

EFFICIENCY IMPROVEMENT OF INDUCTION MOTOR

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Abstract: - The primary objective of numerous ongoing studies across various domains is to increase energy efficiency, particularly in electric drives, which are central to industrial applications. Static and dynamic models serve as the foundation for induction motor simulation, which enables the investigation of mechanical performance, power consumption, and losses. However, the engine's core losses, which have a major effect on energy efficiency, are not included in popular dynamic models. In addition to the mechanical and copper losses already taken into account in widely used models, this paper offers two ways to incorporate iron losses into the dynamic model of a squirrel-cage induction motor (IM). Iron losses are added to the model equations as an equivalent resistance or to the mechanical equations as a decrease in the equivalent torque. The suggested model is crucial for upcoming studies aimed at enhancing engine energy efficiency. Matlab/Simulink is used to analyze and simulate both approaches, and the results are confirmed experimentally. To determine the best approach for upcoming induction motor applications and research, the performance of these suggested approaches is compared.

Introduction

Since Faraday discovered the law of electromagnetic induction in the 18th century, electric motors have been the most significant invention in human history. They have advanced significantly for industrial uses in the 19th and 20th centuries. These engines were utilized in homes as well as in every industry. Following their development, induction motors became more affordable and effective. Without a doubt, induction motors are used extensively in electrical engineering to drive a variety of loads. However, there are a number of issues with induction motors that are covered below in relation to their efficiency.

Induction motor problems

Although every machine in the world ought to be flawless, none of them actually are. All machines should strive for

maximum efficiency, but rotating machines require it more than others. These various types of losses result in a decrease in the efficiency of any machine. The following is a list of losses that happen when an induction motor drives a load. The greatest losses are found in the stator and rotor core. The following factors are causing these losses:

- Magnetic core of stator and rotor
- Stampings used in iron material

So, we have design insulated material for motor which will overcome above problems. Now this thought gives rise to new technology

An insulated core induction motor. Induction Motor with Insulated Core What's That?

The induction motor is composed of magnetic cores. It is this magnetic core that causes flux linkage. Since the magnetic core is made of magnetic material, there will eventually be some magnetic saturation. This leads to magnetic saturation hysteresis losses. Eddy current losses also occur in induction motors. These losses cause the motor's efficiency to decrease, which greatly concerns the machine designers. The idea behind the insulated core induction motor is that these losses can be prevented if the flux linkage occurs through non-magnetic material, such as air, rather than magnetic material.

- An Insulated stator;
- An Insulated rotor,
- A rotating shaft,
- An induction rod inserted into the interior of insulated core induction motor rotor to guide a magnetic flux;
- A stator positioned around insulated rotor

The rotor of an insulated core induction motor is a squirrel cage-shaped conduction cylinder composed of composite material or polymer resin. To make up for the squirrel cage-shaped conduction cylinder's low magnetic permeability,

the composite material or polymer resin contains powder with a high magnetic permeability, such as iron or ferrite powder. Heat pipes, which are incorporated into the slots of the squirrel cage-shaped conduction cylinder to dissipate heat, are another feature of the composite material or polymer resin.

Principle of Insulated Core Induction Motor

The simple precept of insulated middle induction motor induction motor is much like that of induction motor. It is primarily based totally at the faraday's regulation of electromagnetic induction. The AC energy furnished to the motor's stator creates a magnetic area that rotates in time with the AC oscillations. The rotor creates at a decrease velocity than the stator area. The induction motor stator's magnetic area is consequently converting or rotating relative to the rotor. This induces an opposing cutting-edge withinside the induction motor's rotor, in impact the motor's secondary winding, whilst the later is brief-circuited or closed thru outside impedance. The rotating magnetic flux induces currents withinside the winding of the rotor in a way much like currents caused in transformer's secondary windings. This caused emf drives its very own cutting-edge as rotor winding is brief circuited now cutting-edge sporting conductor location in magnetic area stories torque consequently rotor rotates. For production insulated middle electric powered motor middle the distinctive forms of drinks and powders are used to make the fiber middle fabric. The content material used is having distinctive percent this is very vital even as production of fabric. If any percent modifications, the homes of fabric additionally modifications and the product can't be sustained as according to the necessities for insulated middle induction motor induction motor.

