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INTERACTION OF SEVERAL DARRIE WIND TURBINES WITH AIR FLOW

This paper considers mathematical two-dimensional model of interaction between a carousel type wind turbine and a stationary airflow. Its working blades of the turbine are replaced by vortex contours for calculating the aerodynamic parameters of a carousel type wind turbine [1-3]. The working blade creates a disturbance to the stationary airflow and these perturbations are replaced by vortex systems [3,4]. The working blade is replaced by a system of vortices called attached vortices and the perturbation along the flow takes place from the end of the blade (in the track) and it is called a vortex sheet. The aerodynamic parameters of the working blade: the velocities at infinity, the angle of attack and the angular velocity of rotation, which is assumed to be known.

In the article we do not consider boundary effects arising at the end of the wing (such as the flow of the medium from the upper part of the wing to the lower part, as well as other discontinuous and non stationary flows), so we can assume that the vortex intensity distribution is constant along the vortex segment [3-6]. By making such restrictions we can determine the intensity of a vortex over a specifically defined wing profile. Then due to vortex systems they are considered as the velocity field, which will be changing across the whole region. This process is described by the Biot-Savart formula in the form of integral relations of a complex variable.

The components of the velocity of the air flow field of the inner and outer parts of the contour of the vortex layer are calculated by the Biot-Savart formula. So the Biot-Savart law can find the velocity of the element located at a point at a distance s from the induced vortex layer $\gamma d\ell$ for the plane case:

$$V = \frac{\Gamma}{4\pi}\int \frac{dr \times r}{r^3}. \tag{1}$$

This identity can be expressed in terms of the resisting velocity and the complex variable z.

$$q(z) = u - iv = \frac{i}{2\pi}\int \frac{\gamma d\ell}{z - z'}. \tag{2}$$

Here z' - $gd\ell$ is the coordinate of the vortex layer element and $z' = Re^{i\theta}$ for the attached vortex layer for $d\ell = Rd\theta$ from eq. (2) we obtain:

$$q_B(z) = \frac{\gamma R}{2\pi}\int \frac{dz'}{z'(z - z')} \tag{3}$$

Applying this relation for the attached vortex and using a circular vortex layer of intensity -γ and a semicircular layer of intensity in the right half-plane,it is possible to get

$$q_B = \left\{ \begin{array}{l} \dfrac{i\gamma}{\pi z}\left[\pi - 2\operatorname{arctg}\dfrac{z}{R}\right], |z| \geq R, \\ -\dfrac{i\gamma}{\pi z} 2\operatorname{arctg}\dfrac{z}{R}, |z| \leq R. \end{array} \right\} \tag{4}$$

Consider the formulation of the vector R and its vector characteristic quantities, the value of the principal vector is equal to the production of the density of the fluid, the values of the flow velocity and the values of the circulation.

$$|R| = \rho |V_\infty| |\Gamma| \tag{5}$$

And its direction (as shown in Figure 1 a, b) rotating at an angle 90^0 relative to the flow directionof the velocity V_∞ in the clockwise direction if $\Gamma > 0$, counterclockwise if $\Gamma < 0$.

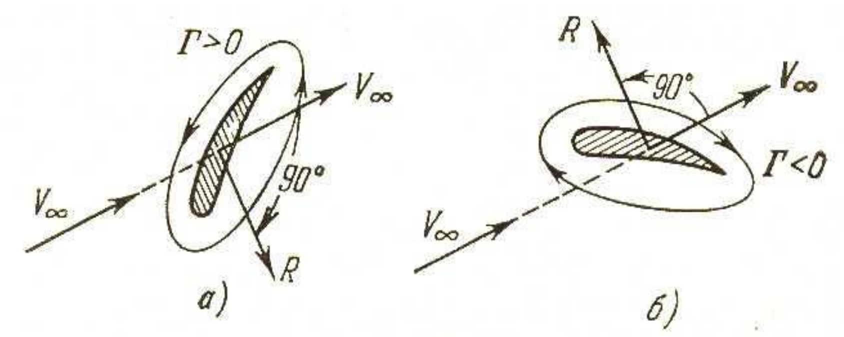

Fig. 1. Scheme for determining the direction of circulation

To determine the direction of the circulation for each individual case we must find the sign of Γ.

This fact satisfies the entire case a plane-parallel irrotational ideal incompressible fluid profile is acted upon by one force its direction is perpendicular to the flow, and it is called the lifting force, so this force ensures the airplane lifts into the air and helps to fly further horizontally [4-7].

