NEW DESIGNS OF ROTORS WITH VARIABLE GEOMETRY PARAMETERS IN DYNAMICS AND THEIR EFFECTIVE USE IN AVIATION AND WIND ENERGY

НОВЫЕ КОНСТРУКЦИИ ВОЗДУШНЫХ ВИНТОВ С ИЗМЕНЯЕМЫМИ ПАРАМЕТРАМИ В ДИНАМИКЕ И ИХ ЭФФЕКТИВНОЕ ПРИМЕНЕНИЕ В АВИАЦИИ И ВЕТРОЭНЕРГЕТИКЕ

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ABSTRACT: *In the report will be presented the investigation results of the working model of rotors with variable geometry parameters in dynamics. Because of aerodynamic and economic calculations, the effectiveness of use of such designs for powerful wind stations is proved. The analysis of various designs and methods of selection of that or other design for various conditions of operation of wind installations in wide range of the wind speed change is given.*
Also rather effective by cost-price method of accumulation of wind energy will be suggested that is the topical world problem and for development of which are annually spent some hundreds of millions of US Dollars.
KEYWORDS: BLADE, SETTING ANGLE, BLADES TWIST, WIND ENERGY.

Recently in conditions of the abrupt increase of the growth tempo of global thaw and considerable deterioration of the ecological state the acquisition of power energy by traditional methods becomes a serious threatening to the mankind. In connection with this especially developed countries become in difficult situation in which annually with quick tempos increases the volume of industrial and accordingly the number of consumed power energy.

In this case especially must be noted those risk factors by which are characterized atomic power stations and the dissatisfaction of population that reached its peak during the disaster in Fukushima that happened in Japan in 2011.

It is known internationally that these processes became the basis of the solutions that make authorities of all countries carry out operative measurements in direction of change of the atomic energy in the general energy balance of the country by some less dangerous kind of energy.

By these processes is preconditioned the fact that in last 10-15 years almost in all countries of the world special attention is paid to updating of the existing and creation of new non-traditional methods of the energy acquisition and maximal use of the existing potential in the country.

Furthermore, the governing bodies of the international community elaborate special encouraging measurements for those countries and firms that effectively work on the development of ecologically pure and non-dangerous methods of acquiring energy.

First of all wind and solar energy refers to such kind of energy. Therefore, the designs of wind stations and technology of acquiring solar panels are extensively updated.

The extensive works in both directions are conducted at the Georgian Technical University.

For increasing of the effectiveness of wind stations several designs of rotors with the ability of change of basic geometry parameters have been created. Such parameters are the rotor diameter, i.e. the length of blades, setting angle of each blade and the law of their twist.

The preliminarily conducted aero-dynamic and economic calculations prove that as a result of use of the designs elaborated by us the annual volume of output of each wind station can be increased as minimum by 100%.

Despite multiple work of well-known companies and scientists of various countries the VGR problem has not been solved yet. There are patents that did not find a real embodiment, mainly, because of complexity and insufficient reliability of technical solutions.

It must be noted that all these companies were busy with any of one parameter. For example, Sikorsky Company was busy with change of only the rotor diameter and the Boeing Company only with blade twist change.

Georgian Technical University (GTU) proposed a combination of changes in the diameter and twist at the same time dynamics.

Initially in the phase of analysis because of separation of the investigation object, the model of the rotor with variable diameter and then the model of the rotor with variable blade twist has been designed and manufactured. After laboratory tests of their main units in the phase of the synthesis, the rotor with simultaneously variable diameter and blade twist (Fig. 1) and the stand for its tests has been created [1].

