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Investigation of aerodynamic characteristics from the airflow angle of the rotating cylinder

Cylindrical body is classically an integral element of almost all aero-hydrodynamic devices and heat exchangers. Particular interest presents aerodynamic features with transverse flow and simultaneous rotation around the cylinder's axis. The analytical calculation of the longitudinal flow past short cylinders with spherical ends, even when flowing around an ideal liquid is complicated. Therefore, to qualitatively evaluate the length of the cylinder on the aerodynamics' flow around the rotating cylinder from the the bevel's angle of the air flow is considered. The paper presents the results of experimental studies to determine the lifting force and the lift coefficient. The results of the beam angle's influence on the aerodynamic characteristics of rotating cylinders are given. The results showed that the reduction in the lift factor is observed at the bevel's angles of over 30^0, so within the bevel angles $-30^0 \le \alpha \le 30^0$ the windmill element in the form of a rotating cylinder works efficiently. The results of experimental studies can be used to develop wind turbines with blades in the form of rotating cylinders with a smooth surface. The results of the lift from the bevel angle of the flow, which varied from 0^0 to 90^0, are shown in the paper.

Keywords: cylinder, angle bevel, lifting force, air flow, coefficient of lift.

Studies of aerodynamics and the establishment of flow regularities around cylinders of finite length with different end forms in a free unlimited flow of air for longitudinal and transverse flow over a wide range of geometric and regime parameters are fragmentary and do not have a wide range in geometric and regime parameters' changes. As a rule, the calculations use dependencies that are obtained up to infinitely long cylinders, but practice shows that the ratio of the cylinder length to its diameter must necessarily be taken into account in practical calculations. The establishment of dependencies for short cylinders with different end geometry, taking into account the change in the relative length, is necessary for many engineering calculations of S.I. Isataev [1].

Indeed, near the ends of finite length cylinder, there is a significant deviation from the pattern of a plane current - the spatial flow predominates. This, in turn, affects the entire aerodynamics of the streamlined body. A significant effect on the coefficients of limited length cylinder's aerodynamic drag was shown in [2], in which cylinders with flat ends are investigated. With a relative length L / D = 40, the value of this coefficient is 18 % different from the data for an infinite cylinder.

Reducing the relative length of the cylinder leads to a significant reduction in lift and drag [3]. It is shown that at L / D = 1.0 the resistance of a short cylinder is 1.3 times higher than that the same sized ball. This circumstance allows us to conclude that there is a significant effect of the ends' shape on the aerodynamics of short cylinders. Theoretical calculation of the flow past short cylinders with spherical ends is not yet possible, even for the simplest case of a potential flow of an ideal fluid. However, a theoretical understanding the effect of a transversely flowing cylinder's finite length can be obtained by considering the transverse ellipsoids' flow of an ideal incompressible fluid, depending on their elongation, a / b, where a and b are the lengths of the large and small semi-axes of the ellipsoid.

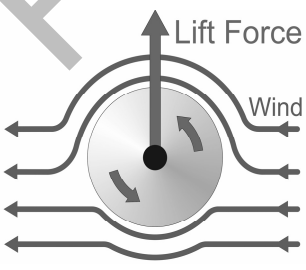


Figure 1. Magnus Effect

In the rotary motion of the cylinder in the upper air flow, the flow rate and the surface speed are the same, they add up and flow acceleration and increase in speed appear (Fig. 1).

At the bottom of the cylinder (Fig. 1) the flow rate and the surface speed have opposite directions, they are deducted, there is deceleration and decrease in speed. The appearance of such a difference in speed leads to a transverse pressure difference and the appearance of a transverse lift force, called the Magnus effect.

We have used this phenomenon to create a wind turbine. The novelty of the study is that, in contrast to the existing simple helical wind turbines, the blades of which reflect the air flow for small angles, in our wind turbine the cylindrical

elements much more efficiently capture the wind flow through the rotation of the cylinders themselves. Due to this fact, the high efficiency of the wind turbine at low wind speeds is ensured.