The component of full speed in the direction of "Ox":

$$u = V_\infty + \frac{C_L h}{4\pi V_\infty}\{((V_\infty^2 - \omega^2(x^2 - y^2)) + (V_\infty + \frac{\omega^2 r^2}{V_\infty}))(\operatorname{arctg}(\frac{y+R}{x}) - \\ - \operatorname{arctg}(\frac{y-R}{x})) + 2\omega^2 xy \,\mathrm{Ln}\sqrt{\frac{x^2+(y+R)^2}{x^2+(y-R)^2}} + 2\omega^2 Rx\} \tag{6}$$

The component of full speed in the direction of "Oy":

$$v = -\frac{C_L h}{4\pi V_\infty}\{((V_\infty^2 - \omega^2(x^2 - y^2)) + (V_\infty + \frac{\omega^2 r^2}{V_\infty}))\mathrm{Ln}(\sqrt{\frac{x^2+(y+R)^2}{x^2+(y-R)^2}}) - \\ - 2\omega^2 xy(\operatorname{arctg}(\frac{y+R}{x}) - \operatorname{arctg}(\frac{y-R}{x})) + 2\omega^2 Ry\} \tag{7}$$

Using this developed method of calculating the location of the carousel wind turbine, in particular formulas (6) and (7) compiled, a calculation program in the language of Visual Fortran carried out series of calculations. The results are shown in Figures 2 and 3. Figure 2 the graph of the velocity fields of wind turbine interaction with the wind flow is obtained for the values of the vortex contour $\gamma = 2$. Figure 3 the graph of the velocity fields of wind turbine interaction with the wind flow is obtained for the values of the vortex contour $\gamma = 4$. If we compare the data in Fig. 2 and 3, then in 3 we can see the effect of the vortex contour γ is twice larger, and this is evident from the deviations of the velocity motors thatin Fig. 3 a deviation of the velocity vector larger than in Fig. 2

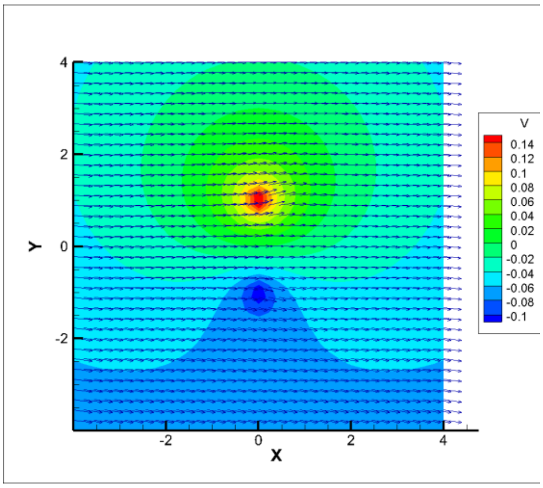

Fig. 2. The velocity field in the interaction of the wind flows with the wind turbine with superimposed vortex contour (V∞ = 10, γ = 2)

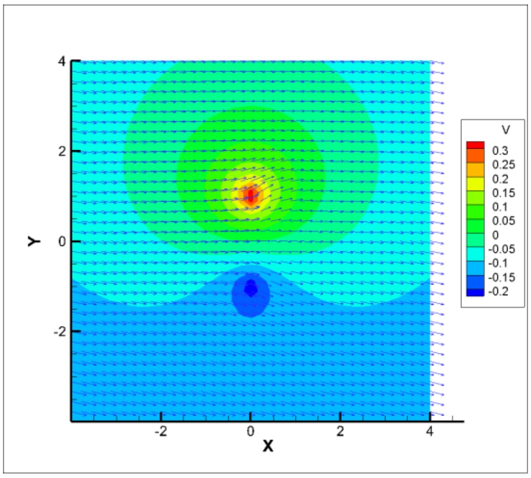

Fig. 3. The velocity field in the interaction of the wind flows with a wind turbine with a superimposed vortex contour (V∞ = 10, γ = 4)

Having studied this numerical method for calculating the flow around one Darrie wind turbine I was interesting to carry out the calculation of the flow of several wind turbines by the airflow. How do they interact with the airflow while the same direction rotation and in different directions.

Also by carrying out series of calculations for this case, compiled by the program in the language of Visual Fortran, received the results, which are shown in Figures 4-5.

