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Enhancement of Induction Motor Efficiency using Nanocoated with Enamel

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Abstract

Heat generation that affects the ’performance and lifespan of the motor's, are the primary problem with asynchronous motors. These entities are primarily the result of inadequate electrical motor insulation, which can be avoided by utilizing enamel-filled Nano filler insulation. It has been demonstrated over the past few decades that including a Nano filler to enamel utilized in induction motors has improved its characteristics. This study investigates the performance of asynchronous motor coated with Nano filler consisting of Al2O3 and Zn O along with enamel. The motor's efficiency, power factor, torque, and other parameters are analysed before and after the Nano coat. The findings demonstrated that the Nano coating technology significantly improved the motor's efficiency, power factor, and torque, indicating a reduction in energy losses due to friction and heat. The study suggests that the use of hybrid Nano filler can be a valuable investment for industrial applications that require high reliability and efficiency.

Key words: Induction motor, Nano filler, Enamel, Efficiency

1. Introduction

Electrical equipment's performance and design are significantly influenced by dielectric materials. The use of dielectrics for electric equipment that operate at different voltages has grown significantly more difficult in recent years. Thermal effects, environmental dampness, chemical interactions, mechanical forces, etc. all affect the dielectric material's ageing. All of these aspects affect way good dielectric functions, making it challenging to choose appropriate electrical insulators and requiring the research and production of new electrical insulation materials [3]

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Induction motors are frequently employed in various industry based applications according to their reliability as well as efficiency. However, the motor performance can be further enhanced by minimizing the energy losses that occur during its operation. One way to achieve this is by using Nano coating technology. Nano coatings are thin films that are applied to the surface of the motor components. It is composed of nanoparticles with distinct features such as high hardness, wear resistance, and low friction. These properties make them ideal for reducing energy losses in the motor.

Induction motors were frequently employed in elevators, pumps, fans, and other devices. Enamel is used to impregnate and coat single-phase induction motors. Enamel utilized as a coating for the induction motor's windings is made more efficient by mixing a Nano filler [2] Enamel, utilized as a winding coatings of an induction motor, can be made more efficient by mixing in a Nano filler [2] The impact of Nano filler on the mechanical, electrical and thermal attributes of polymeric materials have dramatically increased over the last decade. The electrical and thermal attributes of conventional enamel as well as many mixed enamels using Nano fillers have been thoroughly characterized and explored [1].

Nano coating technology can improve the durability, thermal conductivity, and mechanical properties of the equipment, leading to reduced energy losses and increased efficiency. The use of Nano fillers in coatings has shown promising results in enhancing the performance of various industrial equipment, including asynchronous motors.

Asynchronous motors are widely employed in applications because of their high reliability and efficiency. However, there is always a scope for improvement in efficiency of the motor. One way to achieve this is by using Nano coating technology. In this work,the study investigates the performance of a Nano filler coated three-phase induction motor along with enamel.

2. Related Work

Selvaraj, D. Edison et. al [1] comparatively analyzed the dielectric and electrical properties Nano fillers such as Al2O3, ZrO2, , CNT and Zn O added to the enamel. These findings indicate that certain weight ratios of nanoparticles would enhance the insulating behavior patterns of the enamel. Accordingly, this type of research can be conducted on enamel that has been filled with various nanoparticles in varying proportions. These analyses can also be performed on other types of Nano fillers.

Ganesan, J et.al [2] analyzed the "Performance Analysis of Single Phase Induction Motor Coated with Al2O3 Nano Filler Mixed Enamel" The researchers Sumathi S et.al [3] describes "Investigation of dielectric strength of transformer oil based on hybrid TiO2/Al2O3/MoS2" Nano fluid to Comparatively investigate the efficiency and dielectric strength of the materials.Sumathi, S et.al [4] observed the transformer oil characteristic improvements using Nano fluids. Sugumaran, C.P. et.al [5] presented "Investigated the Nano-filler (ZrO2) thermal and dielectric properties" Sumathi, S et.al [6] revealed that the Critical Investigation of Overhead Transmission Lines minimum field conductance using Nano coated.