Aerodynamics and heat and mass transfer in bounded vortex flows [4]. The effect of clogging the flow on the regularities of an infinite cylinder's flow on the aerodynamic and hydraulic resistances are investigated and systematized in the Zh. Akylbaev's work. The aerodynamics of short cylinders that are widely encountered in the elements of power aggregates and installations were studied by experimental and theoretical methods in the V.M. Molochnikov's work [5].

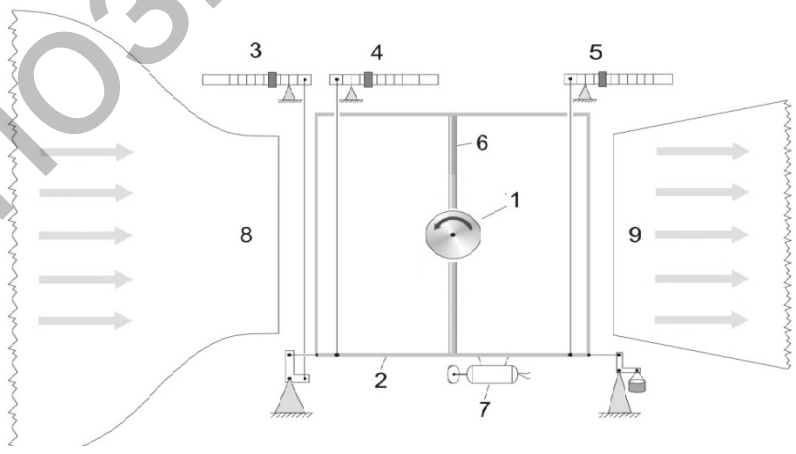
However, nowadays there are very few papers devoted to the aerodynamics study of the flow past single cylinder's complex nature and the rotating cylinders' system, which are elements of the wind turbine being developed, accompanied by a turbulent flow of interacting vortices group. Known works N.M. Bychkov [6] refer to the determination the aerodynamic parameters of rotating single cylinders in the air flow.

On the basis of the available study analysis, the problem was posed an experimental study of a sophisticated model - the aerodynamics of rotating cylinders, which are mutually interacting elements of a windmill using the Magnus effect.

The aim of this work is to study the effect of the bevel angle on the aerodynamic characteristics of a rotating cylinder. Earlier, studies were made of rotating cylinders' aerodynamic characteristics of variable cross-section, which showed positive results [7, 8]. Experimental studies were conducted in the laboratory of aerodynamic measurements of the thermophysics engineering department named after prof. Zh.S. Akylbaev An experimental model of rotating cylinders was assembled, which was subsequently investigated in a transverse air flow of different speeds. The model was fixed in the working part of the T-1-M wind tunnel with the help of thin metal stretches to the frame of the three-component aerodynamic balance. The layout refers to wind power installations using the Magnus effect.

The cylinder was 20 cm in length and 10 cm in diameter. The cylinder is attached to a horizontal shaft supported by two metal stands at each end of the shaft. The racks are mounted on the platform. On the main axis (shaft) are fastened smooth cylinders, an engine, a collector-brush system and at the end of the shaft a pulley.

The experimental setup contained a closedtype wind tunnel with an open working part with a metal frame suspended from a threecomponent aerody namic balance. The diameter of the working part was 0.5 m and its length was 0.8 m. Our experiments were carried out in the air flow velocity range 5–13 m/s (Re = 40 000–105 000) at a constant number of revolutions of the cylinder about its own axis. The head drag and the lift force of the rotating cylinder were measured using the threecom ponent windtunnel balance. This balance makes it possible to measure the head drag and the lift force to a high degree of accuracy. The block diagram of the main elements of the setup in the working part of the wind tunnel is shown in Figure 2. The experimental model was blown by a transverse air flow generated in the working part of the wind tun nel. The cylinder was driven by an electric motor. The air flow incoming to the head part of the cylinder exerts the force detected by all balances (Fig. 2).



