PRELIMINARY CALCULATION ON CHOOSING THE MAXIMUM THICKNESS OF TURBO-BLADE PROFILES FOR HORIZONTAL AXIS WIND TURBINE

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Abstract

Choosing profiles which meet the aerodynamic requirements resulting from the calculation of the blade aerodynamic loading involves the consultation of domain catalogues. Knowledge of the aerodynamic behaviour (energy coefficients) of these profiles in a wide range of angles of incidence is important given that the operation of designed turbine takes place in a wide scope of operation. In addition to appropriate aerodynamic performance, profiles should provide the engineering of an appropriate mechanical structure of the blade from the point of view of mechanical strength.

Key words: profiles, turbine speed and strength, aerodynamic loading, blade geometry.

INTRODUCTION

Following an analysis based on technical, economical and aesthetic grounds, a calculation is made on the number of blades, the turbine speed (λ_0) and its strength, based on its influence on the power coefficient. Blade aerodynamic loading required can be determined on each basic section of the blade associated to each radius section r.

Guiding solidities can be evaluated by means of medium size string as follows:

$$Solid = \frac{z \cdot l_m \cdot L}{\pi \cdot R^2} = 0.1656\ z\ l_m = 0.20 \ldots 0.26$$

$$L = R - r_b = 1.25$$

$$l_m = (l_b + l_p)/2$$

Solidities accepted in the literature for λ0 = 4 fall within the 0.08 ... 0.19 range. One may observe that the method involves a greater strength. One accepts the profiles thickness variation to ensure the space required for the supporting structure based on mechanical strength calculation.

MATERIAL AND METHOD

As a working algorithm one proceeds as follows:

One starts from the aerodynamic load distribution calculated $(Cyl)_{requuired}$ and one chooses a string distribution of l = f (r) radius, leading to the identification of the profiles lift coefficient required for each calculation section. Strings distribution determines the blade's width. Although the blade's shape is a secondary factor in terms of aerodynamics, as being determined in terms of mechanical strength, its width is important when starting, which is as longer as the wider the blade.

After assessing the width distribution w = f (r), for the horizontal axis turbine analyzed, one opts for profiles family which is part of the blading, and one chooses profiles while observing geometry monotony for blade thickness distribution control purposes. After choosing the l = f (r) function and determining the number of blades, for reasons of enough space for the wind turbine backbone, one chooses the maximum thickness profiles.

RESULTS AND DISSCUSIONS

Adjusted string for its implementation in the technical solution adopted has the following configuration, as structured in the following table, and presented in two possible scenarios regarding the turbine's number of blades:

Table 1.

Adjusted string

r [mm]	Variant	300	500	750	1000	1250	1500	1550
l [mm]								
z = 5	A	355	338	316	295	274	252	248
z = 6	A	295	281	263	246	228	211	207

One shows by means of plotting the string dependence l = f (r) for the two cases presented here above.

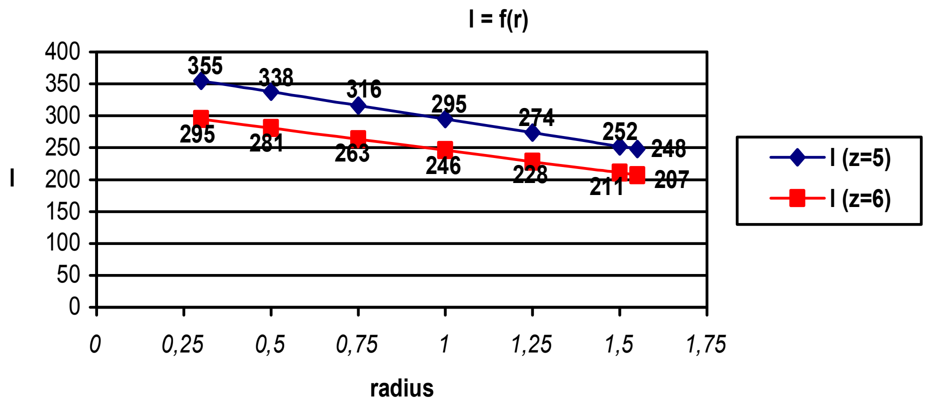

Fig. 1.

One shows by means of plotting the dependence w = f (r) for the two cases analyzed on the number of turbine blades (z = 5, z = 6), by showing the calculation step t = f (r) represented in the table below:

Table 2.

Calculation step t = f (r)

r [mm]	Variant	300	500	750	1000	1250	1500	1550
t [mm]								
z = 5	A	377	628	942	1257	1571	1885	1948
z = 6	A	314	523.6	785	1047	1309	1571	1623

Following this calculation the values of lift coefficient C_y, are shown for the chosen variant, with the two possibilities regarding the number of blades.

Table 3.

The lift coefficient values

r [mm]	Variant	300	500	750	1000	1250	1500	1550
C_y [mm]								
z = 5	A	0.860	1.092	1.198	1.220	1.212	1.203	1.202
z = 6	A	0.863	1.096	1.200	1.220	1.211	1.202	1.200

One plotting the graph on the $(C_y)_{nec} = f(r)$ dependence in two selected cases:

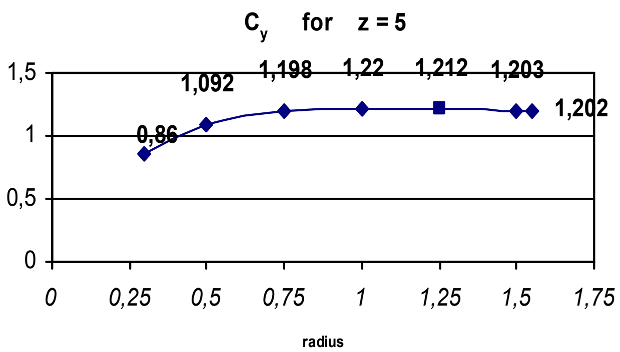

Fig. 2.

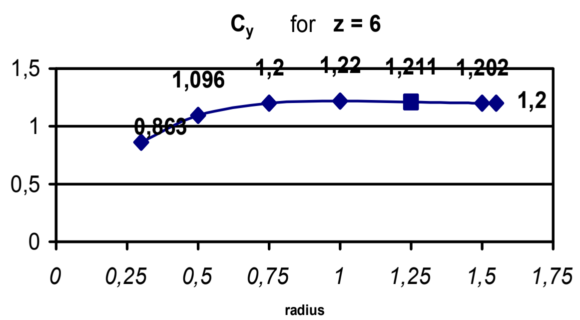

Fig. 3.

CONCLUSIONS

Blades of horizontal axis turbines use blades of different thickness, decreasing from hub to periphery; blade thickness depends on the design solution and material used. For selected profiles we have shown above by using their aerodynamic performance curves (see charts above), corresponding to the values $C_{y\ nec}$ for the chosen variant and the number of blades z = 5 and z = 6, one identifies the incidence angles values required i_{nec}. Distribution $i_{nec} = f(r)$ resulting from the calculation is being analyzed from the carriage point of view, the later being adjusted if necessary for achieving monotony incidence distribution along the radius.

One opts for a profiles family which is part of blading, and one chooses profiles while observing the geometry monotony (by $d_m/l = f(r)$ and $f_m/l = f(r)$). Calculation variant is for the 4-digit NACA profiles family while calling in this respect to a catalogue of available blades for the whole family of profiles in a wider scope of incidence.

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