Design and simulation of a conical rotor axial -radial flux permanent magnet generator of power 1.1kW for micro wind turbines

Diseño y simulación de un generador de imán permanente de rotor radial cónico de flujo axial de potencia 1.1kW para micro aerogeneradores

Author:

Shiva Nourifard[*,1]
Seyyed Mahmoud Hasheminejad[2]
Majid Jami[3]

SCIENTIFIC RESEARCH

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ABSTRACT

In this study, design, design calculations and simulation of a permanent magnet generator, which includes two sections of radial and axial flux, are discussed. The output power from the generator is 1.1 kilowatt. In the design of the generator, a cone-shaped structure with a 90-degree cone angle of 45 degrees from the sides is used for the rotor. In order to compare the various structures of the synchronous generator, and given that today, permanent magnet generators have been considered with regard to features such as lower weight, higher yields and higher power density than other conventional generators. A finite element analysis of the generator developed in Maxwell software. In the radial flux section, the generator includes a conical rotor and a cone stator. The windings on the external stator are trapezoidal and are located in stator racks. The finite element analysis of the generator confirms that permanent magnet magnets designed on the inner rotor have provided a magnetic flux equal to 1.2 Tesla in the air gap between the generator and the winding of the stator. The rotor magnetic field analysis, rotor magnetic field strength, magnetic field intensity, and magnetic field density at a speed of 500 rpm for cone structure have been performed. In the axial flux section, the generator consists of two rotors and a grooved stator, which is obtained by simulating a 1.1 kW power with a sinusoidal three-phase voltage. Two sections of radial flux with a cone-shaped rotor and axial flux side by side make up the generator.

[*] Corresponding author: Shiva Nourifard
[1] Student at Material and Energy research center, Karaj, Iran. Email: nouriafardshiva@gmail.com
[2] Professor at Material and Energy research center, Karaj, Iran
[3] Professor at Material and Energy research center, Karaj, Iran

INTRODUCTION

Increasing demand for electrical energy in recent years has led to a decline in the use of conventional energy sources. This will create an opportunity to use unconventional and renewable energy sources such as wind energy, solar energy, and energy from waves of the sea, etc. as sources of electrical energy. As today, with the ever-increasing demand for power and simultaneous reduction of fossil fuels, as well as the concern for environmental pollution caused by them, experts have sought to find ways to produce electricity from renewable energy sources [1, 2].

Wind energy is cheaper and more reliable than other sources of new energy and is accessible in almost all countries. The contribution of wind energy to power generation has grown faster with technological advances in wind power technology in recent decades. The total installed capacity of wind energy around the world will be around 540 Gigawatts by the end of 2017, and in 2018, wind energy will provide 5% of global energy demand [3, 4]. The total installed capacity of small wind turbines in the world at the end of 2014 was 830 MW, and the total installed units were 45000 units. The average wind turbine capacity in China is 0.5 kilowatts, in the United States it is 1.4 kilowatts and in the UK it is 3.6 kilowatts. Small wind turbines are used in defense, rural electricity, water pumping for agriculture and telecommunication systems to replace diesel generators [4].

According to the Atlas of Wind, according to the information received from 60 stations in different regions of Iran, the nominal capacity of sites is about 60,000 megawatts. Based on the projections, the country's economically recoverable amount of energy is estimated at 18,000 megawatts, which confirms the country's significant potential for the construction of wind power plants as well as the economic viability of investments in the wind energy industry. In the project of wind potentiometric in Iran, the German company Lamire also co-operated as consultant, and according to the company's studies, the wind potential of the country can be estimated at around 100,000 MW [5].

In a fixed speed wind turbine, the generator is directly connected to the network, and in the variable speed type, the generator is controlled by the use of electronic equipment. There are several reasons for using variable speed wind turbines, among which one can reduce the stresses of mechanical structures, the impossibility of using fixed wind speed turbines at high power, reducing hearing loss, increasing annual energy production , Reducing the complexity of the blade angle control system and the ability to control the actual and reactive power [6, 9].

TYPES OF WIND TURBINE GENERATORS

A) Induction generator squirrel cage
B) Simulated rotor induction generator
C) Double induction induction generator
D) Synchronous generator with classical stimulation
E) Synchronous generator with permanent magnetism
F) Switch-off switch generator
G) Permanent Magnetoclaser switch actuator generator

In 2011, Constantine and his colleague Chen pointed out in two articles [11, 10] published for the first time in the conic structure for a wind generator synchronous generator. The title of the first paper is wind turbine winding with a cone-shaped rotor [10]. The second paper, which was written in the next article, is the linearization of the synchronous wind generator with a cone-shaped rotor [11]. In this scheme, a method is proposed to control the power of a synchronous generator that is rotated by a powerful variable speed wind turbine. The rotor of the generator has a conical shape and incorporates changes in the air gap during the lateral movement of the rotor subassembly using a soft gear. In practice, even at high speeds, the generator does not cut off the electrical grid due to the auto-boost of air velocity that limits the generator's power.

However, there is a mechanical limitation of the engine speed at high wind speed, in which the electrical resistance of the system is at risk. The cone synchronous generator has the advantage that it automatically limits it regardless of wind speed and requires no resistance limitations. By lowering the excitation current, the generator current is limited to its nominal value. The construction of the cone rotor results in some complications from the process of manufacturing and assembling the generator's magnetic core, which allows the rotor to travel longitudinally during operation. These problems have been solved and now rotor cone motors are used for electrical braking [10,11].

Wind systems include simulated rotor induction generators, squirrel cages or synchronous generators with permanent magnets or electromagnetic stimulation. The speed of these generators varies greatly, because the speed changes are very high. Turbines that move electric generators, even at high wind speeds, are calm. Currently, most wind systems have a mechanical speed coefficient between wind turbines and electric generators, so that the generator speed reaches high values and reduces the generator's scale. Wind system experts focus their attention on producing wind power systems without a mechanical speed factor, so that a low speed electric generator has the same speed as an air turbine. In this case, the number of pair of generator poles increases and implicitly increases its measurement. The removal of the speed factor is due to the consequences of it, such as heavy maintenance, comprehensive construction, high noise and high prices.

The price increase and the size of the electric generator, which is directly coupled to the turbine shaft mechanically, does not exceed the price and multiplier values of a high-speed generator. The adjustable speed of the generator makes it possible to get a lot of voltage and power changes at its terminals. At very high wind speeds, this power must be limited by certain actions. At present, at high wind speeds, the generator is cut off from the main power grid and limited to resistance to limit flow and load below its nominal values. This is unpleasant and leads to the complications of reconnecting the generator to the network. A method of limiting the power of the simultaneous generator, increasing the air gap and implicitly reducing the voltage of the induced electromotor (by decreasing the magnetic flux). Increasing the air gap during operation can not be done unless the rotor of the generator and stator are cone shaped. In this way, with the rotor's lateral movement to the stator, the aircraft generator is widely different. The cone rotor synchronous generator has disadvantages, which complicates the production of a stator plate (with ground control punch devices) and the mechanical assembly of the device allows control of the longitudinal control of the rotor movement during operation. At the same time, increasing the air gap leads to a reduction in generator power and, consequently, to offset more powerful than reactive power [10].

