have, $F_1L_1=F_2L_2$

$$F_2 = \frac{F_1 L_1}{L_2}$$

From Fig applying sine law to ΔABO, $\frac{L_1}{\sin\gamma} = \frac{r}{\sin\theta 1}$

$$\Rightarrow F_2 = \frac{F_1 \, r \frac{\sin\gamma}{\sin\theta 1}}{L_2}$$

3.Comparison with the slotted lever mechanism

Basic difference lies in the arrangement of slotted bar in between the two mechanisms. Developed force F_2 is always less than the effort F_1 in the crank and slotted lever mechanism whereas F_2 may increase or decrease in the modified design as preconstruction.

3.1. Special design of the slotted bar

In the modified mechanism, if we design the slotted bar in such a way that the junction of link 4 and 5(PR) can be made at various position as shown in the fig. then the design will be able to cope up with variation of developed force F_2 with the stroke length (P_1P_2) within certain limit.

Fig5: Special design of the slotted bar showing various position of the junction between link 4 and link5 (PR).

4.Other possible arrangement

Moreover, automatic class 1 lever is possible which might be applied to construct automatic scissor.

In the modified mechanism, if two slotted levers are included inclined to each other at different angle then two motions would be obtained from the same mechanism simultaneously.

Fig: Two slotted bar inclined to each other using in the same mechanism to obtain two reciprocating motion simultaneously.

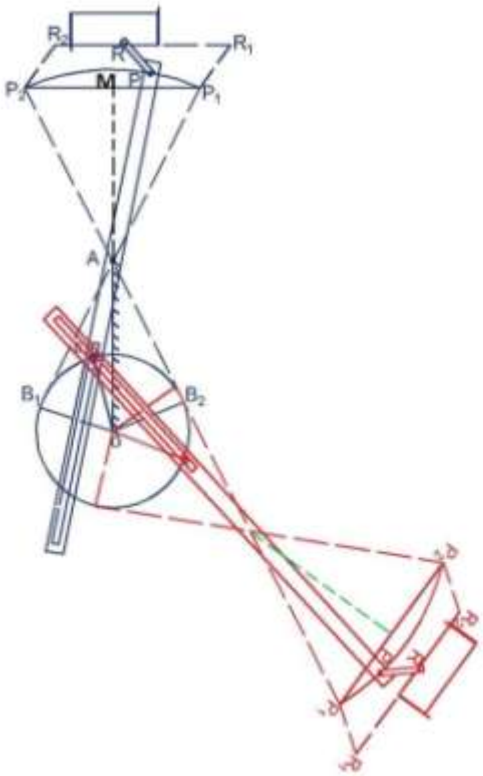

Fig6. Two slotted bar

5.Discussion

In this paper, configuration of a modified design for the quick return mechanism is briefly introduced. This modified mechanism is a good alternative. When specially modified slotted bar is used, this mechanism gives the flexibility of variation of developed force F_2 with the stroke length within certain limit. Using of class-1 lever in the mechanism is helpful to leverage the effort (F_1). Moreover proper construction would give the freedom for more than one motion simultaneously from the same mechanism which would increase productivity rate.

Acknowledgment

I express my sincere gratitude to all the professors, friends and my dear brothers & sisters of our university for theirs inspiring words and to my dear parents for their constant and instant support

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