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AN OVERVIEW OF PROSPECTS AND PROBLEMS FOR CONVENTIONAL ELECTRIC MACHINES AND DRIVES FOR THE WIND POWER GENERATION

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ABSTRACT

The increasing desire to wind power production systems is a result of rising worries about the energy problem and safeguarding the environment. Researchers and engineers urgently need to create new electrical equipment and drives for the production of wind energy since they are essential parts of wind turbines. An in-depth analysis of contemporary electric drives and machines used in the production of wind energy is provided in this study, with a focus on machine topologies, operating theories, performance traits, and control methods. The major characteristics associated with electrical drives and machines are contrasted and summarized, along with their benefits and drawbacks, such as efficiency, torque/power weight, and cost. The trade-offs inherent in the different methodologies and solutions given are emphasized. The main obstacles and problems that electric drives and equipment for the production of wind energy face are highlighted. Additionally, new opportunities and trends are exposed, and the most recent developments are also covered.

1. INTRODUCTION

Electric machines and drives are critical components of wind power-producing systems. These systems generally include a wind generator, a power conversion, a generator, and a control network. The wind turbine flip the potential energy of the breeze rotational energy is converted into is subsequently provided to the generator (Liu, 2018). The generator turns rotational energy into electrical energy, which is subsequently sent into the power converter. The power converter converts electrical energy and feeds it into the electrical grid. There are two kinds of electric machinery utilized in wind power generation: synchronous generators and induction generators. Synchronous generators are commonly utilized on a huge scale wind turbines, while induction generators are employed in lower sizes turbines (Hnatov et al., 2018). To produce the magnetic

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field required to generate electricity, synchronous generators need a separate excitation mechanism. It is possible for this system to be a permanent magnet or an electromagnetic excitation system. Synchronous generators are very efficient and ideal for high-power applications (Vansompel & Sergeant, 2019). In contrast, induction generators do not need a separate excitation mechanism. Instead, they use the magnetic field generated by the rotor's spinning to drive an electrical current in the stator. Induction generators are less efficient than synchronous generators, but they are easier to build and less costly. Wind power production systems, in addition to electric machines, need power converters to condition the electrical energy provided by the generator (Vargas et al., 2019). The power converter must be able to convert the generator output's variable frequency and voltage into a fixed frequency and voltage acceptable for the electrical grid. Finally, to oversee the functioning of the wind power-producing system, a control system is required. The control system must be capable of monitoring wind speed and direction, adjusting turbine blade pitch, and managing the functioning of the electric machines and power converter (Zhang et al., 2018). Advanced control algorithms may also optimize system operation to maximize energy production while minimizing component wear and tear.

The rest of the paper is as follows related works presented in section 2, the proposed method described in section 3, and the section 4 depicts conclusion of the paper.

2. RELATED WORKS

Bramerdorfer et al., 2018 was inspired by rising trends. Advances in mathematics and computer science allow more sophisticated optimization scenarios that encompass an increasing number of physical elements. Previously, electrical machine design included researching electromagnetic efficiency. Ourahou et al., 2020 examined the intelligent grid idea and its dependability in the prevalence of renewable energy sources. Electric energy must be adjusted globally to reduce CO2 emissions, maintain the greenhouse effect, reduce pollution, combat climate change, and boost energy security. The technological specifics of metal recycling processes are discussed in this article based on previous research efforts to offer a thorough picture of the present state. The benefits and drawbacks of several traditional technologies are outlined and contrasted in terms of cost, environmental effect, and recovery efficiency (Hao et al., 2020). It has covered the fundamentals of machine learning as well as typical processes for implementing machine learning in this overview. A quick overview of several types of machine learning algorithms, as well as associated software as well as tools offered. The current status of research in artificial intelligence in organic solar cells is then presented (Mahmood & Wang, 2021). In this context, the paper provides a thorough investigation of the status present state of the art technology, emerging tendencies, as well as techniques that enable next-generation HEV/EVs for each electrical driving component system (López et al., 2019). The review article examines the most recent developments in applications involving energy storage, both cradle, and grave. This article also discusses some energy storage applications and their potential future possibilities. The advantages and disadvantages of various energy storage materials were fully examined (Olabi et al., 2021). The significant shift has shaken established agricultural systems and resulted in the most recent in a series succession of problems. This thorough study article illuminates the promise of IoT in agricultural progress as well as the problems encountered when merging this sophisticated technology with traditional agricultural systems. In advanced agricultural applications, a short examination of these sophisticated technologies with sensors is offered (Khan et al., 2021). Das et al., 2020 provided an in-depth examination of the present state of the EV industry, norms, and equipment for charging, as well as the effect of electric vehicle charging on the grid. The article presents the current state of EVs and gives a thorough assessment of key international EV charging and grid connectivity standards. Different infrastructure designs for EV charging in terms of command and communication systems are being explored and assessed . In the examination, they recognized the numerous challenges that the renewable industry faces. Policymakers, project developers, investors, industries, other interested parties and divisions, academics, and scientists will benefit from the review's suggestions (Majid, 2020). (Sethurajan et al., 2019) focused on current research (2015-2018). This study describes recent developments in several hydrometallurgical techniques for the removal of key WEEEs containing components. Various methods and methods for critical element selective recuperation from WEEEs effluents (using ionic liquids, Adsorption, extraction of solvents, and electro winning, and precipitation) are discussed.

