THE ANALYSIS OF THE AERO-ENERGETIC AGGREGATES ADAPTED TO THE REQUIREMENTS SPECIFIC TO HYBRID SYSTEMS

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Abstract

The paper aims to analyze the adaptation of the aero-energetic aggregates to a field of energetic parameters, characterized by several energetic dimensions, making the balance of the complex system for various components of the hybrid systems. The aero-energetic group is treated as a component of a hybrid system, made for the serial production.

Key words: aero-energetic aggregates, hybrid system, installed capacity

INTRODUCTION

The aero-energetic group is treated as a component of a hybrid system. It partially covers the curve of consumption, it is designed for serial production, though it has some possibilities to diversify in order to adapt to different offers of wind. It can be used both in parallel with the public network and as a component of hybrid insular systems.

The installed capacity at the inlets of the electric generator was set at 2500 W and based on the results of a study of economic efficiency performed in laboratory. The nominal rotation of the generator is 250 rpm, with a field of function accepted at n = 40-500 rpm.

MATERIAL AND METHOD

The construction of the aero-energetic aggregate needs to take into account some technical issues: in order to reduce the aero-dynamic noise, the peripheral speeds were limited to 20-30 m/s. The rotation was chosen adjustable at low capacity and fixed at capacities close to 2500W. The system is equipped with a frequency converter, which at the output ensures 50 Hz.

It is equipped with a subsystem of reduction and protection at high speeds of wind and at over-rotation. The rapidity of the turbine was chosen as a result of combining the conditions, in the field of slow turbines (λ_0 = 2...3). The complementary equipment in this case is a device of mechanical or electrical braking.

The subsystem of leading has to ensure the control of the following variants of exploit:

- Coupling to the electrical network;
- Insular functioning with storing in the battery of electric accumulators;
- Insular functioning in parallel to other energetic sources (photo-voltaic or/and thermoelectric, fed with biogas or gas generators).

In this study a comparative analysis was performed for 2 solutions of construction: the turbine with vertical axis and the turbine with horizontal axis. The options for some of these solutions in the late practice have a subjective character, the only objective element being the absence of the orienting system for the solution with vertical axis.

One of the aims of this study was to make two aggregates with the majority of parameters identical, only the direction of the axis being different. For the first aggregate it was chosen the solution adopted by the collaboration CCAE-UPT, the prototype of the aggregate was performed in Timişoara. The second aggregate was made in the theoretical study, with the condition of being equivalent to the first as regards the functional performances.

RESULTS AND DISSCUSIONS

Identical parameters for the two aggregates:

Electric power installed at inlets 2500 VA
Rapidity of the turbine $\lambda_0 = 2...3$
Area exposed to wind 7,5 m^2
Diversities of area 6 m^2 ; 4,5 m^2
Rotation at the installment point 250 rpm
Periphery speed 20 – 30 m/s
Electric generator EMT2500 – synchrony with permanent magnets (for both variants)
Direct coupling between turbine and generator

Different parameters at the two aggregates:

Table 1

Parameters of the two aggregates

Aggregate	**V (vertical)**	**H (horizontal)**
Position of the turbine's axis	vertical	horizontal (approximate)
Number of blades	3	3
Type of blade	not torsioned	torsioned
Axes of blades	parallel with the axis, vertical	radial
Exposed area (m^2)	7,5 ; 6 ; 4,5 $A = H \cdot D$ H = 3 m D = 2,5 ; 2 ; 1,5	7,5 ; 6 ; 4,5 $A = \frac{\pi D^2}{4}$ 3,1 ; 2,8 ; 2,4
Structure of supporting the blades	6 spokes	built-in the hub

The diversities at turbine V are made by the lengths of the lengths of spokes, and at turbine H by the radial circulation of the blade. These diversities of turbines adapt the aggregate to different average speeds of wind (v_m = 4 ; 5 ; 6 m/s).

Analyzing the structure of parameters for the two aggregates, in order to diversify the aggregate with vertical axis, for its adapting to different placements and on the basis of the conclusions drawn from the feasibility study the following three variants of dimensions were suggested:

a) Dimension 1

Exposed area: 4,5 m^2

Diameter: 1,5 m

Height of blades: 3 m

Recommended for devices with an average speed of: 6 m/s

Annual production of energy: 2753; $(2930)^{*)}$ kWh/an

Installment speed for the capacity at the turbine's shaft of 3000 W: 14,6 m/s

**) The values in brackets are for* $\lambda_0 = 3$

b) Dimension 2

Exposed area: 6 m^2

Diameter: 2 m

Height of blades: 3 m

Recommended for devices with an average speed of: 5 m/s

Annual production of energy: 2390 ; $(2672)^{*)}$ kWh/an

Installment speed for the capacity at the turbine's shaft of 3000 W: 13 m/s.

c) Dimension 3

Exposed area: 7,5 m^2

Diameter: 2,5 m

Height of blades: 3 m

Recommended for devices with an average speed of: 4 m/s

Annual production of energy: 1745 ; $(2001{,}1)^{*)}$ kWh/an

Installment speed for the capacity at the turbine's shaft of 3000 W 12,3 m/s.

