24AG401 THEORY OF MACHINES

UNIT 1 NOTES

Inversions:

By fixing each link at a time we get as many mechanisms as the number of links, then each mechanism is called

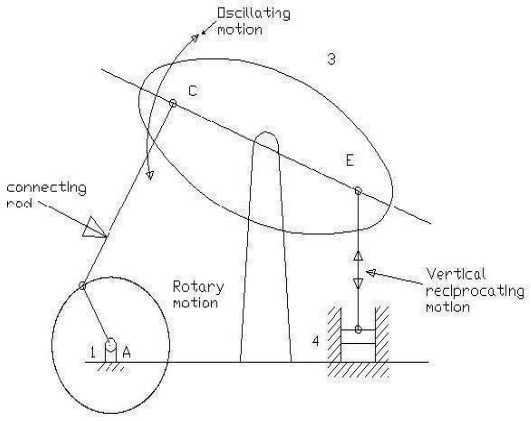
„Inversion" of the original Kinematic Chain.

Inversions of four bar chain mechanism:

There are three inversions: 1) Beam Engine or Crank and lever mechanism. 2) Coupling rod of locomotive or double crank mechanism. 3) Watt"s straight-line mechanism or double lever mechanism.

1. **Beam Engine: - 1st Inversion or 3rd Inversion**

When the crank AB rotates about A, the link CE pivoted at D makes vertical

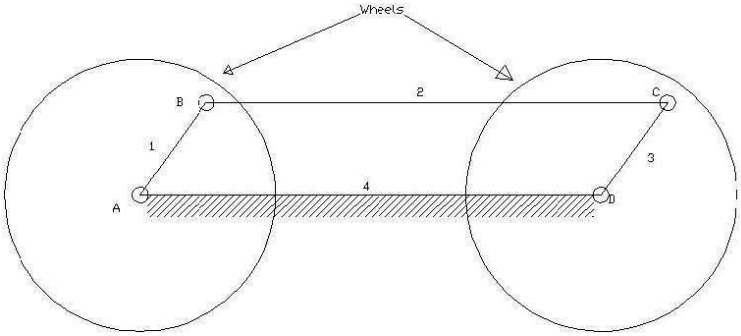


reciprocating motion at end E. This is used to convert rotary motion to reciprocating motion and vice versa. It is also known as Crank and lever mechanism.

2. Coupling rod of locomotive:

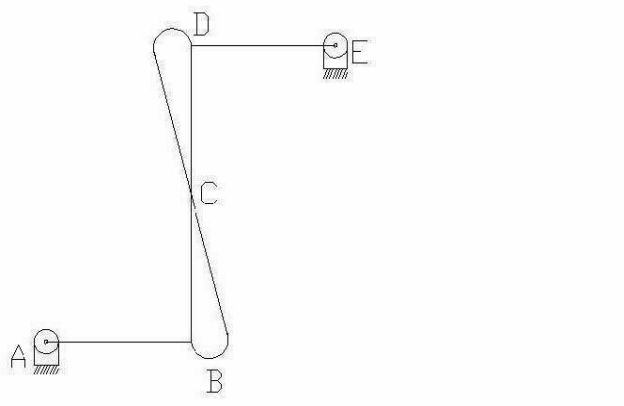
In this mechanism the length of link AD = length of link C. Also, length of link AB = length of link CD. When AB rotates about A, the crank DC rotates about D. this

mechanism is used for coupling locomotive wheels. Since links AB and CD work as cranks, this mechanism is also known as double crank mechanism. This is shown in the figure below.



3. **Watt's straight-line mechanism or Double lever mechanism:** In this mechanism, the links AB & DE act as levers at the ends A & E of these levers are fixed. The AB & DE are parallel in the mean position of the mechanism and coupling rod BD is perpendicular to the levers AB & DE. On any small displacement of the mechanism the tracing point „C" traces the shape of number „8", a

portion of which will be approximately straight. Hence this is also an example for the approximate straight-line mechanism. This mechanism is shown below.



- **2. Slider crank Chain:**

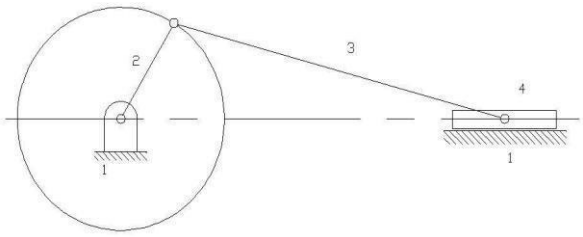
It is a four-bar chain having one sliding pair and three turning pairs. It is shown in the figure below the purpose of this mechanism is to convert rotary motion to reciprocating motion and vice versa.

