# INTELLIGENT TECHNOLOGY FOR NONSTANDARD WIND TURBINES DESIGN: EXPERT SYSTEM "INTEL_WEE"

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***Abstract***: *The variant of intelligent technology for wind turbines custom constructions design: expert system "INTEL_WEE", actual for compromise searching "to provide electricity to the region with minimal damage to the environment", is proposed.*

***Keywords***: *intelligent technology, wind energy equipment (WEE), expert system, wind turbines, sensor.*

## Introduction

Active development of wind-mill electric generating units in the European Union has significantly been accelerated by the known events in the territory of the CIS at a boundary of the 90th years of the XX century – 1 decades of the 21st century when instability of providing with the traditional energy resources using oil and gas was shown (interruptions in supply of gas from Russia to the European Union countries, and also sharp destabilization of a political situation and economic life in the countries of the Middle East – Saudi Arabia, Kuwait, North Africa).

Unpredictability of stability of deliveries of the called traditional hydrocarbonic energy carriers through the territory of the CIS countries was led to the new strategic decision of the European Union on long-term electricity supply at the expense of renewable sources: first of all wind power and solar power. According to plans of the European Union it is accepted to implementation of the plan of finishing industrial power of sea windstation on the North Sea by 2020 in volume of 32 GW, by 2030 to 120 GW of the electric power. According to the latest data only for the first half of 2012 in the European Union countries 50% more WEE than for the first half of the year 2011 is established (generally it is WEE in offshore territories of the North Sea).

It is known for a number of situations where the search of compromise "to provide electricity to the region with minimal damage to the environment" had to design and create nonstandard designs of wind turbines, and using non-traditional methods of accumulation of energy produced. For these and other similar cases of solving the energy problems of the region require new optimized engineering solutions

[Kudrya, 2013]. Such problems make the current issue of establishing a special expert system that can substantiate these new solutions.

The most important element of an integrated approach in the assessment of the technical condition of rotating machinery vibration parameters is the diagnosis. At the end of the twentieth century, the problem of diagnosis of complex multi-component equipment were solved by so-called expert systems, as one of the directions of research on artificial intelligence.

The task of the expert systems is to develop programs to solve problems difficult for a human expert, achieves results that are not inferior to a man of quality and efficiency. Monitoring of a condition of the rotating mechanisms pursues two aims: protective and preventive (predicting). Protective monitoring has to provide protection of the equipment of primary refusal and decrease in secondary risk, danger to personnel and environment. The preventive (predicting) monitoring is aimed at identification of potential problems and high sensitivity to the revealed anomalies and reliability of an assessment of the current technical (vibration) state of the equipment and the forecast of his development is required.

Here periodic expected monitoring which can be executed by means of mobile or figurative collectors of the data using temporarily installed sensors is considered traditional.

## About the system of natural modeling of diagnostic equipment vibro windmill

In recent years, in most industrialized countries in the world are actively expanding network of industrial wind turbines. Technologically are very attractive the location of wind turbines industrial capacity in such areas of relief, where the average wind speed is maximum for the given area. At the same time, it is preferable to choose a place remote from the main local region's infrastructure (lack of roads, residential areas, industrial complexes). As a result of putting into operation new and powerful wind turbines in the majority of cases are removed from the control points and control of their work by people (operators).

The above circumstances (extreme modes of wind turbines operation, the distance of technical personnel placement, designed to monitor the performance of wind-energy complex) are forced to develop a highly reliable means of remote control of wind turbines monitoring. This is especially important for minimize of probability of accidents on wind turbines in extreme weather conditions [Bardik, 2012], the complicated conditions of staff access to wind turbines. In particular, in such difficult conditions are working offshore wind turbines in the North Sea, remoted is not uncommon for a distance 100 km or more. In the context of Ukraine, the actual of remote monitoring at any time in any weather high for existing and future wind turbines mountainous terrain of Carpathia and Transcarpathia.

Especially given the fact that these regions, as known, have a high industrial wind potential, yet poorly developed. In our paper [Pisarenko, 2012], sets out a vision of an expert vibro diagnostics system of wind turbine using remote of current operation mode monitoring by the operator with the sensors mounted in the nacelle wind turbine. For the purpose of simulation modeling of called technique of remote control of pre-emergency modes of wind turbines operation in this paper are presents the results of full-scale experiments on the operating model of rotary mechanisms with a number of important features, highly informative for remote monitoring of rotating machines type wind turbine and industrial ventilators.

