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Enhancement of Efficiency in Nanocoated Induction Motor

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Abstract: Three Phase Induction motors consumes 60% - 65% of industrial electricity. 1% increase in efficiency of all the motors in india will save the power of 500 MW powers. Lots of research work has been carried out by the researches to control the power consumption in all electrical applications more specifically in high voltage applications. In recent days, it has shown that the mixing of nanofillers to enamel can improve the mechanical, electrical and thermal properties. In this work Al_2O_3 has been used as nanofillers for coating the winding of induction motor with enamel. The nanofluids are prepared by ball milling method and particle size of the Al_2O_3 analyzed by Scanning Electron Microscope (SEM). The performance of nanofillers with enamel-coated induction motor is analyzed by the different tests such as open circuit test, short circuit test and load test. It was conformed that the efficiency of the three-phase squirrel cage induction motor coated with enamel filled with Al_2O_3 nanofillers was increased by 3-4% when compared to that of the three phase squirrel cage induction motor coated with pure enamel filled.

Key words: Three phase induction Motor · Nanofillers · Al_2O_3 · Performance analysis

INTRODUCTION

Induction motors are widely used in latches, centrifugal pumps, grinders, drilling machines, printing machines and so on. The efficiency of the induction motors mainly depends on the insulation used [1] [2]. Generally in motors, enamel is used for impregnation, Coating and adhesion. In the resent years solid dielectric are commonly used as insulation for electrical equipment, as these solid dielectric elements have the properties to withstand high electric field and improves efficiency. This characteristics of solid dielectric element will be further improved by reinforcing nanoparticles [3].

The broad application of mineral oil for high voltage insulation and power equipment cooling has promoted research work to improve the characteristics of dielectric and cooling property through nanotechnology after significant research improvement in nanodielectrics. A contemporary instance of this research work is the preparation of dielectric nanofluids. A fluid with dispersion of nanoparticles and is named as nanofluid, a term conferred by Choi at Argonne National Lab in 1995 [4].

The efficiency of the normal three-phase squirrel cage induction motor can be improved by nanofillers with enamel, which is coated on the winding of the motor [5]. It was a well-known fact that the working temperature of an electric machine has a very strong relationship with the life period of the insulation [6]. The insulating enamel mostly used for coating the machine windings were organic in nature, which adversely affected by thermal decomposition and this can be analyzed by heat run test.

The dielectric losses will depend upon the breakdown strength, type of applied voltage, partial discharge characteristics, intensity of electrical field and frequency.

Synthesis and Preparation-Nanocomposites

Synthesis of Nanparticle: Al_2O_3 nanoparticle was synthesized using ball mill. A ball mill is used to grind materials into extremely fine powder to use in lubricants, paints, pyrotechnics and ceramics. Tungsten carbide balls were used as the grinding media. The inner walls of the vial are also coated with a layer of tungsten carbide because of its high hardness, wear resistance and impact strength. Milling was done at the rate of 300rpm under

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normal atmospheric conditions [7]. The mode of operation is through a variable frequency drive whose frequency is 50 Hz. The material and the media are then agitated by a shaft with arms, which are rotating at high speed. This causes the media to exert both shearing and impact forces on the material resulting in optimum size reduction and dispersion. An internal cascading effect reduces the material to a fine powder.

Fig. 2 shows the SEM images of Al_2O_3 after the ball milling process. SEM can produce image of greater clarity and three-dimensional quality and required less sample preparation. SEM is especially useful because it has a large depth of field, i.e. more of the image being magnified is in focus. In addition, it has an extremely wide range of magnification, producing images in the range of 10 to 100000 times the normal size.

The SEM images of Al_2O_3 nanoparticle, which are produced after 40 hours of ball milling process in the atmospheric medium.

