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Tip Speed Ratio & Pitch Angle Relations of Wind Turbine Blade

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Abstract: *- The tip speed ratio Cp will be low as the pitch angle β is high. Meantime it becomes slow decline after 11° with 1.5 of Cp. The Cp difference of 5° and 15° is much smaller than that of 15° and 25°. The more difficult happens with increasing β so that promoting Cp with it is more difficult in terms of this study. This is a key in this conclusion of this research. If it is smaller than 10° it is more convenient for design and use simply than high angle. So we should think over the cost increasing to proceed the high pitch angle work for its high power and low cost at different condition. It is discussed in former other paper. Cp will be slow declining to be below 1 after λ is 55.*

1. Introduction

The wind turbine is a new device used in current generator in many countries. Due to its good power it becomes a big view in the world. The tip speed ratio is a valuated parameter in new wind turbine. [1] It may be used to Valuate the machine main usage power ie. The actual speed and wind velocity. Cp is tip speed ratio that has been v/v0, here v0 is wind speed and v is turbine blade tip rotary speed. Another one is high speed ratio called λ that is a parameter to wind turbine. β is pitch angle which produces rotary and α is attack angle. In this paper the Cp-X is investigated and searched to find the difference between them for further study. In future the more and more Wind Turbine will be applied to modern cities in industry. So we should be responsible for it for upgrade new devices in revolutionary. New energy and clean environment will be created by us as well. For the next generation we shall take responsibilities to them meanwhile recycling energy is our only outlet.

2. Calculation and Modeling

Because of $\frac{v_l}{v} = \frac{R\omega}{v}$ （1）

And $\omega = 2\pi n$ (2)

Also $T = 9.55 * \frac{P}{n}$ (3)

Take place of (1) with (2) and (3) it has

$C_p = \frac{0.31 * \pi P}{Fv}$ (4)

So $F = \frac{vm}{t}$ (5)

And $\rho = m/V$ (6)

$V = 0.15 * sv$ (7)

Take place of (4) it has

$C_p = 2\frac{P}{v^3 \rho s}$ (8)

This is tip speed ratio formula.

Here v_l is blade tip speed m/s; R is blade radius m; ω is rotary r/s; T is torque Nm; P is power KW; n is rotation r/m; F is force N; m is mass Kg; s is area m2; ρ is density Kg/m^3.

3. Discussion

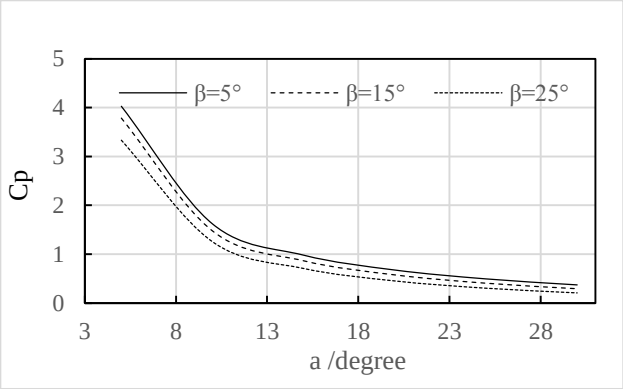

Figure 1 relations of tip speed ratio & angle of attack α with changed pitch angle β and power.

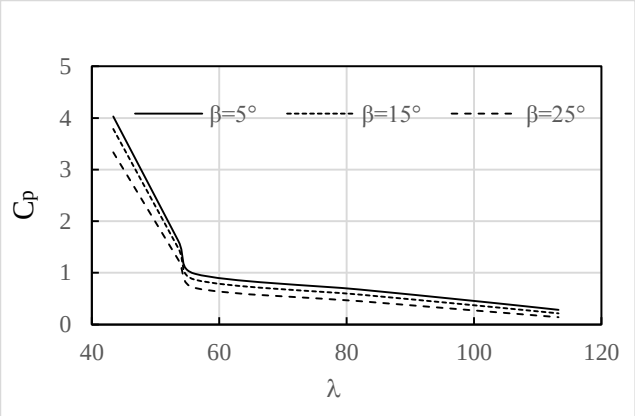

Figure 2 relations of tip speed ratio & high speed ratio λ with changed pitch angle β.

Figure 2 shows that Cp will decrease when high speed ratio increases. With the increasing pitch angle from 5° to 25 °the Cp will decrease. Cp will be slow declining to be below 1 after λ is 55. Here λ=v/vmin. Three blades' is larger than two ones. Usually it's 6 larger than 2.5.

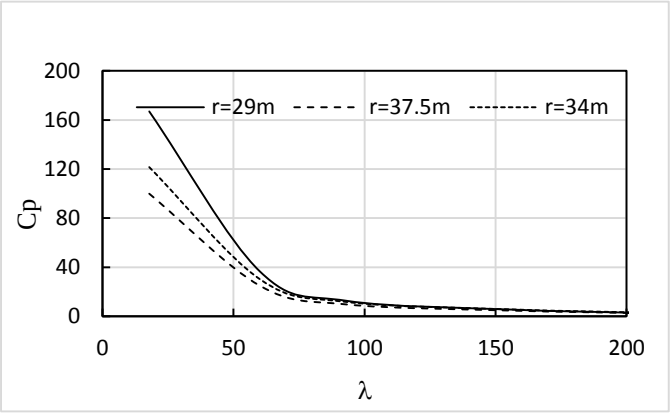

Figure 3 relations of tip speed ratio & high speed ratio λ with changed blade radius.

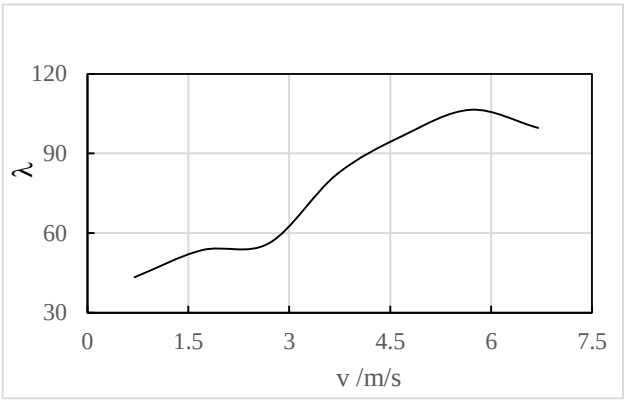

Figure 4 relations of λ and wind speed.

As Figure 1 with the increasing angle of attack the Cp will decrease. With increasing pitch angle the Cp will decrease too. After angle of attack is 10° the Cp will change into slow decreasing which is 1.2~1.5. Meantime the difference of the Cp of 15° and 25° is bigger than that of 15° and 5°. From Figure 3 it is observed that the Cp becomes low steeply at the 65 of λ and them it decreases sluggishly. It results in low Cp which may be explained by low speed when the length is high. As Figure 4 the high speed ratio λ will increase when v increases. It attains 100 of a peak at 5.6m/s.

4. Conclusions

The tip speed ratio Cp will be low as the pitch angle β is high. Meantime it becomes slow declining after 11° with 1.5 of Cp. The Cp difference of 5° and 15° is much smaller than that of 15° and 25°. The more difficult happens with increasing β so that promoting Cp with it is more difficult in terms of this study. If it is smaller than 10° it is more convenient for design and use simply than high angle. So we should think over the cost increasing to proceed the high pitch angle work for its high power and low cost at different condition. Cp will be slow declining to be below 1 after λ is 55.

References

1. Li min. Probabilistic optimization design of wind turbine gear system and power reliability [J]. GM general machinery. 2019, 9:18.