Objective of thesis

The main objective of propose methodologies are as follows:

- 1) Analysis of three phase induction motor.
- 2) Improve the performance of three phase induction motor.
- 3) Analyze the insulated induction motor.

1.3 State of art

Developing a three-phase induction motor fault analysis system is the goal of this dissertation. This project's primary goals are to: 1. Examine the current three-phase induction motor fault analysis method.

1. In the MATLAB Simulink environment, choose the appropriate MATLAB simulation blocks for creating a three-phase induction motor fault analysis system.
2. Choosing the right insulation levels for an induction motor.

1.4 Introduction

An induction motor incorporates a magnetic circuit interlinking electric powered circuits that are located on the 2 primary components of the gadget: (i) the desk bound element referred to as the stator and (ii) the rotating element referred to as the rotor. Power is transferred from one element to the opposite through electromagnetic induction. For this induction gadget is referred as an electromechanical power conversion tool which converts electric power into mechanical power [1]. Rotor is supported on bearings at every end. Generally, each the stator and rotor encompass circuits: (a) an electric powered circuit to hold contemporary and usually product of insulated copper or insulated aluminum and (b) a magnetic circuit, proven in parent 3.2, to hold the magnetic flux product of laminated magnetic fabric usually steel (parent 1).

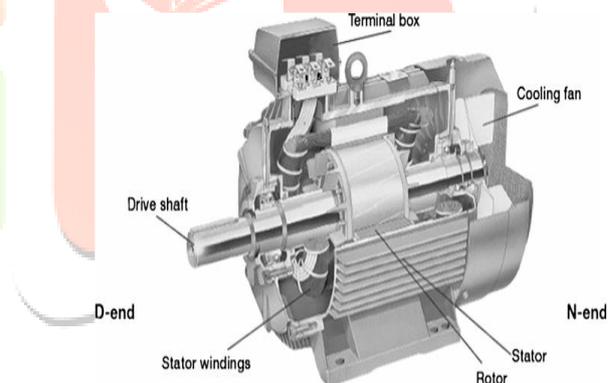


Figure 1: An induction motor (dissected)

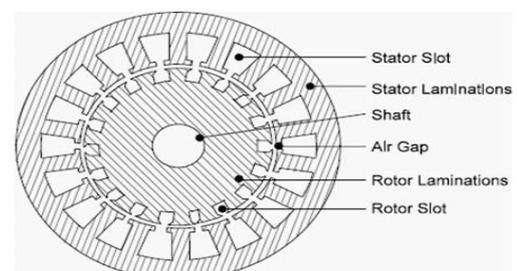


Figure 2: Magnetic circuit of stator and rotor of an induction motor

1.5 Construction

1.5.1 Stator: The stator shown in Figure 3.3 is the outer fixed part of the motor. It consists of (i) an outer cylindrical frame, (ii) a magnetic path, and (iii) a set of insulated

electrical windings. (i) Outer Frame: Made of cast iron, aluminium alloy casting or welded steel plate. These usually include legs for mounting the motor on a stand or flanges for mounting other types of motors.

(ii) Magnetic path: It consists of a set of slotted fins made of high-quality alloy steel supported within the outer cylindrical stator frame. The magnetic path is laminated to reduce eddy current losses and heat generation.

(iii) Sets of insulated electrical windings: In a three-phase motor, the stator circuit has three sets of coils, one for each phase, separated by 120° and excited by a three-phase supply. These coils are placed in slots in the laminated magnetic path.

