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[1]V. M. Sineglazov,
[2]A. V. Kulbaka,
[3]V. M. Boyko

# COMPUTER-AIDED DESIGN SYSTEM OF COMBINED WIND POWER PLANTS

Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine
E-mails: [1]svm@nau.edu.ua, [2]antonkul@ukr.net, [3]detroit324@ukr.net

***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. The structure scheme computer-aided design system is developed.*

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

## Introduction

Due to the decrease of oil and gas stocks under a sharp increase in costs, environmental issues related to oil and gas, it is necessary to use wind and solar energy. The ever-growing needs of humanity in electricity today catered mainly due to the processing of traditional fuels. Number of fuel is limited, and as a result the world will face serious energy problems. The reserves of traditional energy sources will be exhausted one day, and this fact forces to conduct an active search for alternative (renewable) energy sources. Of course this solution is not a panacea, and only one wind power will not save the world from the energy crisis, the outlook for the development of renewable energy sources is very high.

The need for the development of wind energy in Ukraine due to the following reasons: shortage of fossil fuels, the increasing cost of energy, continued environmental degradation. In addition, the use of power plants (PP) as independent sources of energy to consumers, far from thermal power plants is a useful social and economic impact of energy for small farmers and other rural households in terms of the current economic situation in Ukraine.

To date, there is need to look for alternative sources of cheap energy instead of using traditional fuels. The wind potential of the planet is large enough. According to the World Meteorological Organization, wind power is 170 trillion kilowatt hours per year, it is several times more than the entire production of electricity in the world today.

However, despite the considerable potential of wind energy in Ukraine it is only in its infancy and is represented by several wind turbines in southern Ukraine.

The average wind speed in the surface layer in Ukraine is quite low – about 4 m/s. However, estimates of wind potential at an altitude of 50 meters above the ground show to 330 billion kWh (which exceeds the capacity of power plants in Ukraine 6 thousand times).

## Justification of the principle of building and choosing optimal structure of power plant

Famous PP divided by a rotation axis with respect to the wind flow is mainly of two types. The first type – the installation with a propeller with a horizontal axis of rotation is parallel to the wind direction. The plane propeller in this case perpendicular to the direction of flow. This PP is now more common than others, and for this reason is often referred to as “traditional”. The second type of PP include installation having a rotor with a vertical axis of rotation perpendicular to the direction of wind flow. In the future, we will call them vertical axial PP.

Below it is a list of the benefits of vertical wind turbines.

1. Low wind speed. The rotation regardless of wind direction, and the first rotation from the weak winds.
2. A significant increase in the efficiency of the wing, through a combination of sail designs.
3. The system is maintenance (generator uses no brushes in their work, gearboxes, bearings).
4. The system is only for bearing stability wind wing 500 – fold safety margin.
5 Power system is limited only by the height of the mast and a power inverter.
6. Noise load in the range of 20 dB, the magnetic radiation and vibration are absent.
7. The system is absolutely harmless to birds, bees and the environment.
8. Can be installed as close to the housing on the migration path of migratory birds.
9. Multipolar magnet generator arrangement allows the system to achieve rated power at low speed generator.
10. The system is stable in harsh environments (sea air, sudden changes in temperature).
11. The use of inverters will provide all the energy produced by the system, even at wind speeds insufficient to achieve rated capacity.
12. The use of inverters can significantly save on the purchase of a large number of batteries.

13. High resistance to strong wind. Quite resistant to withstand hurricane winds.

14. Easy and simple structure, designed for ease of transport and construction.

15. Requires minimum space for.

16. Perhaps mass production.

17. Flexible design solutions.

18. All the materials that make up the plant, can be recycled.

The problem is the complexity of the rotor run in low wind. Minimum to run the classic Darrieus rotor speed bucket is 6 m/s, i.e. much higher than the average for the territory of Ukraine wind speed. Other designs of rotors even at low wind speeds launcher give very low coefficient of wind energy intake, which makes their use uneconomic.

Therefore, the proposed plant is a combination of two rotors: Darrieus and Savonius. In this setting low starting torque ensured Savonius rotor and its ability to run well. Rotor of Darrieus ensures the profitability of the installation and use of high wattage. To ensure the neutralization of the negative impact of wind vortices Savonius rotor folding mechanism created by the rotor during rotor Darrieus promotion. Below it is a diagram (Fig. 1) and principle of operation of the plant [1]–[3].

