MIT-WORLD PEACE UNIVERSITY

F. Y. B. Tech

Trimester: I/II/III **Subject:** Basic Mechanical Engineering

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Roll No.: 109054 **Batch:** I3

Experiment No.: 2

Name of the Experiment: Demonstration of and working of slider crank mechanism.

Performed on: 9th September 2021

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***Aim*:**

To study the working principle and construction of a slider crank mechanism and to understand working of slider crank mechanism and its inversions.

***Theory*:**

Slider-crank Mechanism is an arrangement of mechanical parts designed to convert straight line motion into rotary motion, as in a reciprocating engine. It is used to transform rotational motion into translational motion by means of a rotating driving beam, a connection rod and a sliding body.

Links and joints: A link is a resistant body or a group of resistant bodies with rigid connections between them preventing any relative motion between them. The connections between links are modelled as providing ideal movement, pure rotation or sliding and are called *joints*.

A linkage modelled as a network of rigid links and ideal joints is called a *kinematic chain.*

Kinematic link: Each part of a machine that undergoes relative motion with respect to some other part, is called kinematic link They help in the transmission of motion, from one machine part to another. Kinematic links form the backbone of any mechanical system.

Types of Kinematic links:
Based on rigidity, kinematic links can be broadly classified into three types.

1. Rigid link
2. Flexible link and
3. Fluid link

Kinematic Pair:

A kinematic pair or a pair is the joint between two links having relative motion between them.

Example: In slider-crank mechanism, link 2 rotates relative to link 1 and constitutes a revolute or turning pair. Link 4 (slider) reciprocates relative to link 1 and is a sliding pair. Kinematic pairs can be classified according to nature of contact and nature of relative motion

Types of Kinematic Pairs upon Nature of contact:

1. *Lower pair*: A pair of links having surfaced or area contact between the members is known as a lower pair. The contact surfaces of the two links are similar. Example: Nut turning on a screw, shaft rotating in a bearing, all pairs of a *slider-crank mechanism*, *universal joint* etc.
2. *Higher pair:* When a pair has appointed or line contact between the links, it is known as higher pair. The contact surfaces of the two links are dissimilar.
   Example: wheel rolling on a surface, cam and follower pair, tooth gears, balls and roller bearings, etc.

Kinematic pairs according Nature of relative motion:

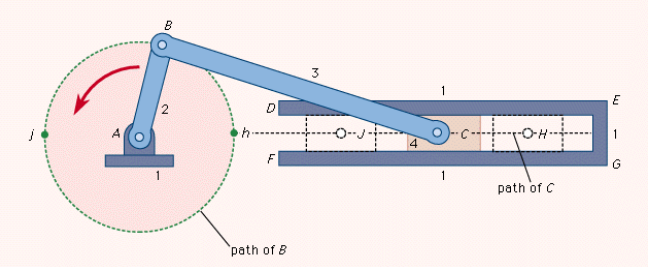
1. *Sliding pair*: If two links have a sliding motion relative to each other, they form a sliding pair.
   A rectangular rod in a prism is a sliding pair.
2. *Turning pair:* when one link has a turning or revolving motion relative to each other, they constitute a turning pair or revolving pair. In slider-crank mechanism, all pairs except the slider and guide pair are turning pairs. A circular shaft revolving inside a bearing is a turning pair.
3. *Rolling pair:* when the links of a pair have a rolling motion relative to each other, they form a rolling pair, e.g. a rolling wheel on a flat surface, ball and roller bearing, the ball and the shaft constitute one rolling pair whereas the ball and the bearing is the second rolling pair.
4. *Screw pair*: If two mating links have turning as well as sliding motion between them, they form a screw pair. This is achieved by cutting matching threads on the two links. The lead screw and the nut of a lathe is a screw pair.
5. *Spherical pair:* when one link in the form of a sphere turns inside a fixed link, it is spherical pair. The ball and socket joint is a spherical pair.

Slider-Crank Mechanism:

A slider crank mechanism converts circular motion of the crank into linear motion of the slider. In order for the crank to rotate fully the following condition must be satisfied

$$L > R + E$$

Where, ‘R’ is the crank length, ‘L’ is the length of the link connecting the crank & the slider
‘E’ is the offset of the slider between its two extreme positions i.e. Path length.



The basic nature of the mechanism and the relative motion of the parts can best be described with the aid of the accompanying figure. the moving parts are lightly shaded.

The darkly shaded part 1, the fixed frame or block of the pump or engine, contains a cylinder, depicted in cross section by its walls DE and FG, in which the piston, part 4, slides back and forth.

The small circle at A represents the main crankshaft bearing, which is also in part 1. The crankshaft, part 2, is shown as a straight member extending from the main bearing at A to the crankpin bearing at B, which connects it to the connecting rod, part 3.

The connecting rod is shown as a straight member extending from the crankpin bearing at B to the wrist-pin bearing at C, which connects it to the piston, part 4, which is shown as a rectangle.

The three bearings shown as circles at A, B, and C permit the connected members to rotate freely with respect to one another. The path of B is a circle of radius AB; when B is at point h the piston will be in position H, and when B is at point j the piston will be in position J.

