RESEARCH WITH PURPOSE OF FINDING OPTIMAL VARIANT OF THE GUIDE BLADES OF THE VORTEX WIND POWER INSTALLATION

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Abstract

The aim of the theoretical study is to determine the effect of speed and pressure on the motion of the welding wind in order to determine the effective version of the blades, by adjusting the geometrical parameters of the guide shafts.

As a result of the theoretical study, the thickness of the spindle blades and their shapes at different wind speeds were determined for the distribution of pressure and velocity in the wind power installation's concentrator. The shape of the sheets was constructed in the COMSOL Multiphysics program, and the air pressure variation along the spindle pressure was investigated according to the shape and thickness of the blade. The Navier-Stokes equation for computable liquids was extracted into the COMSOL Multiphysics program using the Reynolds Averaged Numerical Simulation (RANS).

Introduction

As known, one of the significant factors of the decrease in the efficiency of wind power installation (WPI) is the random nature of the variations in the speed and direction of the air flow. In order to create the required air flow, several designs of wind turbine designs have been proposed in recent years using airflow concentrators [1-3]. Concentrators in many projects are in the form of fixed constructions of diffuser or confuser types. However, their use is not always effective due to large losses of wind energy (from 15 to 25%). As is known, the flow of air entering into such concentrators, air flow contact with the walls of the concentrator and swirls, forming a certain turbulence, creating a rather serious resistance. This disadvantage is absent in multi-channel concentrators, with guide blades. In JS KazISR on energy under the leadership of M.B. Koshumbayev conducts scientific research to develop and create an experimental design for a vortex wind power installation with a flow concentrator [4-7]. One of the experimental model shown in the figure 1.

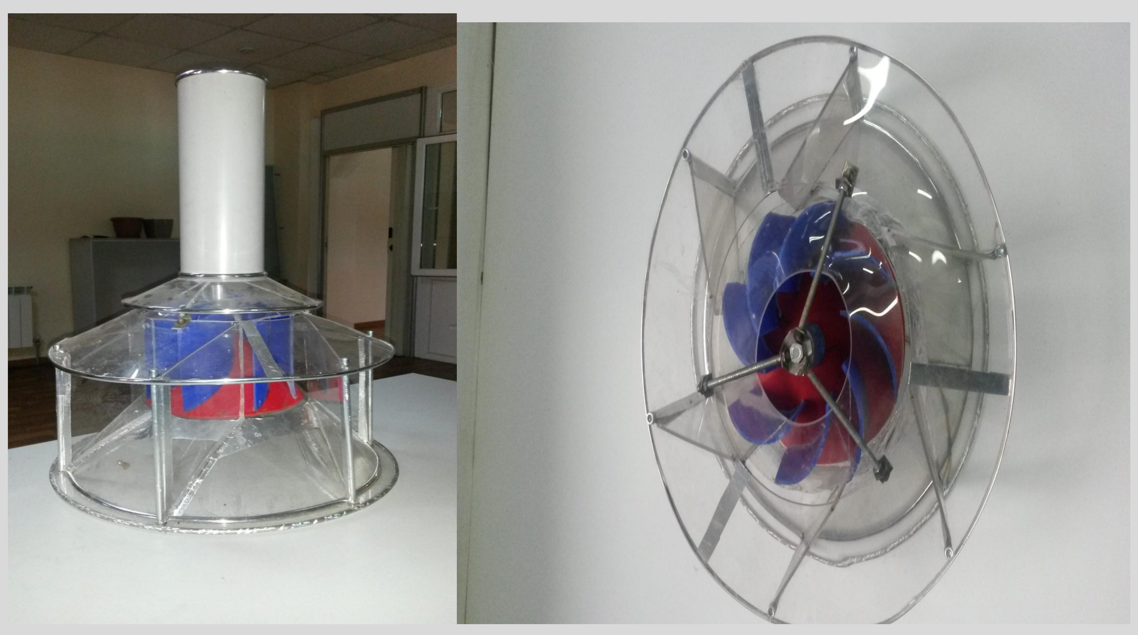
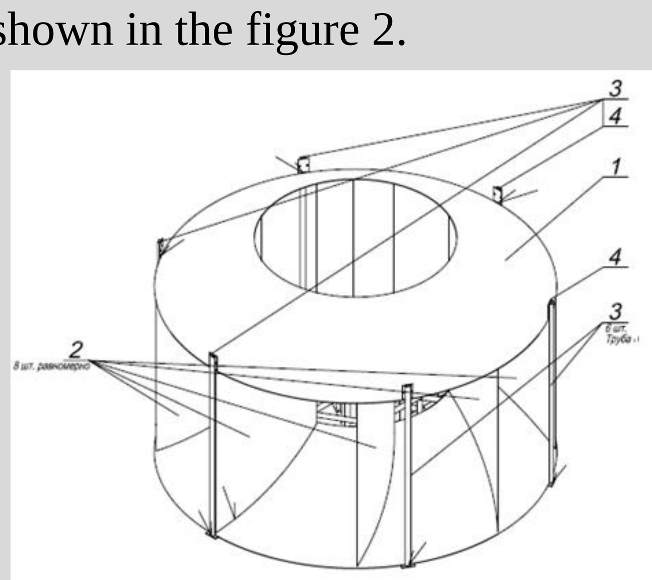


