Chapter 3.

Fundamental of Windmill Characteristic

3.1 Type of Windmills

Type of windmills can be classified from the installation of their rotation axis as

1. Horizontal axis
2. Vertical axis

From these classifications it can be subdivided further by the method of torque generation, either by the lift force or the drag force as shown in Fig.3.1.

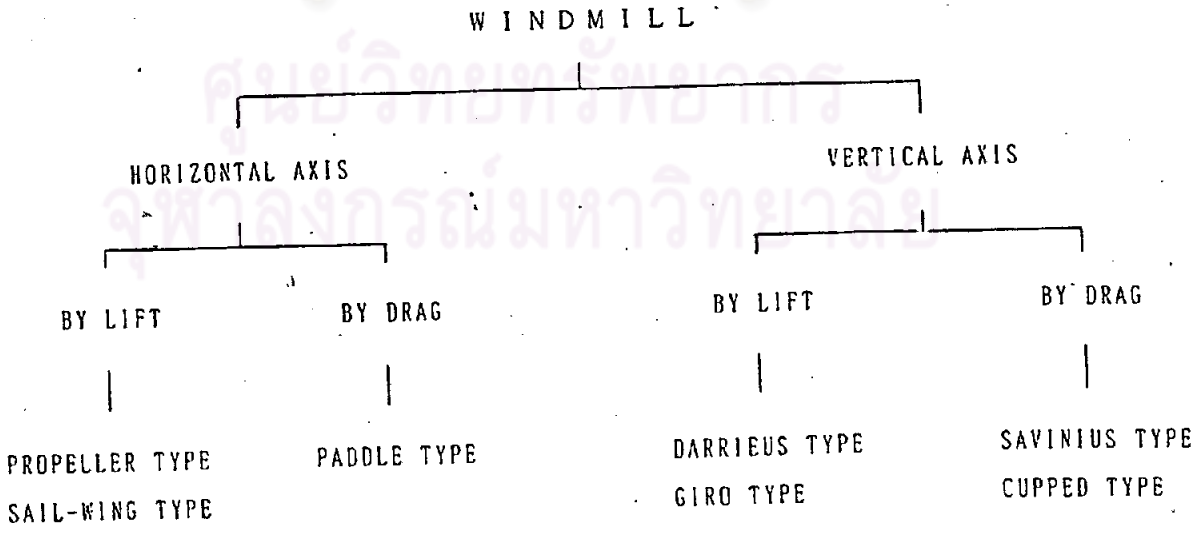

Fig.3.1 Windmill classification

3,2 Power Coefficient

The factor which shows how much of wind energy can be transformed to actual power is called a power coefficient which may be defined by

$$Cp_{max} \equiv \frac{P_{max}}{1/2 \cdot \rho A U^3} \tag{3.1}$$

Figure 3.2 shows the relation between power coefficients and tip speed ratios of various types of windmills.