At present, motors with cone rotors such as induction motors made by DEMAG [12], with a power of up to 42 kW and a speed of 1500 rpm, are made. The company cut the rotor plate and the stator plate with adjustable values. Also, electric motors, which act as a motor or generator with cone bearings and magnetic suspension, are mainly used by NASA [13]. The three-phase synchronous generator model has electromagnetic stimulation, four poles and a cone rotor shape. In Figure 1-9, a rotor section of the generator is presented. In Figure 1-10, the dimensions of the cross section of the generator with a cone-shaped rotor are shown. In Figure 1, the magnetic properties of the armature are shown.

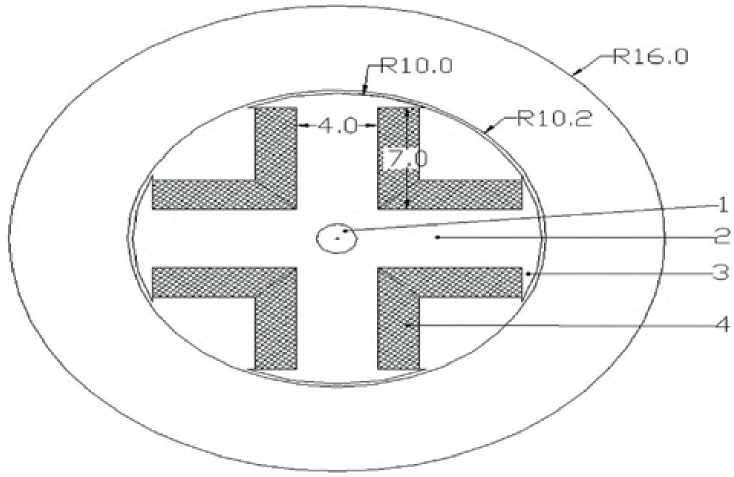

Figure 1. Generator section: 1- Shaft 2- Magnetic rotor core 3- Polar base 4- Wire [10]

In 2018, Wang, Huang and other colleagues presented in two papers [15-14], the permanent magnetoconductor synchronous generator with a direct conical connecting torque for turbo expander, taking into account the axial force constructive equilibrium.

The permanent magneto-sync generator has been used extensively at high speeds in turbo expander to generate energy dissipation. Although for conventional permanent magnetometers based on turbo expander, expensive mechanical balancing devices should be installed on the rotor to limit the high torque power of the turbo-turbine at high speed, which complicates the structure of the system and the high cost of construction Leads. Therefore, in this paper, a permanent magnet synchronous generator with a direct turbulent expansion torque cone rotor has been developed, which can create an axial magnetic force as a balance to counteract the axial force.

In this plan, a permanent magnet synchronous generator with a 1.5-kilowatt-rated cone rotor and a speed of 6000 rpm with a cone angle of 6 degrees is designed. In Figure 2, the geometric cross section of the generator comes with a cone rotor.

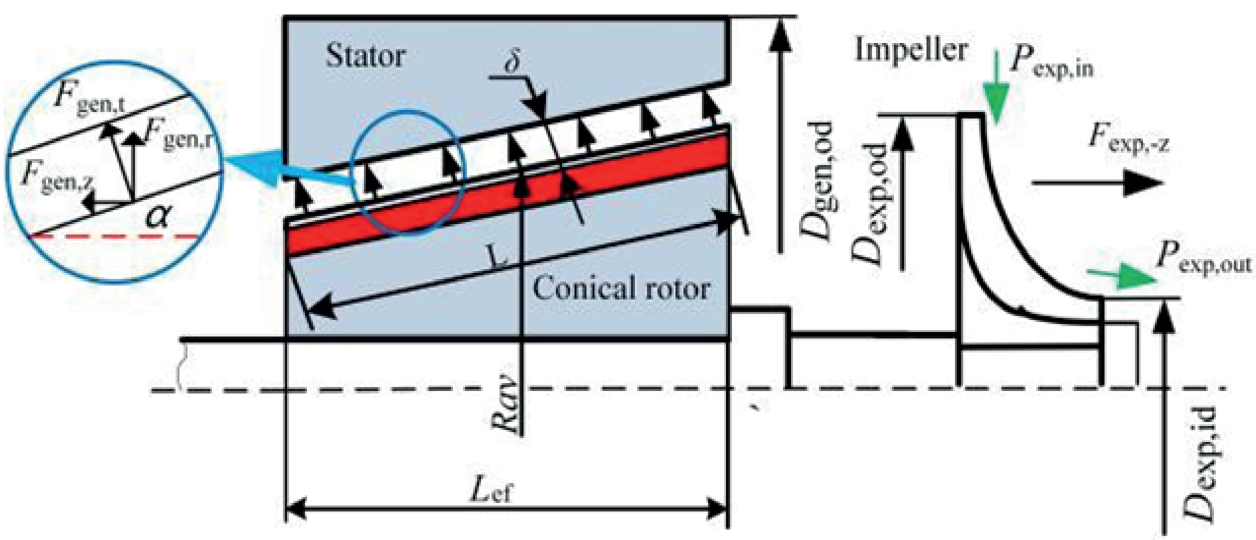

Figure 2. Geometric section of the generator with a cone rotor [14]

Wind energy is one of the most important and most energy-generating energy for electricity generation. The installed capacity of wind turbines is expected to reach 1,500 GW by 2020. Small wind turbines are available for residential use and produce one to ten kilowatts of electricity at optimal wind speeds. The use of a permanent magnet synchronous generator, due to the elimination of the excitation system, will have less weight and mortality.

Instead, due to the use of a synchronous generator, all electrical power must be transmitted through the power electronics to the network, which is possible with the wide development of these types of converters. From the beginning of power generation by generators throughout history, conventional cylindrical structures have been used for radial and disc shaped generators for axial flux generators, and although disc generators were only the first generation of generators developed by Michael Faraday, but The reason for the emergence of radial flux generators and the cost of lowering and maintaining them, disc type generators were not common in recent decades.

The purpose of the present study is to investigate the capability of extracting electrical power from a new geometric structure for a generator, which is a hybrid type of radial-axial flux generator. Investigating the possibility of designing hybrid structures of permanent magnet generator, the advantages of designing unusual geometric structures, challenges in generating design, investigating the idea of lower resistance to turbine overhead turbine with a new geometric structure, promoting cooling and optimal use the space behind the small wind turbine is designed to extract the maximum electric power from the wind.

The three most important structures of permanent magnetism for use in wind turbines are as follows [16].

1. Radial Flux Magnetic Generators (RFPM)
2. Continuous Flux Magnetic Generators (TFPMs)
3. Magnetic Flux Magnetic Generators (AFPM)

PERMANENT MAGNET MATERIALS

The name and some of the properties of the magnetic material are given in Table (1).