Inversions of a Slider crank chain:

There are four inversions in a single slider chain mechanism. They are:

- **Reciprocating engine mechanism:**

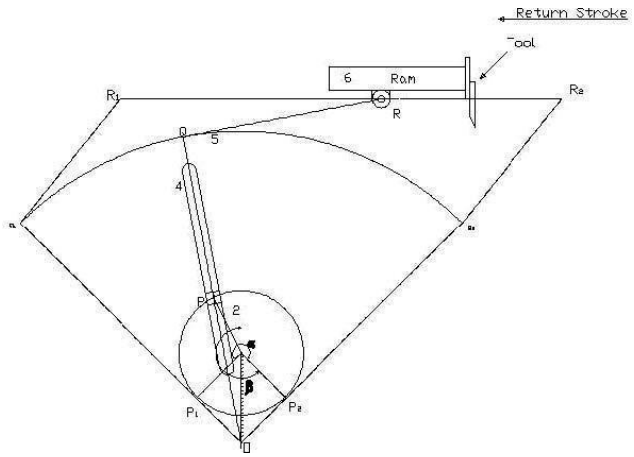
In the first inversion, the link 1 i.e., the cylinder and the frame are kept fixed. The fig below shows a reciprocating engine.



A slotted link 1 is fixed. When the crank 2 rotates about O, the sliding piston 4 reciprocates in the slotted link 1. This mechanism is used in steam engine, pumps, compressors, I.C. engines, etc.

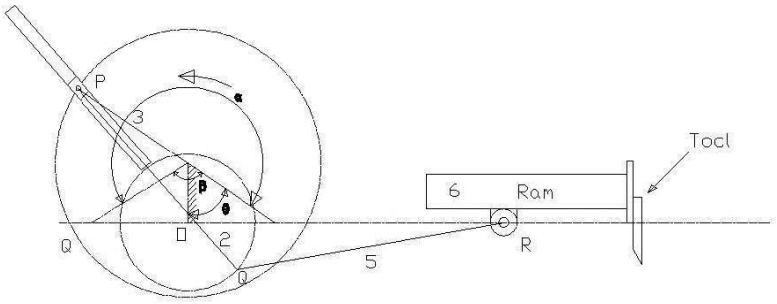
- **Crank and slotted lever mechanism:**

It is an application of second inversion. The crank and slotted lever mechanism is shown in figure below.



- In this mechanism link 3 is fixed. The slider (link 1) reciprocates in oscillating slotted lever (link 4) and crank (link 2) rotates. Link 5 connects link 4 to the ram (link 6).
- The ram with the cutting tool reciprocates perpendicular to the fixed link 3.
- The ram with the tool reverses its direction of motion when link 2 is perpendicular to link 4
- Thus, the cutting stroke is executed during the rotation of the crank through angle α

and the return stroke is executed when the crank rotates through angle β or 360 – α. Therefore, when the crank rotates uniformly, Whitworth quick return motion mechanism:

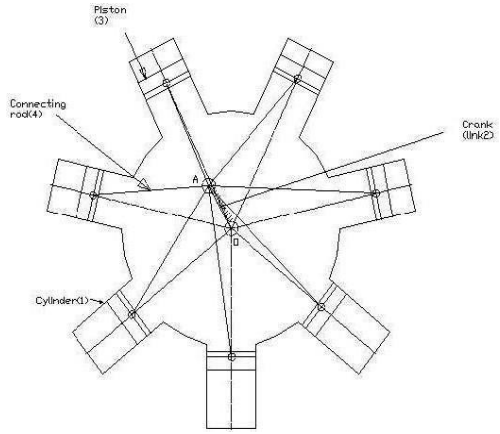


- Third inversion is obtained by fixing the crank i.e. link 2. Whitworth quick return mechanism is an application of third inversion.
- The crank OC is fixed and OQ rotates about O. The slider slides in the slotted link and generates a circle of radius CP. Link 5 connects the extension OQ provided on the opposite side of the link 1 to the ram (link 6).
- The rotary motion of P is taken to the ram R which reciprocates. The quick return motion mechanism is used in shapers and slotting machines.
- The angle covered during cutting stroke from P1 to P2 in counter clockwise direction is α or 360 -2θ. During the return stroke, the angle covered is 2θ or β.

- **Rotary engine mechanism or Gnome Engine:**

- Rotary engine mechanism or gnome engine is another application of third inversion. It is a rotary cylinder V – type internal combustion engine used as an aero – engine.
- The Gnome engine has generally seven cylinders in one plane. The crank OA is fixed and all the connecting rods from the pistons are connected to A.

- In this mechanism when the pistons reciprocate in the cylinders, the whole assembly of cylinders, pistons and connecting rods rotate about the axis O, where the entire mechanical power developed, is obtained in the form of rotation of the crank shaft. This mechanism is shown in the figure below.



Description of common mechanisms-Single, Double and offset slider mechanisms - Quick return mechanisms:

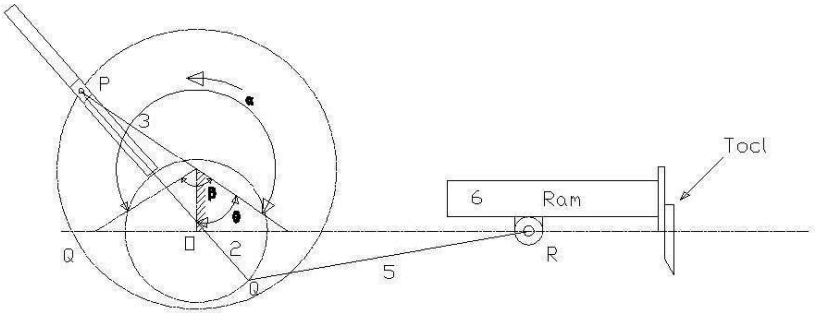
1. Quick Return Motion Mechanisms:

Many times mechanisms are designed to perform repetitive operations. During these operations for a certain period the mechanisms will be under load known as working stroke and the remaining period is known as the return stroke, the mechanism returns to repeat the operation without load. The ratio of time of working stroke to that of the return stroke is known a time ratio.

Quick return mechanisms are used in machine tools to give a slow cutting stroke and a quick return stroke. The various quick return mechanisms commonly used are i) Whitworth ii) Drag link. iii) Crank and slotted lever mechanism

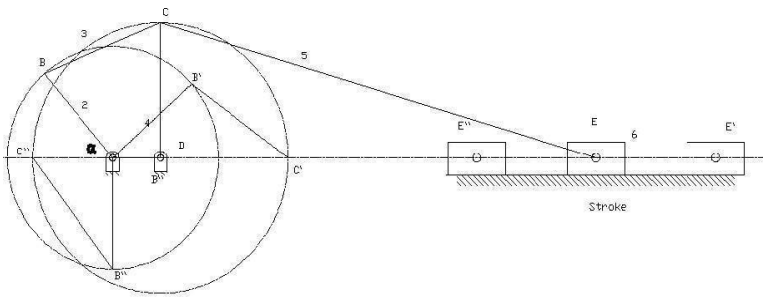
2. Whitworth quick return mechanism:

- Whitworth quick return mechanism is an application of third inversion of the single slider crank chain. This mechanism is shown in the figure below.
- The crank OC is fixed and OQ rotates about O. The slider slides in the slotted link and generates a circle of radius CP. Link 5 connects the extension OQ provided on the opposite side of the link 1 to the ram (link 6). The rotary motion of P is taken to the ram R which reciprocates.
- The quick return motion mechanism is used in shapers and slotting machines.



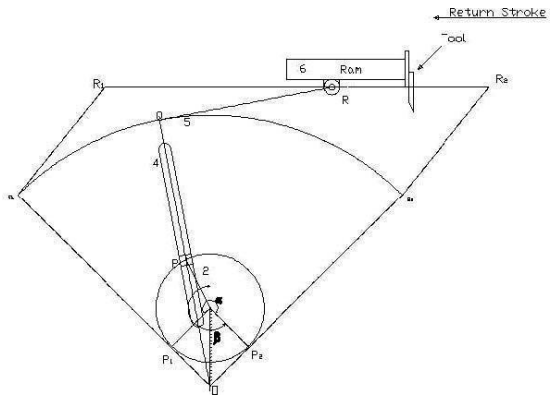
- he angle covered during cutting stroke from P1 to P2 in counter clockwise direction is α or 360 -2θ.
- During the return stroke, the angle covered is 2θ or β.

3. Drag link mechanism:



- This is four bar mechanism with double crank in which the shortest link is fixed. If the crank AB rotates at a uniform speed, the crank CD rotate at a non -uniform speed.
- This rotation of link CD is transformed to quick return reciprocatory motion of the ram E by the link CE as shown in figure.
- When the crank AB rotates through an angle α in Counter clockwise direction during working stroke, the link CD rotates through 180. We can observe that / α >/ β.
- Hence time of working stroke is α /β times more or the return stroke is α /β times quicker. Shortest link is always stationary link.
- Sum of the shortest and the longest links of the four links 1, 2, 3 and 4 are less than the sum of the other two. It is the necessary condition for the drag link quick return mechanism.

4. Crank and slotted lever mechanism:



It is an application of second inversion. The crank and slotted lever mechanism is shown in figure below.

- In this mechanism link 3 is fixed. The slider (link 1) reciprocates in oscillating slotted lever (link 4) and crank (link 2) rotates. Link 5 connects link 4 to the ram

(link 6).

- The ram with the cutting tool reciprocates perpendicular to the fixed link 3. The ram with the tool reverses its direction of motion when link 2 is perpendicular to link 4.
- Thus, the cutting stroke is executed during the rotation of the crank through angle α and the return stroke is executed when the crank rotates through angle β