3. PROPOSED METHOD

In this section, we discuss in detail about the overview of prospects and problems for conventional electric machines and drives for the wind power generation.

3.1 Wind Power Generation Systems

Wind energy is used to power the electric engine or engine in wind power producing systems. Blades with aerodynamic designs collect wind motion and transform it into electrical power. The electric generator and machine then transforms spinning mechanical force into electrical power using the proper control technique to extract the most energy and enhance the quality of the generated electric power. After that, a transformer sends the generated electrical energy to the grid. As can be seen, the electrical device and drive are crucial to the energy conversion process in a wind power generating system, which is the focus of this research.

Electrical machine-drive systems utilized in the production of wind energy are often divided into two categories: corrected-speed electrical drive a machine devices and variable-speed electrical machine-drive devices.

Electrical machine-drive methods with variable speeds: The electronic machine-drive mechanism should have the ability to able to alter its speed in line with wind speed in order to reach the ideal tip-speed ratio. This will allow for the greatest possible wind energy conversion effectiveness across a broad range of wind speeds. As a result, full-variable-speed methods and semi-variable-speed structures for electrical machine drives are receiving increased attention. To comply with highly technical grid standards, an energy converter/controller is often needed, and a different controller is utilized to modify the velocity of an electric machine.

Table 1. Difference between electrical system-drive systems with variable-speed and fixed-speed.

	Variable-speed	Fixed-speed
Velocity rang	0–100%	±1% synchronous speed
Rating of power	>15MW	2.3 MW (max)
Gearbox	Possibly removed	Necessary
Cost	High	Low
Suitable electric machines	Various systems (WRIM, doubly fed IM, SCIM,) and systems	Limited to WRIM or SCIM
Examples	Enercon E126 [3]; Multibrid M5000 [7]; Vestas V66/V-112 [5];	Siemens SWT 2.3-101 [3]; Vestas V82 [1]
Use of wind energy	High	Low
Control struggles	Complicated	Simple
Generated power quality	High because of power transformer/controller adjustments	Low given the likelihood of power flickering problems.

The key benefits of variable-speed systems are increased power quality, short reaction times under transitory and dynamic power system conditions, and optimum wind energy efficiency during conversion. Additionally, a high-pole number generator may be used to do away with the need for a gear box. Their drawbacks include greater costs and control difficulty, as well as higher losses from more power electrical devices. The main distinctions between electric drive systems for machines with fixed-speed and variable-speed are listed in Table 1. As can be seen, despite the fact that many fixed-speed systems which were installed decades ago are still in use, variable-speed systems have excelled their fixed-speed equivalents in regards to adaptability and usefulness.

Electric machine-drive methods with fixed speeds: A combination of their simplicity, cheap starting cost, and stable operation, fixed-rate electric machine-drive methods have so far taken the lead, as illustrated in Figure 3(a). A particular wind speed, the speed is governed by the gear ratio as well as grid frequency. As a result, the electric machine-drive systems must be built to operate at its most efficient level at this specific generator speed. In most cases, a gearbox is necessary to align the generator's speed with the wind. To lessen the current surge when a generator is activated, a starter that is soft is used. Additionally, a bank of capacitors is often used for power factor adjustment when SCIMs (squirrel cage induction machine) or WRIMs (wound rotor induction machine) constantly consume grid-reactive power.