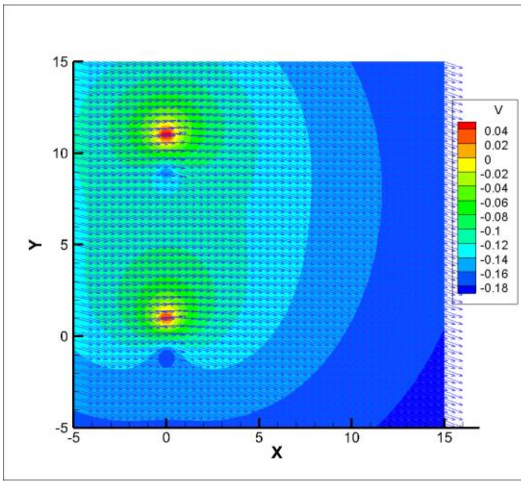

Fig. 4. The velocity field in the interaction of the wind flows with two adjacent wind turbines with a vortex contour (V∞ = 10, γ = 6)

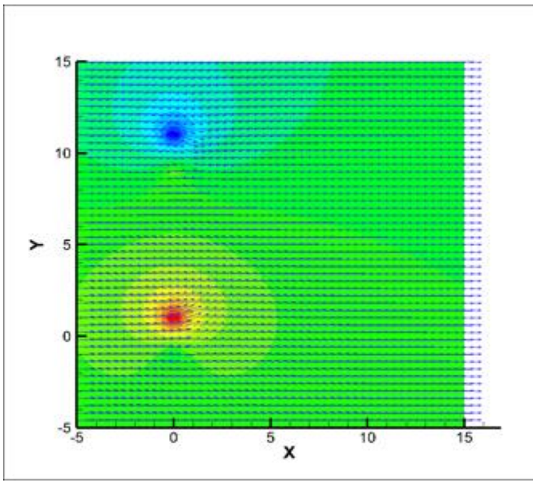

Fig. 5. The velocity field in the interaction of the wind flows with two adjacent wind turbines with a vortex contour (V∞ = 10, γ = 6)

Figure 4 shows a graph of the flow velocity fields for two wind turbines with a wind flow when both wind turbines are rotated in the same direction; In one direction with the values of the vortex contour of both γ = 6. In this case the flow passing through the swept areas of these wind turbines deviates more strongly from its direction.

And in Figure 5 there is the obtained graph of the velocity fields of interaction of the wind turbine with the wind flow with the same values of the vortex contour γ = 6. But here two wind turbines are rotated in different directions when one in one-side rotation, the other in the other direction rotates. It is noticeable that behind the wind turbines the velocity vectors of the flow do not deviate strongly from their direction. In Figures 4 and 5 these two identical-sized wind turbines are located side by side with respect to the flow direction and at distances of one diameter from each other.

Figure 6 shows a graph of the flow velocity fields for two wind turbines located one behind the other in the direction of the wind flow when both wind turbines are rotated in the same direction; In one direction and with the value of the vortex contour of both γ = 6. Flow during flowing of two wind turbines rotating in one direction is more strongly deflected from its direction.

And in Figure 7 in the resulting graph the interaction velocity fields with two wind turbines located one behind the otherwith a wind flow with the same valuesof the vortex contour γ = 6. In the case of rotation of wind turbines in different directions, when one in one direction rotates, the other in the other side rotates. The developed calculation technique can also be used for the case of three carousel type wind turbines with different configurations of location and rotation. The results of a numerical calculation of the flow past three wind turbines of the carousel type are shown in Figures 8 and 9.

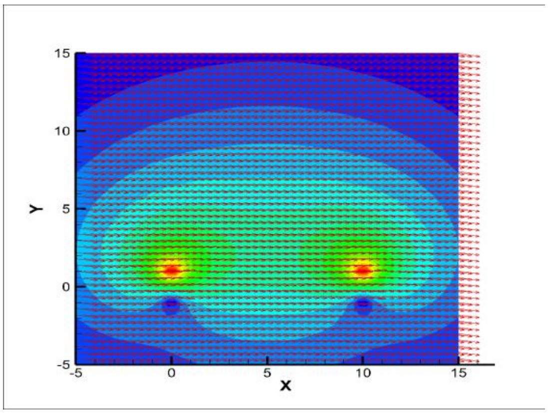

Fig. 6. The velocity field in the interaction of the wind flow with two wind turbines with a vortex contour (V∞ = 10, γ = 8) located one behind the other.

