CHAPTER THREE

MANUFACTURING MODEL AND CALCULATIONS

3.1 Introduction:

Through exposure to previous study in chapter two, when you use wind power to processing of electrical generation must be chosen a horizontal axis wind turbine type of three blades because it has high power coefficient ,sensitive to wind direction, high speed and low cost for manufacturing. For this reason the horizontal axis wind turbine type three blade is suitable design for electrical generation, and then carried it calculate the power output and also has been manufacturing for this model turbine.

3.2 model component:

According to the following design dimensions the turbine diameter is 1.4m and tower height is 4m as shown in the figure below, also the blade dimension are length 0.6m and width is 0.15m

3.3 Designed of wind turbine:

Wind turbine consist of several element to be designed each part alone an then are assembled with one part to formation a wind turbine

3.2.1 Blade:

Figure (3.1) show the blade of wind turbine

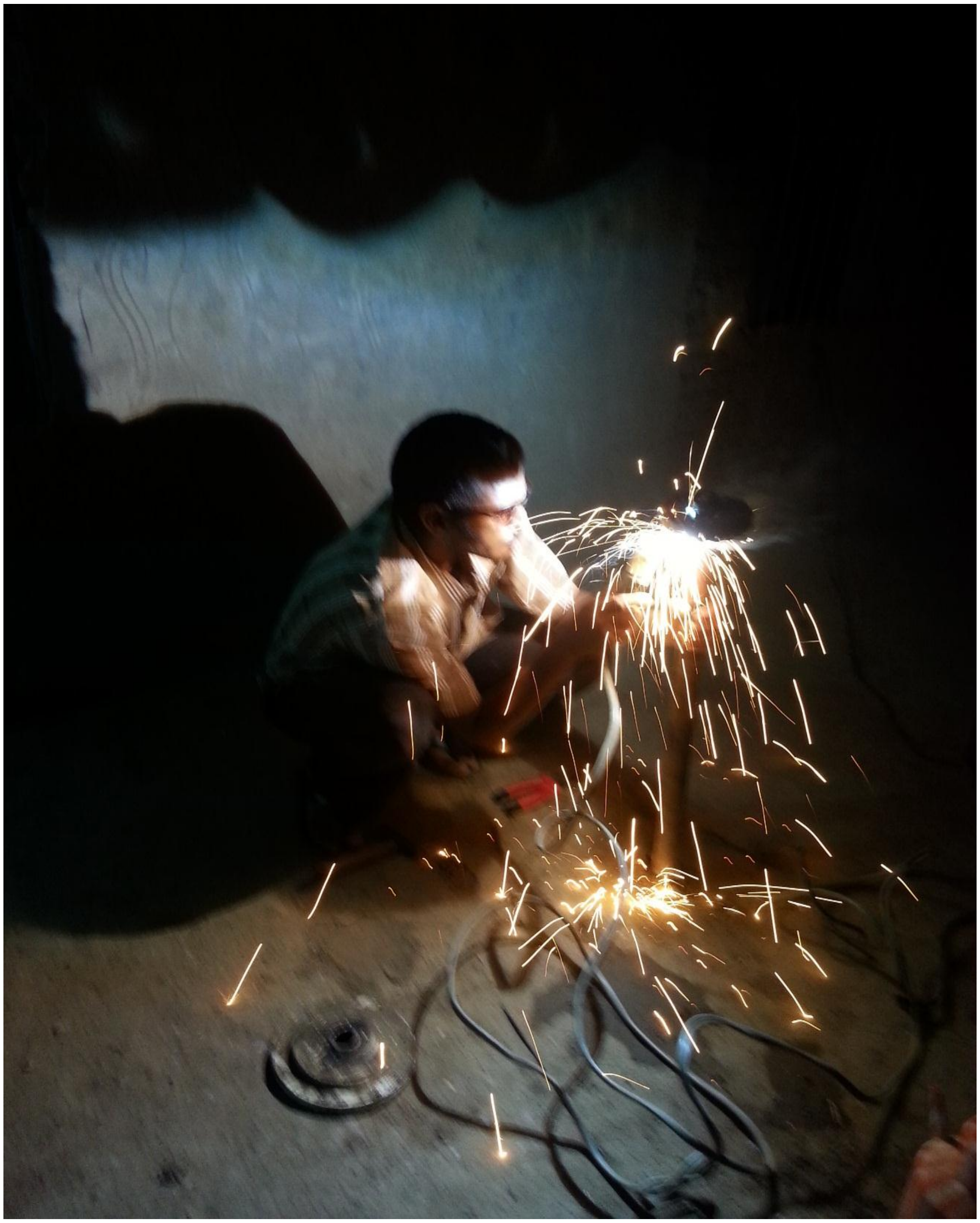