Wind power unit provides the resistance to *1*, set it to vertical shaft *2* of Traverse *3*, fixed profiled blades on them *4* and rotor blades *5* of Savonius rotor starting. The unit is equipped with vertical rods *6* are attached to each vertical edges of every blade *5* of starting rotor. These blades are configured to automatically move along traverses *3* depending on the mode of the wind turbine. For this the vertical rods *6* are connected by their ends with counterweights *7* through links *8*, and in traverse *3* it is provided guides *9*, made in the form of recesses. By these guides *9* along the traverse *3* it is moved the ends of vertical rods *6*, counterweights *7* and links *8*. To return of starting rotor blades *5* to the operating position it is located in these guides *9* the elastic elements *10* which are attached by one end to the counterweights *7*, and others are strengthened in the stops *11*.

Wind power unit operates as follows. In the absence of wind the rotor does not rotate, starting rotor blades *5* are in operating position held by elastic elements *10*.

In case of low velocity on the blades Savonius rotor *5* there is pressure difference, which drives the wind wheel.

With wind increasing the rotor gains speed due to Savonius rotor and enters into rated mode. The effect of centrifugal force action on counterweights *7* is increased, due this fact these counterweights *7* will remove to the direction of profiled blades *4*, overcoming the resistance of the elastic elements *10* and pressing them to the stops *11*. As a result, the rods *6* with Savonius rotor blades *5*, carried away by link *8* and counterweight *7*, will move along the traverse *3* by the guides *9*, forming aerodynamically shaped form shown by dashed line in Fig. 1, and decreasing the area of blown surface.

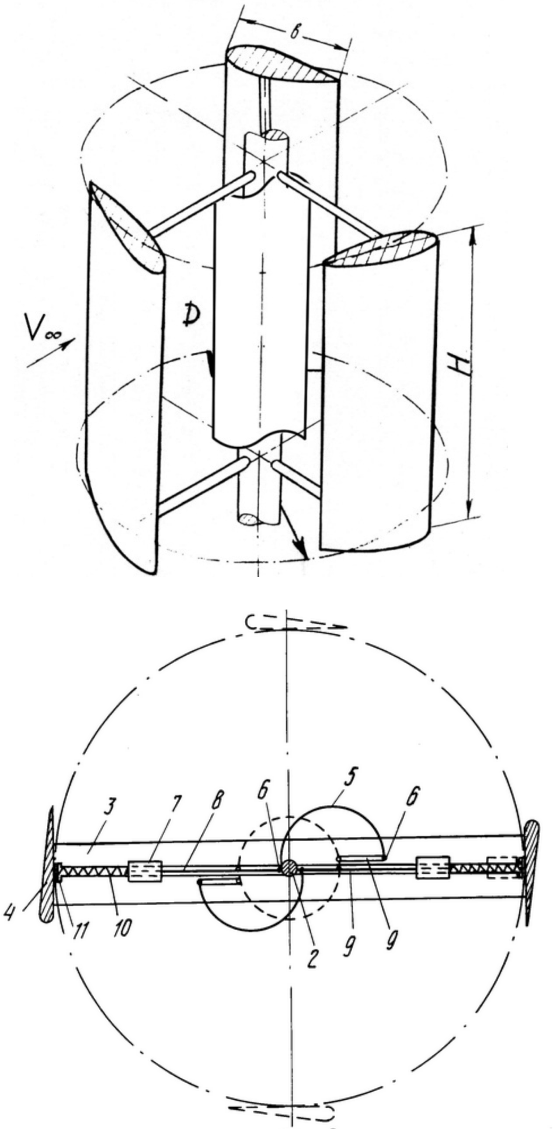


Fig. 1. Structural scheme of combined rotor

In air stream blown the Savonius rotor, compiled in the working position, it is abruptly reduced the number of stall vortexes and energy spent on them.

Upon termination of wind disturbance on power unit the elastic elements *10* will return rotor Savonius blades *6* in operating position, and the rotor will stop.

By automatically reducing of rotor Savonius blades blown area at the outlet of wind turbine at rated mode it is decreased blanketing of wind flow by Savonius rotor the leeward profiled blades of high-speed wind turbine, and also it is decreased wind flow turbulent losses. This can improve the utilization of wind energy airflow and power generation [4]–[7].

The creation of effective wind power plant (WPP) which has optimal geometrical parameters of rotor is possible only with help of computer computer-aided design (CAD) system [8].

