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Autonomous Power Supply System for Lighting Equipment

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Abstract: This study examines the state and the prospects for the use of non-traditional and renewable energy sources and their application within non-industrial scale. The description of autonomous power supply developed system for lighting equipment and its operation principle are described. The obtained results of the conducted study are presented.

Key words: Energy saving, ventilation, energy, development, generator, speed, air

INTRODUCTION

In recent past, diesel generators were used mainly as an alternative power supply for various types of facilities and the needs of power supply system. The alternative was represented by gasoline and gas generators but they were used much less often due to the fact that gasoline is much more expensive than diesel fuel and a gas main is needed for gas generators. At present, diesel generators are not used as alternative sources of electricity but as the backup sources of electricity and their use is gradually reduced.

The development of science and technology made it possible to use such sources as solar panels, wind generators, biogas plants, etc., as the alternative sources of electricity (Cellura *et al*., 2013; Mattes *et al*., 2015; Markard *et al*., 2012).

The use of alternative sources of electricity provides full autonomy for the lighting staircase and elevator units, basements and attics, the use of generated energy for the needs of surveillance and fire protection systems, etc.

The advantages of alternative sources of electricity are their environmental frequency and the independence from traditional energy. The restrictions are represented by their relatively high cost of equipment that allows you to convert solar radiation, wind power, etc. in electricity (Blechinger *et al*., 2016).

Nowadays with the current level of scientific and technological progress, the existing energy consumption needs can only be met by the use of such energy resources as oil, natural gas, coal as well as nuclear energy, hydropower, etc. Based on numerous scientific studies, organic fuels can only partially cover the demands of the world energy in the near future. The remaining needs are expected to be met through alternative energy sources (renewable and non-renewable ones). Non-renewable energy sources mean the use of natural fuel reserves from which a person can produce energy. The example of these sources is nuclear fuel, natural gas, oil, etc. Renewables are the flows of energy constantly existing or periodically occurring energy flows in the environment. UN General Assembly Resolution 33/148 explains what is meant by non-traditional and renewable sources of energy: tidal, geothermal, wind, solar one, etc. In recent years, you can see that much attention is paid to the energy crisis in the media. Many scientists argue that it is enough to increase the amount of energy by the building of various power stations. But as it was written before, the reserves of organic fuel are limited. Due to these circumstances, many researchers are looking for new sources of energy which could preserve and replace organic resources and also, improve the ecology of the planet in the future on energy saving and on energy efficiency increase and on amendment introduction to certain legislative acts of Russian Federation (Paska, 2013; Pang *et al*., 2014).

One of the most promising sources for electricity generation within a non-industrial scale is the energy of air flow movement. There is a large number of ways to convert the energy of an air flow into electricity (wind generators of various designs). There are also the technologies for electricity generation, based on the movement of air due to its heating. As a small amount of energy is required to illuminate the staircase-elevator units, basement and attic rooms, it seems possible to transform these lighting equipment in order to receive power from alternative sources of electrical energy which in its turn will contribute to the energy problem solution (Beccali *et al*., 2015; Jin *et al*., 2017). The research proposed the power supply unit which can be used as an

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alternative source of electricity at housing and utility facilities in the lighting system of entrance staircases, basements and attics in a low-rise and a multi-storey building (Wakui *et al*., 2016).

The unit of an autonomous power supply consists of the following modules: an alternative power source module and a power storage unit. The module of an alternative power source includes aero, hydro and solar generators. An aerogenerator consists of a housing with a generator in it which is fixed to a ventilation shaft outlet. An exchangeable turbo-deflector is attached to the upper part of the body which is attached to the aerogenerator by means of a shaft and connected to the power storage module. The roof of the solar side of the building has a solar photoconductive panel which is connected to the power storage module by the cable. Hydraulic generators are installed in the basement at the inputs of hot and cold water supply systems which are also connected to the power storage module. The latter also has a power connection and contains a battery, a charge control device and a voltage converter (Jin *et al*., 2017).