1.5.2 Rotor: This is the rotating part of the engine. It is placed within the stator bore and rotates coaxially with the stator. Similar to the stator, the rotor consists of a series of slotted thin sheets, called laminations, made of electromagnetic material (special core steel) and compressed into a cylindrical shape. The thin sheets are insulated from each other by paper and varnish [2]. The slots form the circuit and the cylindrical electromagnetic material acts as the magnetic path. There are two types of rotor windings in induction motors: (a) squirrel-cage motors and (b) wound rotors. Induction motors are divided into two groups based on the type of rotor windings [1–3]: (i) squirrel-cage motors and (ii) wound rotor motors. (i) Squirrel cage induction motor: In this case the rotor consists of a series of bars made of copper, aluminium or alloy as rotor conductors, which are embedded in the rotor slots. This results in a very robust rotor structure. The rotor bars are connected at both ends by end rings, forming a closed path. Figure 3.4 shows a squirrel cage rotor.

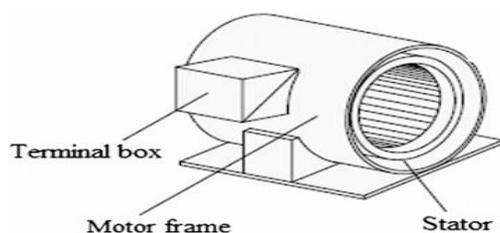


Figure 3: Stator of an induction motor

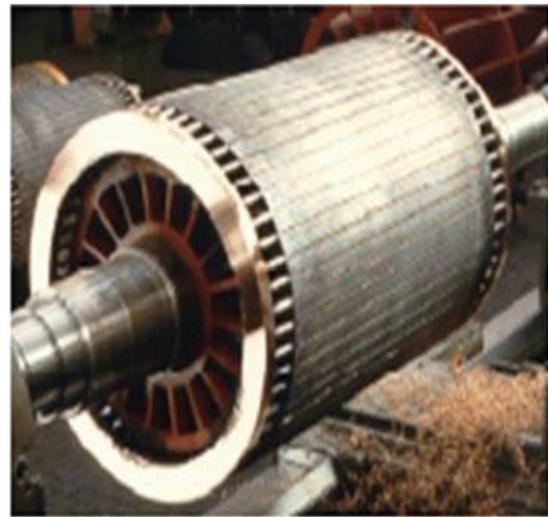


Figure 4: Squirrel-cage rotor

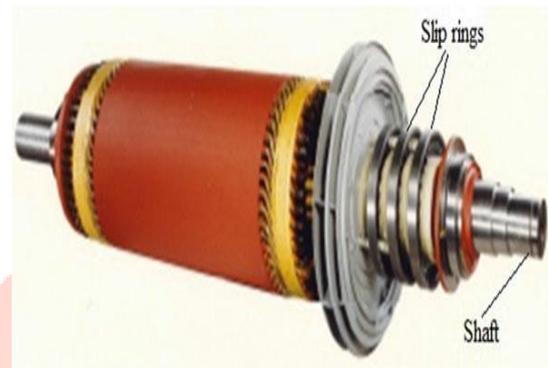


Figure 5: Slip ring rotor

(ii) Wound-rotor type induction motor: In this case rotor conductors are insulated windings which are not shorted by end rings but the terminals of windings are brought out to connect them to three numbers of insulated slip rings which are mounted on the shaft, as shown in figure 3.5. External electrical connections to the rotor are made through brushes placed on the slip rings. For the presence of these slip rings this type of motor is also called slip ring induction motor.

1. 6 Insulated Three Phase Induction Motor

An insulated induction motor is not a distinct category of motor but rather denotes an induction motor that possesses enhanced electrical insulation to safeguard it against problems such as high voltage stresses, especially in applications involving variable frequency drives (VFDs) or challenging environments.

Key Features of Insulated Induction Motors:

Improved Insulation System:

The windings are covered with premium insulation to endure voltage surges and high-frequency switching from VFDs.

This inhibits premature malfunction resulting from partial discharges or insulation failure.

Bearing Insulation:

Bearings may incorporate insulating layers or ceramic coatings to avert electrical arcing. This is vital when shaft currents are induced by VFD operations or other high-frequency influences. In the absence of this, bearing currents can lead to pitting, fluting, and eventual motor malfunction.

Environmental Protection:

Insulation may also shield against moisture, dust, or corrosive conditions, contingent on the motor's application.

