PROJECT ABSTRACT

Whitworth Quick Return Mechanism Demonstration Model

A bench-top demonstration model of the Whitworth crank-and-slotted-lever quick-return drive used in shapers and slotters. A hand-cranked (optionally motor-driven) crank wheel, slotted lever, connecting link and guided ram make the slow cutting stroke and fast return stroke visible and measurable, so the student can time both strokes, compute the cutting-to-return ratio, and verify it against the geometric design target of approximately 1.7:1.

Project type: Hardware

Availability: Built to order

Suitable branches: Mechanical

Technologies: Mild steel fabrication, Crank wheel & crank pin, Slotted lever, Ram & guide rails, 608 ball bearings, Hand-crank drive, 12 V DC gear motor (optional), Masking-tape labels

Price: Request a quotation

Prepared by Projectech · projectech.in — for academic project reference.

1. Abstract

In shapers and slotters the tool must cut slowly on the working stroke and race back on the return stroke, and the Whitworth crank-and-slotted-lever mechanism produces exactly that timing from a single rotating crank. This project builds a bench-top demonstration model of the mechanism: a crank wheel with a crank pin, a slotted lever pivoting on a fixed centre, a connecting link and a ram running on guide rails, all mounted on a fabricated mild-steel frame. Turning the hand crank makes the timing asymmetry visible and measurable — the ram creeps forward on the cutting stroke and snaps back on the return stroke. The student times both strokes with a stopwatch, computes the cutting-to-return ratio, and compares it with the geometric design target of approximately 1.7:1. The build includes fabrication drawings, a timing observation sheet, the project report, PPT and viva Q&A.;

2. Problem Statement

In theory of machines courses, the quick-return mechanism is usually taught as a diagram and a timing-ratio formula. Students are asked to compute the cutting-to-return ratio for crank radii and centre distances they have never touched, so the asymmetry the formula describes remains an abstraction. The unequal division of the crank's rotation between the two extreme positions of the slotted lever is precisely the part that a textbook figure cannot make the student feel.

This project closes that gap with a working physical model. The same geometry that the report derives — crank radius about 60 mm, crank-centre distance about 150 mm — is fabricated in steel, so the student can watch the slow cutting stroke and the quick return, time them, and verify the ratio against theory with their own measurements.

3. Objectives

- Build a bench-top Whitworth crank-and-slotted-lever demonstration model in steel.
- Make the cutting-stroke vs return-stroke timing difference visible and measurable.
- Derive the cutting-to-return timing ratio from the mechanism geometry (design target approx. 1.7:1).
- Enable the student to verify the ratio experimentally with stroke-timing measurements.
- Deliver fabrication-ready drawings, a timing observation sheet, report, PPT and viva Q&A.;

4. System Architecture

The mechanism is organized as a kinematic chain on a bolted mild-steel frame over a plywood base. The **input stage** is the crank wheel (approx. 140 mm steel disc) on a 608-ball-bearing shaft, turned by a hand crank or an optional 12 V DC gear motor at about 30 RPM. The **conversion stage** is the slotted lever (approx. 450 mm mild-steel flat) pivoting on a fixed centre below the wheel, with the crank pin (radius about 60 mm) sliding in its slot. The **output stage** is a connecting link from the top of the lever to a ram block running between twin guide rails, giving straight-line reciprocating motion with an approx. 180 mm stroke.

5. Technologies Used

- Mild steel frame fabrication
- Crank wheel & crank pin
- Slotted lever & connecting link
- Ram block & twin guide rails
- 608 ball bearings
- Hand-crank drive (motor-ready)
- 12 V DC gear motor (optional)
- Masking-tape labels & M6/M8 fasteners

6. Working Principle

- The hand crank (or optional DC gear motor) rotates the crank wheel at approximately constant angular velocity.
- A pin fixed at about 60 mm radius on the wheel slides in the slot of the slotted lever, converting uniform rotation into oscillation about the lever's fixed pivot.
- The lever's extreme positions occur where the crank pin is tangent to the swing geometry, so the crank sweeps a larger angle during the working stroke than during the return stroke.
- Because the crank rotates at constant speed, the larger angle takes longer time — the return stroke is therefore quicker than the cutting stroke.
- The top of the slotted lever drives the connecting link, pushing and pulling the ram block along the guide rails.
- The student times one full cycle with a stopwatch: the working stroke lasts about 1.7 times as long as the return stroke (design target from the nominal geometry).
- Measured times are entered in the timing sheet and compared with the geometric prediction.
- Repeating the timing at different crank speeds shows the ratio is a property of the geometry, not of speed.

7. Key Features

- True Whitworth geometry: crank pin sliding in the slotted lever produces the genuine quick-return asymmetry the report derives.
- Visible cutting vs return timing — the ram's slow forward stroke and fast return are plain to see.
- Student-run stroke timing with a stopwatch, checked against the approx. 1.7:1 design target.
- Hand-crank drive as standard for direct demonstration control; optional 12 V DC gear motor for continuous running.
- Bearing-mounted crank (608 ball bearings) for smooth, low-friction rotation.
- Ram block on twin guide rails showing rotary-to-reciprocating conversion.
- Handwritten masking-tape labels on crank wheel, slotted lever, connecting link, ram and guide rails.
- Timing observation sheet with worked example, fabrication drawings, report, PPT and viva Q&A.;

8. Applications

- Theory of machines laboratory demonstrations of quick-return mechanisms.
- Classroom teaching aid for shaper and slotter drive kinematics.
- Viva and project-exhibition demonstrations in mechanical engineering departments.
- Hands-on verification of textbook timing-ratio derivations.

9. Prerequisites

- Basic knowledge of kinematics of machines (four-bar chains, slider-crank basics).
- Familiarity with simple fabrication drawings and workshop practice.
- Basic trigonometry for following the timing-ratio derivation.
- A stable workbench for setting up the model during demonstration.

10. Limitations

- This is a demonstration model, not a working shaper — there is no cutting tool or workpiece; it demonstrates drive timing, not metal cutting.
- The approx. 1.7:1 timing ratio is a design target from the nominal geometry; measured values depend on the student's own timing and on build tolerances of about ±2–3 mm on link dimensions.
- Hand-cranked speed varies between operators, so the ratio — not the absolute stroke times — is the repeatable result.
- Slot-to-pin clearance of about 0.5–1 mm introduces a small amount of play; the lever dwell this causes is discussed in the report.
- The bolted mild-steel assembly weighs about 8–10 kg (design target) and must sit on a stable bench.
- The optional motor drive runs at a fixed approx. 30 RPM; no speed control is included unless ordered.
- The crank pin sits at a fixed radius of about 60 mm, so the ram stroke is approximately 180 mm by design; adjustable crank radius is future scope.

11. Future Scope

- Adjustable crank radius for variable stroke length and timing ratio.
- Motor drive with speed controller for controlled stroke-rate studies.
- Encoder-based automatic stroke timing instead of a stopwatch.
- Comparative study model placing Whitworth and drag-link (crank-rocker) quick-return drives side by side.

12. Conclusion

The Whitworth Quick Return Mechanism Demonstration Model turns a theory-of-machines formula into something the student can touch and time. By building the actual crank-and-slotted-lever chain in steel — crank wheel, slotted lever, connecting link and guided ram — the project makes the unequal division of the crank's rotation between cutting and return strokes visible, measurable and verifiable against the geometric design target of approximately 1.7:1. The report is honest about what the model is: a kinematics demonstrator with stated design targets and tolerances, not a measured-performance claim, so the student's viva rests on genuine understanding.