Design of a Crank-Driven Toggle Quick-Return Mechanism

Overview

Quick-return mechanisms feature different durations for their “working” and return strokes. The time-ratio of a quick-return mechanism is the ratio of the time of the working stroke to the return stroke. Several basic mechanism types can be used to create mechanisms with a quick-return action. These types include: Whitworth mechanism, offset slider-crank, inverted slider-crank, crank-rocker four-bar, and drag-link four-bar linkages. Quick-return mechanisms are used in shapers, power-driven saws, and many other applications where a slower working stroke in comparison to return stroke is desired. In this project you are asked to analyze an existing mechanism and to redesign it for a different time-ratio.

Existing Mechanism

The current crank-driven toggle quick-return mechanism has the following dimensions:

\[ r_{1x} = 60 \text{ cm}, \quad r_{1y} = 25 \text{ cm}, \quad r_2 = 25 \text{ cm}, \quad r_3 = 65 \text{ cm}, \quad r_4 = 60 \text{ cm}, \quad \text{and} \quad r_5 = 58 \text{ cm} \]
Week 1. Analysis of the existing mechanism

a) Familiarize yourself with Working Model. Draw the existing mechanism and collect enough and reliable data to determine the Time Ratio and the Stroke of the mechanism.

b) Report the maximum velocity and acceleration during the working and return stroke at $\dot{\theta}_2 = \omega_2 = 10$ rad/s.

c) Determine the position of the slider analytically when $\theta_2 = 0^\circ$, report the position with respect to point D.

d) Determine the Time Ratio and the Stroke of the existing mechanism using the analytical method.

Week 2. Design of a New Crank-Driven Toggle Quick-Return Mechanism

The existing mechanism is used as the base of a shaper. Nevertheless, it was found that the tool attached to the piston wears out rapidly. Reducing the speed of the motor may affect the production. As an alternative, the Time Ratio of the mechanism can be modified. An adjustable coupler ($r_3$) is desired for this purpose, which may be useful for further Time Ratio modifications. With an adjustable coupler, the stroke of the slider is consequently altered. However, the stroke of the existing mechanism is required for the current application. To maintain the required stroke, link $r_5$ may be replaced.

a) Determine the range of lengths of the proposed adjustable coupler. Make sure to preserve the type of motion of the mechanism (crank-rocker) and prevent the mechanism to buckle (point C should not go below the slider line, otherwise the slider would move back and forth at the top dead centre).

b) Determine the range of Time Ratios that can be achieved by adjusting the length of the coupler $r_3$, i.e. plot coupler link vs. Time Ratio. Note for this part it is convenient to write a matlab code that evaluates different coupler lengths using the previously found Time Ratio equations of the existing mechanism.

c) Determine the length of the coupler that makes the Time Ratio equal to 1.5.

d) Determine, for the new mechanism, the length of link $r_5$ that will maintain the same stroke of the original mechanism.

Report Requirements

- An abstract (summary)
- A brief introduction
- A description of the methods used and the results obtained
- A discussion and other concerns you feel are important
- A conclusion and references
- An appendix with all the hand written calculations and matlab codes

References

Cleghorn W. L, “Mechanics of Machines,” Oxford University Press, 2005 (Section 2.6)
Firmani F. “MECH 335 Lecture Notes Spring 2014” (Section 2.6)