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doi:10.15199/48.2023.10.38

Study of application characteristics of cylindrical structure induction levitator in general and vertical axis wind turbines

***Abstract**. Human tries to develop a system that works long years of low power and it is developing the Maglev system Windmill. Maglev has a lot of advantages Motion on a Maglev Train (Magnetic Levitation) is fast moving also required low power. If this system a The windmill then loses more power due to this size of the blade get and run low wind energy. It is possible to use it as a decorative element. Here there are two magnets of the same polarity against each other. Bushing is used to reduce friction. A plastic fan blade is used to convert the air pressure mechanical energy. The whole structure is installed on the base plate. It uses 4 round magnets as its power 2 coils are used to generate electricity. 12 volts here a rechargeable battery is used to store electrical energy and secure the circuit.*

***Streszczenie.** Człowiek stara się opracować system, który działa przez długie lata na niskim poborze mocy i rozwija system Maglev Windmill. Maglev ma wiele zalet Ruch pociągu Maglev (lewitacja magnetyczna) jest szybki i wymaga niewielkiej mocy. Jeśli ten system a Wiatrak traci więcej mocy ze względu na ten rozmiar łopaty, uzyskuje i uruchamia niską energię wiatru. Istnieje możliwość zastosowania go jako elementu dekoracyjnego. Tutaj są dwa magnesy o tej samej biegunowości względem siebie. Tuleja służy do zmniejszenia tarcia. Plastikowa łopatka wentylatora służy do przekształcania energii mechanicznej ciśnienia powietrza. Całość konstrukcji montowana jest na płycie podstawy. Wykorzystuje 4 okrągłe magnesy, ponieważ jego cewki zasilające 2 są wykorzystywane do generowania energii elektrycznej. Akumulator o napięciu 12 woltów służy do magazynowania energii elektrycznej i zabezpieczania obwodu. (**Badanie właściwości aplikacyjnych lewitatora indukcyjnego o konstrukcji cylindrycznej w turbinach wiatrowych o ogólnej i pionowej osi obrotu**)*

Keywords: turbine, levitation height, output voltage, induction levitator
Słowa kluczowe: turbina, wysokość lewitacji, napięcie wyjściowe, lewitator indukcyjny

1.Introduction

A turbine tube passes through the middle of the cylinder of the induction levitator and the rotor of the generator. The parts of the pipe passing through the cylinder and the rotor are double-layered. The outer layer of the tube is made of ferromagnet, and the inner layer is made of composite material, which has light weight and great strength. For this reason, the magnetic resistance in the paths of the magnetic currents created by the alternating current loop and permanent magnets is much less, the output voltages of the loops placed on the poles of the stator and the lifting electromagnetic force created by the levitator are large, and the radial stability is strong. Figures 1 and 2 show the principle scheme of the Maglev wind generator [1, 2].

