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COMPUTER-AIDED DESIGN SYSTEM OF WIND-POWER PLANT

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Abstract. *It is proposed a power plant represented a combination of turbo rotors: Darrieus and Savonius. It is showed that the optimal construction of this power plant is possible only by use the computer-aided design system. The structure scheme of computer-aided design system is developed.*

Keywords: computer-aided design; wind power plant; rotor; structure scheme.

I. INTRODUCTION

Computer-aided design allows you to carry out the design in automatic mode and involves solving the following task: construction calculation to ensure maximum intake factor of wind power and the possibility of efficient operation at wind speeds below 2 m/s. The problem is to create an installation that is both effective in low winds of Ukraine and at the same time cost-effective in the production of energy. It should be divided into two separate sub-tasks – development Darrieus rotor that produce user-defined power and development of Savonius rotor that will ensure the largest possible reduction in starting torque of the total installation.

Below in Fig. 1 shows a block diagram of computer aided design installations.

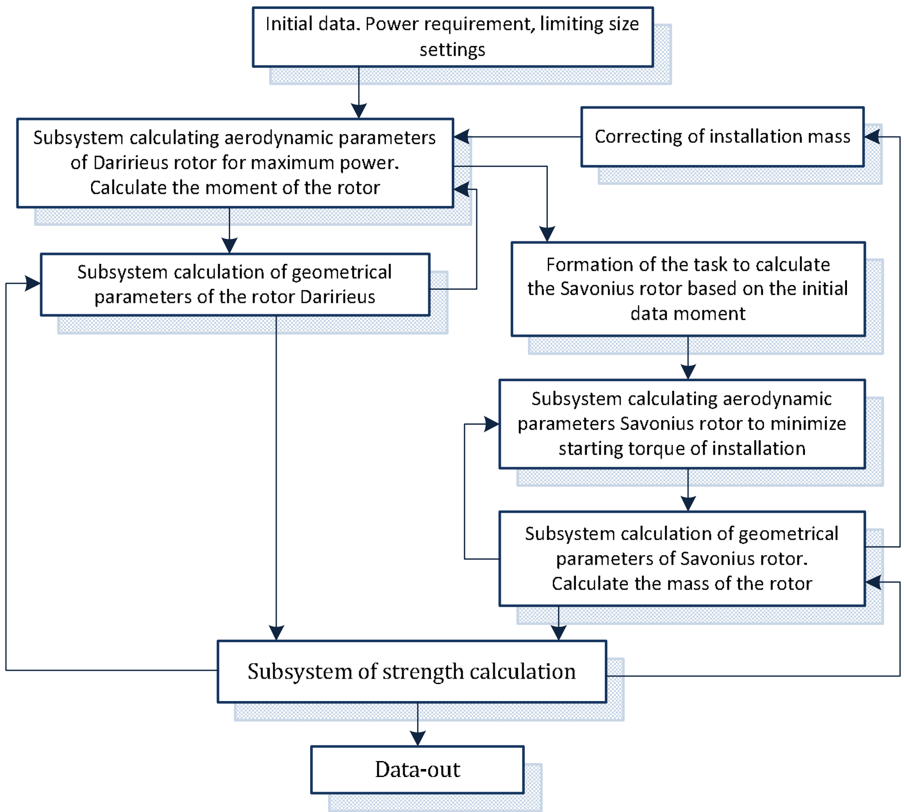

Fig. 1. Block diagram of computer aided design installations

II. THE SOFTWARE

Applications are made in the software package from Oracle. The project itself is made in the programming language Java due to the ease of integration programs written in that language, with different control systems. Thus the rank, the same code can be run under the operating systems Windows, Linux, FreeBSD, Solaris, Apple Mac, etc. This becomes very important when programs are loaded through the Internet and are used on different platforms. The first stage of work is to calculate the output parameters of the Darrieus rotor. Thus the

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main input parameter is the output of powerful rotor. Next, the program will perform the optimization of the parameters of the rotor Darries and display all possible structures that satisfy the input parameters. The next stage of the program is to calculate the Savonius rotor for maximum available geometrical parameters (height and width are limited size of the Darrieus rotor). The main output parameter is the starting moment whose value should be maximized to ensure minimal rotor momentum. After optimizing the parameters of both rotors it is necessary to recalculate starting torque and output power for both units.