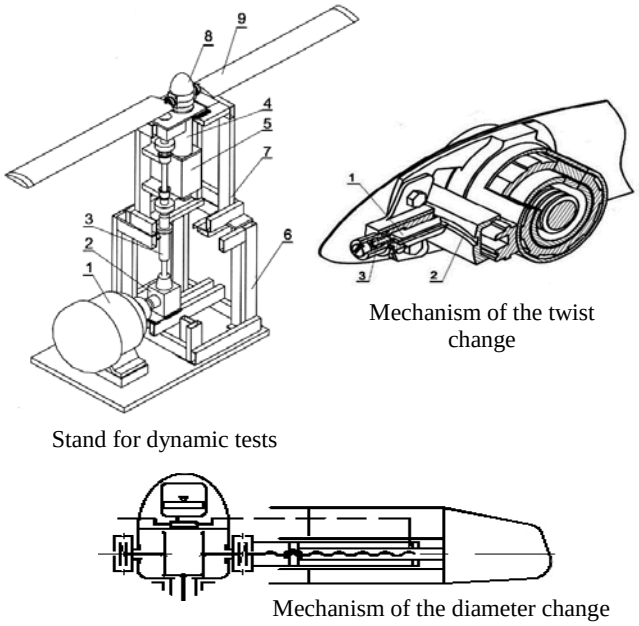

Fig. 1. Mechanisms for management of parameters of the VGR and stand for their tests.

The conducted stand tests of the VGR have shown that at high number of rotations significant centrifugal forces arise that influence on the blade movable part. They are accepted by the jackscrew. The jackscrew is the most loaded element of the rotor design and is the weak unit. The reduction of harmful influence of these forces is the very actual problem.

Therefore, a system was developed compensation of centrifugal forces. The technical approach was in conduct of the model experiment in which the stand is stationary fixed in place. At the rotor rotation at the mode of fan measuring of the thrust were implemented depending on the change of the rotor rotational speed and diameter. In accordance with the principle of reversibility, this imitates the conditions the hover mode of the aircraft. From the possible principles of compensation (mechanical, electrical and hydraulic) was chosen hydraulic (Fig. 2) as the most flexible in control [1, 2, 3].

For the design of this version of the VGR a European Patent has been received Application №/Patent 08737551.5 - 2422 PCT/IB2008001041. At present, it is being patented in the USA. All the financial costs were assumed by the European Union.

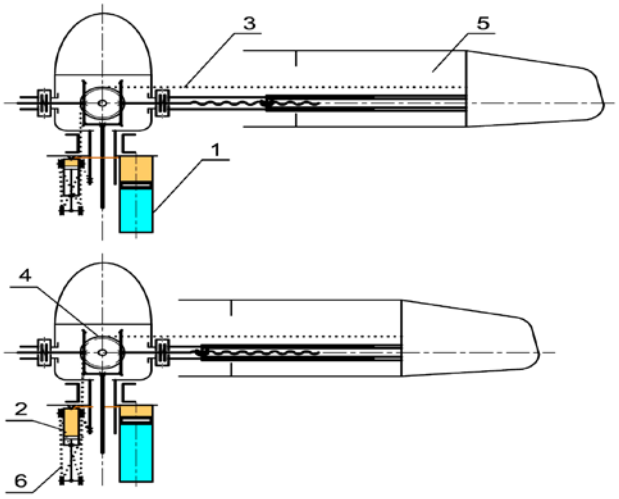

Fig. 2. Schematic arrangement of the VGR with position of the hydro-pneumo-accumulator and hydro-cylinder below the rotor hub.
1-Hydro-pneumatic accumulator, 2-Hydro-cylinder, 3-Rope, 4-Roller, 5-Blade, 6-Pulley block.

The safety of the VGR dynamic tests was provided by the reliability of the VGR units with the compensation system. For evaluation of the reliability was designed and manufactured the stand for static tests (Fig. 3) on which experimentally were imitated loads acting at various rotor rotational speeds. The blade elasticity lines were determined depending on imitated rotational speeds at retracted and extended blade and dependence of forces on the control lever of the stand from imitated rotational speeds.

Fig. 3. Stand for static tests and blade with flexible elements and rib.

The experiments on the stand for dynamic tests (Fig. 4) were conducted by the measuring method of the airflow speed with a revolving-vane analyzer, which for this task was characterized, with a sufficient iteration of measuring results.

It has been established that in case of increase of the rotor diameter 1,4 times and the change of the blade twist within $16 \div 18^0$ the increase of the thrust force is provided approximately 1,6 times.