Table 1. The name and characteristics of permanent magnetic materials [17]

considerations	Price	H_c [kA/m]	B_r[T]	name of the material
-	+++	950	1.2	NdFeB
Low temperature coefficient	++++	900	1.0	SmCo
Low vortex flow	++	500	0.7	Bonded NdFeB
Low vortex flow	+	300	0.04	Ferrite
Top knee point	+	100	1.02	Alnico

Basically, stable magnetic materials have different types, features and applications. Iron oxide, a relatively inexpensive product, is nowadays widely used. Alnico (aluminum, nickel, cobalt) is another type. Especially stable magnetism is classified according to their energy production. Iron oxides and Alnico have a low energy content. Smco magnets (samarium and cobalt) have more energy than iron oxides and Alnico. Samarium and Cobalt produce larger magnetic fields and are in better conditions in terms of temperature. However, it is more expensive than iron oxides and Alnico.

NdFeB compounds (neodymium, iron, boron) have some advantages, including high energy. However, its temperature stability is lower than Smco and is more expensive. NdFeB was discovered in 1983.

The use of stable magnetic materials is not limited to electric machines. They are used in high voltage systems. Neodymium is a permanent magnet, which, as its name suggests, is made of neodymium, iron and boron alloys. This type of magnets has been able to replace old-fashioned iron in the industry because of its high power.

Unipolar models are also available that are used in specific cases such as hard disks. There are two important components in this permanent magnet. One B and the other H, respectively, representing the magnetic field density and magnetic field intensity. The manufacturers used the two-factor multiplication factor to show the strength and degree of a magnets, and since these two factors have a direct relationship, the product of the multipliers can be a good criterion for the classification of iron Neodymium rabbits. One of the biggest problems with this kind of powerful magnets is their corrosion and fragility, so that if they collide strongly, parts may be turned into powder or smaller pieces [17 - 20].

COMPOSITE AXIAL FLUX AND AXIAL RADIUS

The mechanism of two multi-stage, single-groove grooved models is the only difference in the structure of the stator that is in this type of groove and the coils are distributed sinusoidally. The state of the NS has advantages over the NN mode, including less volume of the machine compared to the NN mode, no need for an iron stator due to the removal of the peripheral flux, the removal of stator core losses, the optimal use of flux, higher power density and ultimately higher yields.

This type of machine is in fact a combination of two radial flux and axial flux models and has been able to take advantage of both models. Of course, this model is presented only theoretically and has not yet been developed in practice. Figure 3 shows a view of the car and, as shown in the picture, this machine is particularly fitted with 3 sets of magnets and 3 sets of stators. A complete self-propelled rotor alone consists of 2 permanent magnets, all of which act as axial fluxes like all models, and the third set of magnets is located above the rotor, and in Interacting with the stator itself, this part performs the simulation of radial flux machines. In other words, all levels of the rotor have magnets, all of which contribute to the production of torque, and because we have two machines in practice, we will see a significant power density in this type of machine.

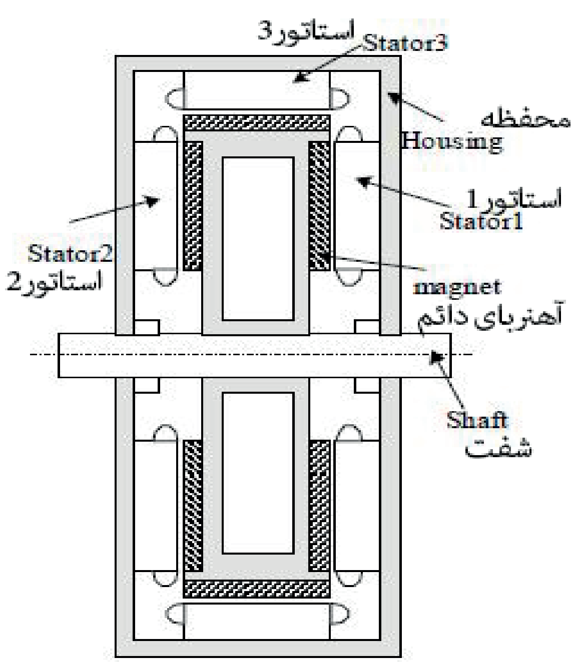

Figure 3. Generator with internal rotor and exterior stator [21]

There is another model in which the rotor of permanent magnets includes a stator. In Figure 4, this model is shown.

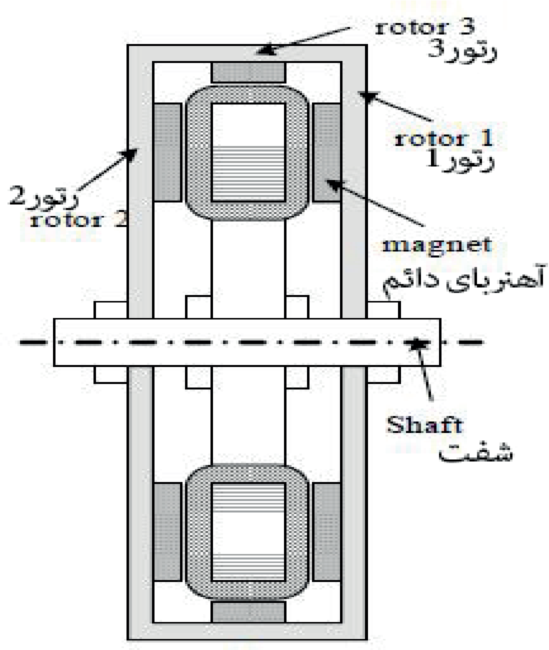

Figure 4. Internal stator and external rotor [21]

In this model all stator surfaces, except its internal surface, are involved in torque production. Both models are also slotted. Perhaps the only weak point of this model is lack of strength [26 - 22].

The first stage of the design involves designing a wind turbine and determining the number of generator poles. The number of small wind turbines is three. Because three-wind turbines are the most common wind turbine-coupled to low power generators. The wind speed can be assumed as a Rayleigh distribution. The function of the probability density distribution of Rayleigh distribution is given by (1) [27].

$$p_{(u)} = \frac{\pi}{2}\frac{u}{\bar{u}^2}e^{\frac{-\pi}{4}\left(\frac{u}{\bar{u}}\right)^2} \quad (1)$$

In relation (1), wind speed and average wind speed is in the wind farm. The input power to the generator obtained from the turbine shaft is calculated from equation (2) [29 - 28].

$$P_{shaft} = \frac{1}{2}\rho_{air}\pi R^2 U^3 C_p \quad (2)$$

In this regard, it is equal to the density of air, which is usually considered to be 1/2 kg / m3. U is the wind speed in m / s, which in the turbine installation area is between 5 and 15 m/s R is equivalent to turbine blade radius and turbine power factor coefficient with an optimum value of 0.25-0.45. The output power of the generator is obtained from equation (3) [30].

$$P_{gen} = \eta_{gen}.P_{shaft} \quad (3)$$

Equal to the efficiency or efficiency of the generator. In this project, the power output or generating capacity of the generator is 1100 Watts. The value of the radius of the turbine blade R, is calculated from equation (4) [30].

$$R = \sqrt{\frac{P_{gen}}{\frac{1}{2}.\rho_{air}.\pi.U^3.C_p.\eta_{gen}}} \quad (4)$$

There is a direct relation between the speed of the generator shaft () in terms of radians per second and, which is the speed of the tip of the turbine blade. The optimum value of is between 5 and 7 [30]. The relation (5) is computed.

$$\lambda = \frac{\omega_r R}{U} \tag{5}$$

In Figure 5, the structure of the permanent magnet generator is presented with a complete step.