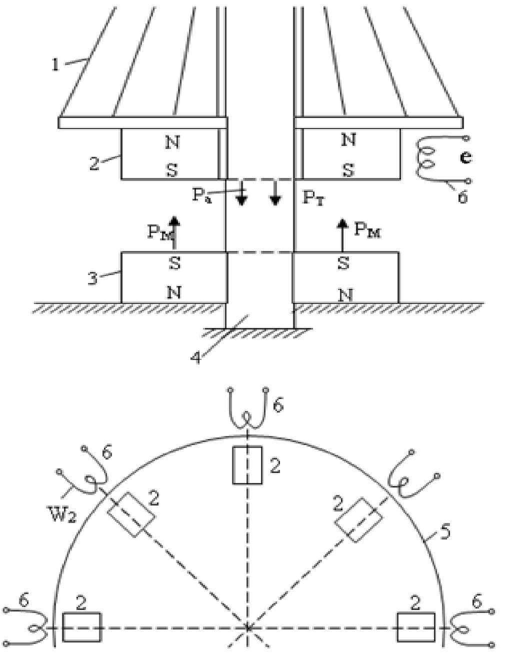

Fig. 1 The principle scheme of the maglev wind generator

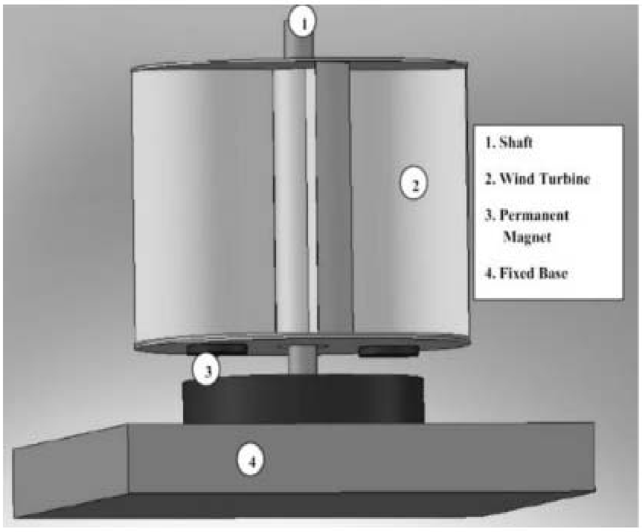

Fig. 2. Maglev wind generator

The wind turbine 1 is connected to a levitating permanent magnet 2 and rotates together with it. The other magnet is stationary and creates a repulsive force. This magnet is connected to the stationary axis 4 of the generator. The output voltage is received through multiple permanent magnets and connected to a special circular plate and levitated. Coils 6 are placed on the edges of the board. The electromotive forces induced in the windings accumulate and form a total ehq (or voltage U) at the output of the generator. That voltage is converted into an alternating voltage by means of an inverter and supplied to the network [3, 4, 5].

The magnetic force P_M generated by the stationary magnet 3 should compensate the gravity force P_g of the levitated magnet and the gravity force of the turbine P_T However, in this case, the condition of levitation $P_M = P_g + P_x$ can be fulfilled. In addition, the levitated magnet must be at a certain height (levitation height) from the stationary magnet. When the distance is too small, the levitating magnet is more likely to touch the stationary magnet. Permanent magnets are made of Neodymium Iron Boron type Nd-Fe-B special materials that can create strong magnetic induction. Such a magnet is more resistant to demagnetization and can generate a strong magnetic force P_M.

Shifting the center of gravity closer to the core in a magnetically levitated VWG increases the stability and productivity of the generator. For this reason, the magnets and coils are placed below the turbine. Despite the above positive features, a number of shortcomings of that generator are known: the output voltage is very low (8.5 V), the frequency is 23-63 Hs, the current is 16.8 A, the turbine rotation speed is 320 revolutions/min. The specified parameters refer to the model of the experimental generator exhibited at the exhibition in China.

Disadvantages of such generators are:

• Since the radial stability of the levitation system made of permanent magnets is weak, the levitation of the wind turbine is disturbed and mechanical friction occurs;
• Since the magnetic circuit in the structure is too open, the output voltage is not at the required level, as the magnetic resistance in the paths of the magnetic currents is large;
• The construction of the levitation system does not allow adjusting the levitation height of the turbine;
• A large number of magnets increases the magnetic forces, but reduces the stability of the system.