Figure (3.2) show step of manufacturing

3.2.2 Turbine blade

Figure (3.3) show the modeling of turbine

3.2.3 Yaw drive

Figure (3.4) show the yaw drive

Figure (3.5) show the rotor shaft and Yaw drive

3.2.4 Gear drive

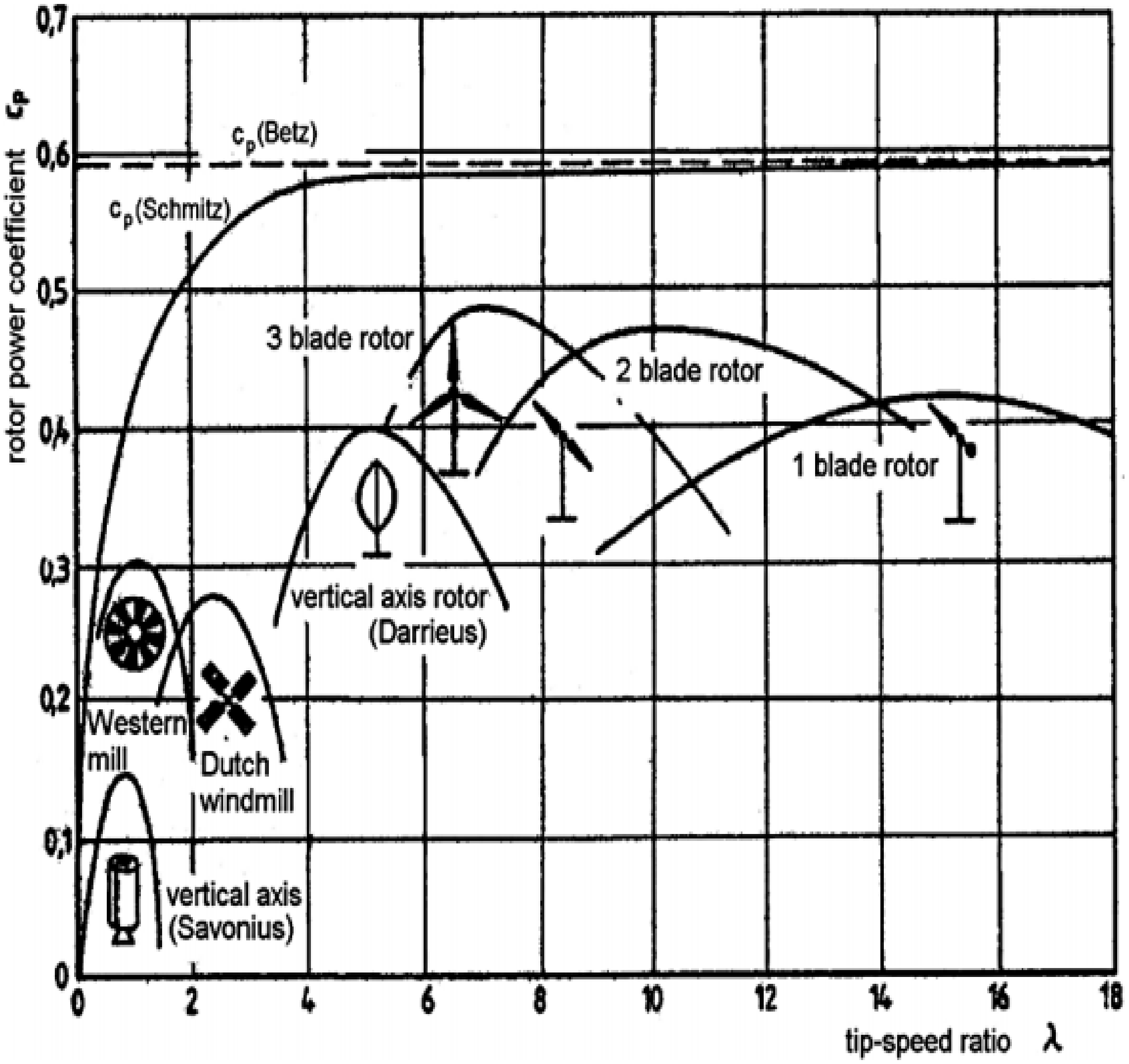
Figure (3.6) show gear drive

3.2.5 Tower

Figure (3.7) show the tower

3.2.6 Model of turbine

Figure (3.8) show the model turbine



1. Figure (3.9): Typical power coefficients of different rotor types over tip-speed ratio

Figure (3.9) shows typical characteristics (λ) cp for different types of rotor. Besides The constant maximum value according to Betz the figure indicates a revised curve cp (Schmitz) which takes the downstream deviation from axial air flow direction to Account.

From the figure (3.9) the value of cp to three blade rotor is equal 0.49.

3.3 The power in the wind

When wind blows it can move things, depending how strong is in, the power of the wind it can be expressed by the following equation:

$$p_{wind} = \frac{1}{2}\rho A V^3 \quad (3.1)$$

Where:

$p_{wind} =$ Power of the wind [w].