Electric machine-drive systems with fixed speeds were common until 20 years ago, but their variable-speed equivalents are now taking their place. This occurs as a result of its built-in drawbacks, which include poor wind energy conversion effectiveness, rigidity regarding grid voltage modification, inescapable power flickering and mechanical stress problems brought on by wind gusts.

3.2 Topologies Of Electronic Machine For Wind Power Generation

Apart from the traditional electrical machines, this subsection will focus on the novel PM machines, such as fluxswitching machines, Vernier machines, magnetic-geared machines and flux-reversing machines. These publications will be covered in-depth.

Conventional wind turbine generators: The electric machine-drive system used for wind energy production has initially employed conventional inductive machines, such as SCIMs and WRIMs. Due to its advantages of cheap cost, excellent dependability, and free of servicing operation, SCIMs are a popular choice for wind turbines. By changing the external resistance, WRIMs may be started with minimal inrush current and high beginning torque. Complicated correction of power factor control techniques are required because these machines need reactive electricity form the grid to keep operating as generators.

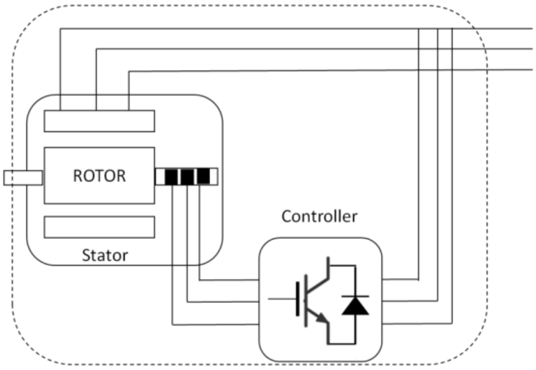

Figure 1a. DFIMs

The suggested As stated in Figure 1(a), DFIMs are made up of a WRIM having a rotor that has been wound and a ring for slipping arrangement using brushes linked to a supervisor rather than resistance from the outside. The windings that make up the rotor of DFIMs are linked to the controller, which regulates both rotor and grids currents, while the windings of the stator have connections to the grid. To account for changes in the turbine's speed, the input current's frequencies and angle of phase are modified in the rotor.

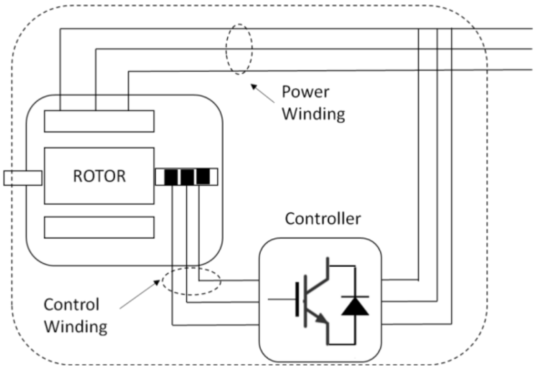

Figure 1b. DFIMs

As stated in Figure 1(a), DFIMs are made up of a WRIM having a rotor that has been wound and a ring for slipping arrangement using brushes linked to a supervisor rather than resistance from the outside. The windings that make up the rotor of DFIMs are linked to the controller, which regulates both rotor and grids currents, while the windings of the stator have connections to the grid. To account for changes in the turbine's speed, the input current's frequencies and angle of phase are modified in the rotor.

As illustrated in Figure 1(b), modern brushless DFIMs differ from traditional DFIMs in that they have two distinct sets of stator windings: power windings and control windings. While control windings are provided via a controller/converter in a "back-to-back" arrangement allowing bidirectional power flow, power windings are linked to the grid.

Vernier PM systems: The vernier PM machines are attracting more attention because of their substantial torque density and straightforward mechanical design. In stator armature the windings, a tiny movement of the PM rotor causes a big movement of the flux linkage. Torque increases when the rotor slows down relative to the spinning field. Vernier machine tools are so appealing in low-speed, high-torque programs, such as the production of wind energy. Furthermore, by effectively combining the winding of a toroid architecture and terminal connections diversities, the rated voltage may be maintained with good modulating continuity during speed changes.

In direct-drive applications, outer-rotor machinery often outperform their conventional inner-rotor counterparts due to greater dissipation of heat and easier installation. Multi-phase machines have more dimensions of freedom in the related control system, more power density, and higher fault-tolerance than their standard three-phase equivalents.