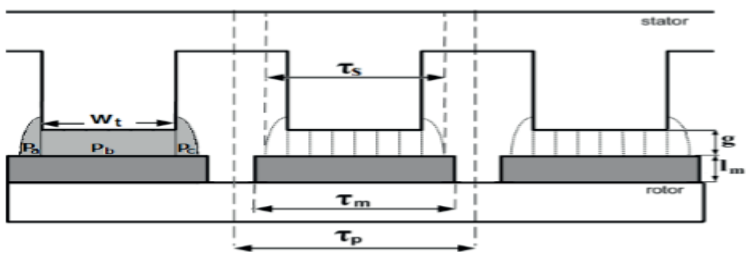

Figure 5. The structure of permanent magnet generator with full step [31]

The first stage of the design involves designing a wind turbine and determining the number of generator poles. The number of small wind turbines is three. Because three-wind turbines are the most common wind turbine-coupled to low power generators. The output power or generating power of the generator is 1100 watts. Three-phase generator is considered. In this design, the speed of the shaft generator is estimated at 500 rpm in design calculations [30]. The output power of the generator is obtained from (3). Generator efficiency is at least ninety percent.

The input power to the generator obtained from the turbine shaft is calculated from equation (2). In this regard, it is equal to the air density, which is 1/2 kg / m3. U is equal to the wind speed in m / s, which in the turbine installation area is between 5 and 15 m Seconds. R is equal to the radius of the turbine blade and the turbine power factor with an optimum value of 0.25-0.45. The wind turbine blade radius is calculated to be 32/87 cm. The wind speed is assumed to be 14 m / s. Is equal to 0.3.

There is a direct relationship between the speed of the generator shaft, in radians per second, and the velocity of the tip of the turbine blade. According to equation (5), the speed ratio of the turbine blade tip is 3,663.

The number of generator poles from equation (6) is equal to 12.

$$\lambda = \frac{\omega_r R}{U} = \frac{52.33 \times 0.8732}{14} = 3.2638 \tag{6}$$

The 12-pole generator is designed. The generator has 6 polar pairs. Table (2) presents the main design parameters and constraints.

Table. 2. Parameters and design constraints

500rpm	n_s ، Machine speed rotation per minute
1.1kW	P_{out} ، Name Capacity
3	Number of phases
Y	Type of connection of the stator
220 Volt	Vph_rms, Machine Output Terminal Phase Voltage
90%	ηmin, Minimum machine efficiency
50 OC	Maximum working environment temprature

To calculate the design of a radial, conical-shaped generator with a 90 degrees angle and 45 degrees from the sides, we first calculate the stator diameter average. In the radial flux generator, the upper and lower stator diameter is 200 mm, with an average of 200 mm. So, in a cone with a 45 degrees angle and a stomatum length of 100 mm, with a high-top diameter of 100 mm and a lower diameter of 300 mm, we get an average diameter of 200 mm. Other calculations of the cone generator are considered, such as the radial flow machine. The ANSYS Maxwell V16.0.2 software is software for the advanced analysis of magnetic fields of electromagnetic objects. This software is used in the design and simulation of motors, transformers, coils, and all the devices that work magnetically. This software is built according to the standards of the day and with the latest technology.

The main idea in the finite element method is to replace the complex problem with a simpler problem. In this ease, it is usually enough to choose and find an approximate solution in the absence of 100% complete relationships and solutions. In the absence of a precise and complete solution using the finite element method with more computational energy, the approximate solution can be approached as closely as possible to the exact solution. The finite element method is used to solve the approximate differential equations governing continuous environments. In Figure 6, the generator polarization is shown.

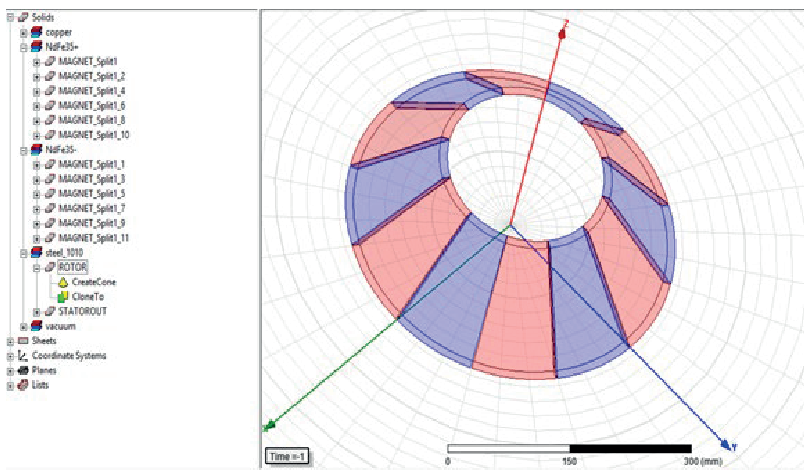

Figure 6. Generator polarization

In Figure 7, a coil positioned in the stator groove is shown.

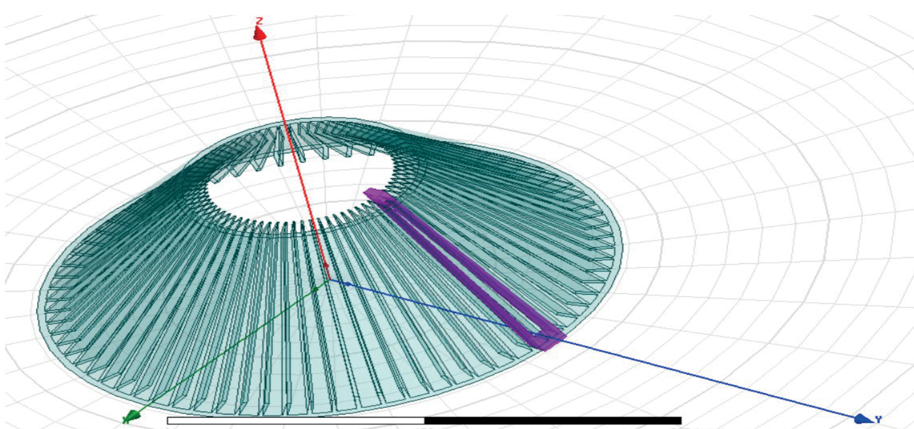

Figure 7. A coil located in the stator groove

After designing the generator coils, the coils are phased out and are in three fuzzy groups. Then, the coils are terminated to determine the cross-sectional current flow. In Figure 8, the terminal is a generator coil.

