

THE STUDY OF INFLUENCE OF THE ATTACK ANGLE ON THE DISTRIBUTION OF THE PRESSURE ON THE WIND TURBINE PADDLE'S CROSS SECTION

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Abstract

This paper aims to contribute to the judicious use of renewable energy resources. It is a study of the influence of the angle of attack on the pressure distribution on the cross section of a wind turbine blade.

The character of air flow (laminar or turbulent) has an influence on the aerodynamics of the blades of wind turbines. It sought to identify where air flow is laminar for good aerodynamic behavior, leading to the emergence of turbulent flow vibration unwanted effects on wind turbines. The angle of inclination, of the blade of the wind turbine influencing the character of the air flow. Thus by tilting blade can get a seaport (current generated higher) and tilt the blade can lead to undesirable dynamic effects (vibrations). It aims to achieve a balance between the blade pitch angle (enlarged portion) and reduced air flow turbulence.

The study was done using a wind tunnel that was introduced a NACA 8410 profile, of a kind used in the wind industry. measured and modeled data were processed using a Matlab 2011 program. The study supports the optimal choice of a wind farm site is helpful in choosing the type of plant and the efficiency calculations .

Key word: wind tunnel, aerodynamic lift, pressure coefficient, air flow rate, renewable energy.

INTRODUCTION

Through the spectacular development of wind power in recent years has begun to take shape and painting major problems of Romanian energy sector. There were drawn orientations of research and development in strategy and forecasting mechanisms, and shifting the emphasis on energy efficiency, economic and ecological. Problems of renewable energy in Romania refers to the energy market, energy security and especially energy efficiency, energy efficiency improvements. The solution is a judicious use of energy potential through an optimal choice of the type of power that fits best energy resources and transport network. Romania has sufficient resources to provide the necessary energy for the economic development of the country but must be addressed simultaneously and ambient pollution problems respectively and efficient use of energy. (1)

MATERIAL AND METHOD

Measurements were performed on a open circuit wind tunnel with guided vein (limited by solid walls), of low subsonic speed with experience chamber in depression.

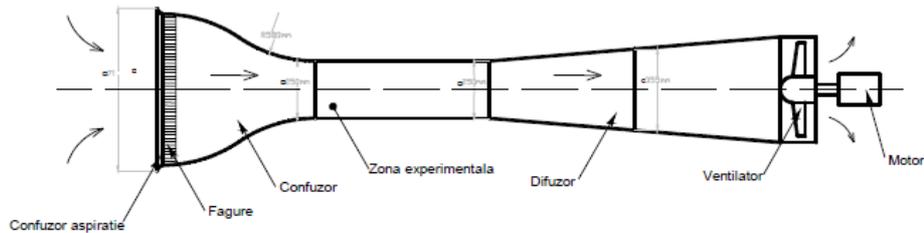


Fig.1. The scheme of the wind tunnel with open-circuit and guided vein (2)

The experimental area is obtained from the air flow speed of installation and the test sample, a NACA 8410 profile, profile type generally used in the wind industry. The model used is an airfoil used in the wind industry in general, designed to achieve an optimal ratio between the port and the resistance generated by its interaction with air. The shape of the aerodynamic profile is elongated in the direction of flow of the fluid. The experimental area is slightly flared in the direction of movement of air, made up to 1° .

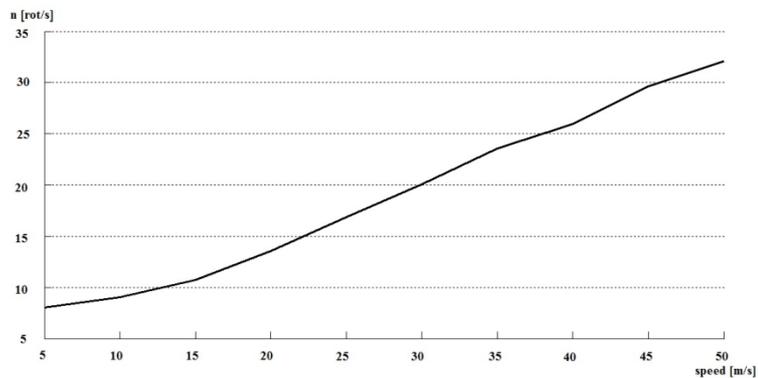


Fig.2. The fan has a variable rotation speed, to control the air velocity in the experimental area.