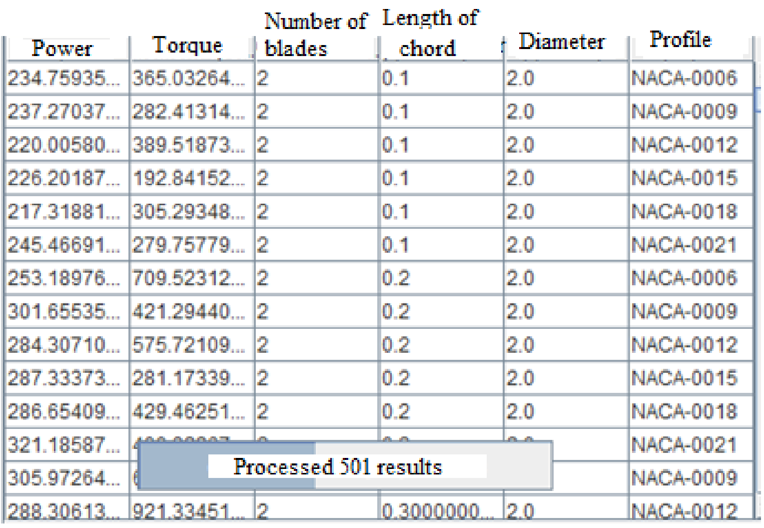
Description of the interface using software.

Starting window prompts the user to select one of the operations of the calculation. These operations have different algorithms calculate the characteristics of wind turbine rotor:

– calculation of the wind turbine rotor geometry;

– finding the optimal parameters.

Choice of blade profile is performed by using the dialog box, which contains different kinds of shapes of blades. One type of blade is used in calculating the geometry of the propeller. When searching for the optimal parameters to get maximum power of wind turbine rotor, several types of blades are used. In calculating the geometry of the rotor wind turbine, it is possible to display graphs of simulation results. It may be, as dependence of one parameter or multiple parameters simultaneously. Calculation while searching the optimal parameters of the rotor propeller to ensure maximum power can be difficult and take a long time. To display the progress of the program, the window display panel that shows the number of processed results of calculation and displays a bar, which displays the number of processed results in the ratio (Fig. 2).



Power	Torque	Number of blades	Length of chord	Diameter	Profile
234.75935...	365.03264...	2	0.1	2.0	NACA-0006
237.27037...	282.41314...	2	0.1	2.0	NACA-0009
220.00580...	389.51873...	2	0.1	2.0	NACA-0012
226.20187...	192.84152...	2	0.1	2.0	NACA-0015
217.31881...	305.29348...	2	0.1	2.0	NACA-0018
245.46691...	279.75779...	2	0.1	2.0	NACA-0021
253.18976...	709.52312...	2	0.2	2.0	NACA-0006
301.65535...	421.29440...	2	0.2	2.0	NACA-0009
284.30710...	575.72109...	2	0.2	2.0	NACA-0012
287.33373...	281.17339...	2	0.2	2.0	NACA-0015
286.65409...	429.46251...	2	0.2	2.0	NACA-0018
321.18587...	[illegible]	[illegible]	[illegible]	[illegible]	NACA-0021
305.97264...	[illegible]	[illegible]	[illegible]	[illegible]	NACA-0009
288.30613...	921.33451...	2	0.3000000...	2.0	NACA-0012

Fig. 2. Showing progress calculation

Window to search the optimal parameters contains two fields for entering values for “Variable” and “Constant value” (Table 1). “Variable” values that change during computation in the program. For example, the number of blades can be changed during the calculation from 2 to 4 in increments of change 1. Moreover, “Constant value” does not change during computation.

III. TEST CASE

To calculate the geometry of the rotor of wind power plants, we will use this software. The values we note, as shown in Table. For the results, in the “Calculation of wind turbine rotor geometry” press the button “Calculate” and the right side will show result of calculations.

Legend of source data and calculation of the value for the chosen example calculation.

The results – the geometric characteristics of wind turbine rotor. The results are shown in units of measurement values, the name and meaning (Table 1). To calculate other parameters, just change them in the table settings and start the calculation again. To find the optimal parameters in order to obtain maximum power grips values are listed in Table 2. For changing values, select the specified settings. The calculation deploy all kinds of blade profiles.