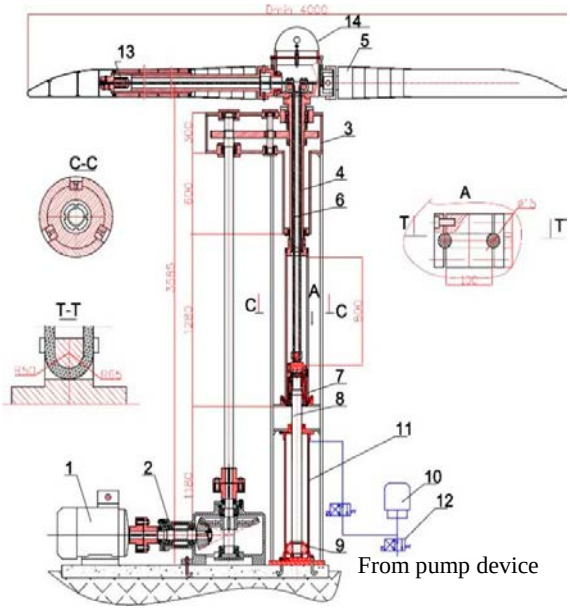

Fig. 4. Stand for dynamic tests and photo of the stand.
1-Electrical engine of direct current, 2-Conical reducer, 3-Cylindrical reducer, 4-Spindle of cylindrical reducer, 5-Blade with flexible elements, 6-Rope, 7-Unit of bearings with body, 8-Rod, 9-Piston, 10-Hydro-pneumo-accumulator, 11-Hydro-cylinder, 12-Hydro-distributor, 13-Unit of the rope mount.14-Hub.

The effectiveness of the compensation system is proved by multiple retraction-extension of the rotor blade in the all range of change of the rotational speed. It conditioned the synchronism of the VGR functioning.

Results of repeated and comprehensive investigation of the working model of air screws with changeable geometrical parameters in dynamics were saved up. In figure 5÷8 as an example, shows the results of the values of lift at maximum and minimum diameters of the rotor in a large range of the rotational speed.

The detailed analysis of the various proposed designs of rotor is carried out and on this basis recommendations of selection of this or that design for different service conditions of wind turbines in the wide range of change of speed of a wind are offered [5].

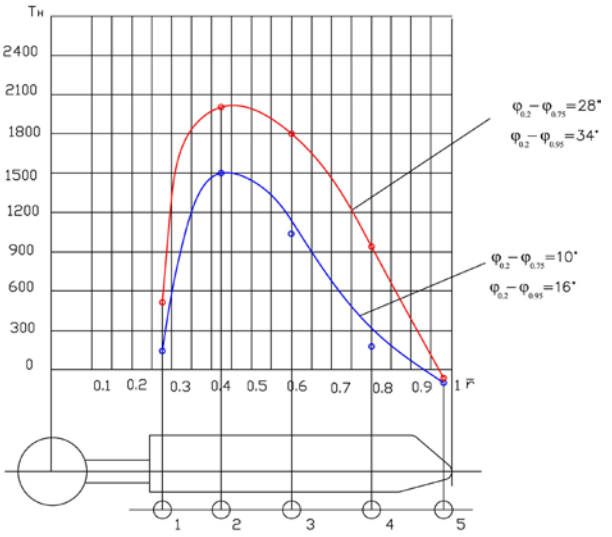

Fig. 5. Diagram of dependence of the VGR thrust from the blades twist change for the minimal diameter D_{min} of the rotor, rotational speed $n = 300$ RPM and setting angle $\varphi = 5^0$.

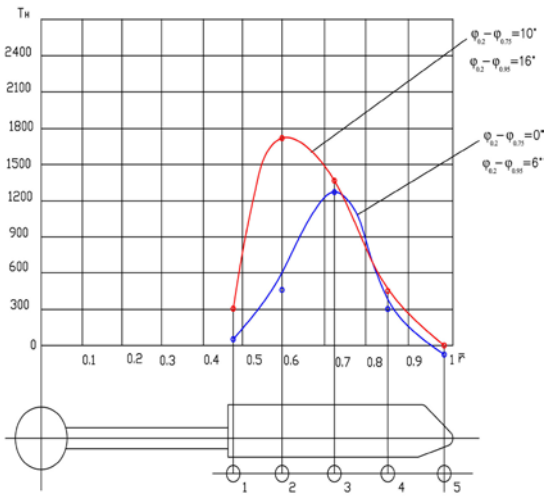

Fig. 6. Diagram of dependence of the VGR thrust from the blades twist change for the maximal diameter D_{max} of the rotor, rotational speed $n = 200$ RPM and setting angle $\varphi = 5^0$.

