Substantiation of Usage Expediency and Analysis of Exploitation Problems of Low-Power Wind Turbines

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Abstract* – *Wind energy is considered as one of the most perspective, developed and ecologically clean energy resource. Nevertheless, it is associated with several harmful factors which influence environment. That's why basic causes and zones of vibration initiation in wind turbines, as well as negative vibratory and acoustic factors of wind turbine influence on natural beings, are analyzed. In conclusion it is substantiated that the ecological problems of low-power wind turbines may be neglected and they should be widely used for economic development and energy independence improvement of our country.

Key words – wind turbine, blades vibrations, acoustic influence, energy of air-flow, alternative energy sources, harmful factors, noise and vibrations.

I. Introduction

The growth of the usage scale of electrical energy, gradual exhaustion of traditional energy sources (oil, gas, coal etc.), aggravation of the problems of environment protection have intensified the search of ecologically clean methods of electrical energy production. Such directions of alternative and renewable power engineering as solar, wind, geothermal, biogas etc. that have practically inexhaustible supplies are actively developing.

Wind energy has weighty ecological preferences in comparison with other traditional and alternative sources. They consist in the absence of any environmental pollutant emission while energy producing, necessity of additional water cooling, requirements to special features of the power plant locating territory (presence of rivers, lakes, rich soils etc.). Unlike the heat power engineering, which is the main source of greenhouse gases and other unhealthy pollutants of the atmosphere wind turbines are much less harmful for environment. In itself output and processing of the coal, oil and gas cause pollution. Nuclear and heat electrical power stations require the presence of large lakes for cooling the power-generating units. Any other fuels which product the energy due to burning (firing) spend some part of the heat for environment warming and cause its heat pollution. And although wind-turbine electric plants occupy much larger areas than traditional power plants, nevertheless, 90% of the territories of wind farms locating can be used for the needs of agriculture or industry [1; 2].

In spite of the chain of preferences, airflow energy causes some harmful influences on the environment. Wind turbines may obstruct the radio wave propagation, influence the natural migrations of birds etc. However, the special attention should be payed to the noise and vibration pollution of the territories adjacent to wind turbines location [2; 3].

II. Vibration and acoustic influence of wind turbines on environment

Noise is one of the most dangerous and harmful forms of the wind turbines influence on environment. However, its emission is bounded by several hundreds meters from the place they are located (Fig. 1). If a man stays in direct nearness to the wind turbine for a long time (e.g. technician, engineer, maintenance man) the acoustic influence is wide-band [2]. The noise level against frequency may vary from 32 dB to 56 dB and the level of infrasound pressure – from 96 dB to 106 dB. In both cases the requirements of state sanitary norms are kept.

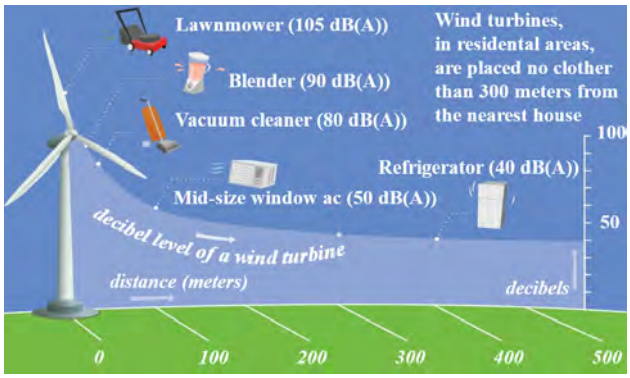

Fig. 1. The dependence of noise level on the distance between wind turbine and research object

Noise during the wind turbine operating may be provided by two main reasons: aerodynamic interaction between the blades and the airflow. It resembles the whistle when the air flows along blades surfaces; 2) mechanical friction between different parts of the plant, such as bearing box or electric generator [4].

Infrasound in wind turbines is weakly generated as a result of blades interaction with airflow. On the blades tips the air swirl appears caused by pressure differential on two opposite sides of a blade. This effect is called flow stall (Fig. 2) and essentially influences not only infrasound generating but also vibration emission, power reduction and decreasing of durability of wind turbine blades operating. The frequency of the infrasound may reach 6-7 Hz which is practically the same as natural rhythm of human brain and can influence his/her psychological state [3; 4]. Thus, these disadvantages are typical for wind turbines of megawatt class, whereas wind turbines of low and middle power in this case are much more undangerous and safer than railway transport, automotive vehicles, trams etc.