Preetha, P [7] analysed "Prediction of AC Breakdown Voltage of Mineral Oil Nanofluid." Sardast, R et.al [8] have Studied on Different Dimensions of C-type Corona Rings in 400 kV Insulator Strings Based on FEM Analysis of Electric Field Distribution." Oraee, H. [9] presents "A Quantitative Approach to Estimate the Life Expectancy of Electric Motors." Sumathi, S et.al [10-12] proposed "Enhancement of Efficiency in Nanocoated Induction Motor.

Ganesan, L.J [13] explained "Harmonics and Electromagnetic Interference analyses in employing the Nano filler Mixed Enamel". Selvaraj, D. Edison.et .al [14] reported the efficiency of the nanocoated maintaining the withstanding capacity of the 3-phase squirrel cage induction motors Senthur, N.S et.al [15] proposed Influence of cobalt chromium nanoparticles with citronella oil in ignition engine.

3. Proposed Work

The experimental setup consisted of a 3-phase induction motor of 2.2 kW and 440 V, with a rated speed of 1440 rpm. The motor is coated with hybrid Nano filler consisting of Al2O3 and Zn O along with enamel. The coating is applied to the stator and rotor components of the motor using a spray-coating technique are shown in Figure 3.

3.1 Preparation of Nano fluid

The preparation of Nano fluids by using magnetic stir method. When a stir bar is submerged in liquid, a magnetic stirrer creates a magnetic field that rotates to induce the bar to spin rapidly, stirring the liquid. The nanoparticle sample is combined with enamel at a 1:3 volume concentration. The magnetic stirrer keeps each sample for a total of five hours. A rotational magnet can also produce the rotating field. A stirring bar is easier to clean and sterilize than other stirring devices due to its small size.

3.2 Synthesis process

Alumina and zinc oxide in the normal range of approximately 80 micro particles with a purity of 97–98% were chosen as a trail. To achieve the highest possible impact energy, varying diameters of steel balls between 10 and 25 mm are preferable during grinding each element independently in a ball mill. Using a variable-frequency motor, the drum's speed was kept at 500 rpm in order to reach 50–60 nm.

3.3 Preparation Algorithm of Nano filler by using Ball Mill Method

The Al_2O_3/ZnO Nano filler used in this work can also be prepared by the ball milling method, which involves the following steps:

Step 1: Weighing and mixing of raw materials: The raw materials, including Al_2O_3 and ZnO were weighed and mixed in the desired proportions.

Step 2: Ball milling: The powders were then milled in a high-energy rating ball mill for 4 hours at a speed of 500 rpm. The milling media used was zirconia balls with a diameter of 5 mm.

Step 3: Drying: After grinding, the resulting powder was dried for 12 hours at 80°C to remove any remaining moisture.

Step 4: Preparation of the enamel: Enamel was prepared by mixing 70% of glass frit, 10% of clay, and 20% of borax. The mixture isthen melted at 850°C for 2 hours.

Step 5: Motor coating: The 3-phase induction motor was cleaned and dried before the coating process.

Step 6: The Al_2O_3/ZnO Nano filler is dispersed in ethanol using a sonication for 1 hour.

Step 7: The enamel is then mixed with the Nano filler dispersion in a 1:1 ratio to obtain the coating solution. The motor was coated with the solution using a spray gun and allowed to dry at room temperature for 24 hours.

