**3. Balancing of Several Masses Rotating in the Same Plane**

Consider any number of masses (say four) of magnitude *m*1, *m*2, *m*3 and *m*4 at distances of  *r*1, *r*2, *r*3 and *r*4 from the axis of the rotating shaft. Let θ1, θ2,θ3 and θ4

be the angles of these masses with the horizontal line *OX*, as shown in Fig. 4 (*a*). Let these masses rotate about an axis through *O* and perpendicular to the plane of paper, with a constant angular velocity of ω rad/s. The magnitude and position of the balancing mass may be found out analytically or graphically as discussed below:



**Fig .4.** Balancing of several masses rotating in the same plane.

**a) Analytical method**

The magnitude and direction of the balancing mass may be obtained, analytically,

as discussed below :

Resolve the centrifugal forces horizontally and vertically and find their sums, *i.e*.

Σ*H* = *m*1 . *r*1 cosθ1 + *m*2 . *r*2 cosθ2 + . . . . . .

Σ*V* = *m*1 . *r*1 sinθ1 + *m*2 . *r*2 sinθ2 + . . . . . .

Magnitude of the resultant centrifugal force,

*F*C = [(ΣH )2 + (ΣV )2]^.5

If θ is the angle, which the resultant force makes with the horizontal, then

tan θ = ΣV/ƩH

The balancing force is then equal to the resultant force, but in ***opposite direction*.** Now find out the magnitude of the balancing mass,

*F*C = *m*. *r*

where *m* = Balancing mass, and

*r* = Its radius of rotation.

**b) Graphical method**

The magnitude and position of the balancing mass may also be obtained graphically using Table: 1 and then draw:

1. Find the centrifugal force (or product of the mass and radius of rotation)

exerted by each mass on the rotating shaft.

2. Draw the vector diagram with the obtained centrifugal forces to some suitable

scale.

3. The closing side of polygon *ae* represents the resultant force in magnitude and

direction, as shown in Fig. 4 (*b*).

4. The balancing force is, then, equal to the resultant force, but in ***opposite***

***direction.***

5. Find the magnitude of the balancing mass (*m*) at a given radius of rotation (*r*),

*m*.*r* = Resultant of  *m*1.*r*1,  *m*2.*r*2, *m*3.*r*3 and  *m*4.*r*4.

Table 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No. of masses** | **Mass (m)** | **Radius (r)** | **Angle (Ө)** | **Centrifugal force ÷ω2**  **(m.r)** |
| **1** | **m1** | **r1** | **Ө1** | **m1.r1** |
| **2** | **m2** | **r2** | **Ө2** | **m2.r2** |
| **3** | **m3** | **r3** | **Ө3** | **m3.r3** |
| **4** | **m4** | **r4** | **Ө4** | **m4.r4** |