

## Power Transmitted by a Rotating Shaft

The work done by a force **F** over a differential displacement vector **dr** is

$$dW = \vec{F} \cdot \vec{dr}$$

Equation 1

If a shaft is being driven by a motor or another shaft, then the motor or attached driving shaft is transmitting an applied torque **T**. One can think of this applied torque as being the result of a force **F** located a distance **r** away from the axis of rotation. If the force is perpendicular to the radial vector **r**, then a scalar equation can be written that, the effective force due to the torque is perpendicular to the displacement vector for the case of a rotating shaft, so the effective force in terms of the applied torque is

$$F = \frac{T}{r}$$

Equation 2

where **r** is the distance from the center of rotation. Since **F** is parallel to **dr**, **dW** may be written in scalar form as

$$dW = F dr$$

Equation 3

So substituting the formula for torque, **T** gives

$$dW = \frac{T}{r} dr$$

Equation 4

Finally, by dividing both sides of Eq. 4 by **dt** -

$$\frac{dW}{dt} = \dot{W} = T \frac{dr}{r} = T \frac{v}{r} = T\omega$$

*Equation 5*

Equation 5 represents the power transmitted by a shaft rotating with angular speed  $\omega$  and applying a torque  $T$  to another shaft.