**Computer-aided design system. The statement of the task**

Computer-aided design system allows you to carry out the design of WPP in automated mode and involves solving the following tasks of calculations:

– aerodynamic parameters of Darrieus rotor to ensure maximal power, torque of rotor calculation;

– geometrical dimensions of Darrieus rotor;

– Savonius rotor based on terminal torque data;

– aerodynamical parameters of Savonius rotor to minimize starting torque of installation;

– geometrical parameters of Savonius rotor, rotor's mass;

– wind power plant strength of Darrieus and Savonius rotors.

The task is to create an WPP that is both effective in low winds of Ukraine and at the same time is cost-effective in the production of energy. It should be divided into two separate sub-tasks – development of 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 WPP.

Below Fig. 2 shows a block diagram of computer aided design system of WPP.

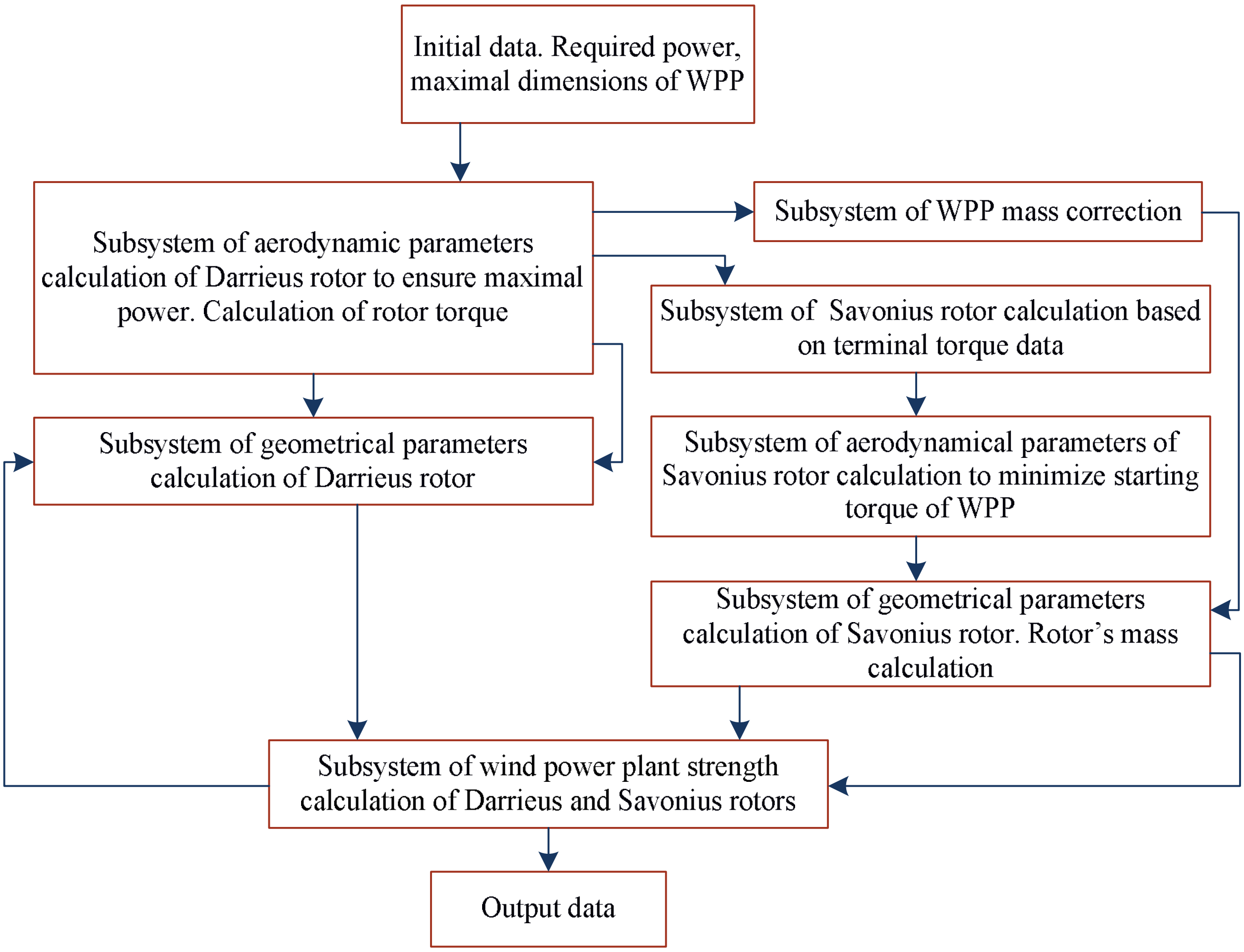


Fig. 2. Block diagram of computer aided design system of WPP

**Conclusions**

1. The structure of WPP for weak winds which includes Savonius rotors and Darrieus is justified. It makes possible to provide the power increase of WPP at lower starting torque.