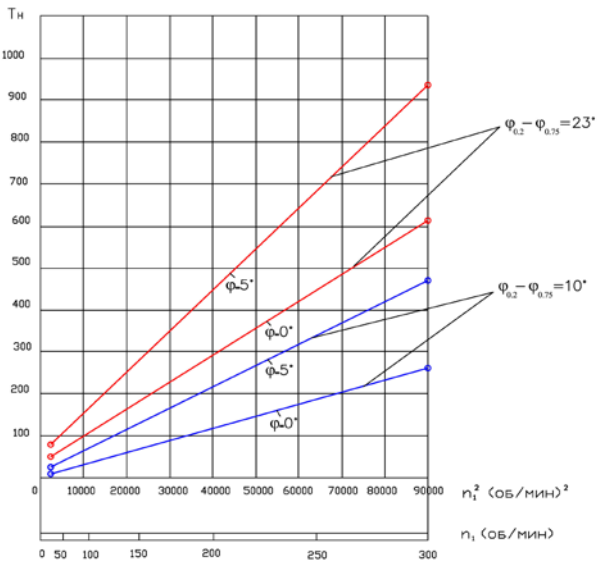

Fig. 7. Diagram of dependence of the VGR thrust from the rotor rotational speed for the minimal diameter D_{min}.

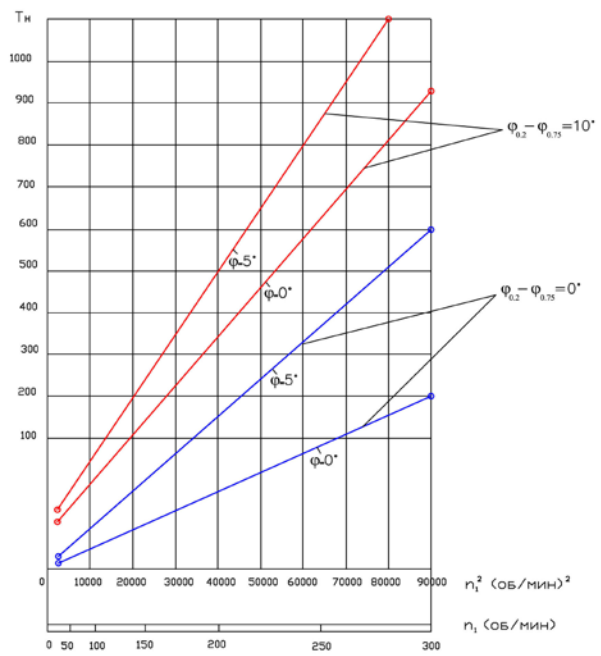

Fig. 8. Diagram of dependence of the VGR thrust from the rotor rotational speed for the maximal diameter D_{max}.

As a result of manufacture and test of a demonstration model of the rotor with variable geometry parameters in dynamics we have proved that for wind energy installations especially with big powers the use of VGR will enable to extend the scale of maximal meanings of efficiency of the setting during the change of the wind speed in big scale from 3 to 20÷22 m/sec and also provide the workability of the setting during those high speeds of wind (22÷35 m/sec) (Fig. 9), at which the existing installations are unable to work [4].