Flux-switching PM systems: As can be observed, the rotating part of FSPM machines has a basic construction, making it mechanically strong. The stator has concentrated windings, circumferentially magnetized PMs, and laminated "U"-shaped stator teeth segments. The 12-phase FSPM system was discovered to have substantially less mutual inductances than its traditional three-phase equivalents, with the majority of them being insignificant. Better magnet isolation between phases is a result of this. Based on this model, examine how the 12-phase FSPM machine's electromagnetic performance is impacted by the phase shift between its winding sets and the number of its rotorpoles.

The best phase shift for the least amount of torque ripple and output corrected voltage oscillation was discovered to depend on the kind of winding used, and symmetric phases shift is not always suitable for all circumstances.The FSPM machine with a partitioned stator splits the windings and PMs on purpose into separate stators so that they do not compete for space in the same stator. As a result, the partitioned-stator FSPM device displays greater torque weight, effectiveness, and PM utilisation ratio as compared to the standard architecture.

PM machines with flux reversal: Due to its benefits of a straightforward rotor structure, quick instantaneous reaction, and high power density, flux-reversal PM (FRPM) devices have grown in popularity in recent years. Each stator tooth's inner surface is attached with a pair of PMs that have different polarity. Additionally, the tooth windings often have short end windings since they are looped around the stator teeth. As the rotor rotates, the two distinct PM segments for each rotor tooth that face toward the rotor teeth shift, resulting in bipolar fluxes and rewind-EMF waves in the molar's the windings.

This machine's no-load induced voltage is twice that of its typical FRPM counterpart with concentrated windings, and both its electrical density and efficiency have increased. However, because of the strong armature response, the voltage control of this machine is quite weak. So, to enhance voltage regulation, more capacitors are required. As observed, the three slots that house the three-phase toroidal windings are located inside the stator core, which is shaped like a solid of rotation. This machine has a higher power density and lower cost than its traditional PMSM counterpart.

PM machines with a magnetic gear: The magnetized gear's ability to transfer torque among an input as well as an output shaft without physical contact is based on the ability of ferromagnetic pole pieces to modulate the magnetic fields created by two PM rotors. Despite any mechanical contact, it works by changing the magnetic fields produced by two PM rotors via ferromagnetic pole pieces.

When the primary rotor is the outermost rotor, which is joined by blades., and the inner rotor operates as the rotor that absorbs wind power. These two rotor move in opposition to one another. Due to the relative angular speeds, the generator's primary winding's generated frequencies almost doubles. Using the flux-modulation model as a basis, which is preferred in wind power production machines, this occurrence occurs. By injecting varying DC field currents, it is possible to modify the pole-pair count of internal excitation mechanisms with great flexibility. In order to effectively change the magnetic field, dominating pole-pair flux components are controlled. As a consequence, this machine's torque intensity and flux-regulation capabilities are both enhanced.

Detailed comparisons: Considering the benefits and drawbacks of electric wind turbine generators is always intriguing. The findings indicate that the Vernier PM device is more likely compared to the FRPM machine to have greater torque density since it used a significant DC aspect of air-gap permeance. Additionally, it is shown that the planned parameters, such as the slot width ratio and PM thickness, have a greater impact on the performance features of the FRPM machine. It should be mentioned that although receiving increasing attention in academics, these new entrants/variants of PMSMs, such as Vernier PM machines, FSPM machines, FRPM devices, and magnetic-geared PM devices, are still not commercially viable in the wind turbine industry.

3.3 Methods For Sensorless Control Of Wind Generators

Electrical units are often used in variable-speed conversion systems for wind energy (WECSs) for improved input control of electricity and grid interface. For instance, the greatest amount of energy may be harvested from a wide range of wind speeds, and power electronics can be used to regulate the grid's reactive as well as active electrical inputs. Power electronics are often used in two different ways in WECSs: partial-scale electrical units and completely power electronics units.

When a large working range is needed, the majority of sensorless manage techniques are created for crucial applications like electrical automobiles and household appliances. The salient pole, flux weakening, low speed, and effective dynamic control are thus treated as distinctive aspects. Therefore, it is preferable to use generators with a low saliency or a non-salient pole. Because of the light wind characteristics, the pace of the generator is often constant, therefore sensorless control technique dynamics are not strictly necessary.

The most often used sensorless control techniques are those that rely on backEMF observers and rotor flux observers.