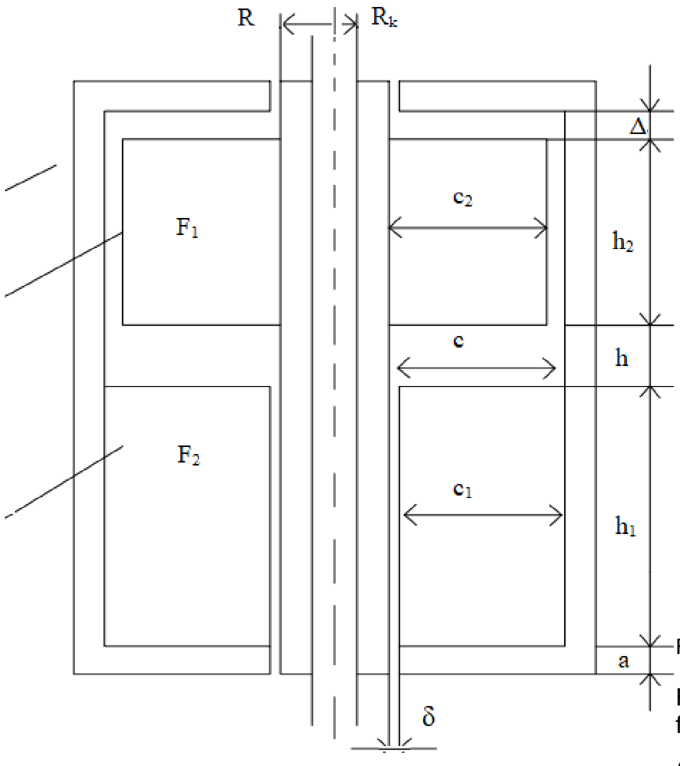

Fig. 3 The principle scheme of the cylindrical induction levitator

2. Experiment and analysis

Our proposed induction levitator with cylindrical structure (ILCC) consists of cylindrical core CC, alternating current induction loop EW, levitation element EL, rotating tube RT together with wind turbine (Figure 3). In order to obtain optimal operating characteristics of the induction levitator with a cylindrical structure (ILCC), it is first necessary to create a homogeneous magnetic field in its working air gap. This condition can be fulfilled when the air gap c between the rotating tube RT and the cylindrical core CC is uniform and the electrotechnical steel parts of the levitator are not saturated [6, 7, 8]. Therefore, ILCC can be presented in the form of a symmetrical electromagnetic energy converter construction. The rotating tube RT is in turn composed of two coaxial tubes. The pipes are mechanically connected to each other and there are no air gaps between them. The inner tube is made of composite material with low specific gravity and high mechanical strength, and the outer tube is made of structural electrotechnical steel. Since EL is mechanically connected to the outer tube, it rotates with it and consists of a short closed loop. In order to reduce the gravity force P_g, EL is assembled from wires made of aluminum or aluminum mixed alloys with low specific gravity. To reduce copper losses, EW is collected from copper wires and U_L is connected to a constant amplitude alternating voltage source. The electric energy supplied to the loop is converted into the energy of the magnetic field Wm, creating a lifting electromagnetic force F_e, which acts on EL. The electromagnetic force F_e in turn raises RT to a certain height h [9, 10, 11]. This height is called levitation height. In this case, the electromagnetic force F_e compensates the general gravity force $\sum P$ and fulfills the condition of levitation $F_e = \sum P$.

To determine the output voltage, it is necessary to analyze the magnetic circuit of the stator-rotor assembly (Fig. 4), and then it is possible to set up the replacement circuit and determine the main parameters [12, 13].

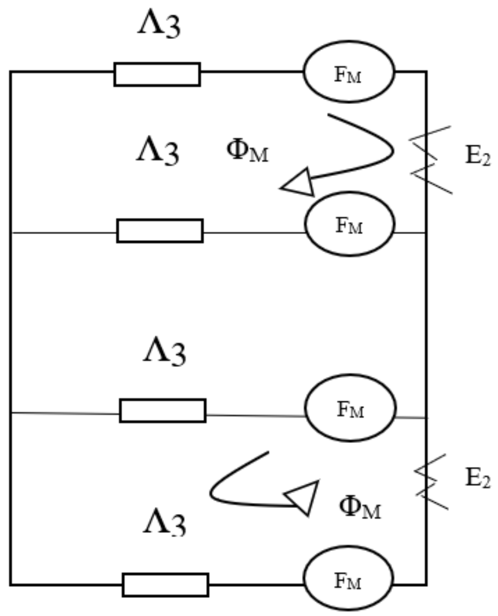

Fig. 4 Substitution scheme

From the replacement scheme of the magnetic circuit of the four-pole stator-rotor unit magnetic flux is defined as:

(1) $$\Phi_M = F_M \cdot \Delta_M = \mu_0 \frac{b}{c}(a-x)F_M$$

Here Δ_M - the magnetic permeability of the air gap between the poles; F_M – magnetic force of permanent magnet; $\mu_0 = 4\pi \cdot 10^{-7}$ HN/m; a and b – width and thickness of poles; c air gap thickness; X- the displacement of the stator pole relative to the rotor pole.

Electromotive force induced in rotor windings:

(2) $$E_2 = 2W_2 \frac{d\Phi}{dt} = 2\mu_0 \frac{b}{c} F_M W_2 V$$

Here, V is the linear speed of the rotor.

Output voltage:

(3) $$U_2 = 2E_2 = 4\mu_0 \frac{b}{c} F_M W_2 V$$

From the last statement, the ways to increase the output voltage are obvious. First of all, it is necessary to increase the number of windings W_2 and the permanent magnetic force on the pole. Note that it is possible to reduce the gravity of the rotor by placing permanent magnets in the stator poles and ferromagnetic poles in the rotor. Another way to increase the output voltage is to make the stator poles with pole caps, so the magnetic permeability Δ_M is increased [14, 15, 16].

To determine the main characteristics, it is necessary to calculate the dependencies $I_1(h), F_1(h)\ v \cdot F_e(h)$.