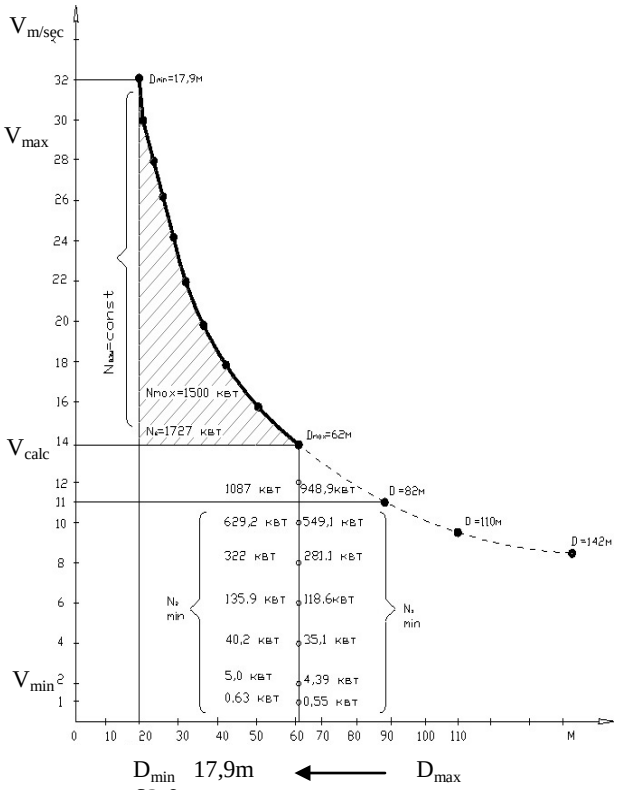

Fig. 9. Necessary combination of the rotor diameter and wind speed for acquisition of the planned power of wind station.

At present negotiations are being held with the famous German firm “ENERCON” for creation of a joint venture or its subsidiary on the territory of Georgia and manufacture along with standard rotors of new designs.

Also negotiations with “SCHMID” firm on production of solar panels are conducted.

Implementation of this project expediently as in Georgia some large enterprises for microelectronics therefore the Georgian scientists have very interesting offers on separate responsible operations of production of plates from a silicium monocrystall, and also by the principles of selection of places for installation of ready solar modules and creation of designs of the corresponding mechanisms which introduction will even more increase efficiency of solar modules functioned.

In particular, installation of these panels, for example over vineyards in in advance calculated parameters, with use of the special mechanisms allowing to change angular position of panels in big range, will give the chance along with obtaining electric energy, to protect plantations from a hail, and also from drying of brushes of grapes and the soil when air temperature constantly keeps some weeks within $35 \div 40^0$ and above. It should be noted that such situation in Georgia very frequent and if it happens before process of cleaning of grapes, it strongly influences crop volume, especially for percent of an exit of grape juice.

Both protection of plantations against a hail, and regulation of process of drying of grapes before harvesting is a burning issue not only for Georgia, but also for all other countries too where there are similar plantations.

Therefore, we intensively work on development of methods of optimization of schemes of installation of solar panels over vineyards.

In fig. 10 one of versions of schemes of installation of such panels is shown.

Fig. 10. Solar panels over vineyards.

At present search of the optimum sizes of panels, schemes of their arrangement and improvement of mechanisms for regulation of their angular situation in wide range for the different period of time is conducted. Also different options of mechanization and automation of these processes are developed.

On the basis of consultations with skilled peasants it is established that use of such schemes of installation will significantly increase the volume and quality of a crop that finally will give notable economic effect.

The presented idea contains also scientific novelty that together with the German experts is already made out and in the near future European Patent will be issued.

Now the consent of our partners for gratuitous transfer about 200m2 of solar panels for the purpose of the organization in Georgia of a skilled site where prototypes of solar panels will be established is reached and all necessary researches are conducted.

There is one very actual problem on which long time the leading scientists of many known scientific centers of the whole world work, however, unfortunately the effective solution of this problem till today doesn't exist. The question concerns a method of the accumulation received solar and wind energy for which decision some hundreds of millions of US dollars are annually spent.

We have in our opinion the interesting offer for the solution of this problem in those countries where there are hydroelectric power stations with average and with big capacities, i.e. where there are already constructed high dams and reservoirs.

It is known that all such power plants have big deficiency of water and that volume which, is gained generally in the spring, then gradually, the whole year according to the special schedule is very economically spent.

The essence of our offer is that it is possible to mount the greatest possible number of wind stations and solar panels round a reservoir. When there is an order for electric energy they will work for its development and when orders are not present, to work for water pumping back from the lower reservoir in its top part. It will give the chance that all power sources worked constantly for profit, day and night, daily and all the year round.

In fig. 11 the approximate scheme of configuration of such constructions where the mounted one small group of wind-driven generators and solar modules is visible is shown. It is also visible that round a reservoir it is possible to place still such some groups.

Consultations with leading experts of power show that after creation of such skilled object and improvement of its separate knots and system of their management it will be wide, successful and effective to be used in many countries of the world.

Fig. 11. Approximate option of composition of aggregates and system of their management for accumulation of the received wind and solar energy.

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