On a gasoline engine, the head end of the cylinder (where the explosion of the gasoline-air mixture takes place) is at EG; the pressure produced by the explosion will push the piston from position H to position J; return motion from J to H will require the rotational energy of a flywheel attached to the crankshaft and rotating about a bearing collinear with bearing A. On a reciprocating piston pump the crankshaft would be driven by a motor.

Example**:** Internal combustion engines are a common example of this mechanism, where combustion in a *cylinder* creates pressure which drives a *piston*. The linear motion of the piston is then converted into rotational motion at the crank through a mutual link, referred to as the *connecting rod*. As the geometry of the crank forces the conversion of linear motion to rotational, shaking forces are generated and applied to the crank's housing. The shaking forces result in vibrations which impede the operation of the engine.

*Inversions***:** If we change the fixed pair in a slider-crank mechanism, we can get a achieve different pre-defined motions which are different from each other. These mechanisms are called Inversions of the slider-crank mechanism. As there are four pairs in a slider-crank mechanism, we have 4 inversions. Mechanisms obtained by fixing different links of slider crank chain are as follows:

I. *First inversion* This inversion is obtained when link 1 (ground body) is fixed.
Applications: Reciprocating engine, reciprocating compressor.

II. *Second inversion*
This inversion is obtained when link 2 (crank) is fixed.
Application-Whitworth quick return mechanism, Rotary engine.

III. *Third inversion*
This inversion is obtained when link 3 (connecting rod) is fixed.
Application- Slotted crank mechanism, Oscillatory engine

IV. *Fourth inversion*
This inversion is obtained when link 4 (slider) is fixed.
Application- Hand pump, pendulum pump or Bull engine, etc. revolver mechanisms

Conclusion:

The dynamic behaviour of a slider-crank mechanism with a flexible connecting rod is investigated. Slider-crank mechanism converts rotary motion into reciprocating motion by means of a rotating driving beam, a connection rod & sliding body. The use of this mechanism in the wide range of machines like pumps and compressors is observed.

Questions:

1. What is the difference between a rigid and resistant body?
   A. A body is said to be ***rigid*** if under the action of forces, it does not suffer any distortion or if the distance between any two points on it is not changing. The bodies which are rigid for the purposes they serve as called as ***resistant bodies***. They act as a rigid body under specific loading conditions are also called as resistant bodies. For example, the mechanism of strings in a lift.

2. What is the difference between a chain, mechanism, and machine?
   A. *Chain* is an assembly of links, and is classified on the basis of relative motion between those links.
   B. *Mechanism* is also an assembly of links. If upon fixing any one or more of the links of a chain, a useful pre-defined motion is achieved, then that chain is called a mechanism.
   C. *Machine* is a mechanism or a combination of mechanisms which apart from imparting definite motion to parts, also transmits and modifies the available mechanical energy into some kind of desired work.

3. What is the difference between a four-bar chain and a four-bar mechanism?
   A. *Four-bar chains*: There are four links which are connected together to obtain desired predefined motion.
   B. *Four-bar mechanism:* If any one of the four links of a four-bar chain is fixed, then it is called a four-bar mechanism. The sum of any three links must be more than or equal to the 4^{th} link for it to work.
4. How can a four-bar mechanism be converted into a slider-crank mechanism?
   A. A slider-crank mechanism can be made from a four-bar mechanism by replacing any one of the turning pairs into a sliding pair.
5. What do you understand by inversion of slider-crank mechanism? Name the inversions of the slider-crank mechanism with its applications.
   A. If we change the fixed pair in a slider-crank mechanism, we can get a achieve different pre-defined motions which are different from each other. These mechanisms are called Inversions of the slider-crank mechanism. As there are four pairs in a slider-crank mechanism, we have 4 inversions.
      1. *First inversion:* This inversion is obtained when link 1 (ground body) is fixed. Applications: Reciprocating engine, reciprocating compressor.
      2. *Second inversion:* This inversion is obtained when link 2 (crank) is fixed. Application-Whitworth quick return mechanism, Rotary engine.
      3. *Third inversion:* This inversion is obtained when link 3 (connecting rod) is fixed. Application- Slotted crank mechanism, Oscillatory engine
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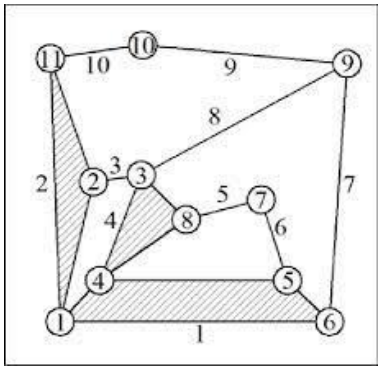
6. Try to identify the number and type of pairs and links in Figure 1.



A. The Number of kinematic pairs or joints in the figure are 11, and the number of links are 10.

Pairs:

- Binary Joints: 1, 2, 5, 6, 7, 8, 10, 11
- Tertiary Joints: 3, 4, 9

Links:

- Binary Links: 3, 5, 6, 7, 8, 9, 10
- Tertiary Links: 2, 4
- Quaternary Links: 1

7. What do you understand by the degree of freedom?

A. Degrees of freedom (DOF) of a mechanical system is the number of independent parameters that define its configuration or state.