Voltage Withstand Capability:

Insulated motors are engineered to manage the elevated voltage spikes prevalent in systems governed by rapid-switching semiconductor devices like IGBTs in contemporary drives.

1.7 Construction of Insulated Induction Motor

The development of an insulated induction motor parallels that of a standard induction motor but incorporates extra separator highlights to protect against electrical stresses, such as voltage spikes, fractional releases, and bearing streams. Underneath is an outline of its key components and their development:

1. Stator:

Core: Composed of covered steel to minimize whirlpool current misfortunes.

Windings: Copper or aluminum windings are secured with high-quality separator, such as polyester, epoxy, or mica-based materials.

Reinforced separator layers are utilized to persevere high-frequency exchanging surges from variable recurrence drives (VFDs).

Slot Separator: Separator paper or fabric (e. g. , Nomex) is situated between the windings and the stator spaces to give extra assurance.

2. Rotor:

Squirrel Cage (Common Sort): By and large created from aluminum or copper bars short-circuited at both closes by rings. Separator is superfluous for the rotor as it is a short-circuited component, but safety measures are taken to deflect initiated shaft streams.

Wound Rotor (Less Common): If a wound rotor is utilized, its windings are moreover protected, associated to stator windings.

3. Orientation: Protects Orientation: Ceramic or half breed heading are utilized to block electrical streams from navigating the orientation, which can result in fluting and setting.

Shaft Establishing Gadgets: Shaft establishing brushes or rings are included to divert stray streams absent from the orientation.

4. Separator Framework: Varnishing: Windings are penetrated with varnish to upgrade mechanical quality and cover.

High-Voltage Separator: Designed to oblige voltage homeless people, especially in VFD applications.

Partial Release Resistance: Specialized cover materials lessen the chance of halfway releases actuated by high-frequency exchanging.

5. Outline: Regularly built from cast press, steel, or aluminum. The outline may be planned with fixed or encased lodgings to secure the engine in antagonistic situations.

7. Terminal Box: Separated Associations: Terminal boxes are outlined with protects bushings to deflect voltage spillage or arcing.

Surge Protection: Surge suppressors (like MOVs or TVS diodes) may be integrated to guard against voltage spikes.

8. Special Coatings: Anti-Corrosion Coatings: For motors employed in corrosive environments.

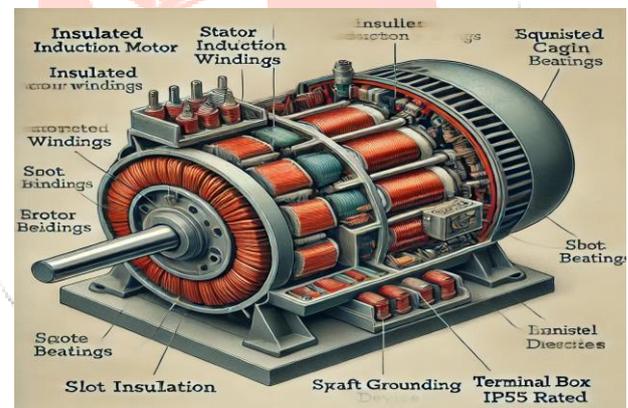


figure 6 insulated induction motor

The specifications of an insulated induction motor vary depending on the application, size, and insulation requirements. Below is a general outline of typical specifications:

1.8 Block diagram

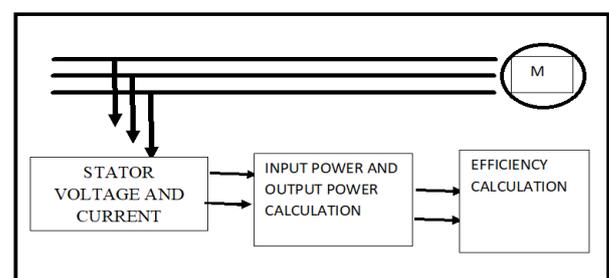


Figure 7: Generalized block diagram of propose approach

The figure appears to depict a block diagram of a system used for calculating the efficiency of an electrical machine (denoted as "M" in the diagram). Here's an explanation of the key components:

- 1. Stator Voltage and Current Measurement:** The leftmost block shows that the stator's voltage and current are measured. These signals represent the input electrical power provided to the machine.
- 2. Input Power and Output Power Calculation:** The second block takes the stator voltage and current measurements and uses them to calculate the input power. Additionally, the mechanical output power of the machine (likely derived from torque and speed measurements) is determined here.
- 3. Efficiency Calculation:** The third block uses the input and output power values to calculate the efficiency of the machine. Efficiency is typically calculated as: $\text{Efficiency} = (\text{Output Power} / \text{Input Power}) \times 100\%$
- 4. Connections:** The arrows represent the flow of data, starting from the measured electrical signals, proceeding to power calculations, and finally to efficiency computation.

Model Implementation

This Model implementation will be done using MATLAB Simulink software. The major blocks will be design in MATLAB simulink as follows:

- Simulation of power system using simpower system toolbox.
- Simulation of general three phase induction motor using sim power system toolbox.
- Simulation of insulated three phase induction motor using sim power system toolbox.
- Simulation of insulation and general induction motor efficiency and compare the result of both simulations.

MATLAB Simulation model

Case (A) General Induction motor

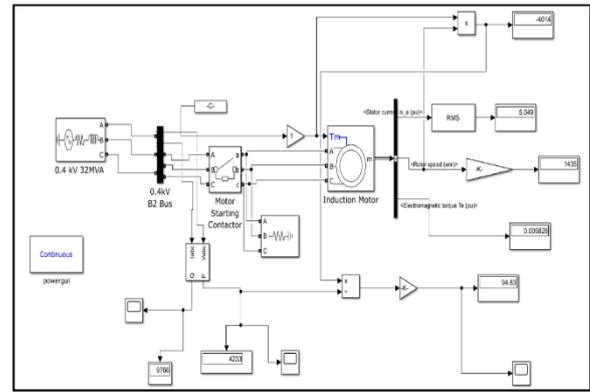


Figure 8: MATLAB Simulation model of general induction motor analysis

The image is a detailed simulation block diagram, likely developed in MATLAB/Simulink or a similar simulation tool. It represents the operation of an induction motor connected to a 0.4 kV power system and the calculation of various parameters such as stator current, rotor speed, torque, and efficiency. Below is a breakdown of the main components:

MATLAB simulation model parameter

Case (B) insulated Induction motor

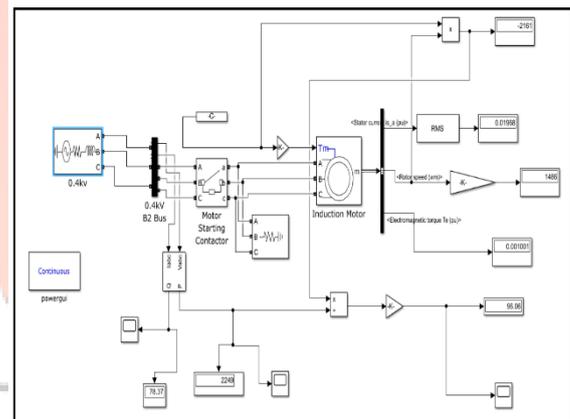


Figure 9: MATLAB Simulation model of insulated induction motor fault analysis

Key Parameters

- 1. Machine Rating (Power Output, kW):** Establishes cost variations and energy consumption.
- 2. Annual Operating Hours:** Impacts energy usage and cost savings associated with efficiency.
- 3. The economic impact of efficiency differences is influenced by the energy cost per kWh.**
- 4. Initial Cost:** Because they use better materials and designs, more efficient machines frequently have higher upfront costs.
- 5. Machine Lifetime:** Specifies the amount of time that energy savings accrue.