ρ = density of air [kg/m^3].

A = area [m^2].

V = speed of air [m/s].

3.3 The power in the wind is proportional to:

- The area of turbine being swept by the wind.
- The air density.
- The cube of wind speed.

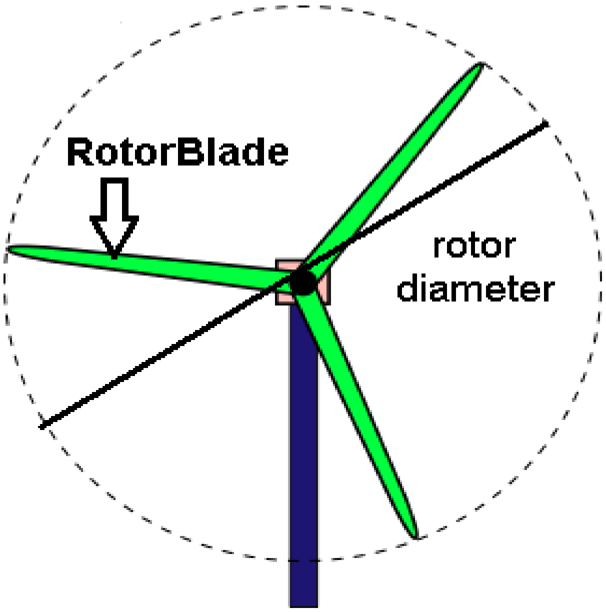


Figure (3.10) show the a swept area of HAWT

$$A= \pi r^2 \qquad (3.2)$$

$$\rho = \frac{353.049}{T} e^{-.034\frac{Z}{T}} \qquad (3.3)$$

Where:

Z = the height from the sea level.

T = the temperature measured in this height.

The density of the air varies with the height above sea level and temperature, the standard value for Sweden used usually is density at sea level 1bar and a temperature of 296k. Using these value .which the density of air is 1.2kg/m^3.

The following conclusions can be derived from equation (3.1):

- For the same turbine and at the same time, if the wind speed doubles, the Power in the wind increases by a factor of 8.
- For the same turbine and the same wind speed, if the weather is cold (Higher density), more power exists in the wind available for the turbine.
- In the same weather conditions and for the same wind speed, a turbine that is two times larger in cross-sectional area than a smaller one has twice as Much wind power available to it.

Although the power equation above gives us the power in the wind, but the actual power that we can extract from the wind is significantly less than this equation suggests. The actual power will depend on several factors, such as the type of turbine, rotor used, sophistication of blade design and friction losses

And there are also physical limits to the amount of power which the turbine can be extracted from the wind. It can be shown theoretically that any turbine machine can only possibly extracted a maximum of 60% of power from the wind (this is known as the Betz limit).in electrical generation there usually used 45% at the maximum value of Betz limit.

$$Cp = \frac{P}{\frac{1}{2}\rho A V^3} \qquad (3.4)$$

Where:

Cp = power coefficient

P = power extracted by the turbine

3.4Calculation:-

After three blades horizontal turbine has been made, and power amount extracted from the turbine calculated

According to the following design dimension the turbine diameter is 1.4 m and tower height is 5 m as shown is figure below

According to the following equation:

$$P = {}^{1}\!/_{2}\, C_p \rho A V^3$$

Where:

$$A = \pi r^2 = \frac{\pi D^2}{4}$$

$$A = \frac{\pi(1.4)^2}{4} = 1.54\text{m}^2$$

It can be calculate the density of air at the height 5m and temperature assumption equal 308k.then the value of density

$$\rho = \frac{353.049}{308} e^{-.034\frac{5}{308}} = 1.146\text{kg/m}^3$$

In this model we used three blade type horizontal turbine where $C_p = 0.6$.

The average velocity is Sudan is equal to 5m/s.

So the power calculation is:

$$P = {}^{1}\!/_{2} * 0.49 * 1.146 * 1.54 * V^3$$

P = 0.4324*V^3.

At V = 0:

P = 0.4324*$(0)^3$ = 0

At V = 2m/s:

P = 0.4324*$(2)^3$= 3.4592w

At V = 4m/s:

P = 0.4324*$(4)^3$ =27.6736w

At V = 6m/s:

P = 0.4324*$(6)^3$ = 93.3984w

At V = 8m/s:

P = 0.4324*$(8)^3$ = 221.3888w

At V = 10m/s:

P = 0.4324*$(10)^3$ = 432.4w

At V = 12m/s:

P = 0.4324*$(12)^3$ = 747.1872w

At V = 14m/s:

P = 0.4324*$(14)^3$ = 1186.5056w

At V = 16m/s:

P = 0.4324*$(16)^3$ = 1771.1104w

At V = 18m/s:

P = 0.4324*$(18)^3$ = 2521.7568w

At V = 20m/s:

P = 0.4324*$(20)^3$ = 3459.200w