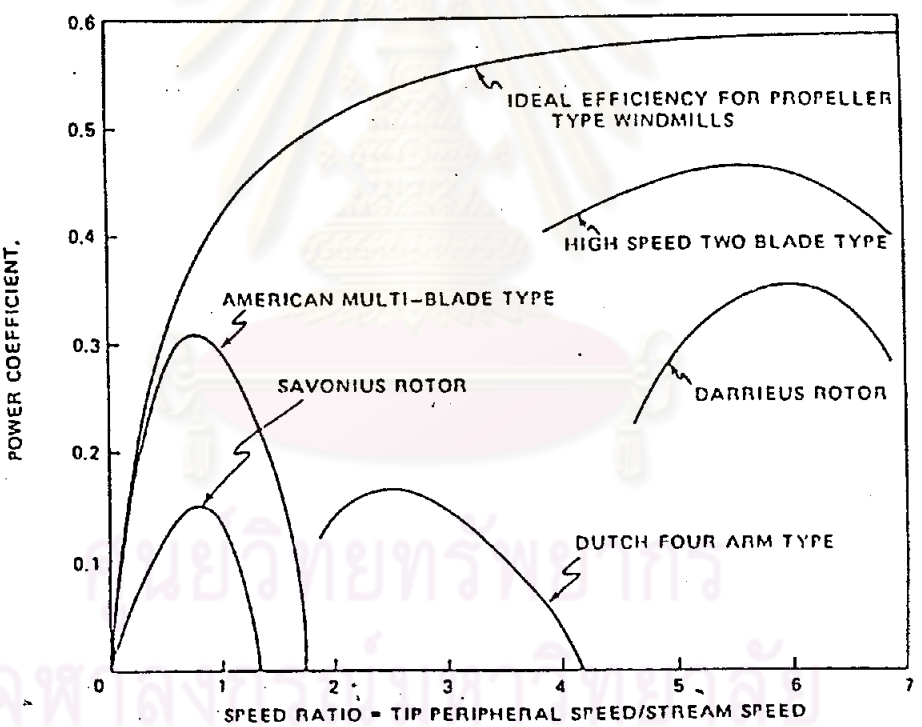

Fig. 3.2 Typical performance of wind machines

3.3 Solidity

A solidity of a windmill is defined as a ratio of

$$\text{Solidity} = \frac{\text{swept area by rotor}}{\text{surface area of rotor}} \tag{3.2}$$

When this value is small, the speed of rotation of the windmill is high, on the other hand, the speed is low when solidity value is large. Figure 3.3 shows solidity ratio with tip speed ratio on some types of windmills.

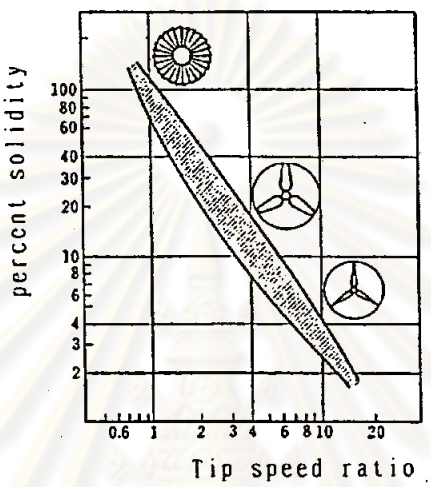

Fig.3.3 solidity ratio of windmills

For American multiblade windmills and savonius windmills, the value of solidity is large while this value is small for propeller type windmills or darrius type windmills. The values of solidity for various types of windmills are shown in Fig.3.3.

3.4 Torque Coefficient

In general the power coefficient of a low speed windmill is lower than that of a high speed one, but its torque coefficient is higher, as shown in Fig.3.4. Therefore this type of windmill is usually applied for pumping water rather than for electrical generation as in a high speed windmill.

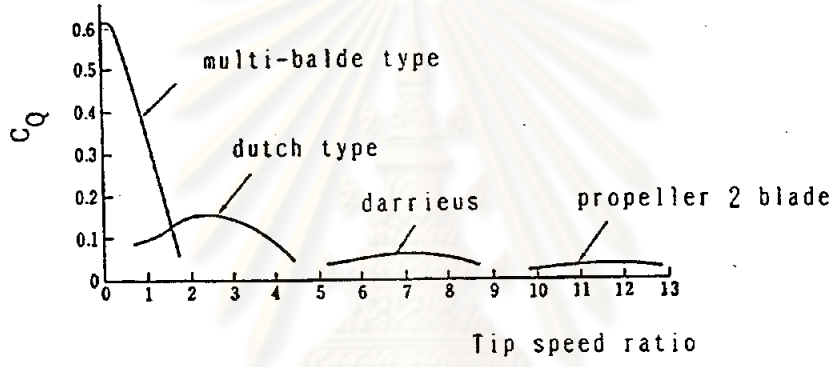

Fig.3.4 Torque coefficient of windmills