Figure 1. Experimental model of vortex wind power installation

Methodology

The objective of the research is guide blades which shown in the figure 2.



1 - cone, 2 - rectilinear blades, 3 - booth stands, 4 - roof rails with a conical wound.
Figure 2. A general view of the concentrator.

The research was carried out in 2d model of concentrator of VWPI. The method of investigation is a computational experiment.

In general, the COMSOL Multiphysics model uses the Reynolds equations for the modeling of turbulent flows (RANS) and several turbulence models: L-VEL, yPlus, Spencer-Allemar, k-ε, k-ω and SST. But in this case was chosen the model of k-ω. Because this model gives good results when considering internal flows and curves on bending ducts. At the same time, wall functions are taken into account. This is most important when you examine turbulent flows.

Math. model

The medium considered compressible, viscous and steady. The general law of conservation and movement equation is written as follows:

$$\rho(u\bullet\nabla)u=\nabla\bullet[-pI+(\mu+\mu_T)(\nabla u+(\nabla u)^T)+F \qquad (1)$$

$$\nabla\bullet\rho(u)=0 \qquad (2)$$

The medium turbulent and obtained k-ω model, the following additional equations are added.

Turbulent kinetic energy:

$$U_j\frac{\partial k}{\partial x_j}=\tau_{ij}\frac{\partial U_i}{\partial x_j}-\beta^* k\omega+\frac{\partial U_i}{\partial x_j}[(\nu+\sigma^*\frac{k}{\omega})\frac{\partial k}{\partial x_j}] \qquad (3)$$

Specific frequency of dissipation:

$$U_j\frac{\partial\omega}{\partial x_j}=\alpha\frac{\omega}{k}\tau_{ij}\frac{\partial U_i}{\partial x_j}-\beta\omega^2+\frac{\sigma_d}{\omega}\frac{\partial k}{\partial x_j}\frac{\partial\omega}{\partial x_j}+\frac{\partial}{\partial x_j}[(\nu+\sigma\frac{k}{\omega})\frac{\partial\omega}{\partial x_j}] \qquad (4)$$

Results

The thickness of the guiding blade was considered as 14, 26, and 70 mm, and the circumstances under which the shape (curvature) was changed. The air velocity was 10, 15, 20 m / sec for each case. The flow is directed from left to right and is given in several degrees (0, 15, 30, 45). The results, when the velocity is 15 and 20 m / s, are analogous to the results with a velocity of 10 m / s, and the results, given at 0, 15, 30, 45 degrees, are analogous to the initial, i.e. velocity of 10 m / s, 0 g in the following illustrations.

The case when curvature of the blades chosen to create vortex motion.