The goal of experiments, in this case, was to identify possible situations that resonant oscillations occur within the test speed range of the main shaft of the rotor installation. Technologically for solving the problem was used the following installation scheme, comprising: main shaft of rotary, sensors of vibration frequencies of the main shaft near the resonant frequencies of the individual components of the entire system (provides the ability to identify of the pre-emergency modes of vibration due to wear out of rolling bearings of the shaft defects, violating the normal mode of the fixation of through-hole assemblies of throughout installation, etc.).

The Table 1 shows the indications for each of the three cases of forced frequency selected for experiment. At first was extracted from the spectrum the four nearest competitor, then were calculated for each of the frequencies of the most dangerous competitors. According to the criterion:

$$\min\left(\delta\left(f_{forced}\right)-\delta\left(f_i\right)\right) \ , \tag{1}$$

where $f_{forced}$ – frequency in emergency mode of wind turbine vibration,

$f_i$ – frequencies-satellites from the spectrum the four nearest competitor,

was selected the most dangerous mode with $f_i\left(f_{forced}\right)$=70 Hz.

Table 1 - Severity of accidents ( $f_i$ – frequencies-satellites of $f_{forced}$ ) for three variants of the forced frequency $f_{forced}$

| № | $f_{forced}$ , Hz | $\delta(f_{forced})$, dB | $f_i(f_{forced})$, Hz | $\delta(f_i)$, dB | $\min(\delta(f_{forced}) - \delta(f_i))$, dB |
|---|---|---|---|---|---|
| 1 | 42 | -25,5 | 50 | -31 | 5,5 |
| | | | 55 | -35,5 | |
| 2 | 70 | -16 | 52 | -22,5 | 6,5 |
| | | | 87 | -32 | |
| | | | 105 | -33 | |
| | | | 125 | -45 | |
| 3 | 73 | -16,5 | 50 | -26,5 | 6,5 |
| | | | 54 | -23 | |
| | | | 125 | -28 | |
| | | | 150 | -28 | |

## About the intelligent technology for wind turbines nonstandard constructions design

For such tasks is expedient design and development of intelligent design technologies unconventional designs of wind turbines, which can be called as follows: expert system "INTEL_WEE". Moreover, among the primary questions arise, in particular, the problem of a priori estimate of the profitability of specific samples of commercially available wind turbine or a wind turbine at the task of creating a new type (for example, - if necessary, taking into account non-traditional geographic and climatic conditions). For example, in the drafting of the wind farm can be a problem associated with the inability to exact a priori determination of wind turbines generating electricity. As a result, it will be difficult to determine the real economic parameters of future wind farms. Under these conditions, important to have a

methodology for calculating a priori estimation of depreciation expense projected new wind turbines. The methodology should be based on a generalization of similar data for the design and operation of wind turbines already known similar type. Therefore, in this paper we propose enlarged block diagram of such an expert system shown in Fig. 1.

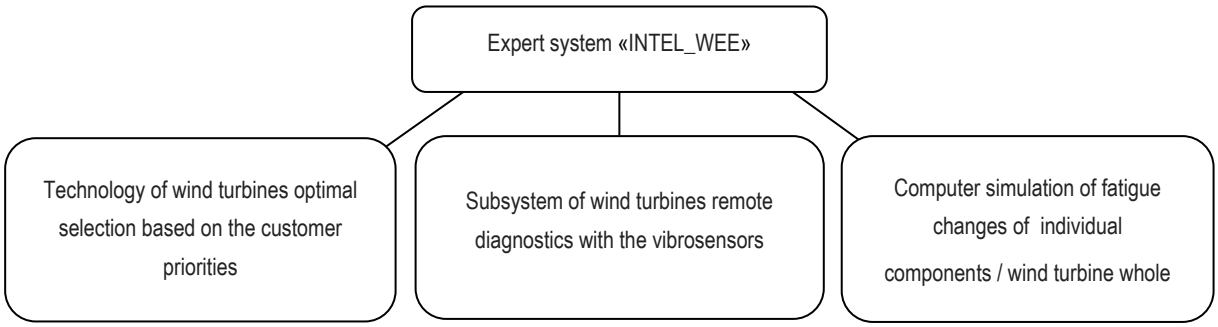


Fig. 1 Block diagram of the expert system "INTEL_WEE" described in the article.