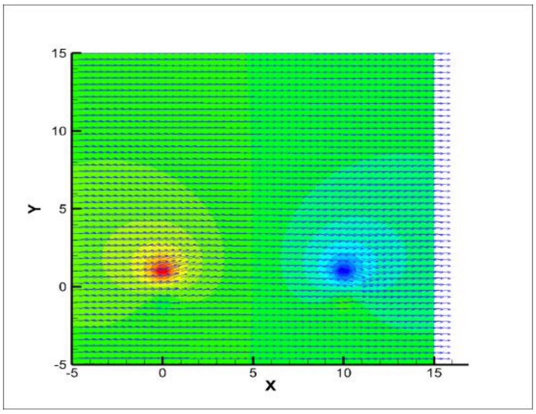

Fig. 7. The velocity field in the interaction of the wind flow with two wind turbines with a vortex contour (V∞ = 10, γ = 8) located one behind the other.

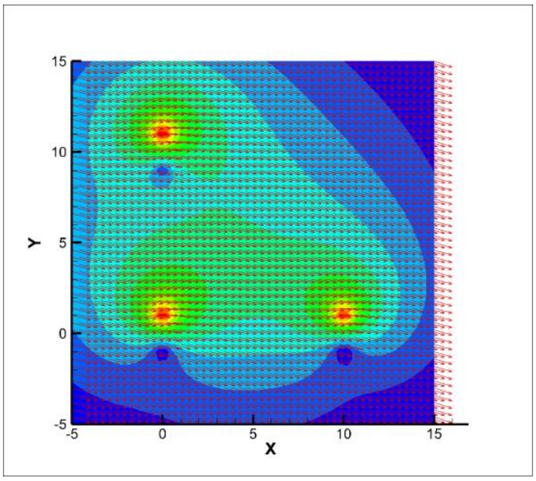

Fig. 8. The velocity field in the interaction of the wind flows with three wind turbines with a vortex contour (located side by side and one after another, V∞ = 10, γ = 4)

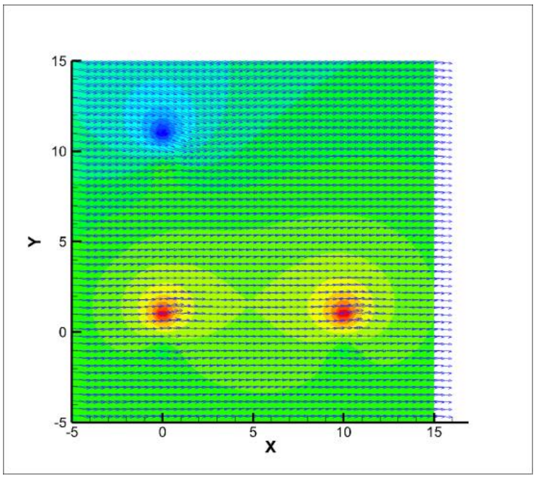

Fig. 9. The velocity field in the interaction of the wind flows with three wind turbines with a vortex contour (located side by side and one after another, V∞ = 10, γ = 6)

Figure 8 shows a graph of the flow velocity fields for three wind turbines, their location from this figure is visible (two are located side by side, and the third is behind it) when all three wind turbines rotate in the same direction; In one direction and with a value of the vortex contour γ = 4. The flow in flowing past three wind turbines rotating in one direction is more strongly deflected from its direction therefore the vortices value γ = 4 is smaller than the previous ones.

In Figure 9 the resulting graph, the velocity fields of interaction of the wind flow with three wind turbines with rotating in different directions.

The results of the calculations for the flow of four wind turbines are shown in Figures 10, 11.

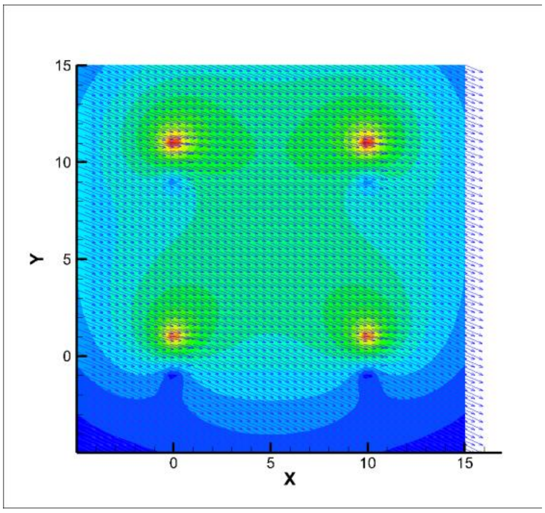

Fig. 10. The velocity field in the interaction of the wind flows with four wind turbines with a contour (located squarely, V∞ = 10, γ = 4)

