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VERTICAL-AXIAL TWO-ROTOR WIND POWER UNITS BIDARRIEUS-1Yershin Sh.¹, Yershina A.K.², Ydyryssova A.A.²¹ al-Farabi Kazakh National University, Almaty, Kazakhstan²Kazakh State Women's Teacher Training University, Almaty, Kazakhstan, ainakul82@mail.ru

The article is devoted to problems of modern wind energy. The technical characteristics and advantages of the two-rotor wind powers Bidarrieus have been described. The design concept and principle of operation of original vertically axial two-rotor semi-industrial specimens of Bidarrieus-1 are shown. It is proposed to use the independent principle of operation of rotating shafts connected to a wind turbine, as a distinctive feature of the design of this power unit. This original design of Bidarrieus-1 allows obtaining a high coefficient of wind energy use.

Keywords: two-rotor wind powers, Darrieus, Bidarrieus, vertically axial wind turbine, semi-industrial specimen, wind power utilization factor

Introduction

According report of the global wind energy industry development by the World Wind Energy Association (WWEA), June 8, 2017[1] the worldwide wind capacity reached 486'661 MW by the end of 2016. Out of which 54'846 MW were added in 2016, this represents a growth rate of 11,8 % (17,2 % in 2015). All wind turbines installed worldwide by the end of 2016 can generate around 5 % of the world's electricity demand.

To reduce the level of the greenhouse effect, for about 20 years, a group of Kazakhstan scientists-enthusiasts of using the wind power have been developing vertical-axial units (Darrieus type) with two coaxially arranged rotary shafts (two-rotor wind turbines) [2-8]. A detailed review of the development of wind power in Kazakhstan, with an analysis of the characteristics of various types of wind generators developed over the past 20 years, was given in [8]. Until now, these developments are not implemented in a wide-scale production. In addition to objective reasons, this is due to the fact that they are ineffective and can convert wind energy only in a narrow range of speeds.

The proposed Darrieus type wind turbine designs are highly efficient. Up to now, three versions of these units have been developed. As is known, Darrieus construction has a single rotary shaft and the rectilinear span is related to two oppositely arranged working blades (see figure 1). Spans and working blades can be shaped in the form of symmetrical wind profiles of NASA. Rotation of the wind turbine takes place on account of lift action on working blades. The working blade can be jointed with the rotary shaft with the help of a span or by the way of troposkino (Figure 1b).

1. Two-rotor wind power unit Bidarrieus – 1.

The first version of two-rotor machines called Bidarrieus-1 is already a sufficiently well-known wind power unit in Kazakhstan. To a certain extent, such wind power unit can be considered as two Darrieus units inserted into one another and positioned at 90^0 , so that spans are perpendicular to each other [2-7].



Fig.1. Darrieus wind turbine: a) with straight blades; b) of troposkino system (with curved blades).

At fig. 2 - 4 schematic constructive diagrams of Bidarrieus-1 wind turbine are shown. On the first of them – option with direct cover blades (1) H-shaped rotor. Each of two coaxially located shafts (4) by means of spans (2) are connected with symmetrically located pair of blades (1) which rotating create the moment of force which is independently acts on "own" shaft. In this option both shafts have to rotate in one direction with the same angular speed.

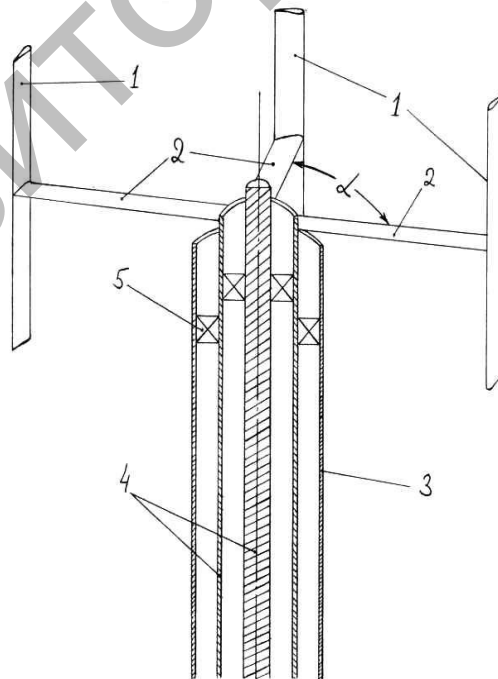


Fig.2. The schematic diagram of Bidarrieus-1 with direct wings (one-way rotation):
1 - blades, 2 - spans, 3 - case, 4 - shafts of rotation, 5 - bearing, $\alpha = 90^\circ$.

