UDK 533.682

THE RESEARCH OF DRAG OF TWO-BLADED WIND TURBINE IN THE OPERATING MODE

Schrager E.R.[1], Tanasheva N.K.[2], Turgunov M.M.[2], Dyusembaeva A.[2], Kussaiynov Ye.K.[2]

[1]Tomsk State University, Tomsk, Russia;
[2]Karaganda State University named after E.A. Buketov, Universitetskaya Str.28, Karaganda, 100026, Kazakhstan,
nazgulya_tans@mail.ru

The paper presents the results of experimental studies to determine the drag forces and drag coefficient of two-bladed wind turbine based on the Magnus effect with smooth rotating cylinders in the range of velocities of airflow 4 ÷ 13 m / s. Dependences of drag forces on the flow rate of two-bladed wind turbine with rotating smooth cylinder at the diameter of cylinders is 5 cm,10 cm and the length of each cylinder is 20 cm were obtained. Universal dependences of drag coefficient of two-bladed wind turbine on the Reynolds number at the diameter of cylinders is 5 cm, 10 cm and the length of each cylinder is 20 cm were investigated. The results showed that an increase in Reynolds' number leads to a decrease in drag coefficient since drag coefficient is directly proportional to the drag force but is inversely proportional to the square value of speed.

Keywords: renewable energy sources, two-bladed wind turbine, rotating cylinders, drag force, flow rate.

Introduction

The interest in alternative energy sources in the world has become very actual in recent times. One requires the development of renewable energy sources to save fuel and energy resources, to reduce negative influence on the environment as well as to provide regions with electricity. Wind energy has become one of the developing types of renewable energy sources in the world.

The actual task is to develop a wind turbine that can operate effectively even at low wind speeds. The wind turbine based on the rotating cylinder of constant cross section which operates efficiently at low wind velocities is of particular interest. It is necessary to study the aerodynamic characteristics of rotating cylinder in order to increase efficiency of the wind turbine. Thus, this task is actual both from the scientific and practical use viewpoint [1, 2].

The work purpose is to study the drag force and drag coefficient of two-bladed wind turbine based on the Magnus effect of changes in flow rate of rotation of the cylinder.

To achieve this goal the authors of the given article made laboratory model of two rotating cylinders at the Laboratory of aerodynamic measurements of engineering thermophysics chair named after prof. Akylbaev Zh. S. Experimental installation belongs to wind power installations with the use of Magnus effect. The main part of the experimental model is a smooth counter-rotating cylinders with equal diameters and surfaces. The length of each cylinder is 20 cm. The cylinders are set on a horizontal shaft which is supported by two metal struts at each end of the shaft. Racks are set on a platform. Smooth cylinders, engine, collector-brush system and a pulley at the end of the shaft are fixed on the main axis [3].

Experimental technique

Electric current (voltage) is supplied to the engine rotating cylinders from the power source which supplies current with the sign "+" and "-" through the brush-collector mechanism in order to put the cylinder in rotation. The collector is fixed on a shaft and isolated from it by means of an insulating material. After a collector current goes to the generator which brings cylindrical blades into rotation. The diagram of rotation of wind turbine cylinders in opposite directions is given below.

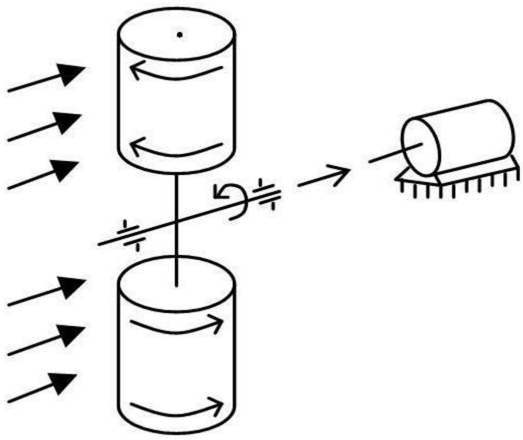

Fig.1. Scheme of rotation of wind turbine cylinders

Drag force is measured by dynamic scales installed in the working part of the wind tunnel. After the wind turbine blades with smooth cylindrical, i.e. rotating cylinder is fixed on the suspension of the working part of the wind tunnel we begin measuring the drag at different speeds [4]. Airflow running on the front part of the cylinder by applying force is reflected in scales. Measurement error of the drag force is 5-6%.

