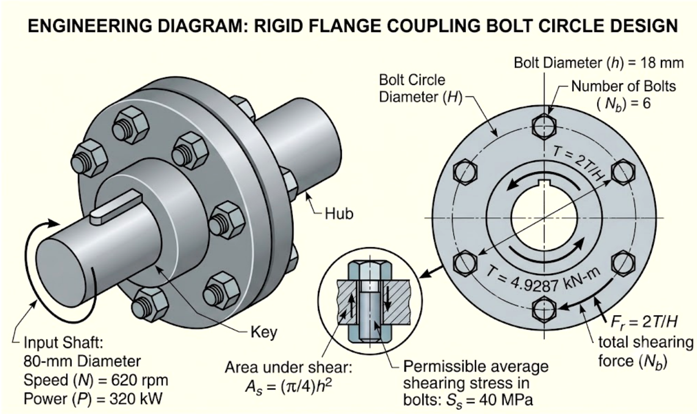

Step 1: Calculate the Transmitted Torque (T)

In any power transmission problem, the first parameter to determine is the torque or torsional moment being carried by the system. Power, speed, and torque are related by the fundamental rotational power equation:

$$P = \frac{2\pi TN}{60}$$

Where P is the power in kilowatts (kW), T is the torque in kilonewton-meters (kN-m), and N is the rotational speed in revolutions per minute (rpm). Rearranging this equation to isolate torque gives:

$$320\ kW = \frac{2\pi T\ (620\ rpm)}{60}$$

$$T = 4.92866\ kN - m$$

<u>Step 2:</u> Relate Torque to the Shearing of Bolts

When torque is transmitted through a flange coupling, it is transferred from one flange face to the other through the bolts via shear force. The total torque capacity of the coupling is equal to the total shearing force experienced by all the bolts multiplied by the radius at which they act (the bolt circle radius, $R = \frac{H}{2}$).

The total force causing shear across all bolts is given by:

$$F_{total} = \frac{T}{R} = \frac{2T}{H}$$

Since the torque is distributed equally among the N_b bolts, the shear force per individual bolt $\left(F_b\right)$ is: $F_b = \frac{2T}{HN_b}$

The cross-sectional area of a single bolt resisting this shear force is: $A_S = \frac{\pi}{4}h^2$

The average shearing stress (S_S) in the bolts is defined as the force per bolt divided by its shear area: $S_S = \frac{F_b}{A_S} = \frac{2T}{H\left[\frac{\pi}{4}h^2\right]N_b}$

<u>Step 3:</u> Solve for the Bolt Circle Diameter (H)

Rearranging the formula to isolate the unknown bolt circle diameter (H), we obtain:

$$H = \frac{2T}{H\left[\frac{\pi}{4}h^2\right]N_b} = \frac{2(4{,}928{,}660\ N-mm)}{40mm\left[\frac{\pi}{4}(18mm)^2\right](6)} = 161.4\ mm$$

Increasing the bolt circle diameter (H) gives the bolts a larger moment arm to fight the applied torque. This means you can reduce the required size or number of bolts by expanding the flange diameter. However, engineers must balance this against material cost, rotational inertia, and spatial constraints.

While this problem establishes the minimum dimension needed to prevent bolt failure, mechanical systems are typically designed so that the **key** fails first under extreme overloads. A key is cheap and easily replaceable, whereas shearing the coupling bolts or warping the shaft can destroy adjacent machine bearings and cause catastrophic housing damage.