A) general condition (Without insulation)

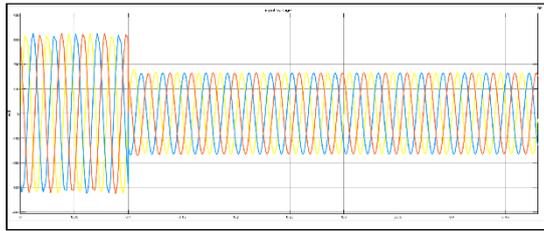


Figure 5.1: Analysis on voltage signal during normal condition

This figure appears to be a time-domain plot of input voltages. Here are the key observations:

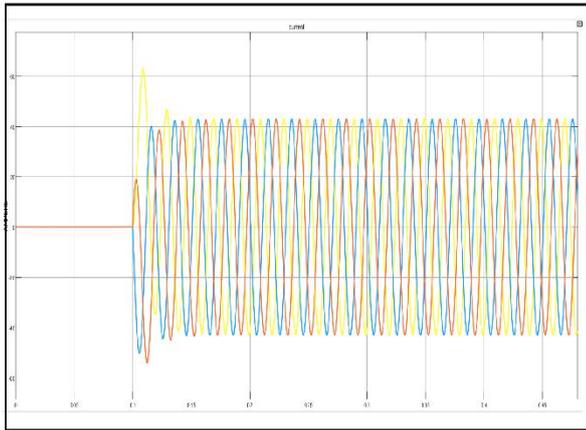


Figure 10: Analysis on current signal during normal condition

This type of plot could be from simulations or measurements in electrical systems, such as a power converter, motor control system, or a circuit simulation, where the goal is to analyze how the input voltages behave over time

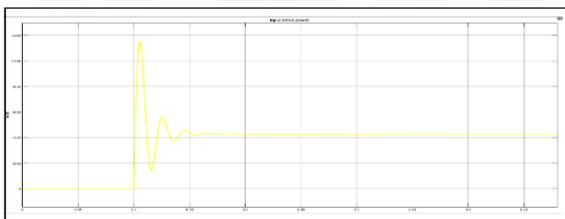


Figure 11: Analysis on input active power signal during normal condition

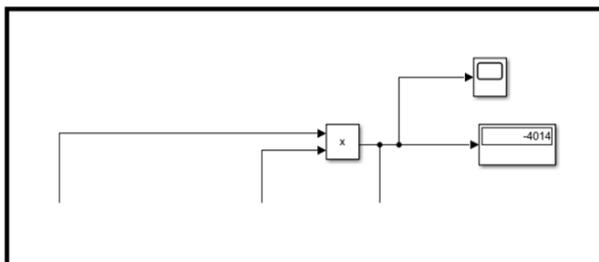


Figure 12: Analysis on output power signal during normal condition

This figure is a block diagram, likely representing part of a control or simulation model, possibly created in a simulation tool like MATLAB/Simulink. Here's an explanation of the components:

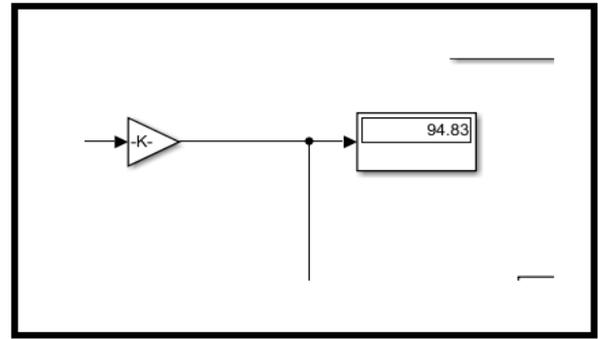


Figure 13: Analysis on efficiency signal during normal condition

This figure is another block diagram, likely from a simulation environment, showing a simple operation. Here's an explanation of the components:

B) Insulated condition (With insulation)