Estimating the back-EMF: In the dq reference frame, the dynamical framework of a general three-phase PMSG may be expressed as

$$\begin{cases} u_d = R_s i_d + L_d\left(di_q/dt\right) - \omega_r L_q i_q \\ u_q = R_s i_q + L_q(di_q/dt) + \omega_r L_d i_d + \omega_r \psi_f \end{cases} \quad (1)$$

wherein udq, idq, and Ldq are the armature resonance electric currents, voltages, and inductive capacitance in the dq references structure, accordingly, Rs is the armature obstruction, f is the flux coupling created by PMs, and r is the rotor flux angular speed.

The movement of the PMSG may be simulated in a reference frame that is stationary employing the inverse Park rearrangement as

$$u_{fffi} = R_s i_{fffi} + L_d\left(di_{fffi}/dt\right) + e_{fffi} \quad (2)$$

These elements can be explained as follows:

$$\begin{cases} e_\alpha = -e_{e\alpha} \sin\theta_r ; e\beta = e_{ex} \cos\theta_r \\ e_{ex} = \omega_r \psi_f + \left(L_d - L_q\right)\left(\omega_r i_d - i_q\right) \end{cases} \quad (3)$$

Because stator electrical currents and voltages are observed, deadbeats the observer may acquire the backEMF.

Observers of the state linear: The most basic sequential state monitor is the minimum-order situation spectator, sometimes referred to as the disturbance monitor in an automatic manage system. When using the minimal level-order state monitor with an initial-order low-frequency filter where frequency is controlled by the observation's gain, the predicted (electromotive force)back-EMF is close to the actual back-EMF.

Whenever the sinusoidal backEMF is treated as one state with a presumption of zero derivative, a second-degree phase observers or linear expanded state observation (ESO) is built. Figure 2(a) and 2(b) depicts the block diagram of two comparable continuous state observers utilizing complex vectors.

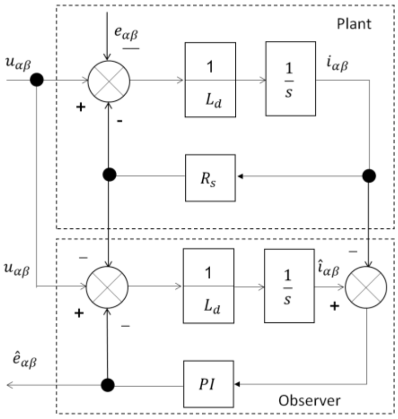

Figure 2a. Block diagram of linear phase monitor

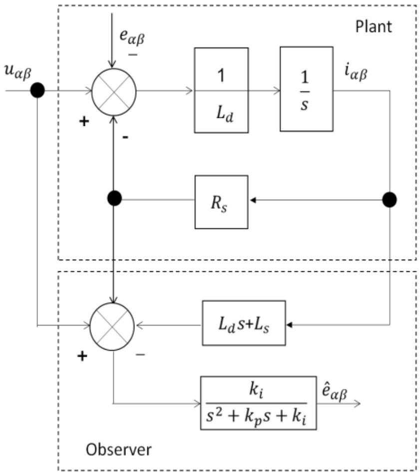

Figure 2b. Block diagram of linear phase monitor

For example, when the inductance decreases owing to saturation with magnetism, the calculated back-EMF may oscillate. Another issue with employing the simple linear state monitor is its phase delay, which increases with speed. Non-linear observers are better for improving resilience to parameter fluctuations and reducing phase delay.

Observers of non-linear states: The sliding-mode observer (SMO) is the most often used non-linear observer. The SMO is equally resistant to variable changes being the moving-mode management, but it imposes distinct constraints on the managed object. The employment associated leads to a state delay when used with the initial-order LPF.

While the stage delay may be adjusted using the anticipated speed of the rotor, it complicates the process. The chattering issue caused by the employment of the signum operator is much reduced because of the more complex forms of SMO. As a result, the filter may be avoided. A part-locked quaternary loop is also suggested to address the speed adaptation issue. SOGI-based monitors find use in sensorless control structures with corrupted back-EMF and current due to their good frequency selection properties.

