DIMENSIONLESS CURVES IN OPTIMAZING WIND TURBINES CONSTRUCTION WITH HORIZONTAL AXIS

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Abstract

The present paper establishes the goal function regarding a mathematical model based on the operating curves. This is an important aim called generic "desideratum curves", consisting in some steps by means of which the optimization of the blades of turbines with horizontal axis is provided. Physical model of the turbine is a theoretical concept, which allows evaluation analysis of characteristic parameters of wind turbines. The results are applied for different values of rapidity and are developed in a comparative presentation for two types of turbine. This paper highlights the importance of certain parameters of wine turbine in the process of construction and development of the aero-electrical aggregates and their optimal functioning.

Key words: Optimization of the blades turbines geometry, wind turbines, operating curves, dimensionless curves.

INTRODUCTION

Turbine geometry optimization consists in selecting those forms that maximizing the exchange of energy in certain given conditions (wind speed, engine revs).

Wind turbine is composed mainly of a rotator fixed on a support shaft, comprising a hub and a moving blade consisting of one or more blades. Active body of aeolian turbines which made the quantity of converted energy is the blade (Bej A., 2003). The achieving of aerodynamic performances, kinematics and energy curves of the aeolian turbines depend on the choice of certain geometry.

Optimum performance is built through iterations "geometry-performance" in order to maximize the energy extracted from the wind for exploitation.

The physical and mathematical associated model involves the following components: site offer, exchange energy in the aerodynamic engine, optimized geometry of the motor and the functional characteristic curves of the engine in terms of optimized geometries (Gyulai F. and Bej, A., 2000).

MATERIAL AND METHOD

By optimizing constructive solution of the blade wind turbine we understand those aerodynamic contours which perform a desired functional characteristic for a certain application.

Energy performance representation that produces a wind turbine, as a whole operating area, is materialized by the characteristic curves that are operating in the optimization process. They are of two types namely: operating (exploitation) curves, respectively dimensionless curves of the type of turbine (Dubau C., 2003).

The characteristic curves associated to the geometry of the blade are calculated by the method of bearing. These are materialized by the two families of curves:

- operating curves

$P_T = f(\nu, n)$, $M_T = f(\nu, n)$, $F_{ax} = f(\nu, n)$;

- adimensional curbes

$C_{PT} = f(\lambda)$, $C_{MT} = f(\lambda)$, $C_F = f(\lambda)$

Taking into consideration (Dubau C., 2004), in order to characterize the functionality of various types of turbines three adimensional coefficients are used, respectively: power coefficient, moment coefficient or torque coefficients and axial force coefficient, which have the following calculation expressions:

$$C_{P_{el}} = \frac{P_{el}}{\rho \cdot \frac{v^3}{2} \cdot S_b}; \quad C_M = \frac{M}{\rho \cdot \frac{v^2}{2} \cdot S \cdot R}; \quad C_{F_a} = \frac{F_a}{\rho \cdot \frac{v^2}{2} \cdot S}; \ \nu = \frac{\pi \cdot n \cdot R}{30 \cdot \lambda}$$

where we have used the following notations:

S – Area swept by the turbine,
R – Radius of the turbine,
P – Power turbine,
M – The moment at the engine line axis,
F_a – Axial force,
ρ – Mass density of air [kg/m^3],
v – Wind speed [m/s].

The optimization of the turbine designed for an aeroelectrical power station has as a final goal the maximization of the energy extracts from wind, for exploitation in the specific conditions of a certain emplacement. This is translated in achievement of an operating curve of a turbine having a allure which ensures the maximization of the energy.

The achievement of such objective generic called „desideratum curves” or goal function consists in many steps, by successive corrections, starting with an initial geometry.

The characteristic number, namely rapidity of the turbine, is defined by the relation bellow:

$$\lambda = \frac{\pi \cdot n \cdot R}{30 \cdot v},$$

where *n* is the speed turbine [rpm].

There are various types of wind turbines. Between various types of wind turbines the rapid axial horizontal wind turbines are the most development ones (Gyulai, F., 2000). Many studies are also elaborated taking in consideration the turbines with vertical axes. Such a study regarding the adimensional curves was presented by the first author (Dubau C., 2009).