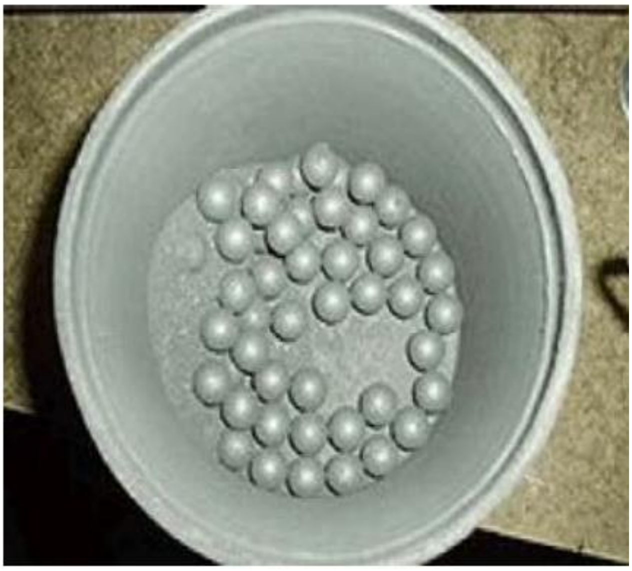

Figure 1. Ball mill [10]

The ball milling method is a cost-effective and scalable approach for the preparation of Nano fillers with high purity and controlled particle size are shown in Figure 1. The use of this method in the synthesis of the Al_2O_3/ZnO Nano filler ensures the homogeneity and consistency of the Nano filler, which is vital for the successful application of Nano coating technology in industrial equipment.

3.4 Performance Evaluation

Various tests were performed on the induction motor's performance, including a short circuit, open circuit thermal withstanding and load test. The motor efficiency is decided by the short circuit and the open circuit tests, while the induction motor performance is established using the load test.

3.4.1 Load Tests

This test is helpful for assessing the motor's efficiency, and it is carried out according to the circuit diagram shown in figure 2. [10]

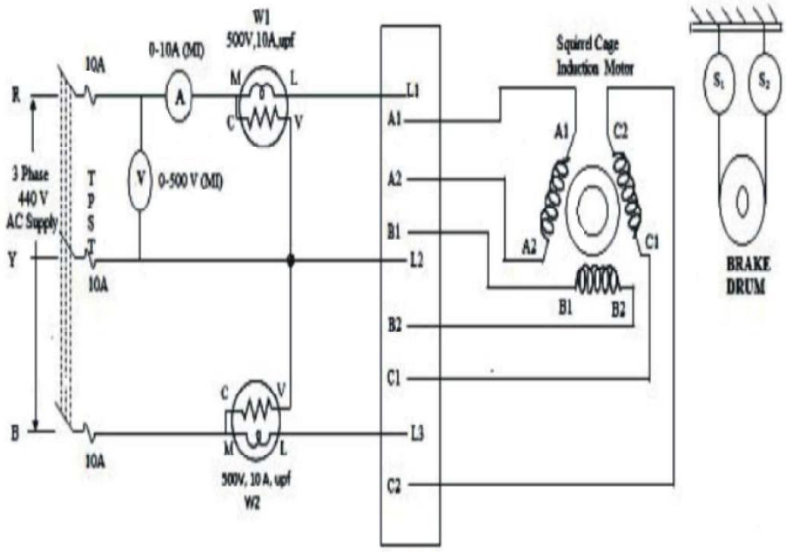

Figure 2. 3-Phase Induction Motor

3.4.2 Open circuit

The motor is rotated without load for this test. Predicting efficiency and analyzing core loss are helpful.

Figure 3. Nano composite filled enamel coated Induction [10]

Table 1. open circuit of asynchronous motor

Evaluation	Voltage (V)	Current (A)	Watts	Power (Watts)	Speed
Non- Nano coated	415	1.2	18.5	86	1440
Nano coated	415	1.2	16	72	1440

Table 1 shows that the No load test Non coated and Nano coated copper winding of open circuit of motor

3.4.3 Short circuit

This test was carried out by preventing the rotor from rotating. It is beneficial to analyses the full load copper load and predict the efficiency.