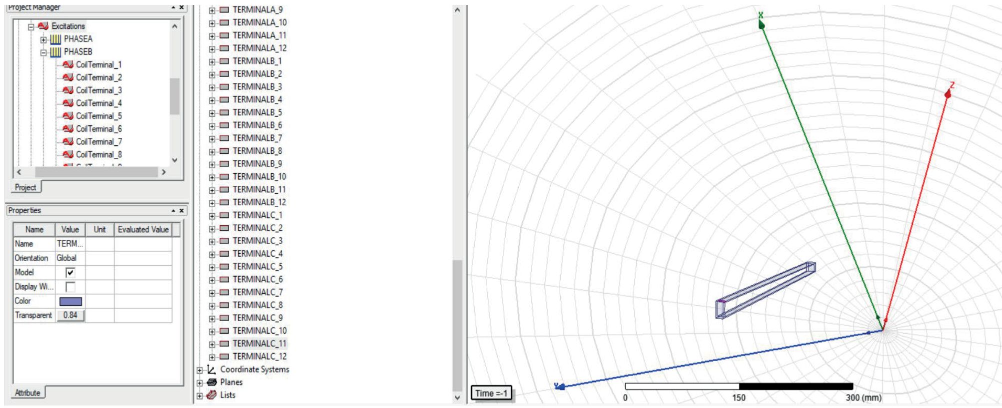

Figure 8. Terminal of a generator coil

In Figure 9, a generator with a cone-shaped rotor designed in Maxwell software and its analytic section is presented.

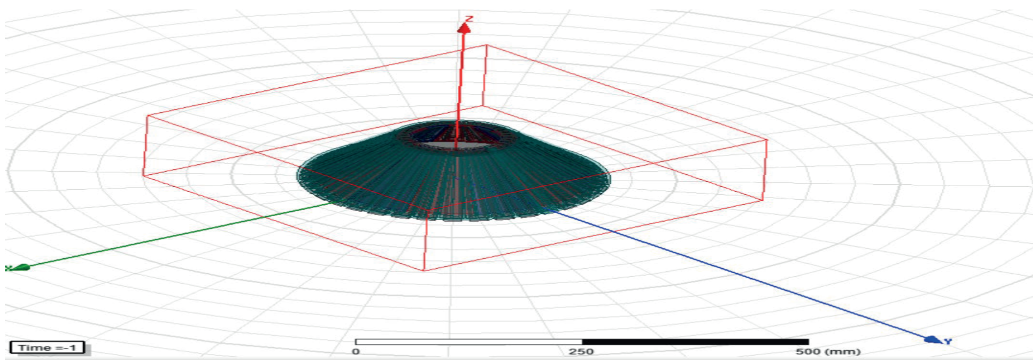

Figure 9. Generator with cone rotor

In Figure 10, a radial flux generator is constructed with a cylindrical rotor designed to fit a cone rotor generator.

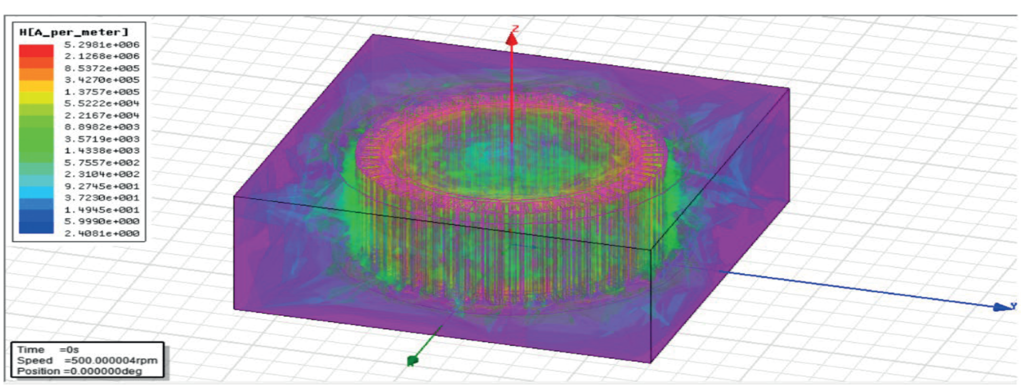

Figure 10. Radial flux generator with cylindrical rotor

In Figure 11, a radial flux generator is designed to connect to a radial flux portion that includes two rotors and a stator. The generator has 12 poles.

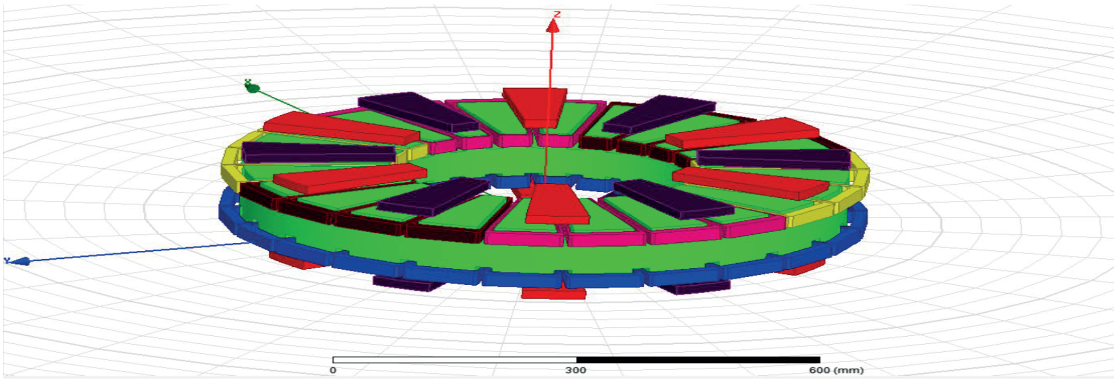

Figure 11. Axial Flow Generator

The rotor speed is set according to Figures 12, 13 and 14.

