

Theoretical Calculations for the Wind Turbine

The wind turbine design is based on real-time wind speed data collection and theoretical calculations. Key considerations include:

Given:

1. Type of Wind Turbine: Vertical Axis Wind Turbine (VAWT) H Rotor Type
2. Main supporting Column:
 - a. Diameter: 60 mm
 - b. Length: 1.2 m
3. Rotor Shaft:
 - a. Diameter: 25 mm
 - b. Length: 30 cm
4. Rotor Diameter: 80 cm
5. Blades:
 - a. NO. 6
 - b. Height: 60 cm
 - c. Semi-circle of area $A \approx 91.1\text{cm}^2$
6. Wind Speed: 3.9 m/s

1) Tip Speed Ratio (TSR):

3.5 (Chosen for typical efficiency in VAWT systems, considering blade characteristics and rotor design.)

2) Calculate RPM:

The formula to calculate RPM (Revolutions Per Minute) is:

$$\text{RPM} = (V_{\text{rotor}} * 60) / (\pi * D_{\text{rotor}})$$

- Where:
- V_{rotor} = Rotor speed in m/s (calculated earlier as 9.74 m/s)
- D_{rotor} = Rotor diameter in meters (80 cm)

Substituting the values:

$$\text{RPM} = (9.74 * 60) / (\pi * 1.03)$$

$$\text{RPM} = 232.52$$

Calculated RPM: 232.52

3) Calculate Angular Velocity:

The formula to calculate angular velocity (ω) is:

$$\omega = (2 * \pi * \text{RPM}) / 60$$

- Where:
- RPM = Rotational speed in revolutions per minute (calculated as 180.7)

Substituting the values:

$$\omega = (2 * \pi * 232.52) / 60$$

$$\omega \approx 24.35 \text{ rad/s}$$

Calculated Angular Velocity: 24.35 rad/s

4) Calculate Power:

The formula to calculate power (P) is:

$$P = 0.5 * \rho * A * v_{\text{wind}}^3 * C_p$$

- Where:
- ρ = Air density (1.225 kg/m³ at sea level)
- A = Swept area of the turbine ($\pi * (D_{\text{rotor}} / 2)^2$)
- V_{wind} = Wind speed (3.9 m/s)
- C_p = Power coefficient (typically 0.35 for VAWTs)

Substituting the values:

$$A = \pi * (0.8 / 2)^2 \approx 0.5 \text{ m}^2$$

$$P = 0.5 * 1.225 * 0.5 * (3.9)^3 * 0.35$$

$$P \approx 10.33 \text{ W}$$

Calculated Power: 6.51 W

5) Calculate Torque:

The formula to calculate torque (T) is:

$$T = P / \omega$$

- Where:
- P = Power in watts (calculated as 6.51 W)
- ω = Angular velocity in rad/s (calculated as 24.35 rad/s)

Substituting the values:

$$T = 10.33 / 24.35$$

$$T \approx 0.547 \text{ N}\cdot\text{m}$$

Calculated Torque: 0.424 N·m

Wind turbine Block Diagram