The results of experiment

The research of smooth cylinders drag was carried out with diameters of 5 cm and 10 cm and length of each cylinder was 20cm.

Figures 2 and 3 show the drag forces of two-bladed wind turbine on the wind speed at the cylinder diameter of 5 cm and 10 cm. Cylinders rotated at 400, 357 and 315 r/min at rotation number.

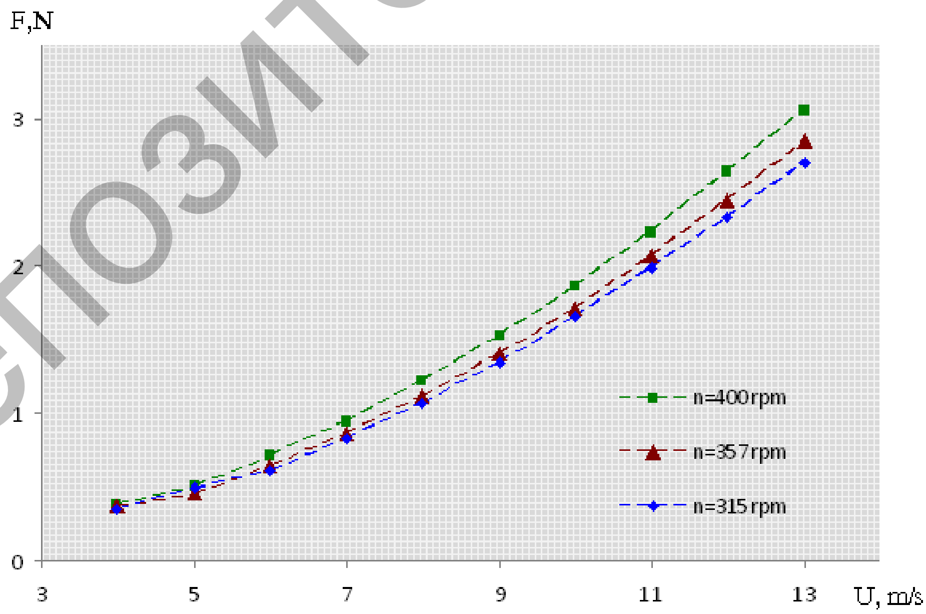

Fig.2. The schedule of dependence of drag forces on the flow rate of two-bladed wind turbine with rotating smooth cylinder. The diameter of cylinders is 5 cm, the length of each cylinder is 20 cm.