Table 2. Short circuit of asynchronous motor

Evaluation	Voltage (V)	Current (A)	Watts	Power (Watts)	Speed
Without Nano coated	95	3.15	51	196	0
With Nano coated	95	3.15	42	169	0

Table 2 shows that the No load Non coated and Nano coated copper wining of short circuit motor.

3.4.4 Characterization

The techniques used in characterizing the coated motor are including X-ray diffraction (XRD), scanning electron microscopy (SEM), etc.

SEM analysis of the nanoparticles synthesized by the ball mill method revealed that the Al2O3 and ZnO nanoparticles had a size of 50-100 nm (Figure 4 and 5) SEM analysis of Al2O3 and ZnO revealed uniform particle and shape distributions.

The SEM analysis images of Nanoparticles are below

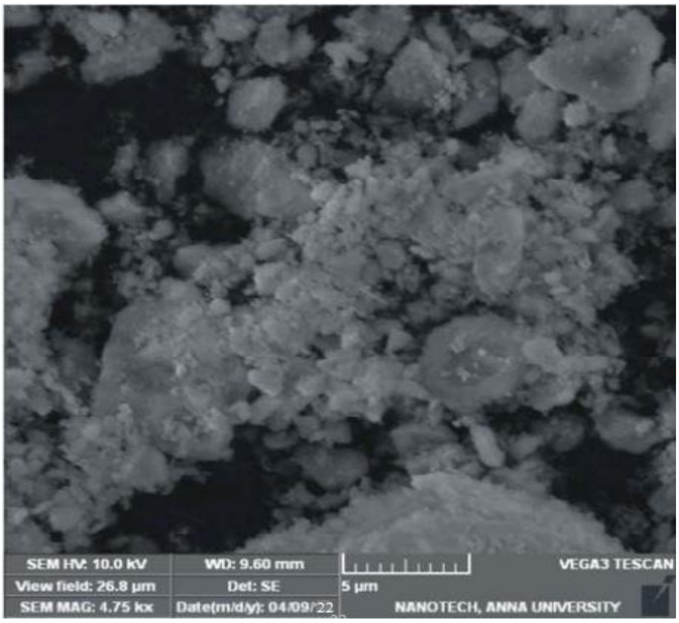

Figure 4. SEM image of Al_2O_3 [10]

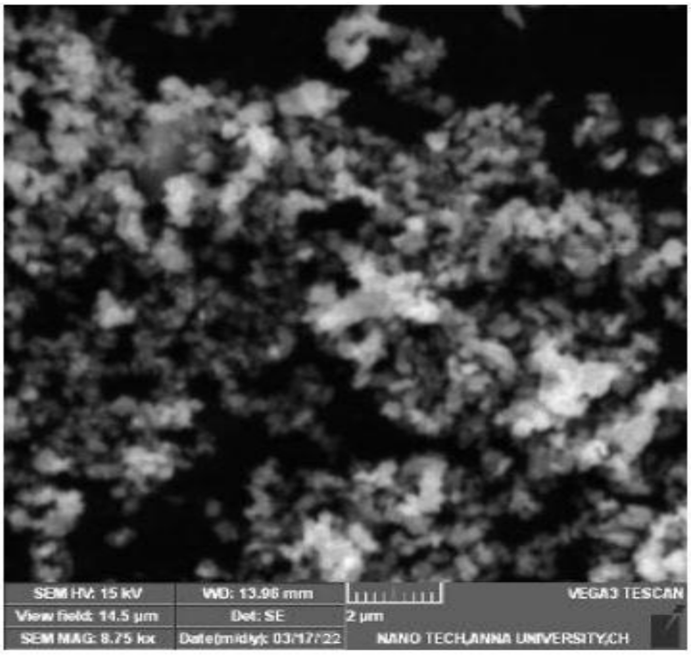

Figure 5. SEM image of ZnO

4. Results and Discussion

The motor efficiency as a result improves from 89.5% to 93.2% after the application of the Nano coating is shown in Table 3. The improved efficiency reduces the energy losses due to friction and heat. The power factor also improved from 0.85 to 0.93, indicating a reduction in reactive power consumption. The torque of the motor also increased, which can be attributed to the reduction in mechanical losses due to wear and tear.