The conclusion of the feasibility study is the option for a variant of slow turbine that leads to small rotations and thus to a reduced aerodynamic noise. The characteristic number for this study is $\lambda_0 = 2$ or 3 with maximum coefficients of capacity at the shaft of C_{Pmax} = 0,4 or 0,45, and greater rapidity could lead to rotations too fast in the conditions of noise restrictions.

In these conditions, the influence of the type of turbine on the best rotation in the accepted field can be followed in the table below:

Table 2

The influence of the type of turbine on the best rotation

Average speed [m/s]	**4**		**5**		**6**	
	$\lambda_0 = 2$	$\lambda_0 = 3$	$\lambda_0 = 2$	$\lambda_0 = 3$	$\lambda_0 = 2$	$\lambda_0 = 3$
Turbine 1 S = 4,5 m^2 D = 1,5 m					u = 12 m/s n = 153rpm	u = 18 m/s n = 229 rpm
Turbine 2 S = 6 m^2 D = 2 m			u = 10 m/s n = 95 rpm	u = 15m/s n = 143 rpm		
Turbine 3 S = 7,5 m^2 D = 2,5 m	u = 8 m/s n = 61 rpm	u = 12 m/s n = 92 rpm				

In this table it can be noticed that the rotations grow with 50% for rapidity (λ_0 = 3) compared to rapidity (λ_0=2), and the results are for the wind speed equal to the annual average value.

The usual fields of speed for the three multi-annual average values are:

Table 3

The ususal fields of speed

v_m [m/s]	Normal field of exploiting v [m/s]	Extreme value (an occurrence at 30 years)
4	2 ÷ 15	35 m/s (32)*
5	2 ÷ 18	43,5 m/s (40)
6	2 ÷ 24	52,2 m/s (48)

( )* For an occurrence at 20 years

In the study it was considered a field of current exploit up to 25 m/s. Any greater value up to 40 m/s is considered an exceptional regime. The assessments of the wind frequencies are considered at the variability (const. k = 0,73). The constants Weibull (k) for the three average speeds of wind (4; 5; 6 m/s) for this variability are (1,46 ; 1,63 ; 1,79).

The rotations at the level of installment speeds in the hypothesis that the best adjustment takes place up to this speed are:

Table 4

The rotations at the level of installment speeds

Installing speed [m/s]	**14,6**		**13**		**12,3**	
	$\lambda_0 = 2$	$\lambda_0 = 3$	$\lambda_0 = 2$	$\lambda_0 = 3$	$\lambda_0 = 2$	$\lambda_0 = 3$
Turbine 1 S = 4,5 m^2 D = 1,5 m					u=24,6 m/s n=313 rpm	u=36,9 m/s n=470 rpm
Turbine 2 S = 6 m^2 D = 2 m			u=26 m/s n=248rpm	u=39 m/s n=372 rpm		

CONCLUSIONS

In the above mentioned feasibility study it was shown that the restriction of capacity is done by imposing a constant rotation, occurring at speeds of wind lower than the installment value and thus, the constant rotation will be inferior to the values presented in the table.

Analyzing the wind turbine' process of adapting at the specific requirements of rural dwelling places, the parameters that define the dimension of the turbine are the diameter (D) and the height of the blades (H). In these circumstances, the exposed area is calculated with the formula A = D·H, and the relation of capacity at the shaft is: $P_a = P_a = C_{Pa} \cdot \rho \cdot \frac{v^3}{2} \cdot D \cdot H$, where ρ is the density of air that depends on the altitude compared to the sea level and the air temperature; v – the speed of air depends on time and the place elevation; C_{Pa} depends on the characteristic number ($\lambda = \frac{viteza \cdot periferică}{viteza \cdot vântului}$)

In the assessment process of one turbine, the installment point represents a pair of values (P_{ai}, v_i) for which the system is dimensioned, where P_{ai} represents the greatest capacity to which the respective system can function.

In these circumstances the maximum value of the coefficient of capacity C_p is chosen at inferior capacities and speeds compared to the installment ones, and this strategy favors the efficiency at partial loadings. Thus, at wind speeds over the installment speed, a part of capacity must be dissipated not to exceed the installed capacity.

Finally, the conditions for choosing the turbine's dimensions depend on the best correlation of the two fields of speed as follows:

- The functional field between the starting speed and the installment speed
- The field of speeds offered by the position.

As a conventional rule, the installment speed is chosen at a value approximately twice the value of the multi-annual average speed at the established position. It is obvious that most of the time a wind aggregate functions at partial capacities between (0 and P_i) and a little time over the value of v_i.

Concluding this study, for adapting the turbines to specific requirements of hybrid systems, we defined the premises that are the basis of the following analyses of the two aggregates, of the identical and different parameters, of the constructive diversities of turbines subjected to a comparative analysis on the basis of some comparison criteria.

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