Results when blades locate vertically and thickness is 26 mm:

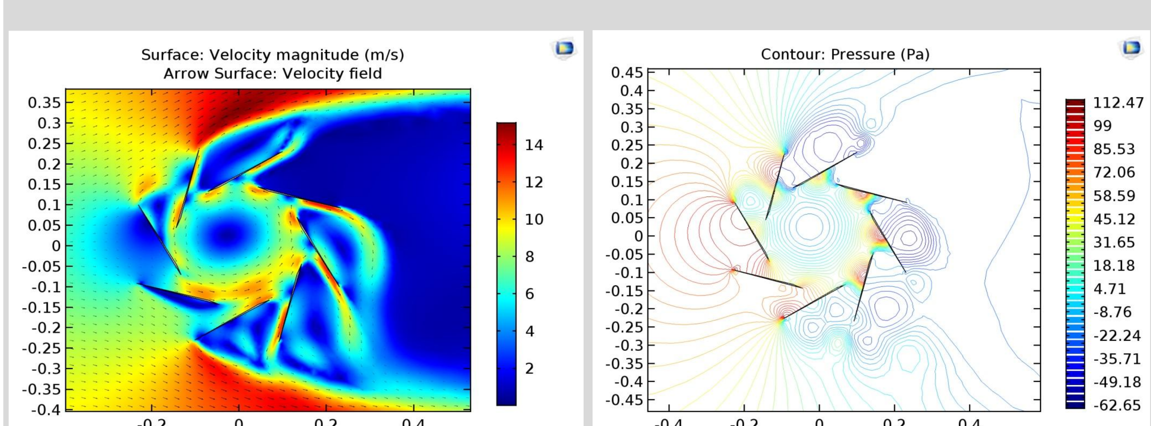


Figure 3. Velocity and pressure distribution when velocity was equal to 10 m/s

The following results when form of the blades was changed:

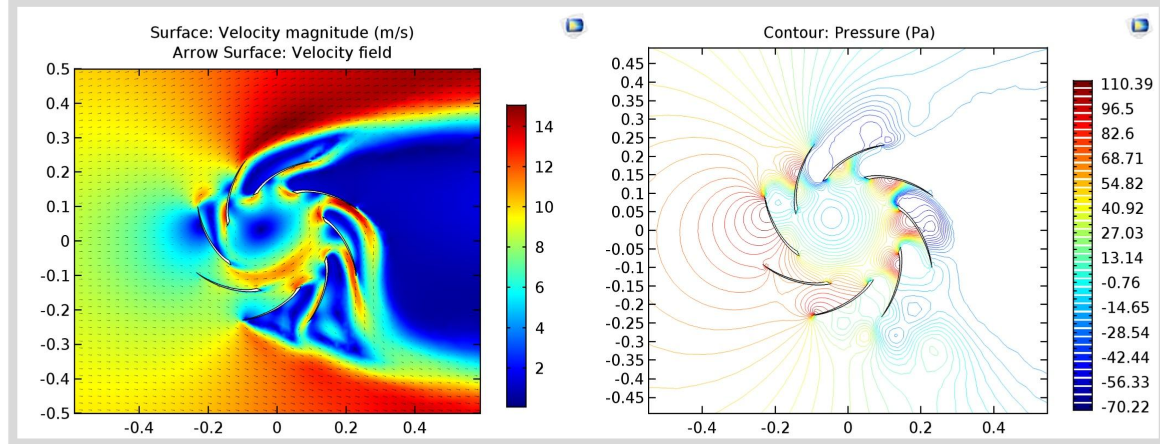


Figure 4. Velocity and pressure distribution when thickness was 14 mm (velocity of flow is 10 m/s)