The system of "INTEL_WEE" must contain, in particular, a number of modules for monitoring and diagnosing the level of performance of the unit of wind turbines using special remote-controlled vibrosensors [Pisarenko, 2013], as well as forecasting system depreciation. One of the aims of the report is the inclusion of maximum likelihood estimates of a particular wind turbine designed through the use of an appropriate system of intelligent control design, development and operation of newly developed design of wind electro stations for specific conditions of the customer. In particular, is the basis of installed capacity, structural type (vertical / horizontal axis), the climatic conditions of operation, the proximity to the area of the energy produced wind turbine, the failure rate of selected components of the wind turbine construction (including use of basic components offered by suppliers from any available manufacturers of wind turbines). In our studies [Pisarenko, 2012], [Pisarenko, 2013], [Pisarenko, 2014], [Malachinskij, 2014], [Pisarenko J.V., 2014] considered the possibility and expediency of the use of mobile remote sensors that can inspect the area specified by the operator operating units without stopping the wind turbine equipment in order to detect dangerous abnormalities in the course of the entire set of units of wind turbines, as well as If necessary, locate the source of the detected abnormally dangerous vibrate.

In our paper [Pisarenko, 2013] noted that the problem of diagnosis of complex multi-component equipment, such as wind turbines, it is advisable to solve the complex using so-called expert systems - as one of the areas of research in artificial intelligence.

The expert WEE-robot system is intended for the choice of the optimal technical and technological solution of rather optimum use of sources of renewable power in a farm. The expert WEE-robot system allows to make fully optimum choice of couple: WEE-concrete farm. The system is founded on the principle of the accounting of the weather conditions of the region correlating with data of meteorological supervision for the last more than 100 years.

## Conclusion

In this paper were presents the results of full-scale experiments on the operating model of rotary mechanisms with a number of important features, highly informative for remote monitoring of rotating machines type wind turbine and industrial ventilators. In experiment were identified possible situations when resonant oscillations occur within the test speed range of the main shaft of the rotor installation. Also in this paper were presents the enlarged concept and modules of expert system "INTEL_WEE". "INTEL_WEE" is intelligent technology for wind energy equipment of nonstandard constructions design.

## Bibliography

[Bardik, 2012] Bardik E.I. Simulation of a wind farm to assess the reliability of the changing weather conditions// The XIII International konference of renewable power (c. Mykolaivka). – 2012.

[Kudrya, 2013] Kudrya S.A. Status and prospects of the development of renewable power industry // Theses of the XIV-th International Scientific and Practical Conference “Renewable energy of XXI century” (September 16 - 20, 2013, c.Mykolaivka, Crimea, Ukraine). – 2013. – P. 27-28.

[Malachinskij, 2014] Pisarenko V.G., Pisarenko Yu.V., Malachinskij V.Yu. A computer dialog with wind power gives the non-emergency wind energy // Theses of the XX-th International Conference «Knowledge – Dialogue – Solution (KDS-2014)» (September 08 - 11, 2014, Kyiv, Ukraine). – 2014. – 2 p.

[Pisarenko J.V., 2014] Pisarenko V.G., Pisarenko J.V., Malachinskij V.Yu. Vibration diagnostics system for wind turbines // Theses of the Anniversary XV-th International Scientific and Practical Conference “Renewable energy of XXI century” (September 16 - 17, 2014, Kyiv, Ukraine). – 2014. – 2 p.

[Pisarenko, 2012] Pisarenko V.G., Shevtchenko O.A., Prokopchuk V.V., Pisarenko Yu.V., Varava I.A., Koval S.A. About possibility of expert system creating for monitoring and diagnostics of wind turbines units efficiency degree with the using of remotely operated mobil vibrosensors // Theses of the XIII-th International Scientific and Practical Conference “Renewable energy of XXI century” (September 10 - 14, 2012, c.Mykolaivka, Crimea, Ukraine). – 2012. – P. 14-16.

[Pisarenko, 2013] Pisarenko V.G., Shevtchenko O.A., Prokopchuk V.V., Pisarenko Yu.V., Varava I.A., Koval S.A. The concept of expert system vibrodiagnostics of wind turbines units on the base of remotely operated multichannel vibrosensors // Theses of the XIV-th International Scientific and Practical Conference "Renewable energy of XXI century" (September 16 - 20, 2013, c.Mykolaivka, Crimea, Ukraine). – 2013. – 3 p.

[Pisarenko, 2014] Pisarenko V.G., Pisarenko Yu.V., Malachinskij V.Yu. The Structure of the Concept of Information-Analytical System «Optimal Choice of Renewable Energy Sources» // „Artificial Intelligence". – 2014. – №1. – P. 24-27.

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