The fan is designed to entrain in wind tunnel circuit shall be sized as necessary to achieve a flow rate after data transmission in an experimental section and pressure jump you need to perform to emulate the circuit pressure losses in wind tunnel. The fan has a variable rotation speed, the maximum speed of 2860 rpm, which is the flow rate of $9358 \text{ m}^3 / \text{hr}$. (2)

We analyzed the angle of attack (α), the angle at which the profile is positioned towards the general direction of fluid flow. On the body, subjected to the action of an air stream aerodynamic force is exerted. If this body is an airfoil chord which makes incidence angle to the direction of flow speed (flow speed profile upstream unperturbed) 2D components of aerodynamic force R are shown in Fig.3.

These components result from the decomposition of aerodynamic force R (7):

$$F_p = F_z \cdot \cos \alpha - F_x \cdot \sin \alpha \quad (1)$$

$$F_r = F_z \cdot \sin \alpha + F_x \cdot \cos \alpha$$

F_p - load force perpendicular component to the direction of flow,

F_r - drag force parallel component to the direction of flow,

F_z - R component in a direction perpendicular to the chord c ,

F_x - R component in a direction parallel to the chord c .

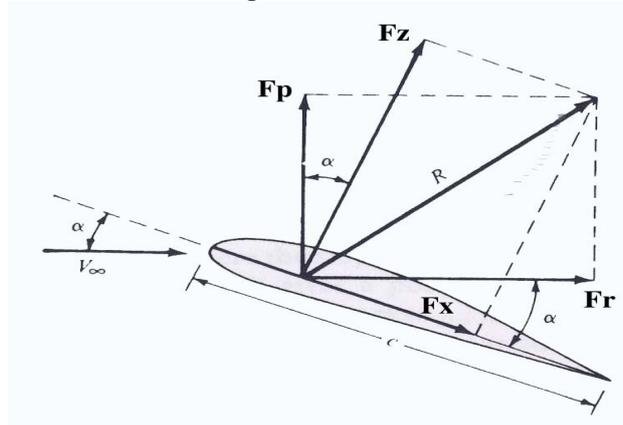


Fig. 3 Resultant force R acting on the profile (7)

The resultant force R acting on the profile, it depends on the parameters (geometry, length and degree of processing of the surface) and the qualities of the current (the degree of turbulence and Reynolds number). It varies with the angle of incidence.

Direct assessment F_p and F_r components separately requires detailed knowledge of the distribution of pressure and shear friction over the entire surface of the profile studied. Overall aerodynamic force components can be evaluated experimentally directly with a aerodynamic balance. Aerodynamic characteristics of the profiles are the dimensionless coefficients of lift, drag and moment, defined as follows (7):

$$c_L = \frac{F_p}{\frac{1}{2} \rho_\infty v_\infty^2 cb}, \quad c_R = \frac{F_r}{\frac{1}{2} \rho_\infty v_\infty^2 cb}, \quad c_M = \frac{F_0}{\frac{1}{2} \rho_\infty v_\infty^2 cb} \quad (2)$$

These coefficients are characteristics of the profile and are criteria of similarity of movement around the profile, having equal values for all geometric profiles as well.

The ratio of the coefficient of lift and drag defines the smoothness profile:

$$f = \frac{c_L}{c_R} \quad (3)$$

Most commonly used is the coefficient of aerodynamic studies pressure c_p , defined by the relation:

$$c_p = \frac{P_{locS} - P_\infty}{P_{din\infty}} \quad (4)$$

where:

p_{locS} local static pressure measured at a point on the surface to interact with the air stream;

p_∞ static pressure air flow undisturbed;

$p_{din\infty}$ dynamic pressure undisturbed airflow

In order to describe how a solid interacts with the ambient air, there are built diagrams of the variation of the pressure coefficient on its surfaces, Fig. 4. C_{pe} represents the variation coefficient of pressure on the upper side and C_{pi} is the variation coefficient on the lower pressure. It may be noted that negative values of pressure coefficients are represented register on the upper side quadrant I.