Estimating the flow of a rotor: The active-flux idea, like the expanded back-EMF concept, converts all substantive-pole travelling field devices into nonsalient-pole ones. As a consequence, for movement-sensorless control, all electric motors can make use of a single phase observer.

$$\begin{cases}\psi_d = L_d i_d + \psi_f = L_q i_d + \psi_d^a \\ \psi_q = L_d i_q\end{cases} \tag{4}$$

$$\begin{bmatrix}\psi_{r\alpha} \\ \psi_{r\beta}\end{bmatrix} = \psi_d^a \begin{bmatrix}\cos\theta_r \\ \sin\theta_r\end{bmatrix} = \begin{bmatrix}\psi_{s\alpha} - L_q i_\alpha \\ \psi_{s\beta} - L_q i_\beta\end{bmatrix} \tag{5}$$

$$d_{sfffi}/dt = u_{fffi} - R_s i_{fffi} \tag{6}$$

Integrating the voltage equation yields an estimate of the stator flow. Because the electrical voltage concept is an integral without feedback, it is susceptible to offset and drifting issues.

Although q-axis inductor is employed to calculate the rotor flux, the stator is a component flow-linkage monitor is entirely responsive for machine specifications are important at the fast connectivity region because the stator voltage is more crucial than the resistance caused by the voltage drop. The rotor's electromagnetic flux is not influenced by rotor speed, unlike the back-EMF. As a result, it may be utilized at low speeds while avoiding speed adaptation. Furthermore, the torque the the strength of the stator flux may be evaluated concurrently. As a result, sensorless control is simple to incorporate with straight torque and flux control.

Observers of rotor position and speed: Speed-related /Position states like back-EMF or rotor flux may be acquired by using the right technique. The location and speed data may then be detected using certain suitable detection techniques.

Straight forward computation: If two symmetrical rotor flux components or back-EMF components are found, the location and speed may be determined using equations (7) and (8) as follows.

$$\theta_r = \tan^{-1}\left(-e_\alpha/e_\beta\right) = \tan^{-1}(\psi_{r\beta}/\psi_{r\alpha}) \tag{7}$$

$$\omega_r = d\theta_r/dt \tag{8}$$

Despite being easy and simple, the approach is extremely dependent on the noise in the predicted rotors flux. Flux rotor or EMF observers are thus needed.

PLL observer: Since the viewer is often made to operate at constant speed, the state equations for location and speed may be written as

$$\theta_r = \omega_r, \omega_r = 0 \tag{9}$$

The function of transfer from the location and speed to the observers' estimates may be altered by choosing several observers. The observer serves as an internal filter, and it is anticipated that it will perform admirably in terms of noise suppression and excellent dynamics. Since constant speed is assumed throughout the construction of the traditional, acceleration or deceleration will cause an estimating inaccuracy.

The ASOs (adaptive state observer) look favorable for machines running under imbalanced and operating distortion circumstances because they offer the best filtering features, including no magnitude distortion and phasing waiting at the center low-frequency, frequency disruption rejection.

Along with to the accomplishments on the previously mentioned sophisticated electrical equipment and drives for the production of wind energy, innovation still persists, which might provide direction for the development of this subject in the future. Furthermore to the accomplishments on the mentioned sophisticated electrical devices and engines for the production of wind energy, invention still persists, which might provide direction for the development of this subject in the future.

3.4 Challenges

Even though several sophisticated methodologies provided for electrical machinery and drivers in wind energy producing systems, design and analysis of these electric machines and drives remain difficult owing to the presence of strong merging, more variables and , multiple domain physics. This section will discuss the primary issues that electric machines and wind turbine drives face. Modeling challenges, electrical failures, parameter uncertainties and manufacturing issues are underlined in particular.

Modelling difficulties: Finite element analysis (FEA) mothods and analytical methods, for example, are two modeling techniques that having been created for the model and study of electrical devices. Models for analysis are rapid, but they don't take into consideration the magnetic nonlinearity of materials and local saturations. Fig 3 shows the improving the FEA modeling of inductive devices' transient reaction time
However, FEA models take a long time because of the heavy computing load imposed by finite-element (FE) computations. Fig 4 depicts the methodology for flux-linkage reconstruction

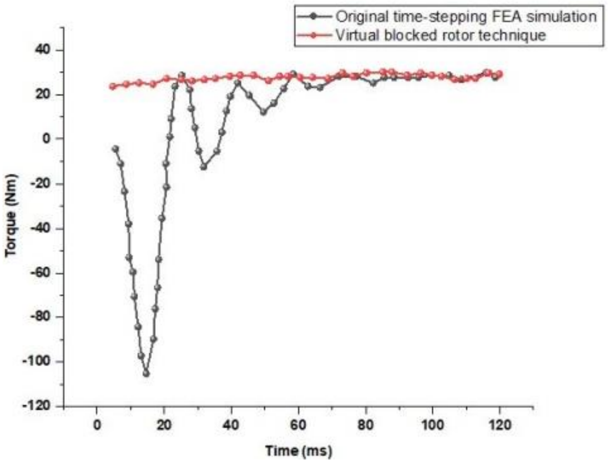

Figure 3. Improving the FEA modeling of inductive devices' transient reaction time