1 — the cylinders studied; 2 — the frame for fixing the layout with the aerodynamic balance; 3 — the balance measuring the drag force; 4,5 — the balance measuring the lift force; 6 — the cylinder anchor point; 7 — the motor for rotating the cylinders; 8,9 — the diffuser and confuser of the wind tunnel

Figure 2. Working section scheme, T-1-M wind tunnel

The experiments have been conducted with both single cylinders and a system consisting of two cylinders, as shown in the Figure 2. The experiments investigated the effect of the frequency and direction of the cylinders rotation on the magnitude of the lift and drag forces. The measurements have been conducted at different speeds of the approach air flow in the presence of various degrees of the cylinders surface roughness.

The coefficient of lift Cy and the similarity criterion (Reynolds number) were determined by the following formulas (1):

$$C_y = \frac{\Delta F_y}{\rho \cdot \frac{u^2}{2} \cdot S}, \ \mathrm{Re} = \frac{u \cdot d_u}{\nu}, \tag{1}$$

where F_y — lift, H; ρ — air density, kg/m^3; u — flow rate, m/sec; S — area of the midsection, m^2; L — characteristic sail size m [6].

The drag force and lifting force were measured using a three-component aerodynamic balance.

The flow rate varied within 5÷15 m/sec.

As a result of experimental studies, dependence graph of the lift force on the angle of the airflow slope is constructed (Fig. 3).

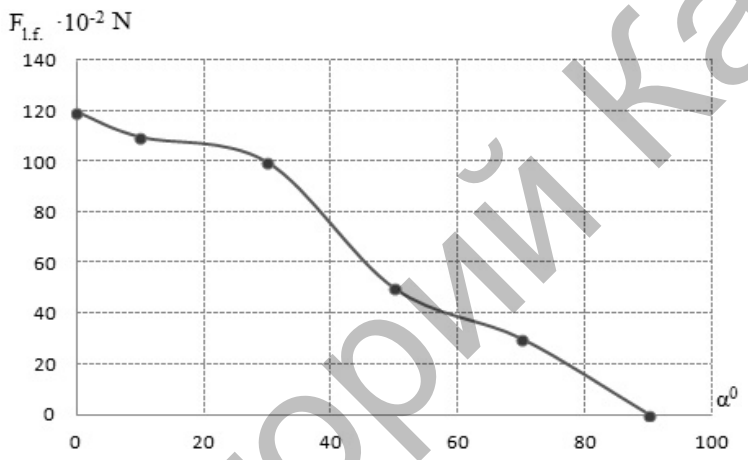


Figure 3. Graph of the lifting force's dependence on the bevel's angle of the flow for a cylinder 10 cm in diameter with a smooth surface

It can be seen from Figure 3 that when the angle of the airflow is increased, the lifting force decreases. The efficiency of the cylinders' rotation was shown at angles of the flow's bevel α = 300 ÷ 450. A further increase in the bevel angle of the flow leads to a deterioration in the rotational efficiency of the cylinder.

Based on the experimental results of the lifting force, we calculated the coefficient of aerodynamic characteristics from the bevel's angle at different values of the wind speed.

Figure 4 shows dependence graph of the lift factor on the bevel's angle at different wind speeds.