2. A computer-aided design system of WPP for weak winds is developed.

3. The CAD system calculated blocks are developed, namely subsystems of:

– aerodynamic parameters calculation of Darrieus rotor to ensure maximal power. Calculation of rotor torque;

– geometrical parameters calculation of Darrieus rotor;

– WPP mass correction;

– Savonius rotor calculation based on terminal torque data;

– aerodynamical parameters of Savonius rotor calculation to minimize starting torque of WPP;

– geometrical parameters calculation of Savonius rotor. Rotor's mass calculation;

– wind power plant strength calculation of Darrieus and Savonius rotors.

– correction of mass WPP.

The increase of efficiency is supplied due to coordination of different blocks of WPP and the decrease of design time and cost.

4. A CAD system software is designed. It is differed computing efficiency, user friendly interface and the ability to get the final results in minimum time.

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**Sineglazov Viktor Mikhaylovich.** Doctor of Engineering. Professor.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine
Education: Kyiv Polytechnic Institute, Kyiv, Ukraine (1973).
Research area: Air Navigation, Air Traffic Control, Identification of Complex Systems, Wind/Solar power plant.
Publications: 452.
E-mail: svm@nau.edu.ua

**Kulbaka Anton Valeriyovych**. Post-graduate student.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine
Education: National Technical University of Ukraine "Kyiv Polytechnic Institute", Kyiv, Ukraine (2011).
Research area: wind power plant
Publications: 4.
E-mail: antonkul@ukr,net

**Boyko Vitaliy Mykolayovych**. Student.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine.
Research area: wind power plant.
Publications: 0.
E-mail: detroit324@ukr,net

**В. М. Синеглазов, А. В. Кульбака, В. М. Бойко. Система автоматизованого проектування комбінованих вітроенергетичних установок**

Запропоновано вітроенергетичну 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; вітроенергетична установка; структурна схема.

**Синєглазов Віктор Михайлович.** Доктор технічних наук. Професор.
Кафедра авіаційних комп'ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Освіта: Київський політехнічний інститут, Київ, Україна (1973).
Напрям наукової діяльності: аеронавігація, управління повітряним рухом, ідентифікація складних систем, вітроенергетичні установки.
Кількість публікацій: 452.
E-mail: svm@nau.edu.ua

**Кульбака Антон Валерійович.** Аспірант.
Кафедра авіаційних комп'ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Освіта: Національний авіаційний університет, Київ, Україна (2011).
Напрям наукової діяльності: вітроенергетичні установки.
Кількість публікацій: 4.
E-mail: antonkul@ukr,net

**Бойко Віталій Миколайович**. Студент.
Кафедра авіаційних комп'ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Напрям наукової діяльності: вітроенергетичні установки.
Кількість публікацій: 0.
E-mail: detroit324@ukr,net

**В. М. Синеглазов, А. В. Кульбака, В. Н. Бойко. Система автоматизированного проектирования комбинированных ветроэнергетических установок**

Предложена ветроэнергетическая 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; ветроэнергетическая установка; структурная схема.

**Синеглазов Виктор Михайлович.** Доктор технических наук. Профессор.
Кафедра авиационных компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Образование: Киевский политехнический институт, Киев, Украина (1973).
Направление научной деятельности: аэронавигация, управление воздушным движением, идентификация сложных систем, ветроэнергетические установки.
Количество публикаций: 452.
E-mail: svm@nau.edu.ua

**Кульбака Антон Валерьевич.** Аспирант.
Кафедра авиационных компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Образование: Национальный авиационный университет, Киев, Украина (2011).
Направление научной деятельности: ветроэнергетические установки.
Количество публикаций: 4.
E-mail: antonkul@ukr,net

**Бойко Виталий Николаевич.** Студент.
Кафедра авиационных компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Направление научной деятельности: ветроэнергетические установки.
Количество публикаций: 0.
E-mail: detroit324@ukr,net