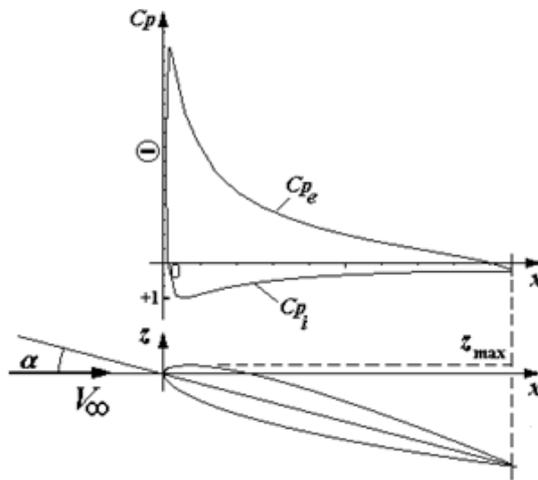


Fig. 4. Theoretical distribution of pressure coefficient on the airfoil contour (7)

Thus, the overall aerodynamic force components can be evaluated experimentally, indirectly, by measuring the differences in pressure that occur in two symmetrical planes with respect to the reference system in relation to the direction of air flow, such as by measuring the difference in

pressure between the two perpendicular planes to the flow direction in front of and behind the tested structure for determining the drag force thereof.

RESULTS AND DISCUSSIONS

This paper aims experimental determination of local pressure coefficients and their graphical representation of the distribution on the contours of the analyzed aerodynamic profile.

Orders, impressions, and saving the results table is achieved through the acquisition system.

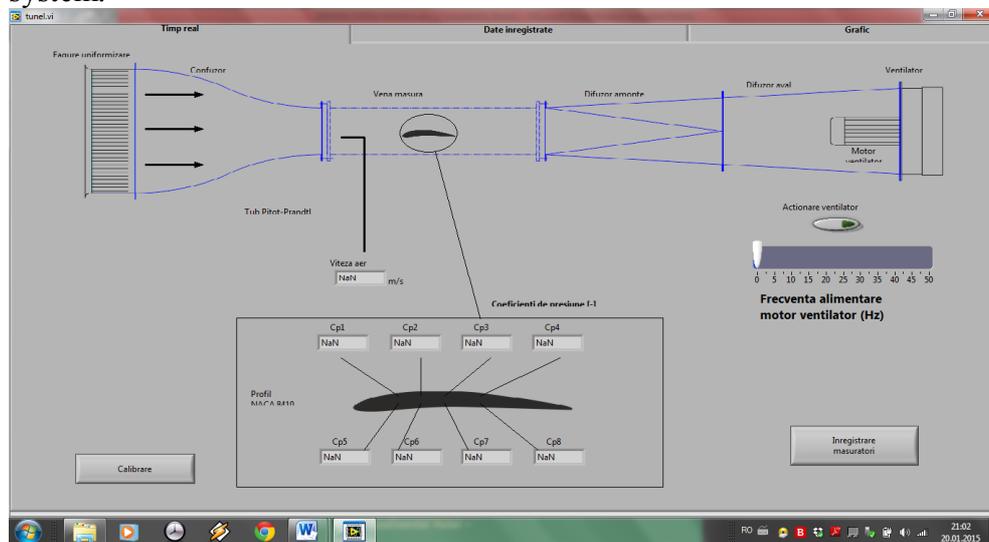
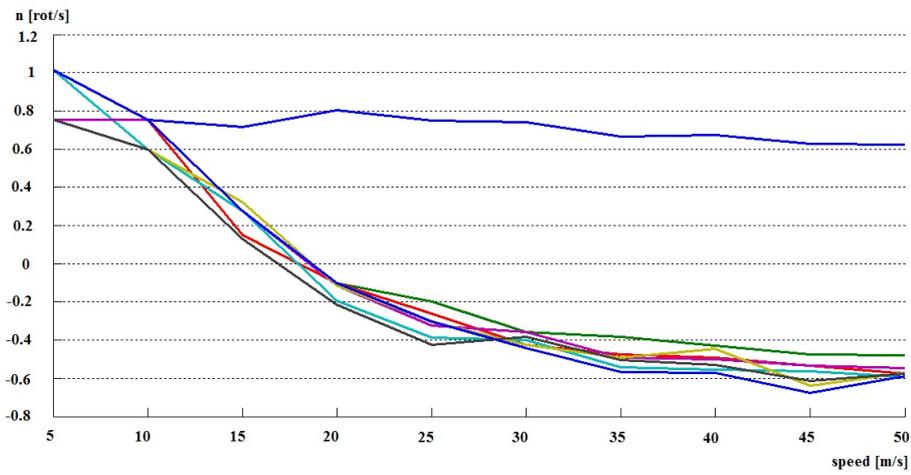