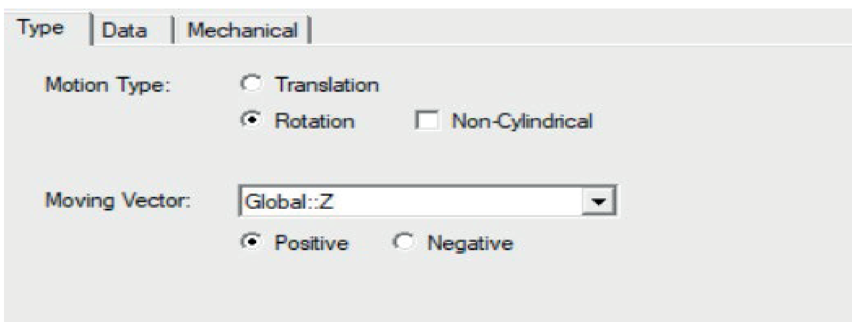

Figure 12. Setting the rotor rotation vector

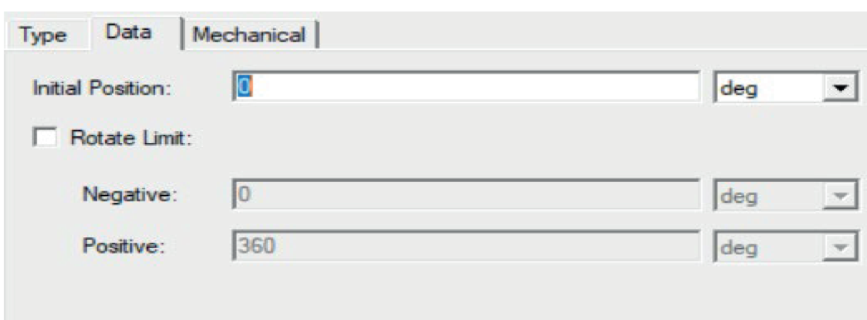

Figure 13. Setting the initial rotation point

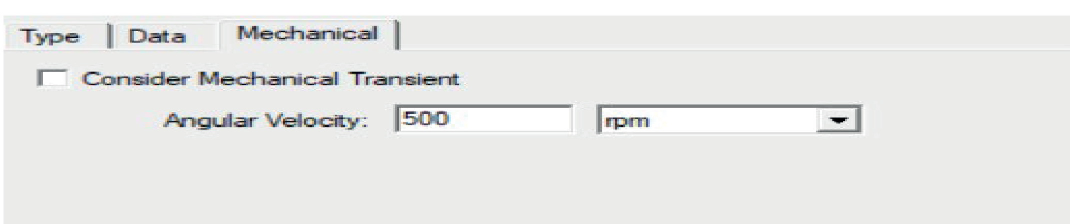

Figure 14. Adjust the rotor rotation speed

In Figure 15, rotor mesh is shown after the program execution.

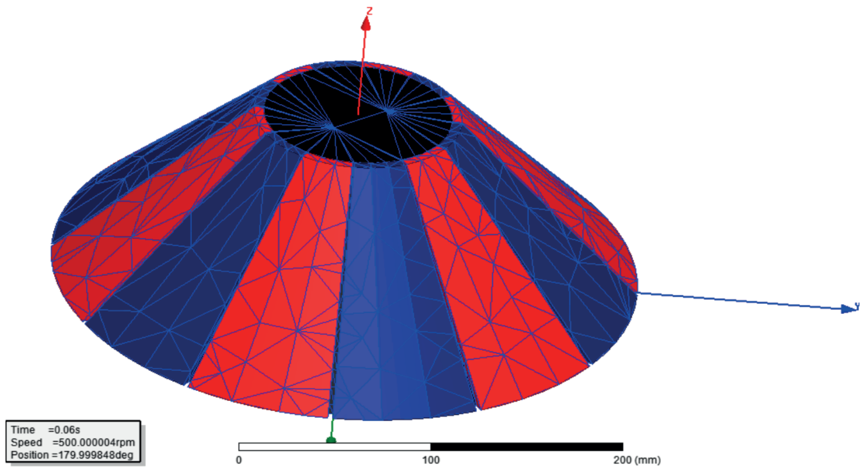

Figure 15. Rotor mesh

In Figure 16, the vector of the magnetic field around the rotor at the end of a rotational cycle is given in a period of 12.12 seconds.

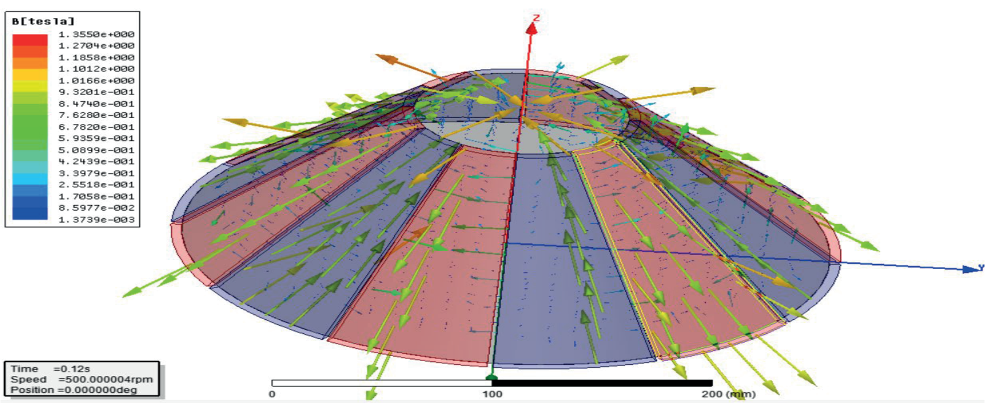

Figure 16. Rotor magnetic field vector in time of 0.26 seconds

The intensity of the magnetic field is expressed in amperes per meter, at 0.04 seconds, in Figure 17.

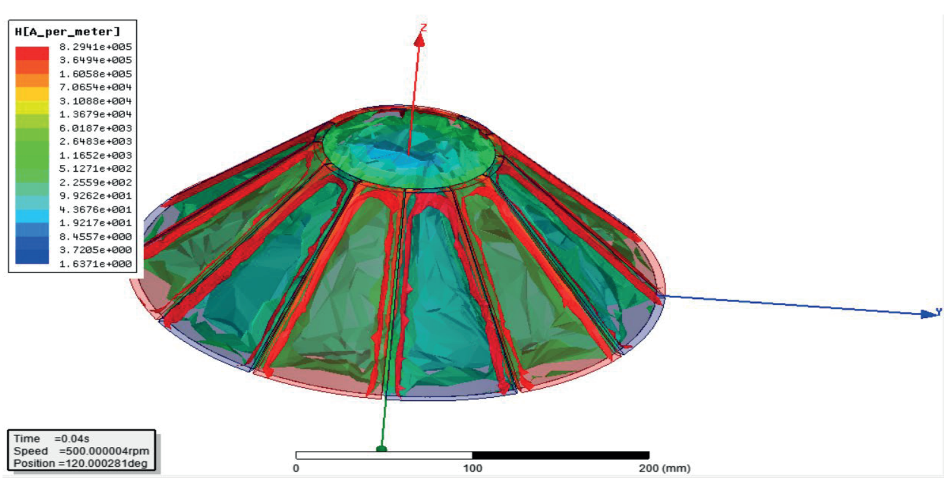

Figure 17. Magnetic field intensity at 0.04 seconds

In Figure 18, the magnetic flux lines are shown from the top view (page XY).