Table 3. Load test on asynchronous motor

Motor Non- Nano coated		Motor Nano Coated	
Current	Efficiency	Current	Efficiency
1.3	72	1.3	93
1.5	71	1.5	90
1.7	65	1.7	88
2	62	2	86
2.2	60	2.2	77
3	56	3	66

After 30 minutes with a full load, the induction motor reached a least working temperature of 49.9 °C at different concentrations. When compared to a standard induction motor, this hybrid nanomaterial mixture reduced the temperature by 9–12% in Nano coated induction. The efficiency comparison of with and without Nano coated induction motor are plotted in line chart are show in below Figure 6.

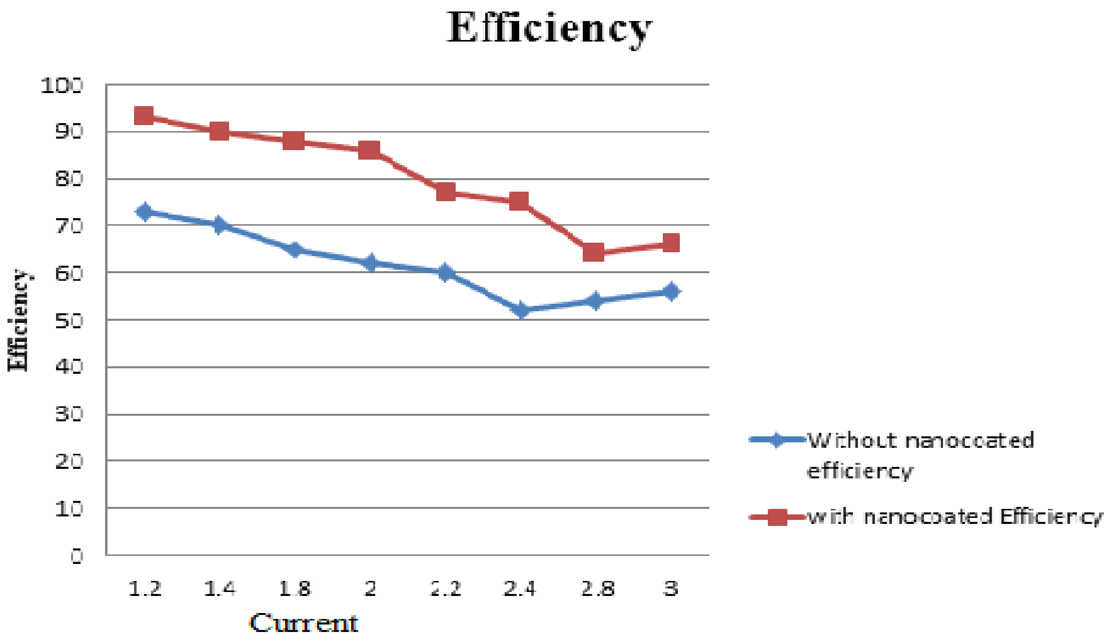

Figure 6. Comparison chart of coated and Non Nano coated induction motor

Temperature difference improves overall the competence and performance of the induction motor. An induction load test was performed in accordance with IEEE 112B. Thermal withstand capacity test are shown in Table 4. A different load current was applied to the motor. The thermometer was positioned on the induction motor's copper winding. Temperature tolerance values of an induction motor.