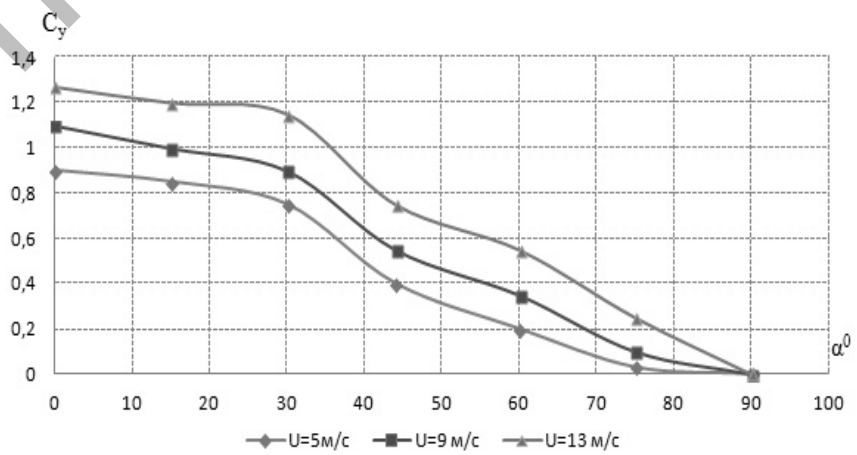


Figure 4. Dependence of the lift coefficient on the bevel's angle at different values of wind speed

From the obtained data of influence studies of the bevel's angle of the air flow on the rotating cylinder's aerodynamic characteristics, the following conclusions can be drawn:

– a reduction in the lift factor is observed at angles of the bevel over 30^0, so within the bevel angles $-30^0 \le \alpha \le 30^0$ the windmill element in the form of a rotating cylinder works effectively;

– at the bevel angles $-45^0 \le \alpha \le 45^0$ the power element of the wind turbine works normally, the technically minimal effect of the operation is provided, and at angles above 45^0 the efficiency of the operation decreases sharply.

Cylinders, during rotation, entrain particles of air near their surface. These particles will move along the surface of the cylinder in the direction of cylinder's rotation, creating a rotational air flow.

When the air stream flows around the rotating cylinder with an air stream, the cylinder moves from the flow around the surface of the rotating cylinder, changing its trajectory in the direction of the cylinder rotation. The entrainment of the incident flow's particles by the rotational flow and the bend of the oncoming stream line depends on the type of surface and the speed of rotation.

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Н.К. Танашева, А.Н. Дюсембаева, Л.Л. Миньков

Айналмалы цилиндрдің аэродинамикалық сипаттамаларына ауа ағыны бұрышы әсерін зерттеу

Классикалық түрдегі цилиндрлік дене барлық аэрогидродинамикалық құрылғылар мен жылуалмастырғыштардың ажырамас элементі болып табылады. Аэродинамиканың көлденең ағынымен және цилиндрдің өзінің осі айналасында бір мезгілде айналуы ерекше қызығушылық туғызады. Мінсіз сұйықтық айналасында болғанда да, сфералық ұштары бар қысқа цилиндрлердің бойлық ағынының аналитикалық есептеуі күрделі. Сондықтанда цилиндрдің ұзындығының аэродинамикада ағуын сапалы бағалау үшін, айналмалы цилиндрдің ауа ағынының бұрышы қарастырылды. Мақалада көтеру күші және оның коэффициентін анықтау үшін тәжірибелік зерттеулер нәтижелері келтірілген. Айналмалы цилиндрдің аэродинамикалық сипаттамаларына ағын бұрышының әсер ету нәтижелері келтірілген. Нәтижелер ауа ағынының бұрышы 30^0 кезінде көтеру күші коэффицентінің төмендейтінін, сондықтан да ауа ағыны $-30^0 \le \alpha \le 30^0$ кезінде айналмалы цилиндрлі желқозғалтқыш элементі тиімді жұмыс жасайтынын көрсетті. Алынған тәжірибелік нәтижелер желқозғалтқышының тегіс бетті айналмалы

цилиндрлі қалақшаларын жасауда қолданылуы мүмкін. Нәтижесінде 0 ^{0}–90 ^{0} дейінгі аралықта көтеру күшінің ауа ағынының бұрышынан өзгергені көрсетілген.

Кілт сөздер: цилиндр, бұрыш, көтеру күші, ауа ағыны, көтеру күші коэффициенті, ауа ағын бұрышы.