The unit of an alternative power source comprises the housing 2 with the generator 3 located therein which is attached to the outlet of the ventilation shaft 1. A replaceable turbo-deflector 6 is attached to the upper part of the housing 2 which is fixed to the generator 3 by the shaft which is connected by an electric cable to the power accumulation system 8. The air guide element 4 is installed inside the housing. The heated room contains the power accumulation system 8. The roof of the solar side of the building has the solar photoconductive panel 7 installed by the means of the fastening system. The panel 7 is connected to the power accumulation system 8 by the electric cable. The hydroelectric generators 9 are installed at the entrance of the hot and cold water supply systems which are also connected by the electric cable to the power accumulation system 8 in the basement. The power accumulation system 8 is connected to the 220 V power.

MATERIALS AND METHODS

The obtained results allowed to draw the following conclusions: the airflow velocity in the natural ventilation shaft increases with the ambient air temperature decrease and on the condition that the temperature inside a heated object and the temperature outside have a difference interval of 10°C at least. It was also found that the airflow velocity is uneven in different parts of the natural ventilation shaft outlet. A portable aerotube with the ability to regulate the speed of the air flow from 0.5-3 m/sec was designed for a detailed study.

RESULTS AND DISCUSSION

Connected to the power storage module by the cable. Hydraulic generators are installed in the basement at the inputs of hot and cold water supply systems which are also connected to the power storage module. The latter also has a power connection and contains a battery, a charge control device and a voltage converter. Network and contains the battery 10, the charge control device 11 of the battery 10 and the voltage converter 12. The operation of the stand-alone power supply unit is performed in the following way. The system converts the energy of the ascending airflow of the building ventilation, the energy coming from the hydraulic generators and the energy of the solar photoconductive panel 7 into electrical energy.

In this study, we discuss the results of the aerogenerator design study. The electricity is generated by the force of an airflow, the building ventilation, acting by the air of the guide element 4 on the shaft with the blades 5 of the generator 3 which generates the constant electric current of 12 V. The electric current is supplied to the power accumulation system 8.

The researcher carried out studies concerning the speed of air flow in natural ventilation shaft of the multistory apartment building during the heating season. The determination of air flow speed in the shafts of natural ventilation of the multistory apartment building was carried out by a vane anemometer (Fig. 1).

Since, during the research of ventilation flows they revealed that the speed of the air flow is uneven in different parts of the natural ventilation shaft output channel, an experimental 3D Model of the nozzle on the outlet part of the natural ventilation shaft was developed to obtain a uniform airflow at the outlet from the ventilation duct. The purpose of the nozzle installation is a uniform provision of air flow to the wind wheel of the unit. The design of the nozzle is shown on Fig. 2. The effect of the installed nozzle on the outlet part of the ventilation duct was studied which showed that the airflow velocity in the natural ventilation shaft decreased by 0.2 m/sec before the installation and with the installation of the special nozzle. In order to compensate for the decrease of a natural ventilation draft draught, the deflectors of natural ventilation systems are used. They studied the effect of exchangeable deflectors on the change of airflow velocity in natural ventilation shaft of the building. The best results were obtained with the active venting deflectors. The turbine of an active deflector creates a partial vacuum in a channel. Thus, the airflow velocity in a natural ventilation shaft is strengthened and does not reduce draught during

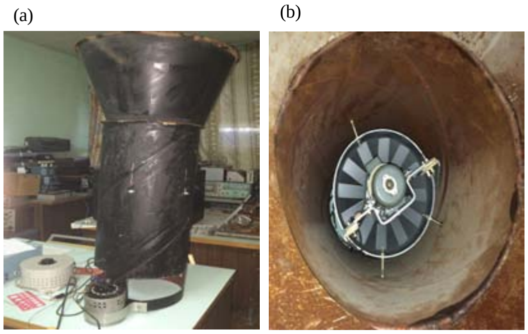

Fig. 1: A portable aerotube with the ability to regulate an air flow speed

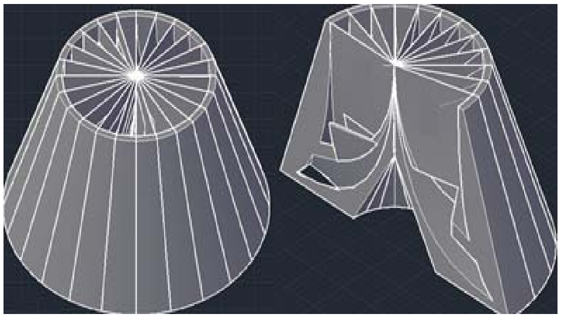

Fig. 2: Design of the nozzle for uniform distribution of air flow at the outlet of the ventilation shaft