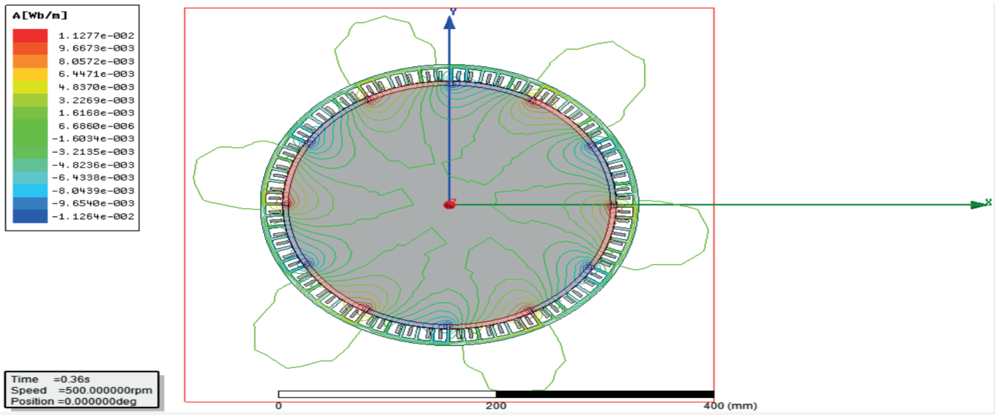

Figure 18. Magnetic Flux Lines in 0.36 seconds

The density of the magnetic field in terms of Tesla at 0.20 seconds is indicated in Figure 19.

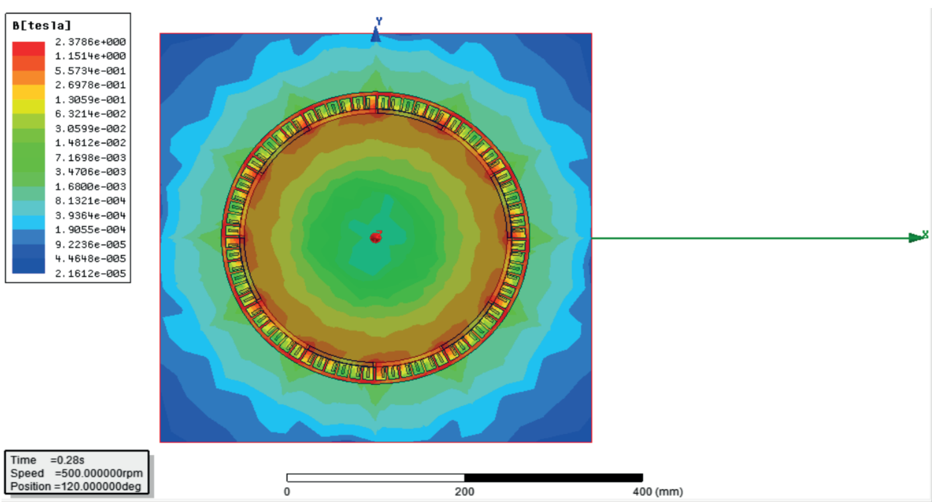

Figure 19. Magnetic field density at 0.20 seconds

The figure of the force input on the generator is shown in Figure 20.

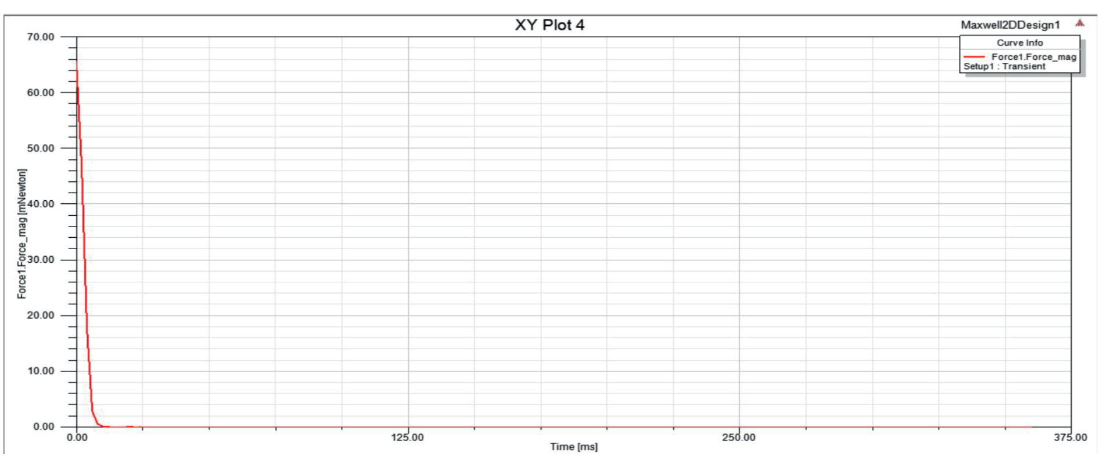

Figure 20. Force value

The amount of flux of phase A is given in Figure 21.

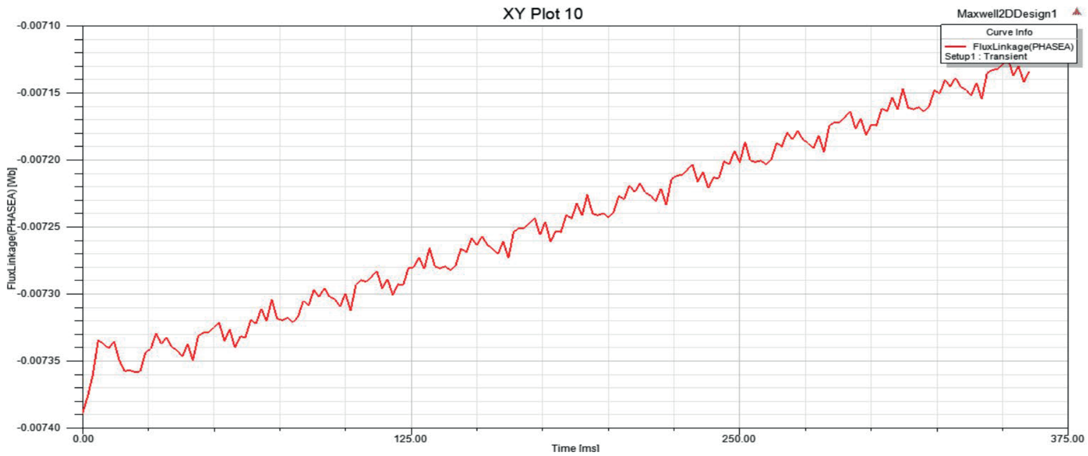

Figure 21. Flux ratio of phase A

In Figure 22, a three-phase coupling section voltage diagram is presented to the axial flux generator with a cone rotor.

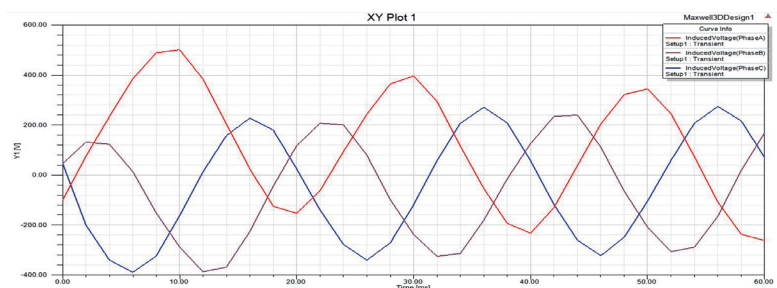

Figure 22. Three-phase voltage diagram

In Figure 23, the three-phase flow diagram of the coupler section is introduced into the radial flux generator under the generic load rating.