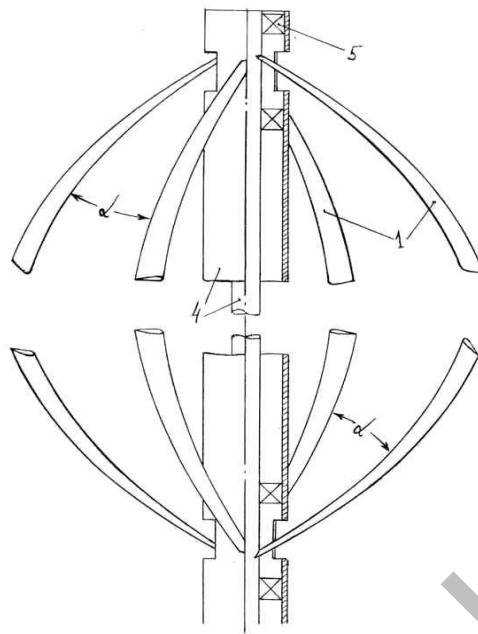


Fig.3. Schematic diagram of Bidarrieus-1 of troposkino system (one-way rotation).

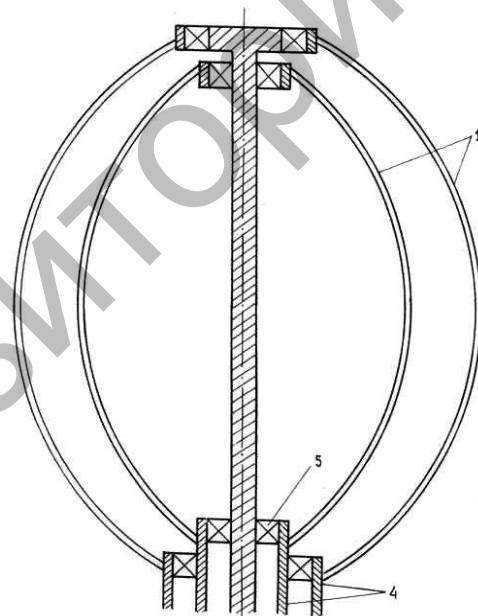


Fig.4. The schematic diagram of design of Bidarrieus-1 wind turbine with blades troposkino (rotation of shafts in different directions).

There is a special correcting device (clamp) maintaining an angle $\alpha = 90^0$ between the spans during operation of Bidarrieus-1. In the figure 3 the operating scheme of WPP Bidarrieus-1 is the same, as in the first case, but blades are executed in a form of "troposkino". There are the same designations, as in fig. 2. ($\alpha = 90^0$). Stability of operation of the wind turbine is achieved by symmetric arrangement of blades. At last, in the figure 4 - the design allowing rotation of shafts in different directions. There are the same designations, as in fig. 3.

2. Semi-industrial specimen of Bidarrieus-1

At first, an acting laboratory model (Figure 5) was constructed and tested in an aerodynamic tunnel. The acting model of wind power unit Bidarrieus-1 was constructed in a joint-stock SRI “Gidropribor” (Uralsk). The sizes of the model are chosen so that it can be placed into the working site of the aerodynamic tunnel of this institute. The work area of a wind tunnel has the ellipse form with big axis located horizontally and equals to 2100 mm, and small axis of the ellipse makes-1200 mm. The working model had following sizes: total height is 785 mm; wingspan with four cover blades on it is 800 mm.

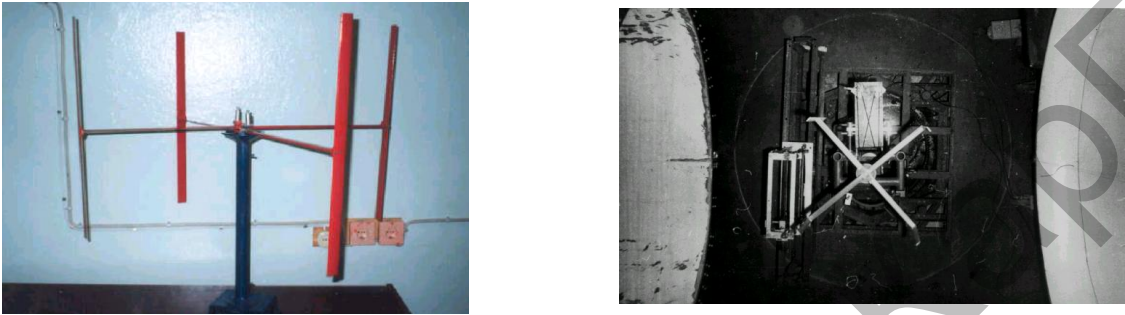


Fig.5. Two-rotor Bidarrieus-1: a) an acting laboratory model of Bidarrieus-1; b) Bidarrieus-1 model in the working site of the aerodynamic tunnel made on joint-stock SRI “Gidropribor” Uralsk (a view from above).