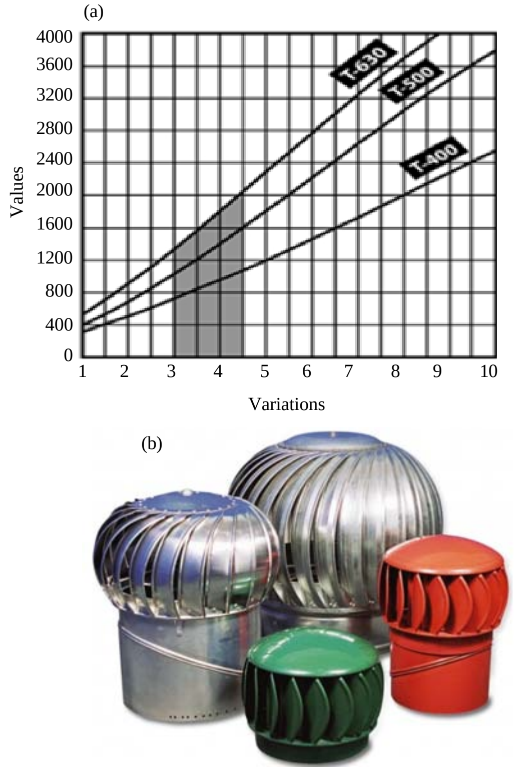

Fig. 3: The diagram of draught variation in the natural ventilation shaft of MSB with the following active deflector diameters: 400-630 mm

installation. Figure 3 demonstrates the graph of draught variation in a natural ventilation shaft of a multi-storeyed building equipped with an active deflector depending on the air flow speed and the appearance of the active deflectors.

The diagrams of draught variation in the ventilation duct of natural ventilation show that when you install a nozzle under an active deflector, the decrease of airflow speed is compensated by an active deflector. Figure 4 shows the model of the wind wheel which is mounted on the generator shaft located inside the nozzle which is installed in the natural ventilation shaft. Figure 5 demonstrates the wind wheel which is attached to the generator shaft.

The researcher carried out the studies of aerodynamic characteristics for various kinds of wind-driven wheels. Three variants were chosen from a number of alternative designs which are presented on Fig. 9-11. Figure 6 shows the design of the wind wheel with 17 blades.

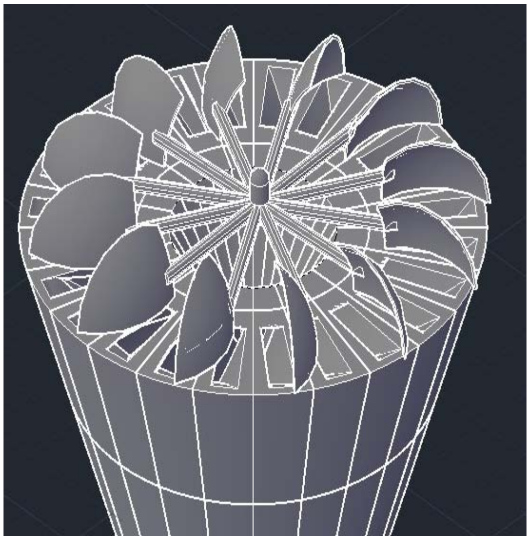

Fig. 4: Wind wheel model

During the performed studies it was revealed that the wind-wheel shown on Fig. 8 has the best aerodynamic characteristics. It allowed to obtain a higher efficiency as compared to others. Figure 9 and 10 show the unit with this wind wheel. During the research with the use of this slow-moving generator, the following values were obtained at the air speed of 2.8 m/sec. The speed of the wind generator rotation makes 55 rpm, the output power is 1 W.