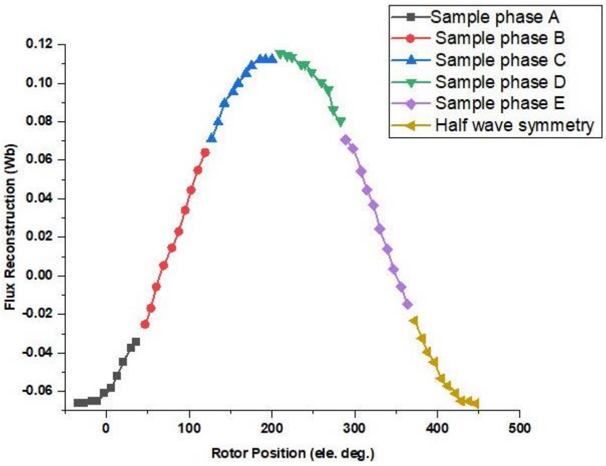

Figure 4. Methodology for flux-linkage reconstruction

This suggests that there is a considerable barrier to using such FEA models to optimize induction machine design within an acceptable amount of time for calculation. Several methods have been developed to speed up the FEA transient process. Applying an extra voltage component within a brief window of time for each phase winding eliminates the transient DC flux-linkage component.

Manufacturing difficulties: Electric wind turbine machines are difficult to manufacture, particularly as they become larger and more complicated. Electric machine-drive energy transformation devices must function in addition possible while avoiding any propensity faults, which calls for the use of advanced production and assembly processes. Naturally, greater machine ratings and sizes come from the development of induction machines for wind power production. Therefore, higher rotor bar cross sections will be fitted on these sorts of machines. The big rotor bars will experience significant skin effects, which will increase unwanted rotor resistance. Reluctance rotors for DFIMs, which are really doubly fed reluctance machines, are suggested in order to eliminate the drawbacks related with skin effects.

Failures of electric devices and drives: The breakdown of different electric machines and drives is one of the main issues with wind power production systems. Understanding these failures, their accompanying fault diagnosis techniques, and fault-tolerant solutions is crucial because they are often expensive and take a while to fix.

The most frequent mistake is failure of the winding insulation. It may be brought on by severe heat, high voltage strains, corrosion, etc. Poor ventilation may cause excessive winding temperatures, which in turn cause problems in the insulation around the windings and demagnetization of PMs. For the construction of wind generators, appropriate cooling design considerations are required additional to liquid cooling technologies and traditional air-forced cooling.

Control without sensors under unusual circumstances: Designing rotor position/speed sensorless control systems for generators in WECSs presents two significant issues. The rise of new generator types, as well as the association among WECS and unbalanced power grid, will first cause harmonic and imbalance issues in the back EMF.

The combined use of non-linear state viewers and ASO is seen to be a useful way to cope to various handling situations as microprocessor technology advances. Additional research includes assessments of the non-linear observers' parameter setting concept together with the dynamical and massive-state performances of different monitors and their associations.

4. CONCLUSION

The article provided a thorough examination of the constraints and possibilities associated with wind energy generation requires electric devices and drives. PMSMs are considered as the most potential choice for wind power production when compared to traditional electric machines such as WRIMs, SCIMs, EESMs, and DFIMs. As a result, sophisticated PMSMs, such as conventional surface-mounted Vernier PM systems, PMSMs, FRPM systems, FSPM systems, and magnetic-geared PM systems, are addressed and contrasted with a focus on essential needs such as torque/power density, cost, efficiency, dependability, and so on. On the other hand, there are still many technological obstacles to solve in electric machines and drives, such as modeling issues, manufacturing issues, breakdowns of electric machines and drives, and Control without sensors in unexpected conditions. Emerging innovations in electric machines and drives, on the other hand, play a significant role in the production of wind energy generation more effective systems, dependable, and cost-effective. This document serves as a complete reference and blueprint for academics and engineers interested in current electric machines and wind turbine drives production. It may be useful to review what has been done, and it may spark the production of additional original ideas in this rapidly developing field.

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