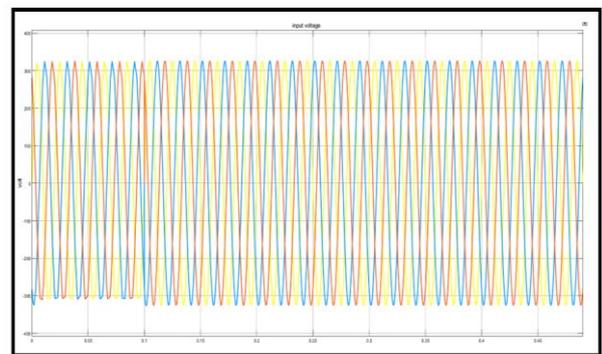


Figure 14 Analysis on voltage signal during insulated condition

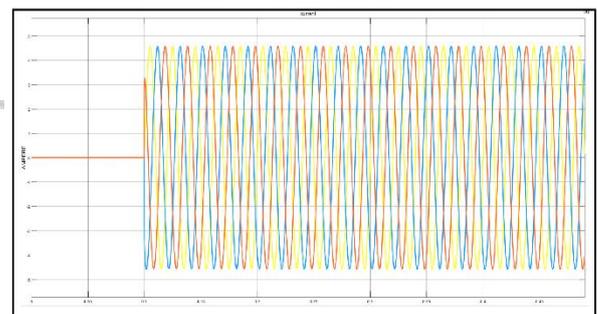


Figure 15 Analysis on current signal during insulated condition

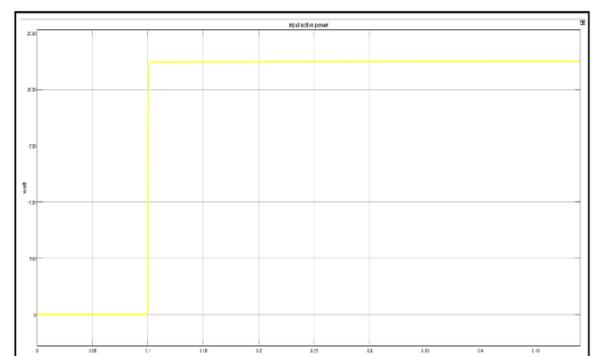


Figure 16 Analysis on power signal during insulated condition

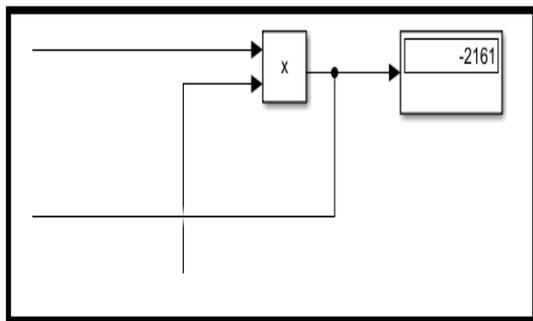


Figure 17 Analysis on output power signal during insulated condition

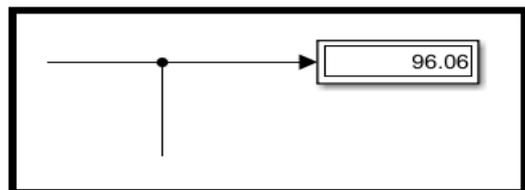


Figure 18 Analysis on output efficiency signal during insulated condition

Table 1 Comparison of Normal and insulated motor techniques

Sr No	Specification	Normal Motor	Insulated Motor
1	Input power	4233 watts	2249 watt
2	Output power	4014 watts	2161 watt
3	Stator resisitance	0.03513 ohm	6.03
4	Rotor resisitance	0.03488	6.085
5	Stator inductor	0.04586	489.3e-3
6	Rotor inductor	0.04586	489.3e-3
7	Speed RPM	1430	1486
8	efficiency	94.83%	96.06%
9	Electromagnetic torque	0.005828	0.001001
10	Input torque	26.71	61.369

Table 1 makes it evident that insulated induction motors are more efficient than general induction motors and that they also have superior speed, slip, and torque parameters.

Conclusion

We conduct a taste test at MATLAB after each machine has been designed and all electrical connections have been finished. The rotor rotates with a low initial torque when the motor is powered by a three-phase, 440-volt, 50-hertz supply. Therefore, we are altering the motor's rotor to achieve high starting torque. In order to properly check and run the insulated motor parameter and the general mode

without insulation motor, this thesis makes use of MATLAB software. The efficiency of the non-insulated motor is 94%, whereas that of the insulated motor is 96%.

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