Fig. 5: Wind wheel on the generator shaft

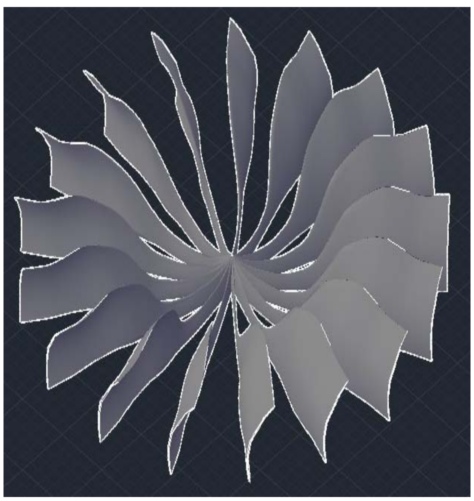

Fig. 6: Wind wheel with 17 blades

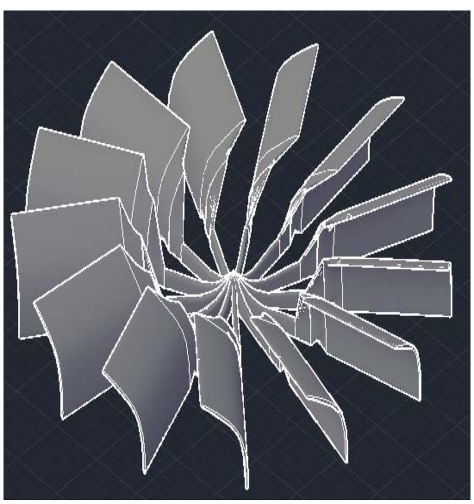

Fig. 7: The wind wheel with 13 blades

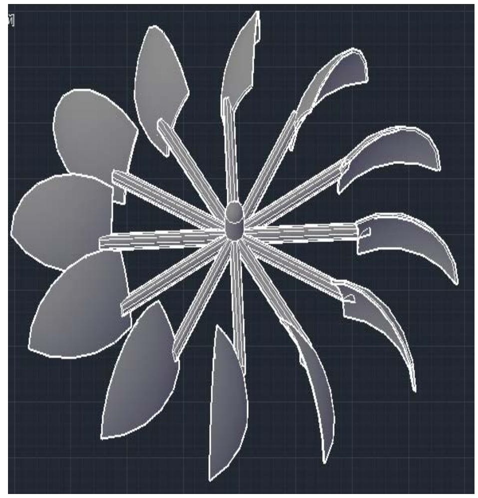

Fig. 8: The wind wheel with 12 blades

Fig. 9: The wind wheel with 13 blades

Fig. 10: The unit with the wind wheel of 13 blades

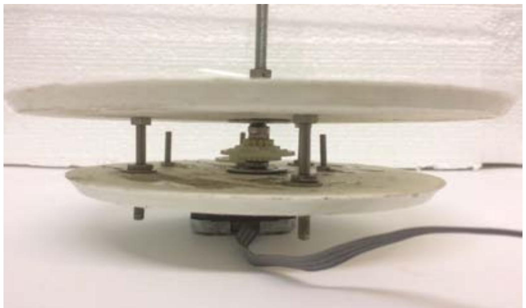

Fig. 11: The generator with the reducer

CONCLUSION

The performed the review of modern methods concerning the obtaining of alternative electric power for the illumination of staircase-lift units, basements and attics of multi-storey apartment buildings. The method for alternative electricity obtaining was proposed to light staircase-elevator units, basements and attics of multi-storey apartment buildings.

The studies of airflow velocity in natural ventilation shafts of a multistory apartment building in winter conditions were carried out, the 3D model was developed to obtain a uniform air flow at the ventilation shaft output. The studies of various types of wind wheels were carried out and an optimal design was chosen. They studied the effect of exchangeable deflectors on the change of airflow velocity in natural ventilation shafts of a building. The most promising removable deflectors for application were determined.

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