Н.К. Танашева, А.Н. Дюсембаева, Л.Л. Миньков

Исследование влияния угла скоса воздушного потока на аэродинамические характеристики вращающегося цилиндра

Цилиндрическое тело классически является неотъемлемым элементом практически всех аэрогидродинамических аппаратов и теплообменных устройств. Особый интерес представляют особенности аэродинамики при поперечном обтекании и одновременном вращении цилиндра вокруг своей оси. Аналитический расчет продольного обтекания коротких цилиндров со сферическими торцами, даже при обтекании идеальной жидкостью, сложен. Поэтому для качественной оценки длины цилиндра на аэродинамику его обтекания рассматривается обтекание вращающегося цилиндра от угла скоса воздушного потока. В работе приведены результаты экспериментальных исследований по определению подъемной силы и коэффициента подъемной силы. Приведены результаты влияния угла скоса потока, который менялся от 0^0 до 90^0, на аэродинамические характеристики вращающихся цилиндров. Результаты показали, что уменьшение коэффициента подъемной силы наблюдается при углах скоса потока свыше 30^0, поэтому в пределах углов скоса $-30^0 \leq \alpha \leq 30^0$ элемент ветродвигателя в виде вращающегося цилиндра работает эффективно. Результаты экспериментальных исследований могут быть использованы при разработке ветродвигателей с лопастями в виде вращающихся цилиндров с гладкой поверхностью.

Ключевые слова: цилиндр, угол скоса, подъемная сила, воздушный поток, коэффициент подъемной силы, угол скоса потока.

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UDC 372.853

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Using of workbook on the subject «Physics and astronomy» in English at the secondary school

The article considers a multilingual education which is a new program of Kazakhstan's education system. This education program carries out not only the teaching of languages (Kazakh, Russian and English languages) but also the teaching of disciplines of natural sciences in the languages mentioned above. Base on the example of physics the article presents some principles and approaches of teaching natural science disciplines in English by using workbook of «Physics and astronomy». It helps to teacher to make a correct procedure of a lesson and organize students' activity for effective mastering both physics material and language skills. The main didactic purpose of the workbook is to speed up process of mastering the teaching material, i.e. to bring the educational process closer to the most effective characteristics. One of the main advantages of the workbook is that it allows teacher to control flow and formation of students` thinking activity. The workbook will help to formulate necessary knowledge, skills and skills for students. Thanks to the workbook on the subject «physics and astronomy», the lesson material is better understood, the lesson time is rationally used. The effectiveness of teaching Physics through a foreign language is opened by numerous advantages, such as formation of intercultural knowledge and understanding; development of intercultural skills; introduction of a broader cultural context; expansion of school and university profile; increase of general and specific language competence; development of communication skills; preparation for future research and / or labour activity; addition of individual learning strategies; increase of students` motivation.

Keywords: workbook, physics and astronomy, tasks, multilingual education, school, science direction, language skills.

President`s strategic initiative aims at the stable development of country and entering of Kazakhstan into 30 the most developed countries of the world. Within the scope of Plan of nation President charged to carry out some reforms in the sphere of education. The main task is compliance of scientific educational system with requirement of time. According to Plan of nation «100 concrete steps on realization of 5 institutional reforms» it will be planned to switch over step-by-step to English language teaching at Kazakhstan schools and institutes of higher education [1]. The main aim is competitive recovery of the trained personnel, export potential increase of the educational sector and participation of Kazakhstan people in the world association and international processes. This innovation will improve quality of human capital on the basis of economic cooperation and standards of development organization countries. It is accepted to introduce and realize project of three languages at the secondary schools, Republic of Kazakhstan takes the first steps to educational system by entering of English into teaching of natural sciences.

The major tasks for teacher are to ensure a sufficient learning by pupils, to develop their creative and cognitive abilities, to provide connection of teaching with life, labour, moral and aesthetic education. Teacher uses different teaching aids for successful solving of these problems. We decided to develop a teaching aid which enables to solve a whole complex of pedagogical problems. This teaching aid is a printed workbook.

The modern specialist must find unusual decisions of practical tasks, acquire knowledge without assistance, work with information and make interpersonal relations skillfully. In connection with these requirements in the process of teaching: