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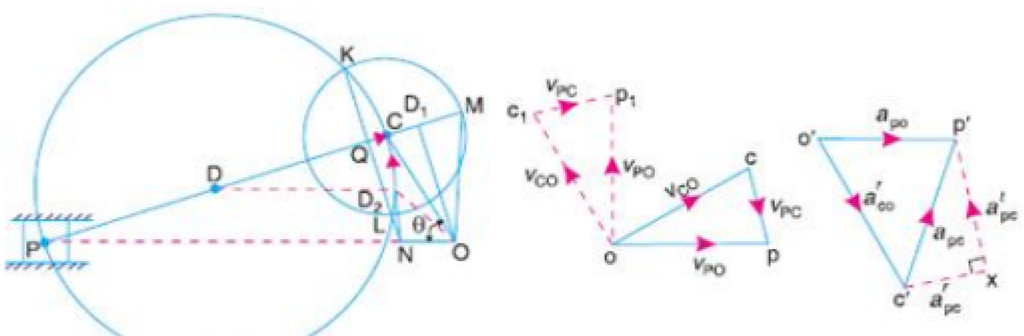
Question:
Explain the Klein's construction to determine velocity and acceleration of single slider crank mechanism.

Answer:

Let OC be the crank and PC the connecting rod of a reciprocating steam engine, as shown in Fig. Let the crank makes an angle θ with the line of stroke PO and rotates with uniform angular velocity ω rad/s in a clockwise direction. The Klien's velocity and acceleration diagrams are drawn as discussed below:



(*a*) Klien's acceleration diagram. (*b*) Velocity diagram. (*c*) Acceleration diagram.

Klien's velocity diagram

First of all, draw OM perpendicular to OP; such that it intersects the line PC produced at M. The triangle OCM is known as *Klien's velocity diagram*. In this triangle OCM,

OM may be regarded as a line perpendicular to PO,

CM may be regarded as a line parallel to PC, and ...($\because$ It is the same line.)

CO may be regarded as a line parallel to CO.

We have already discussed that the velocity diagram for given configuration is a triangle OCP as shown in Fig. If this triangle is rotated through 90°, it will be a triangle oc1 p1, in which oc1 represents VCO (i.e. velocity of C with respect to O or velocity of crank pin C) and is parallel to OC, op1 represents VPO (i.e. velocity of P with respect to O or velocity of cross-head or piston P) and is perpendicular to OP, and c1p1 represents VPC (i.e. velocity of P with respect to C) and is parallel to CP. A little consideration will show that the triangles oc1p1 and OCM are similar. Therefore,

$$\frac{oc_1}{OC} = \frac{op_1}{OM} = \frac{c_1p_1}{CM} = \omega \text{ (a constant)}$$

$$\frac{v_{CO}}{OC} = \frac{v_{PO}}{OM} = \frac{v_{PC}}{CM} = \omega$$

$$v_{CO} = \omega \times OC\,;\; v_{PO} = \omega \times OM, \text{ and } v_{PC} = \omega \times CM$$

Thus, we see that by drawing the Klein’s velocity diagram, the velocities of various points may be obtained without drawing a separate velocity diagram. Klien’s acceleration diagram: The Klien’s acceleration diagram is drawn as discussed below: 1. First of all, draw a circle with C as centre and CM as radius. 2. Draw another circle with PC as diameter. Let this circle intersect the previous circle at K and L. 3. Join KL and produce it to intersect PO at N. Let KL intersect PC at Q. This forms the quadrilateral CQNO, which is known as Klien’s acceleration diagram. We have already discussed that the acceleration diagram for the given configuration is as shown in Fig. We know that (i) o'c' represents CO ar (i.e. radial component of the acceleration of crank pin C with respect to O) and is parallel to CO; (ii) c'x represents PC ar (i.e. radial component of the acceleration of crosshead or piston P with respect to crank pin C) and is parallel to CP or CQ; (iii) xp' represents PC at (i.e. tangential component of the acceleration of P with respect to C) and is parallel to QN (because QN is perpendicular to CQ); and (iv) o'p' represents aPO (i.e. acceleration of P with respect to O or the acceleration of piston P) and is parallel to PO or NO. A little consideration will show that the quadrilateral o'c'x p' is similar to quadrilateral CQNO . Therefore,

$$\frac{o'c'}{OC} = \frac{c'x}{CQ} = \frac{xp'}{QN} = \frac{o'p'}{NO} = \omega^2 \text{ (a constant)}$$