TABLE 1

The results of calculation of the rotor geometry

Parameters	Values
Starting torque (N×m)	603.204
Rotating speed(rpm)	70.280
Chord length of the profile (m)	0.303
Radius (m)	3.777
Blade height (m)	11.330

TABLE 2

Legend of source data and calculation of the value for the chosen example calculation

Parameter name	Value
The number of propeller blades	2
The number of steps in the numerical integration of the angle	36
The relative proportions of the profile chord outer radius of the propeller	0,08
The average wind speed	5.0
Number of points supporting rapidity	11
The initial value of the supporting rapidity	1.05
The final value of the supporting rapidity	12.05
Coefficient of abscissas operating point	0.25
Rated power	1000
Efficiency of electric elements	0.6
Efficiency of electric elements	0.9
Density of air	1.2
The relative magnitude of half the height of the propeller in fractions	1.5
The number of steps in the numerical integration of the height of the blade	20

Since the task of optimization includes maximum power at minimum starting point in the field "Start time", specify 550 (*N … m*). This means that will be selected only those results in which the starting point less then entered value. As a result of calculations, we get a list of the geometrical parameters of the rotor and their power characteristics. Thus, in the field "Results sorted by maximum power" shown results in which reached maximum power (Table 3). In the table, you can also view other results, chosing desired column for convenience.

TABLE 3

The results of calculation of optimal parameters

Power	Torque	Numer of blades	Length of chord	Diameter	Profile
1138,443	531,917	3	0,5	8	NACA-0015
1086,183	449,312	3	0,4	8	NACA-0015
1086,183	449,312	4	0,3	8	NACA-0015
1077,502	544,499	3	0,5	7,5	NACA-0015
1034,469	455,151	3	0,4	7,5	NACA-0015
1034,469	455,151	4	0,4	7,5	NACA-0015
980,02	462,97	3	0,4	7	NACA-0015
980,02	462,97	4	0,3	7	NACA-0015
963,664	443,312	2	0,5	8	NACA-0015
938,02	413,258	3	0,3	8	NACA-0015

The results of the program shows that automate the process of calculating the geometrical characteristics of wind turbine rotor can accelerate the mathematical modeling and obtain results for different input parameters.

For test cases to verify the results and obtain illustrative data were constructed following graphs (Figs 3 – 8).