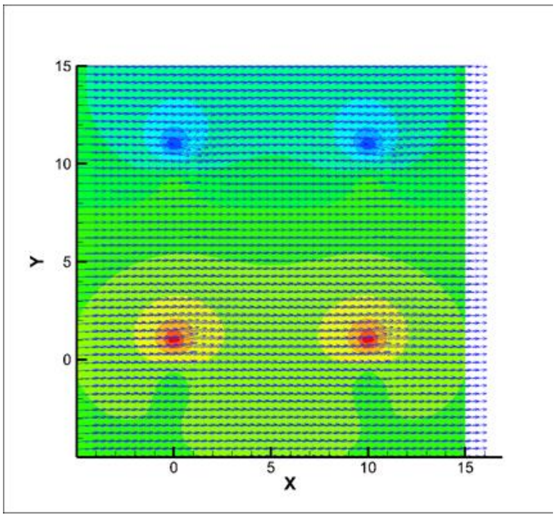

Fig. 11. The velocity field in the interaction of the wind flows with four wind turbines with a vortex contour (located squarely, V∞ = 10, γ = 6)

Figure 10 shows a graph of the flow velocity fields for four wind turbines, their arrangement from this figure can be seen (square arrangement) when all four wind turbines are rotated in the same direction; In one direction and with a value of the vortex contour $\gamma = 4$. Flow during flowing of four wind turbines rotating in one direction is more strongly deflected from its direction in the direction of their rotation.

In Figure 11 in the resulting graph of the wind speed interaction fields with four wind turbines rotating in different directions, the top two in one direction, the lower two in the other direction.

The direction of rotation for the four wind turbines is taken into account in formulas (28) and (29) in the velocity components along the "Ox" and "Oy" directions. A vorticity sign for four wind turbines rotating in one direction "plus-plus-plus-plus" (the results are in Figure 10).

In the case of rotation of four wind turbines in different directions, respectively, combinations can select the vorticity signs. The upper two are in one direction and the lower two are in the other direction "plus-plus-minus-minus" (the results are shown in Figure 11).

Conclusions

In this paper a method is developed for calculating a 2D model for the flow of several wind turbines with different locations and directions of their rotation. A vortex model describes the mathematical model of the interaction of a wind turbine with a stationary airflow the flow throughout the region is considered steady. A series of numerical experiments were developed by the developed calculation procedure and graphs were constructed on the basis of the computations obtained:

• the velocity field in the interaction of the wind flow with the wind turbine (at V = 10 m / s, γ = 2,4,6,8) i.e. With a vortex circuit.

• the velocity field in the interaction of the wind flow with two, three, four wind turbines with different arrangements (V = 10 m / s, γ = 2,4,6,8), also with a vortex contour for the same parameters and with directed and counter-directed rotations.

The constructed graphs from the obtained numerical calculations give a good physical representation of this problem. The results obtained from the calculation are useful for an in-depth, extended theoretical and experimental study of the design of the locations of several Darrie wind turbines i.e. in the whole wind station.

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КОЛЛОИДНЫЕ КВАНТОВЫЕ ТОЧКИ CdSe: ОПТИЧЕСКИЕ СВОЙСТВА И ОСОБЕННОСТИ СИНТЕЗА

Введение. Интерес к синтезу и исследованию наноразмерных полупроводниковых частиц, так называемых квантовых точек (КТ) связана с изучением их энергетических спектров и перспективных практических применений [1].

Ключевую роль в оптических свойствах КТ играют квантово-размерные эффекты, позволяющие управлять длиной волны оптического поглощения или полосой люминесценции варьируя линейными размерами наночастиц. В зависимости от условий синтеза можно получить люминесцирующую наночастицу с заданными спектральными характеристиками, например при изменении температуре и времени синтеза, подбора химических реагентов, условии заморозки получаемых наночастиц и др. Зависимость энергетического спектра полупроводниковых нанокристаллов от ее размера дает огромный потенциал для их практического применения [2, 3]. В настоящей работе изложены результаты исследований КТ CdSe нашей группой.

Экспериментальная часть. Для синтеза КТ CdSe используется модифицированнаяметодикаприведенная в работе [4]. Синтез квантовых точек проводился при 170 ^{0}C, 200 ^{0}C и 240 ^{0}C. Для всех синтезируемых КТ берутся аликвоты небольшого объема (~0,1 мл) во время роста через регулярные промежутки времени после инжекции прекурсора селена и разбавляются в толуоле. Для изучения оптических характеристик аликвот не применялись постпрепаративные процедуры очистки.

Характеризация. Все оптические измерения выполнены в течение 2-4 часов после синтеза. Фотолюминесцентные измерения выполнены на спектрофлуориметре СМ2203 позволяющем измерять спектры возбуждения и испускания в широкой спектральной области от 200 до 820 нм. Спектры