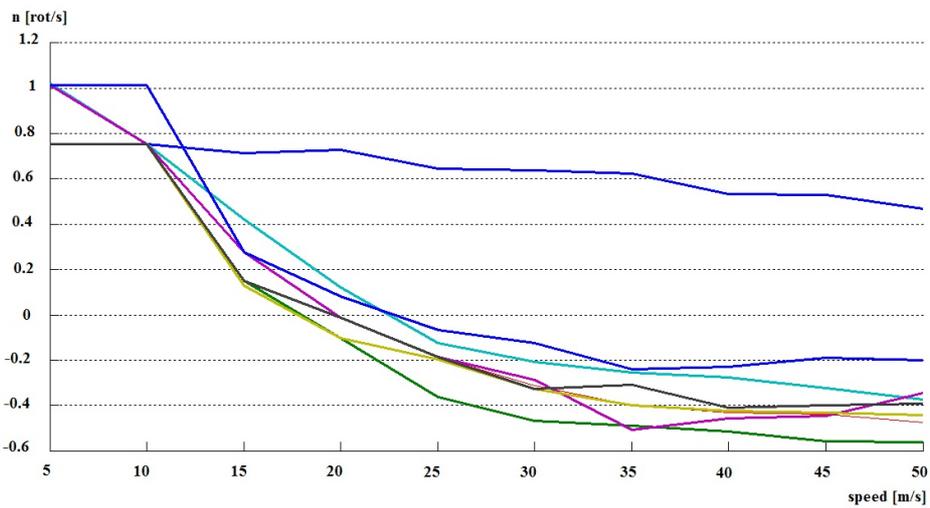
Fig. 5. The main interface

It was worked at various angles of incidence, frequency set to power the fan. Depending on which fan speed is automatically calculated values unperturbed velocity of flow (Fig. 2).

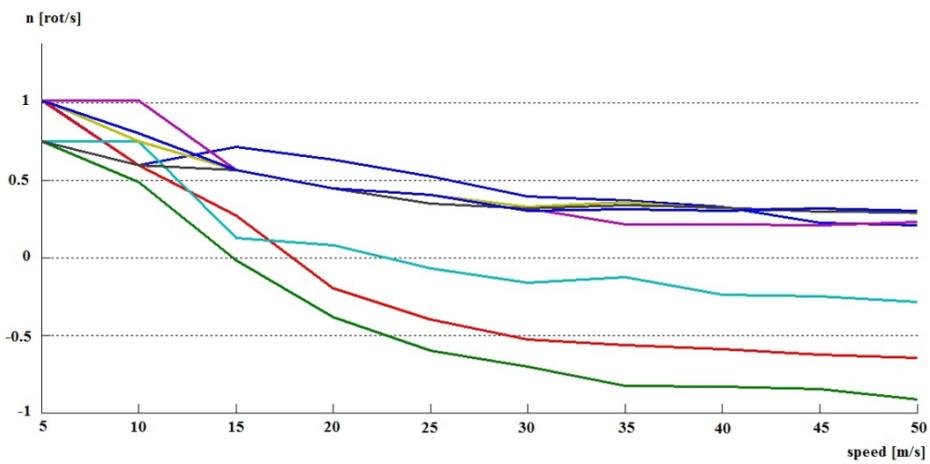
It is aimed at the interface of the pressure measured values of the differences for each of the eight pressure outlet 4 located on the lower and 4 located on the upper side. View graphic evolutions of local pressure coefficients for each outlet pressure was achieved in Matlab 2011 and are shown in Figures 6.