We perform these calculations for $h_2 = 10\cdot 10^{-3}\ m$, $h_{12} = 25\cdot 10^{-3}\ m$, $h = 10\cdot 10^{-3}\ m$, $h = 20\cdot 10^{-3}\ m$, $h = 30\cdot 10^{-3}\ m$ and $h = 70\cdot 10^{-3}\ m$.

1. When the levitation height is h = 0:

(4) $$I_1 = \left(\frac{K_u U_1}{\omega W_1^2 \lambda}\right)\frac{1}{(h_{12}+h)} = \frac{158.421\cdot 10^{-3}}{(25+0)\cdot 10^{-3}} = 6.336\,A$$

(5) $$F_1 = I_1 W_1 = 6.336\cdot 1457 = 9232.827\,A$$

(6) $$F_e = 0.5\lambda F_1^2 = 10^{-6}\cdot F_1^2 = 10^{-6}\cdot(9232.827)^2 = 85.245\,N$$

(7) $$\left(\frac{K_u U_1}{\omega W_1^2 \lambda}\right) = \frac{0.96\cdot 220}{314\cdot(1457)^2\cdot 2\cdot 10^{-6}} = 158.421\cdot 10^{-3}$$

(8) $$0.5\lambda = 0.5\cdot 2\cdot 10^{-6} = 10^{-6}\,HN/m$$

2. When the levitation height $h = 10\cdot 10^{-3} m$:

(9) $$I_1 = \frac{158.421\cdot 10^{-3}}{(25+10)\cdot 10^{-3}} = 4.526\,A$$

(10) $$F_1 = I_1 W_1 = 4.526\cdot 1457 = 6594.876\,A$$

(11) $$F_e = 10^{-6}\cdot F_1^2 = 10^{-6}\cdot(6594.876)^2 = 43.492\,N$$

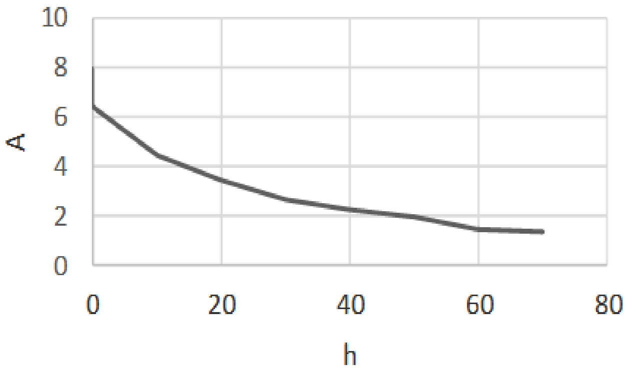

Fig. 5 Dependence of current on levitation height

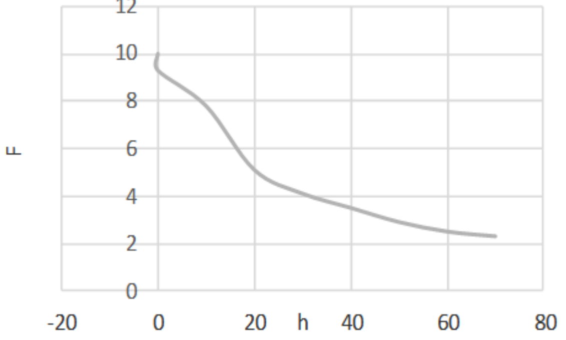

Fig. 6 Dependence of lift force on levitation height

Table 1. Values of I_1(h), F_1(h), and F_e(h) dependencies

h_x ,10^{-3}	0	10	20	30	70
I_1, A	6.336	4.526	3.52	2.88	1.67
F_1 x 10^{-3} A	9.232	6.594	5.129	4.196	2.37
F_e , N	85.245	43.492	26.31	17.612	5.62

3. Conclusion

In regions where the wind speed is less than 7 m/s, horizontal wind generators cannot work efficiently, as the frictional resistance is quite large. High frictional resistances also cause them to generate loud noises at high wind speeds. The absence of mechanical contacts, friction and other defects in maglev or magnetically levitated vertical axis wind generators (VWG) has made it possible for these generators to work effectively at low wind speeds. Increasing the efficiency of wind generators has led to a gradual reduction in the need for expensive traditional generators that cause environmental pollution and more wind energy production. Therefore, improvement of VWG with magnetic and induction levitation is relevant. From the analysis of the articles devoted to magnetic levitation vertical axis wind generators, it was found that the radial resistance and output voltage of the levitation systems of those generators are not at the required level. The newly designed induction levitator allows you to adjust the levitation height and is easily connected to the axis of the generator.

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