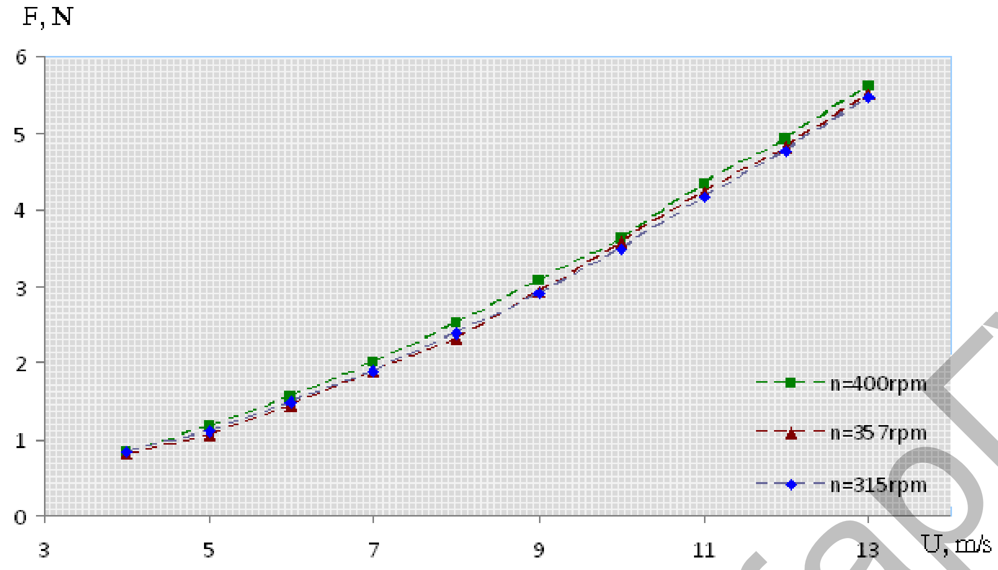

Fig. 3. The schedule of dependence of drag forces on the flow rate of two-bladed wind turbine with rotating smooth cylinder. The diameter of cylinders is 10 cm, the length of each cylinder is 20 cm.

Figure 2 and 3 show that the drag increases with the increasing of wind speed at 400, 357 and 315 r/min rotation number. Comparing schedules with diameter 5cm and 10cm one can see that with the bigger diameter equal to 10 cm, drag is more. This is due to the fact that with increasing diameter of the cylinder transversal section increases which counteracts the movement of the stream. Also, drag increases with the number of turns. This is because when the wind speed increases, delivery pressure increases as well having an influence on the front part of the rotary cylinder. Thus, the drag of two-bladed wind turbine will increase by increasing the flow rate.

Figure 4 and 5 show the schedule of dependence of drag coefficient of two-bladed wind turbine on the Reynolds number.

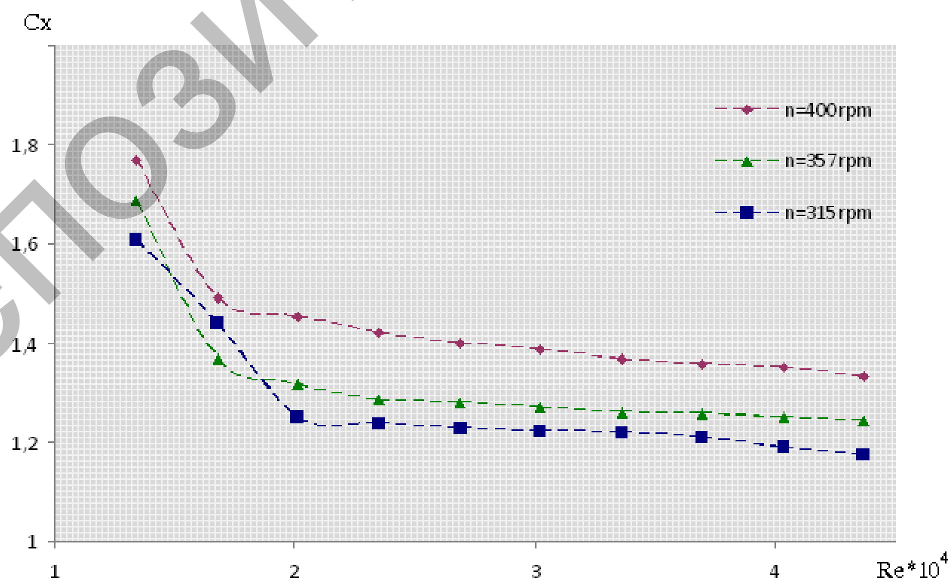

Fig.4. The schedule of dependence of drag coefficient of two-bladed wind turbine on the Reynolds number. The diameter of cylinders is 5 cm, the length of each cylinder is 20 cm.