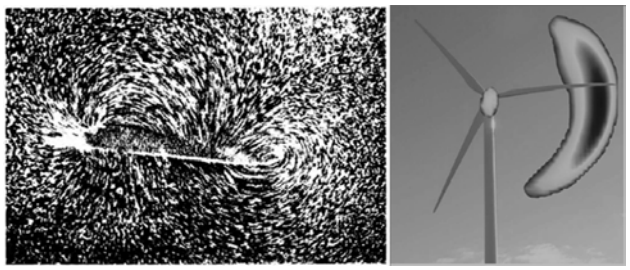

Fig. 2. The effect of flow stall and its acoustic influence

During the wind turbine operation aerodynamic, inertial and gravitational time-dependent loads act upon its elements and cause the vibrations of different parts (blades, nacelle, tower). These vibrations may be transmitted to the wind turbine foundation. Together with constrained oscillations caused by the action of external forces the vibrations may appear as a result of unbalanced masses of different parts of a wind turbine: windwheel with blades, step-up gear, generator etc.

To a considerable extent, airflow fluctuations and turbulence influence exactly the blades. Most of blades loads have time-dependent pattern and their amplitudes and frequencies steeply rise while increasing of the wind turbine overall sizes and worsening of weather conditions (sudden wind gusts with simultaneous changing of its speed and direction).

Dynamic vibrations appears in the majority of cases as a result of static disbalance of the windwheel, that is the displacement of its gravity center due to the difference between the blades masses. Vibrations may also appear as a result of nonuniform distribution of the snow or hitting the blades by other objects. Disbalance causes the vibrational displacements of different parts of a wind turbine, which harmfully influence its structure and may produce noise and infrasound. However, modern technologies of the windwheel balancing, installation of vibrated insulating and damping systems allow completely avoid static and reduce dynamic disbalance to the safe level [4].

Conclusions

One of the main arguments against wind turbines usage is noise. Wind turbines produce two types of noise: mechanical and aerodynamic. Mechanical noise is generally produced by the many different components of the wind turbine, such as the generator, the hydraulic systems or the gearbox. Various mechanical noise prevention strategies exist, such as vibration suppression, vibration isolation and fault detection techniques, which are described in the paper [4]. The noise value of modern wind turbines of middle power at the distance of 20 m reaches 34-45 dB. In comparison with wind turbines the noise level in a town at night approximately equals 20-40 dB, when driving a car on the block pavement road – 55 dB, while using a perforator – 95 dB [3]. That's why we may consider wind turbines as the same noise producers as the other domestic and customary technique (lawnmower, blender, vacuum cleaner, refrigerator etc.).

Infrasound and vibrations also harmfully influence the environment. During the wind turbine operating, on the blades tips the air swirl appears which is actually a source of infrasound. The larger wind turbine power and sizes are, the more harmful influence of these effects on environment is revealed. Strategies for reducing aerodynamic noise include adaptive solutions and wind turbine blade modification methods [4]. Adaptive noise reduction techniques include varying the speed of rotation of the blades and increasing the pitch angle. Although such strategies have been successfully implemented for noise reduction purposes, they can cause significant power loss [4]. Therefore, alternative adaptive solutions are sought. Blade modification methods such as adding serrations have proven to be beneficial in reducing noise without any power loss [4]. As for vibrations reducing, modern technologies of the windwheel balancing, installation of vibrated insulating and damping systems allow completely avoid static and reduce dynamic disbalance to the safe level.

Thus, these disadvantages are typical for wind turbines of megawatt class, whereas wind turbines of low and middle power in this case are much more undangerous and safer than railway transport, automotive vehicles, trams and other sources of infrasound with which people deal every day.

As for the advantages of the wind turbine usage, widespread application of wind turbines will positively influence the dynamic of the ozone layer reducing and, respectively, the intensity of the global warming. In addition, the stocks of water and traditional energy resources (coal, gas, oil etc.) will not reduce so quickly, because wind turbines in comparison with nuclear and heat power stations do not need cooling and do not cause the exhausting of the earth bowels.

Analyzing aforecited facts, we may confidently say that from the ecological point of view wind turbines of low and middle power do not cause essential harmful influence on environment. As a practical confirmation of this conclusion, we may take into consideration the fact that wind power engineering steeply develops in European Union, USA, China and other countries. In general, the energy of airflow can completely provide the increasing energy needs of humanity. Nowadays modern wind turbines produce more than 200 billion kilowatt-hours per year, which is approximately equal to 1.3% of the global world electrical energy producing. At the same time in some countries this rate reaches 40%.

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