This paper provides a mathematical simulation on the computer of the output coefficient power for different rapidity, based on the model proposed in the work (Dubău C., 2007). There are compared two well-known types of turbines namely LM 18 H (DANMARK 36) and AEROTECH-17PI 85. The analyzed turbines are listed in the following table.

Table 1

The values of certain parameters for the analyzed turbines

Turbine code	The name of the turbine	Installed power $[kW]$	Rotor diameter $[m]$	Operating speed [rpm]	Power control
1	LM 18 H (DANMARK 36)	500	36	31	Auto-capping
2	AEROTECH-17PI 85	100	17	53	Control blade

RESULTS AND DISCUSIONS

In order to obtain the “desideratum curves” we have analyzed certain reference curve of two tested wind turbine and also confirmed as performance, designed by consecrated companies in the field.

All the studied operating curves associated to the above mentioned curves are measured curves. These types of curves are currently in operation in aeroelectrical power station in different emplacement from the entire world.

In the table below (table 2) are pointed the operating curves for two type of turbine. These are given for electric power at the electric generator terminals $\left(P_{el}\right)$.

Table 2

The electric power at the electric generator terminals $\left(P_{el}\left[kW\right]\right)$

	$v\left[m/s\right]$	6	8	10	12	14
Turbine code	The type of the turbine					
1	LM 18 H (DANMARK 36)	40.4	126.3	249	386.7	492.3
2	AEROTECH-17PI 85	12.5	27	52.5	77	83

For the constants computation which depends on the type turbine we will use different values of the rapidity.

In order to establish an accurate comparison, the curves were transposed in terms of dimensionless forms $C_{P_{el}} = f\left(\lambda\right)$ by the following relations:

- power coefficient (associated to the power P_{el})

$$C_{P_{el}} = \frac{P_{el}}{\rho \cdot \frac{v^3}{2} \cdot S_b} = \frac{P_{el}}{\frac{\pi}{8} \cdot \rho \cdot v^3 \cdot \pi \cdot D^2 \left[1 - \left(\frac{d}{D}\right)^2\right]};$$

- the characteristic number $\lambda = \frac{u_R}{v} = \frac{D}{2} \cdot \varpi = \frac{\pi}{60} \cdot \frac{D \cdot n}{v}$.

In computations we have used for the mass density of air [kg/m^3] the value of 1.23 kg/m^3.

In the table 3 are presented the determined values for the power coefficients ($C_{P_{el}}$) and also the determined values for the characteristic number λ as a function of wind speed $\left(v\right)$

Table 3

The power coefficient ($C_{P_{el}}$)

	$v\left[m/s\right]$		6	8	10	12	14
The type of the turbine							
LM 18 H (DANMARK 36)		λ	9.7	7.3	5.8	4.9	4.2
		$C_{P_{el}}$	0.311	0.410	0.414	0.372	0.298
AEROTECH-17PI 85		λ	9.9	7.4	5.9	4.9	4.2
		$C_{P_{el}}$	0.234	0.213	0.212	0.181	0.122

For two types of turbine we plot below dimensionless curves (Fig.1).

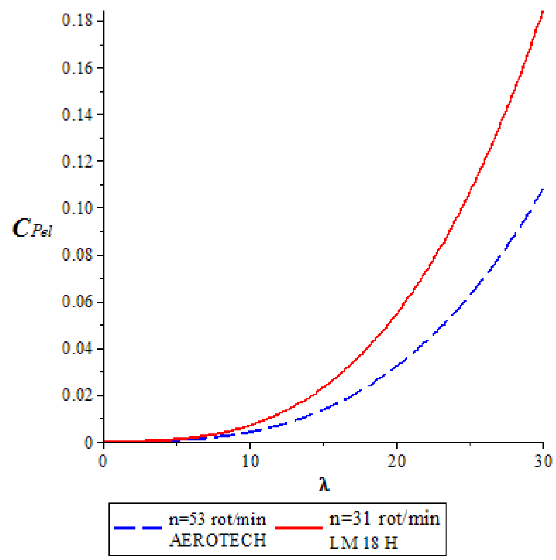

Fig. 1 Dimensionless curves

CONCLUSIONS

The presented model permits a better optimization of the parameters of the turbine also the optimization of energy performance of the wind turbines. They are also permitted a good management of the control and automation.

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