Cover blades and spans have been made in a form of symmetric profile NASA-0021. The chord of blades and spans is similar and equals to 32 mm, length of working blades - 550 mm, length of wingspans - 400 mm. Each pair of blades was joined by mutually perpendicular spans. Thus, four blades were placed at 90° from each other. A picture of the model of Darrieus wind turbine is presented in Fig. 5a and b. To compare the values of wind power utilization factor ξ , the model could work both under the conditions of Darrieus and Bidarrieus-1.

Being convinced of the efficiency of a two-rotor machine on the acting laboratory model, we constructed a semi-industrial specimen of Bidarrieus-1 wind power unit (Figure 6).



Fig.6. A semi-industrial specimen Bidarrieus-1 working in the mode with opposite rotation.

The construction of a semi-industrial specimen of this unit allows the coaxially arranged shafts to rotate in opposite directions. In this case, one two-contour electro-generator can be used. WPP Bidarrieus-1 provides an output of electric power at the speed of 5-15 m/s. The device operates in a wide interval of wind speed. The total height of WPP is 10.6 m, the weight is 800 kg. WPP is installed on an easy base and in addition is fixed by means of wire ropes. Dimensions of rotors: span of external rotor – 2 m, length of blade – 4.5 m, span of internal rotor – 1.7 m, blade length – 4 m. Blades profile - NASA-0021, blades chord – 0.3 m.

The proposed unit Bidarrieus-1 is placed into a casing and consists of two coaxially arranged rotary shafts with which the working blades are jointed with the help of spans. A distinguishing peculiarity in the construction of the unit is the use of the independent principle of operation of rotary shafts jointed with the wind turbine and transmitting wind power to two electro-generators.

The tests of wind power unit Bidarrieus-1 showed that wind power utilization factor ξ is 40% higher than that of Darrieus unit at equal capacities of the wind power unit. The value ξ reaches the limiting value limited by Betz postulate and can even somewhat exceed it. The thing is that Bidarrieus-1 consists of two usual Darrieus with the total sum of about 0.6. The invention protected by patents of the Republic of Kazakhstan [3-5].

Conclusion

It is known that all wind power plants operate on the same principle: wind energy is converted into rotational motion of the turbine and then into electricity. The main indicator of the effectiveness of the wind turbine is wind power utilization factor ξ . From this point of view, the most promising in Kazakhstan are wind turbines with a vertical axis of rotation, in particular rotary or carousel type [9]. A distinguishing peculiarity in the construction of the proposed unit Bidarrieus-1 is the use of the independence principle of operation of two coaxially arranged shafts jointed with the turbine and transferring the wind power to two current generators. Thus, the power of two direct current electro-generators is summed up. For centering coaxially arranged rotary shafts are separated from each other with the help of bearings, this providing the possibility of their independent rotation: in both concerted one and the same and opposite ways. These design features of Bidarrieus-1 ensure its high efficiency and, accordingly, the prospects for using it in practice.

REFERENCES

- 1 World Wind Energy Association, June 8, 2017. Available at: <http://www.wwindea.org/11961-2/>
- 2 The Kazakhstan Electricity Association Committee on Renewable Energy Sources. Febr. 24, 2016. Available at: <http://www.windenergy.kz>
- 3 Yershina Sh.A. et al. *Vertical axial compound wind turbine of carousel type. Preliminary patent No.20748 RK, F032D 9/00 (2006/01)*. Published on 16.02.2009, Bull. No. 2, 59 p.
- 4 Yershina A.K., Yershina Sh.A. et al. *Bi-Darrieus wind turbine. Preliminary patent No. 19114 RK, F03D 3/06 (2006/01)*. Published on 15.02.2008, Bull. No. 2, 48p.
- 5 Yershina A.K., Yershina Sh.A., Manatbayev R.K. *Wind motor. Patent RK No. 31662, F03D 3/06 (2006/01)*. Published on 15.11.2016, Bull. No.15, 6p.
- 6 Yershina A.K., Yershina Sh.A., Tulepbergenov A.K., Manatbayev R.K. *Bi – Darrie wind turbine. Proceeding of the Intern. Conf. on Thermal and Environmental. ASME – ATI – UIT 2010. Issues in Energy Systems. Sorrento, Italy, 2010, pp. 615 – 619.*
- 7 Yershina A.K., Yershina Sh.A., Manatbayev R.K., Kuykabaeva A.A., Tursynbayeva A.E., Kalassov N.B. *A Bi-Darrieus-1 wind turbine. Proceeding of the 15th Intern. Scient. Conf. «RE&IT – 2016», Smolyan – Bulgaria, 2016, pp.1 – 8.*
- 8 Yershina A.K., Nursadykova Zh.K., Borybaeva M.A. *Analysis of development wind power apparatus in Kazakhstan. Eurasian Physical Technical Journal, 2016, Vol.13, No. 2(26), pp. 99 – 106.*
- 9 *Wind power in Kazakhstan: ideas and perspectives*, Febr. 21, 2013. Available at: <https://www.zakon.kz/4542663-vetrojenergetika-v-kazakhstane-idei-i.html>