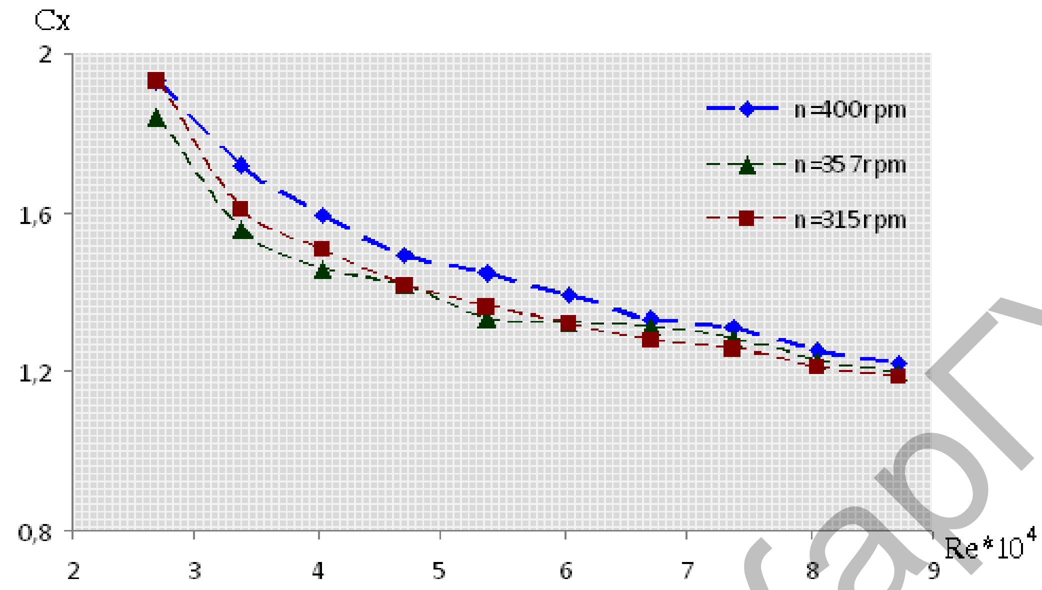

Fig.5. The schedule of dependence of drag coefficient of two-bladed wind turbine on the Reynolds number. The diameter of cylinders is 10 cm, the length of each cylinder is 20 cm.

Figures 4 and 5 show that the drag coefficient decreases with increasing Reynolds number. These curves can explain a physical point of rotating cylinders of airflow. As it is known the vortex zone of contraflows appears behind cylinders at an airflow which is the main cause of formation of drag cylinders. The rotating movements of cylinders lead to the formation of volume vortex zone of contraflows behind the cylinders the size of which depends on the flow velocity.

Conclusion

Thus, at low flow rates corresponding low Reynolds number ($2*10^4$ – $6*10^4$) the increase of flow speed leads to an intensive mixing and reducing the volume of the vortex zone of contraflows. We observe a relatively sudden decrease in the coefficient of drag of rotating cylinders.

At rather big speedflow corresponding Reynolds number $8 * 10^4$ and above there are rather strongly intensively vortex zone of contraflows behind cylinders which sizes the increase in speed of a stream practically doesn't influence and as a result of it the drag coefficient of the cylinder remains almost constant.

REFERENCES

1. Bychkov N.M. Magnus wind turbine. 2.Specifications of rotating cylinder. *Thermophysics and Aeromechanics*, 2005, Vol. 12, No. 1, pp. 159-175.

2. Bolotov A.V., Bolotov S.A., Strebkov V.S. Rotary wind turbines. *Proc. 5^th Russian exhibition "Dual-use products and technology"*, Moscow, 2004, Vol. 2, pp. 44-48.

3. Dyusembaeva A.N., Kussaiynov K., Sakipova S.E., Tansykbaeva N.K. Experimental research of aerodynamics of the system of the revolved cylinders in a turbulent stream. *Proc. 7^th International Symposium "Turbulence, Heat and Mass Transfer"*, Italy, Palermo, 2012, pp. 577-580.

4. Kussaiynov K., Akhmadiev B.A, Tanasheva N.K, Dyusembaeva A.N., Turgunov M.M. The influence of porosity on the aerodynamic characteristics of a rotating cylinder. *Modern science: research, ideas, results, technology*. Dnepropetrovsk, NPVK Triakon Publ., 2013, Vol. 1 (12), pp. 425-429.

Article accepted for publication 28.04.2014