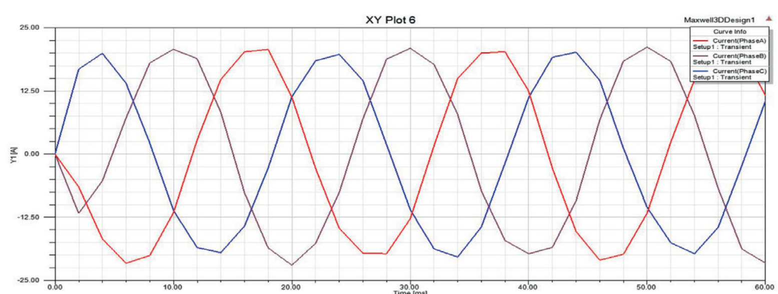

Figure 23. Three-phase flows

In Figure 24, a diagram of the induction voltage of the three-phase coupling section is given to the radial flux generator.

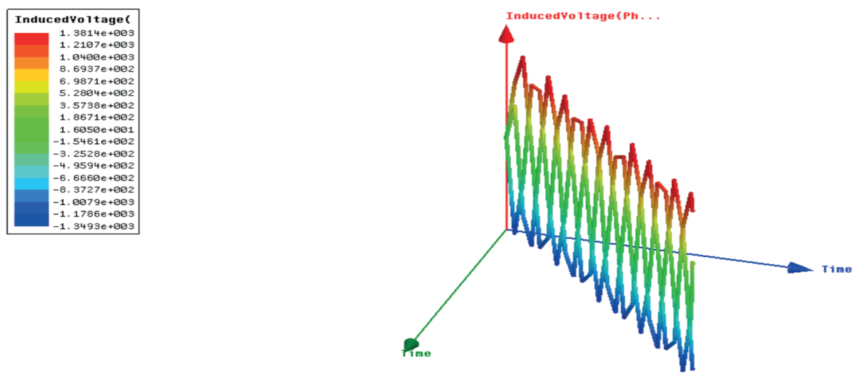

Figure 24. Induction Voltage Chart

RESULTS

The results of this study are simulated with the following data:

1) Considering the different angles for the rotor cone from 0 ° to 90 °. Given that in the stator design in Maxwell software, external stator windings should be uncovered without touching the stator body, the distance The air and the rotor body are located in the stator racks, a 90 degree angle for designing this type of generator in Maxwell software is appropriate, so that the rotor and stator cones from each side have a 45 degree angle with the horizon and The windings are placed at a 45 degree angle in the stator grooves.
   This result is achieved by considering software design considerations.
   The other advantage of the 45 degree angle achieved in the design is that the tangent has a 45-degree angle that maintains a vertical, horizontal ratio equal to one in line with the advantages of this easy mounting mode of the axial flux generator The conical base is the radial flux section, which is one of the remarkable points in design calculations. Also, with the aim of examining the properties of the cone, a 90 degree angle, which is the middle of the two values of zero degrees and 180 degrees, is appropriate and covers the extreme features of both of the two trigonometric quadrants.
2) For a rotor and a stator selected from a steel material 1010 having a saturation flux density of about 2 Tesla, the density of the magnetic flux in the simulation results is less than 2 Tesla and the rotor and the stator generator are saturated There are no hysteresis losses, vortex flow losses and thermal losses due to the rotor and stator core saturation.
3) The permanent magneto magnets used on the rotor surface, according to, have the ability to produce a maximum magnetic field density of 1.2 Tesla, which, according to the simulation results, in addition to inducing the voltage in the windings the stator has also prevented the saturation of rotor and stator nuclei.
4) The air gap is considered to be equal to one millimeter, passing through the magnetic flux and inducing the voltage in the current coils in the stator grooves.
5) The thickness considered for rotor level magnets, equal to 5 mm, has a luminance density of about 1.5 Tesla transferred to the stator and leads to voltage induction.
6) The magnetic flux density at the rotor's air distance is equal to 1 Tesla, and the magnetic flux lines are transmitted in radially two-way. The flux density at the rotor level is about 1,373.31 Tesla, which prevents the rotor core from saturation.
7) The magnitude of the magnitude of the magnetic field on the magneto magnets of the rotor surface at the two edges of the beginning and the end

along the Z axis is higher than that of the other points, which leads to hysteresis losses at the level of the magnets. The density of flux in the two edges of the beginning and the end is equal to 355.1 Tesla and in the middle of the surface of the magnets is about 0.1 Tesla. This may be due to the placement of magnets together on a surface with different poles.

8) The magnitude of the magnetic flux density at the location of the generator shaft is equal to 0.098 Tesla, which is less than the magnetic shaft saturation.
9) The intensity of the magnetic field in terms of amperes per meter, at the two edges of the rotor magnets, is the highest of 829410 amps per meter, and in other parts there is a balanced value of 252.59 amps per meter, which is the intensity The magnetic field of 829410 A / m can lead to the loss of magnetic properties. This level of electrical loading corresponds to the amount intended for electrical loading in the design computing section.
10) The copper infiltration coefficient of the stator is due to the low top of the generator and should be increased to about 1.
11) The maximum magnetic flux path in the stator windings is closed at the collision of two rotor magnets, the intensity of which is 012777 amps per meter.
12) The intensity of the magnetic field output from the stator body to the outside is 769650 amps per meter, which results in the loss of useful magnetic flux.
13) The magnetic field density at the junction of the magnets is equal to 2.37 Tesla, and in the stator windings it is equal to about 15141 Tesla, at the place where the magnets connect, this value is approximately equal to the density of the flux The rotor core is equal.
14) Electrical loading at the generator level is 78832 A / m 2, which corresponds to the design value of the design.
15) Electric loading in several windings is more than 78832 amps per square meter and in a few windings is much less than this value and is about 0.01 milli per meter per square meter.
16) The energy density in jules per cubic meter, in the stator windings, is equal to the value of 73.53.
17) The amount of force applied to the generator in the initial 10 milliseconds of the generator's start up is about 60 milliunion and then becomes zero.
18) The rotational rotation period is 120 ms.
19) The phase difference of the magnetic flux, the inductive voltage and the phase of the windings of the phases in the three phase generators is 120 degrees, which confirms the accuracy and precision of the stator winding phases and superstructures.
20) The maximum fuzzy voltage induced in the stator windings of the coupler generator to the cone generator section is approximately 220 volts.
21) The nominal load is equal to the division of the fuzzy voltage squared into the generating power of 50 ohms to the centrifugal generator and the maximum fuzzy current is 20 amps.
22) Two sections of radial flux and axial flux of the generator have been analyzed separately due to software constraints.
23) The radial-axial hybrid generator has the capability of producing 1/1 kilowatt power.

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