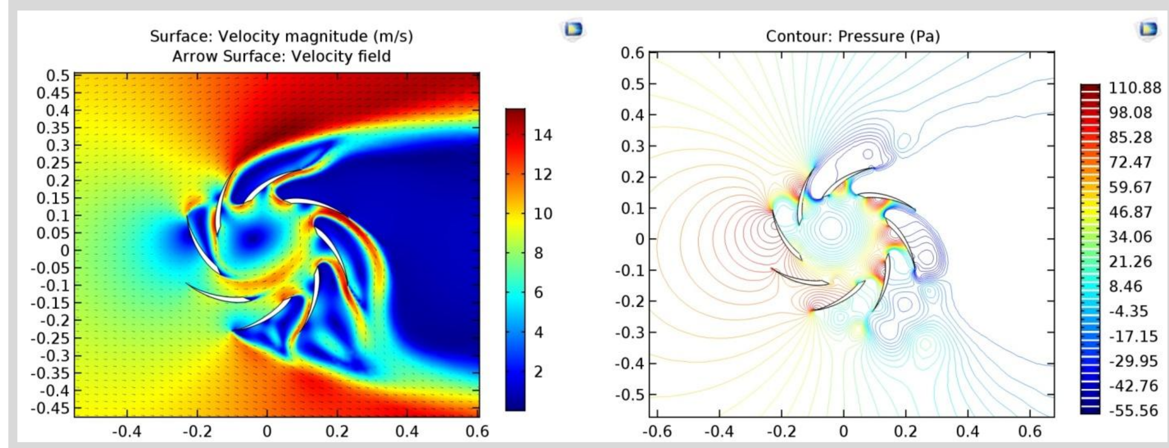


Figure 5. Velocity and pressure distribution when thickness was 26 mm (velocity of flow is 10 m/s)

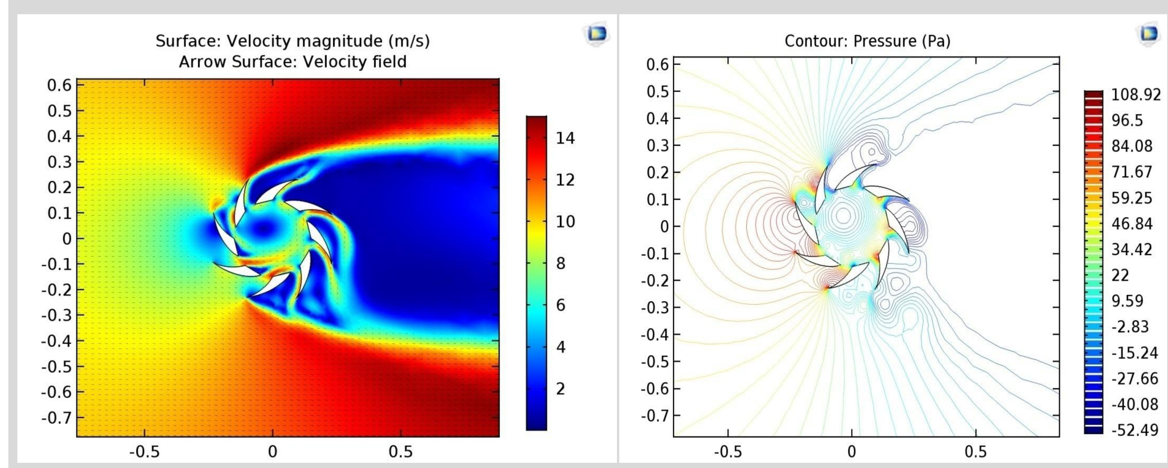


Fig.19. Velocity and pressure distribution when thickness was 70 mm (velocity of flow is 10 m/s)

Conclusions

The research work was carried out within the framework of the scientific project "Creation of optimal wind power installation (WPI) with concentrator of flow" at the Ch.Chokin Energy Research Institute.

By analyzing the results of the calculations, as the thickness of the wind power installation guide blade increases the thickness of the air duct was decreased, velocity increased. When the form was as an arc, the air flow turned into a vortex motion, with increasing of velocity of 10-20%. Initially, when the blade thickness was 14 mm and 26 mm, velocity at the entrance increased by 20%, and the velocity increased by 40% when the thickness was 70 mm. This work needs further research. The future is focused on determining the effective type of its thickness and determining the shape of the blade, its radius of curvature.

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