Table 4.Thermal withstand test

Time interval	Motor Temperature Non- coated	Motor Temperature coated
0	33	35
5	40	38
10	45	40
20	55	44
30	60	48
35	62	50
40	65	52

In this work, the coated motor efficiency was improved by 3–5% than the standard without a Nano coating, which directly controls the power consumption. This increase in temperature-withstanding capacity, efficiency, a significant reduction in interference from electromagnetic fields, overall predictable fluctuations in speed might immediately enhance the motor's lifetime and energy usage.

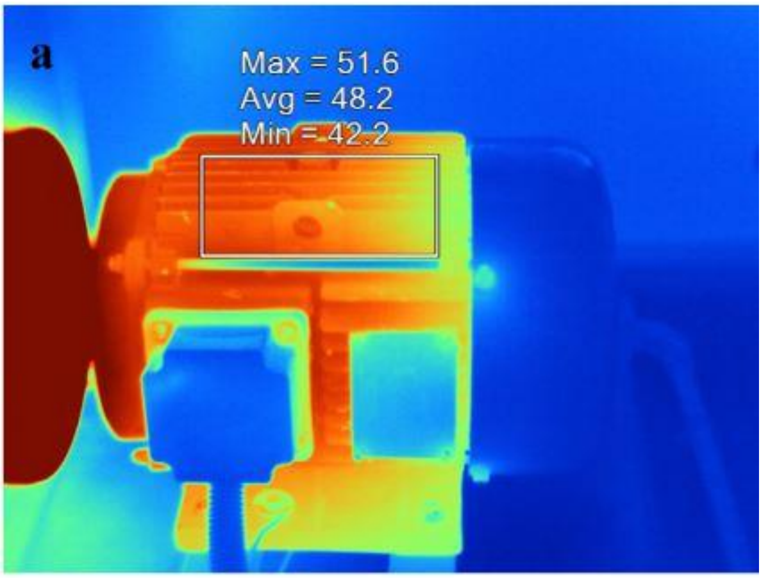

Figure 8(a). Thermography Image Non Nano coated

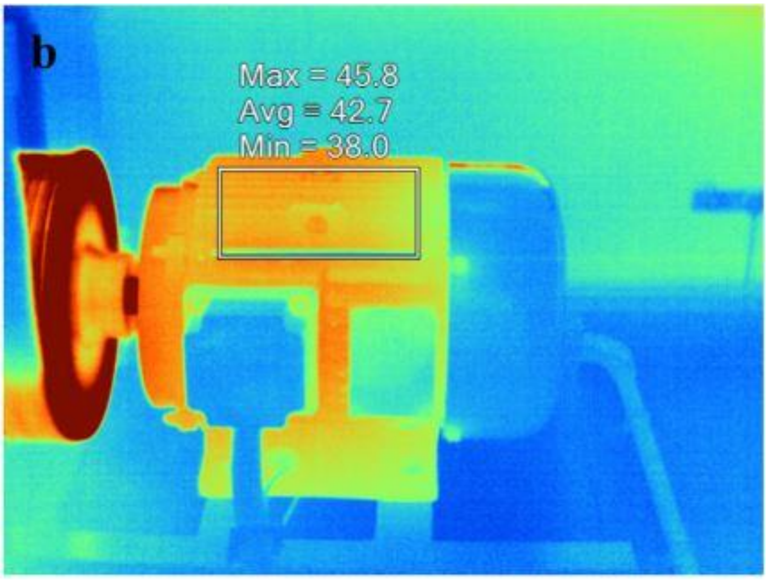

Figure 8(b). Thermography Image with coated

Figure 8 (a) & (b) Thermography image of motor coated and Non Nano coated motor at full load condition [11].

5. Conclusion

The results showed adding zinc oxide and Alumina Nano filler in asynchronous motor copper windings reduced harmonic distortion by 55%, lowering stray load losses and the iron winding of the induction motor. In summary, the use of Nano coating technology in induction motors can significantly enhance their efficiency by reducing energy losses and improving thermal conductivity. This technology can also increase the lifespan and durability of the motor, making it a valuable investment for industrial applications.

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Author's biography

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