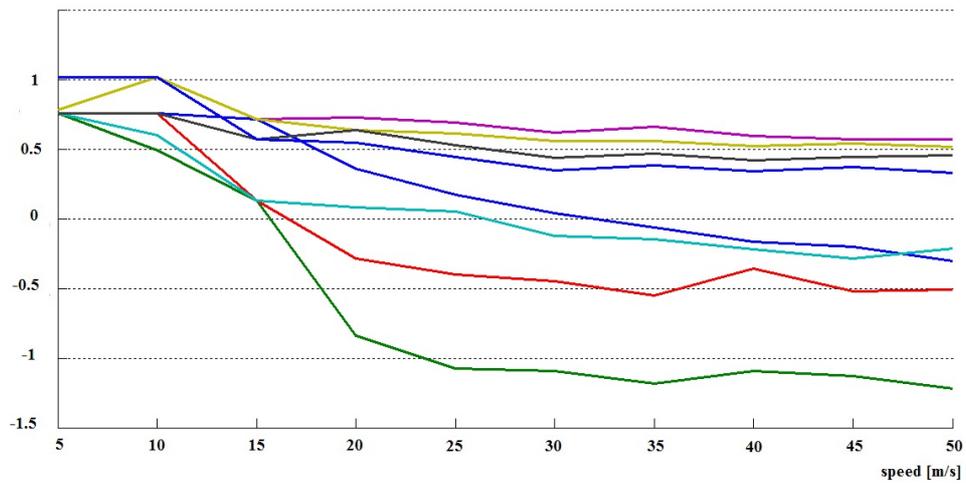
Case 1: The angle of -20 degrees



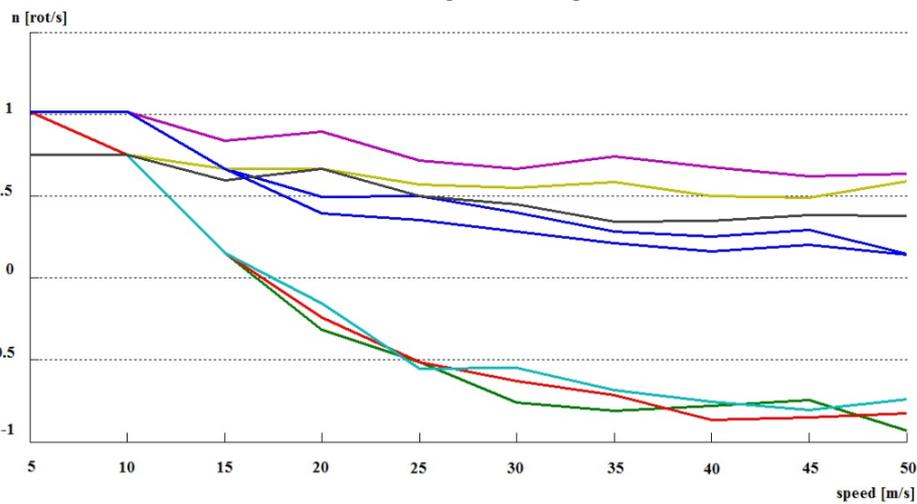
Case 2: The angle of -10 degrees



Case 3 : The angle of 0 degrees



Case 4: The angle of 10 degrees



Case 5: The angle of 20 degrees

Fig.6. The graphical representation of the pressure coefficients depending on air flow rate

CONCLUSIONS

1. Through the experimental determination of local pressure coefficients and graphical representation of the distribution on pressure coefficients contour of the analyzed aerodynamic profile was found a good correlation between the graphs obtained experimentally (Fig.6) and theoretical (Fig. 4) for angles of attack the values 0, 10 and 20 degrees.

3. With these coefficients are obtained forces F_x and F_z of the coefficients. Given that between the coefficients of lift and drag forces F_x and F_z coefficients are the same relationships as those between forces.

2. To increase the carrying capacity within the given profile up to a maximum value corresponding to angles of incidence of 10° to 15° , depending on the profile. The higher rate of flow separation occurs on the field, leading to a decrease in lift and an increase in drag.

REFERENCES

1. Costea M, 2014, Analiza statistica pentru stiintele mediului, Editura Universitatii Oradea
2. Costea M, 2009, Estimarea potențialului eolian în zone cu orografie complexă, Editura Universității din Oradea,
3. Coșoiu, Costin Ioan, et.al., 2008, Modelare experimentală și numerică în ingineria vântului, Editura Printech, Bucuresti
4. Lateș M. O., 2012, Sisteme eoliene, Teorie și practică, Editura Universității Transilvania , Brașov
5. Lucrări de laborator, Determinarea experimentală a distribuției de presiuni pe un profil de aripă și Măsurarea vitezei unui curent de aer cu ajutorul tubului Pitot-Prandl, Facultatea de Inginerie Aerospațială, UPB, <http://www.termo.utcluj.ro/mf/luc12.pdf>
6. Egbert Boeker, Rienk van Grondelle, Environmental Physics, Sustainable Energy and Climate Change, VU University Amsterdam, Wiley, ISBN 978-0-470-66675-3
7. Gary L Johnson, (2006), Wind Energy Systems, Manhattan, Kansas State University,
8. Pedlosky, P.K. (1987) Geophysical Fluid Dynamics, Springer.
9. <http://www.bizenergy.ro/mesajul-foren-2014-in-comunitatea-europeana-un-document-strategic-pentru-viitorul-energetic-al-romaniei-si-ue/#.VDKlWsjnrc>
10. SES 115-STAND TUNEL AERODINAMIC,(2012) Manual de instrucțiuni de operare, Sangari Engineering Services, Romania, pag. 8-12.