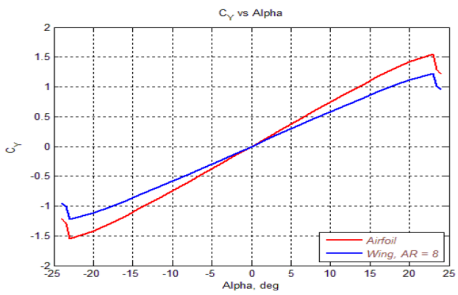


Fig. 3. Lift Curve

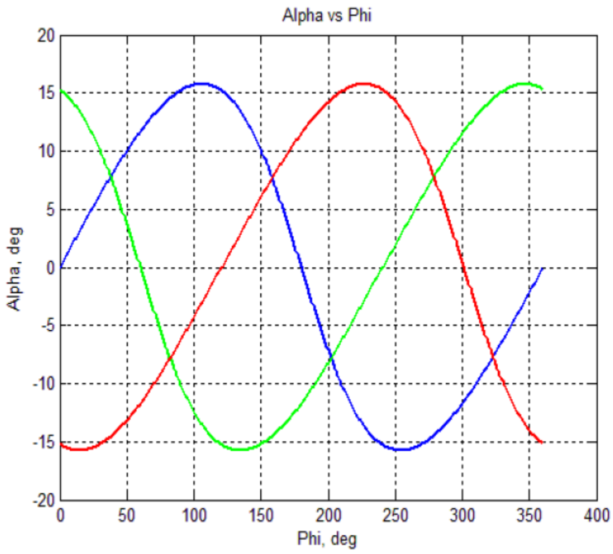


Fig. 4. Variation of the angle of attack

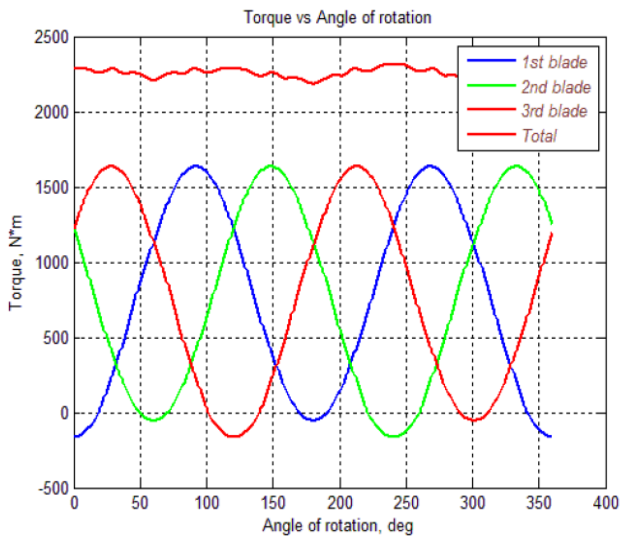


Fig. 5. Variation of starting torque

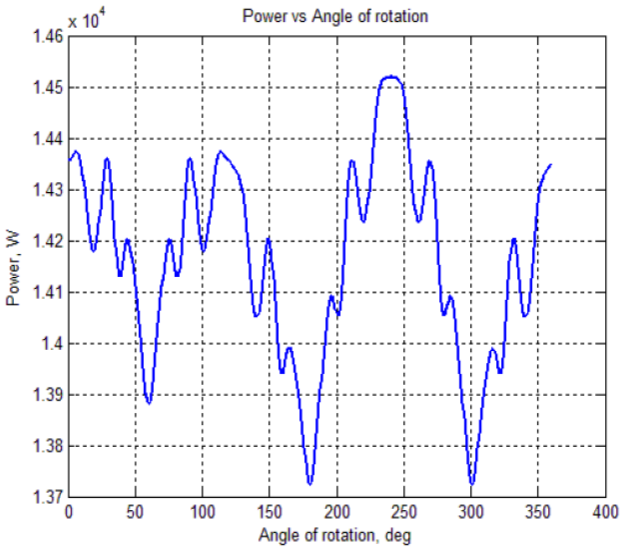


Fig. 6. Variation of power

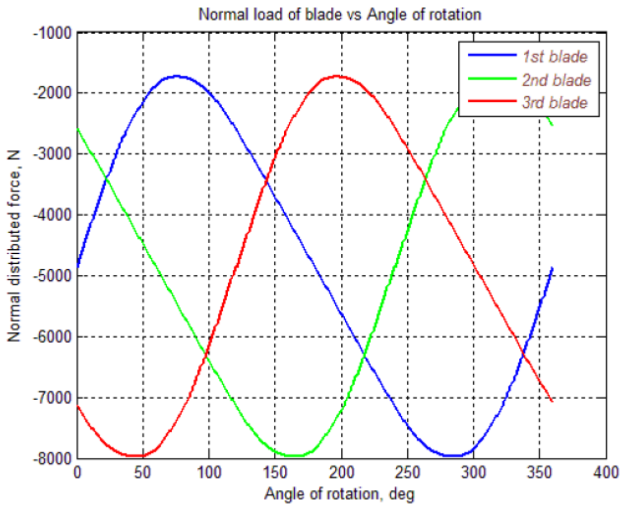


Fig.7. Load distribution depending on the angle of rotation

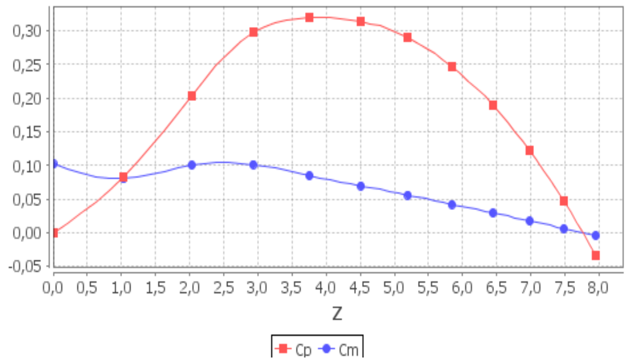


Fig. 8. The graphs of power factor and momentum

V. Conclusion

The wind power plant for weak winds includes Savonius rotors and Darries, that makes it possible to provide increasing power installation at lower starting torque.

Computer-aided design system is can be used for wind power plant design in case of weak winds.

All this provide increased efficiency through coordination aerodynamic, strength characteristics while reducing its cost.

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В. М. Синеглазов, А. В. Кульбака, В. М. Бойко. Система автоматизованого проектування вітро-енергетичної установки

Запропоновано вітро-енергетичну установку, яка представляє комбінацію двох роторів: Дар'є і Савоніуса. Показано, що оптимальна конструкція такої установки можлива тільки у разі використання системи автоматизованого проектування. Розроблено структурну схему системи автоматизованого проектування.
Ключові слова: автоматизоване проектування; вітро-енергетична установка; структурна схема.

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В. М. Синеглазов, А. В. Кульбака, В. Н. Бойко. Система автоматизированного проектирования ветро-энергетической установки

Предложена ветро-энергетическая установка, которая представляет комбинацию двух роторов: Дарье и Савониуса. Показано, что оптимальная конструкция такой установки возможна только при использовании системы автоматизированного проектирования. Разработана структурная схема системы автоматизированного проектирования.

Ключевые слова: автоматизированное проектирование; ветро-энергетическая установка; структурная схема.

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