Velocity and acceleration

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The status of motion of links of a mechanism is determined by:

- locations: "Zero-order transfer function“ $\Psi=f(\varphi)$
- velocities: "First-order transfer function“ $d\Psi/d\varphi$
- accelerations: "Second-order tr. function“ $d^2\Psi/d\varphi^2$

Velocity and acceleration are vectors which can be analysed by calculation but also by graphic-computational methods.

The vectors vB and aB of the rockerpin B were in former times determined graphically, since the calculated solution is complicated. Nowadays PC-Programs (e.g. SAM 5.0) based on **F**inite **E**lement **M**ethods are normally used.

Angular velocity	$w = d\varphi/dt = v/r = 2\pi n$
Velocity	$v = w\ r$
Angular acceleration	$a = d^2\varphi/dt^2$
Tangential acceleration	$a_t = dv/dt = a\ r$
Normal acceleration	$a_n = v^2/r = w^2\ r$
Acceleration (total)	$a = (a_n^2 + a_t^2)^{1/2}$

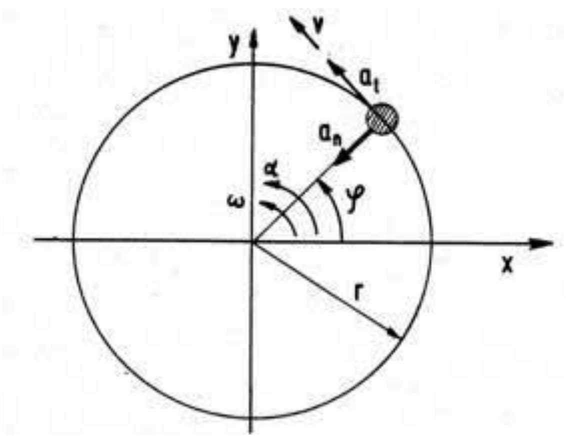

Fig. 1.14 Kinematics on a rotating point

1. Instantaneous Center of Rotation (InstantCenter)

For plane motion there is always a point which can be instantaneously regarded as a pure rotation, i.e. a point that is temporarily at rest.

This instant center is obtained as the point of intersection of the perpendicular of two velocity directions. Fig. 1.15 shows a crank-and-rocker mechanism with the coupler points A, B, C and Fig. 1.16 only shows the coupler with the respective velocity vectors v_A, v_B, v_C. If, in addition to two velocity directions, the value of a velocity is given (e.g. v_A), then the instantaneous angular velocity w is defined as:

$$\omega = v_A / AP = v_B / BP = v_C / CP = \tan J$$

With the angle J or the length AP, BP, CP the unknown velocities v_B and v_C can be determined (Fig 1.16).

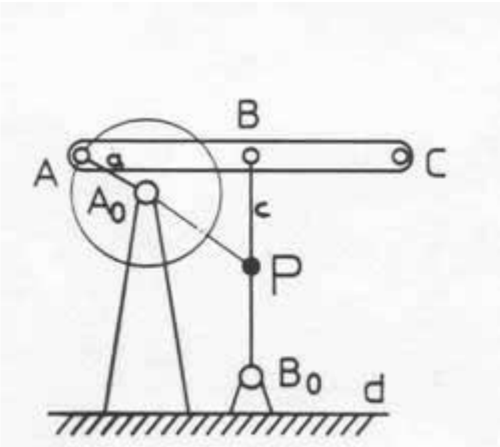

Fig. 1.15 Crank-and-rocker with instant center P

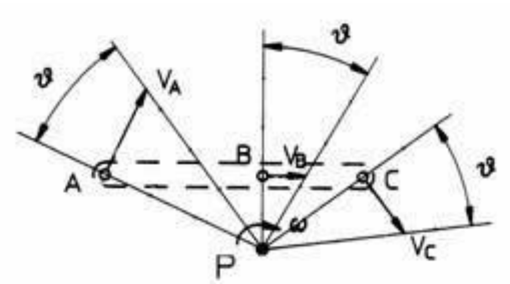

Fig. 1.16 Coupler of Fig. 1.15 with velocities

2. Method of ‘rotated’ velocities

Graphically the value of the velocities is derived using the method of “rotated velocities” i.e., v_A is rotated by 90° (Fig. 1.17) and it describes a parallel to the line AB. The vectors v_B and v_C appear and provide the values of the not rotated velocities.

If, in a crank-mechanism, the velocity of the crankpin A, v_A is given, it is assumed to take the length of v_A equal to the length of the crank A_0A.

The method of 'rotated' velocities has the advantage of being able to work without using the instant center. The rotated velocities are marked with an edge (v_A┐).

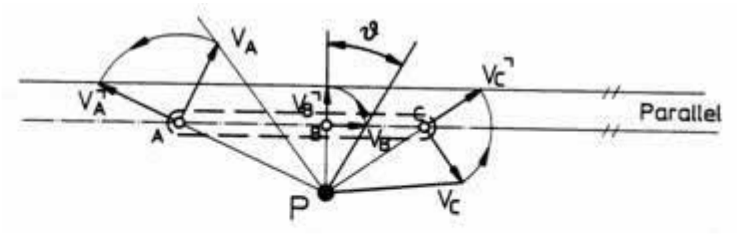

Fig. 1.17 Coupler of Fig. 1.15 with rotated and not rotated velocities

3. Burmester's criterion for velocities

In a plane mechanism the vector heads (e.g. v_A , v_B , v_C) produce a figure which is similar to the one of the coupler (e.g. A, B, C) (Fig. 1.18).

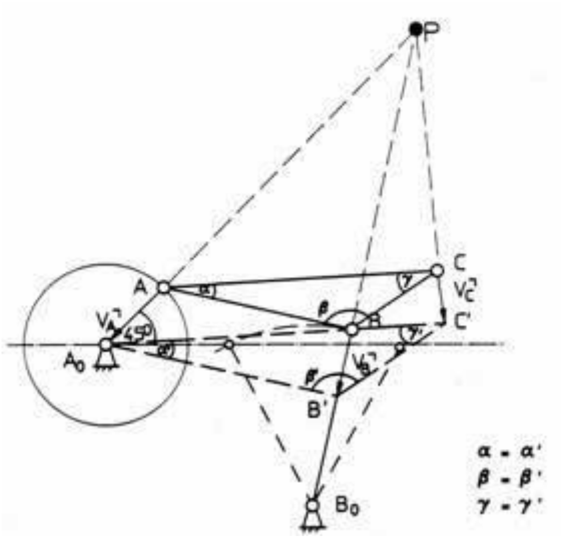

Fig. 1.18 Burmester's criterion for velocities shown for a triangle coupler ABC

Go to Exercise 1.7

4. Acceleration

It is complicated to determine the acceleration of the point B of a slider crank or a crank-and-rocker by means of graphic methods. So SAM 5.0 is used to calculatethe acceleration a_B .

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Go to Exercise 1.9
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Go to Exercise 1.12
Go to Exercise 1.13