Fig. 1: Ball Milling

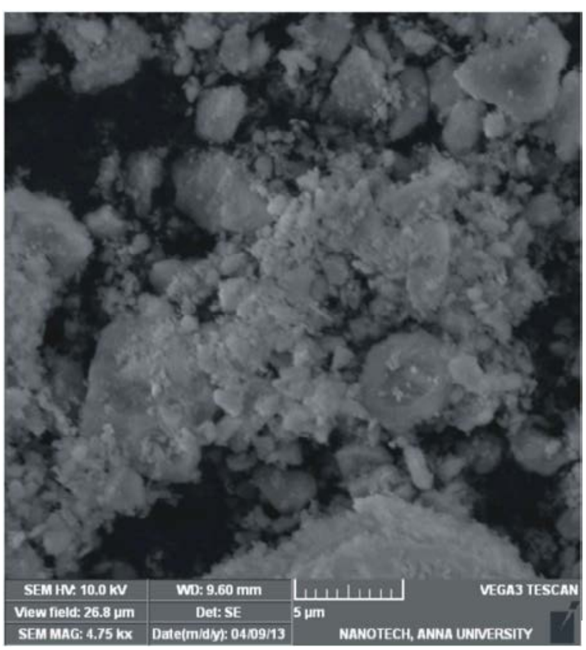

Fig. 2: SEM image for aluminium dioxide

Preparation of Nanofluid: Nanofluid is prepared by using magnetic stirrer. A magnetic stirrer employs rotating magnetic field to cause a stir bar immersed in a liquid to spin very quickly, thus stirring it.

The sample of Al_2O_3 taken with 1:3 volume concentrations mixed with enamel. Each sample is kept for 5 hours in magnetic stirrer. The rotating field may be created either by a rotating magnet or a set of stationary electromagnets, placed beneath the vessel with the liquid. Because of its small size, a stirring bar is more easily cleaned and sterilized than other stirring devices. Magnetic stirrers may also include a hot plate or some other means for heating the liquid. The specifications of the three phase squirrel cage induction motor were shown in Table 1.

Review of Aluminium Oxide: Al_2O_3 is an electrical insulator but has a relatively high thermal conductivity (30 Wm-1K-1) for a ceramic material. Aluminium oxide is completely insoluble in water.

In its most commonly occurring crystalline form, called corundum or α-aluminium oxide, its hardness makes it suitable for use as an abrasive and as a component in cutting tools.

Performance Analysis: The performance of the three phase squirrel cage induction is analyzed by performing various test.

Open Circuit Test: This test was performed by rotating the motor without load. It is useful to analysis the core loss and pre determine the efficiency [8].

Table 6 shows the No-load test without and with nano coated copper winding of three phase squirrel gage induction motor.

Fig. 3: Nanocomposite filled enamel coated Induction motor

Table 1: Specicications of 3Φ Induction motor

Quality	Rating
Power	0.5 HP
Speed	1500 rpm
Current	4 A
Voltage	220 v

Table 2: Physical properties of Aluminium Oxide

Property	Value
Atomic Composition	> 99%
Crystalline structure	corundum
Grain size (microns)	1 - 5
Density (g/cm3)	3.95
Water absorption (%)	0

Table 3: Mechanical Properties of Aluminium Oxide at 20°C

Property	Value
Tensile strength (N/mm^2)	200-250
Bending strength (N/mm^2)	200-600
Compressive strength (N/mm^2)	1900-2000
Young's modulus (N/mm^2)	3.8 * 10^5
Poisson's ratio	0.25-0.30
Density	3.95-4.1 g/cm^3
Melting point	2977°C
Boiling point	2997°C
Solubility in water	Insoluble

Table 4: Thermal Properties of Aluminium Oxide

Property	Value
Dilation co-efficient (20-2000°C)(°C^{-1})	8.4 *10^{-6}
Specific heat 100°C (J/kg.K)	930
Thermal conductivity at 20°C (W/m.K)	40
Thermal shock resistance (°C)	200

Table 5: Electrical Properties of Aluminium Oxide

Property	Value
Resistance at 20°C (ohm.cm)	>10^{14}
Dielectric constant at 20°C and 1Ghz	9.5
Dielectric rigidity at 50Hz (KV/mm)	30

Table 6: Open Circuit Test of 3Φ Induction motor

Test	Line Voltage v	Line Current A	Watt. Reading	Power watts	Speed rpm
Without Nano Coated	415	1.2	18	85	1440
With Nano Coated	415	1.2	15.75	70	1440

Table 7: Short Circuit Test of 3Φ Induction motor

Test	Line Voltage v	Line Current A	Watt Reading	Power watts	Speed rpm
Without Nano Coated	95	3.15	50.5	195	0
With Nano Coated	95	3.15	43	170	0

Short Circuit Test: This test was performed by blocking rotor, so that it will not rotate. It is useful to analysis the full load copper loss and predetermines the efficiency [8].

Table 7 shows the No-load test without and with nano coated copper winding of three phase squirrel gage induction motor.

Load Test: This test is useful in determine the efficiency of motor [8] and test conducted as per the circuit diagram as shown in Fig. 4.

The efficiency of the Nano coated induction motor was increased to maximum of 4%. This is mainly due to reduction of dielectric losses.

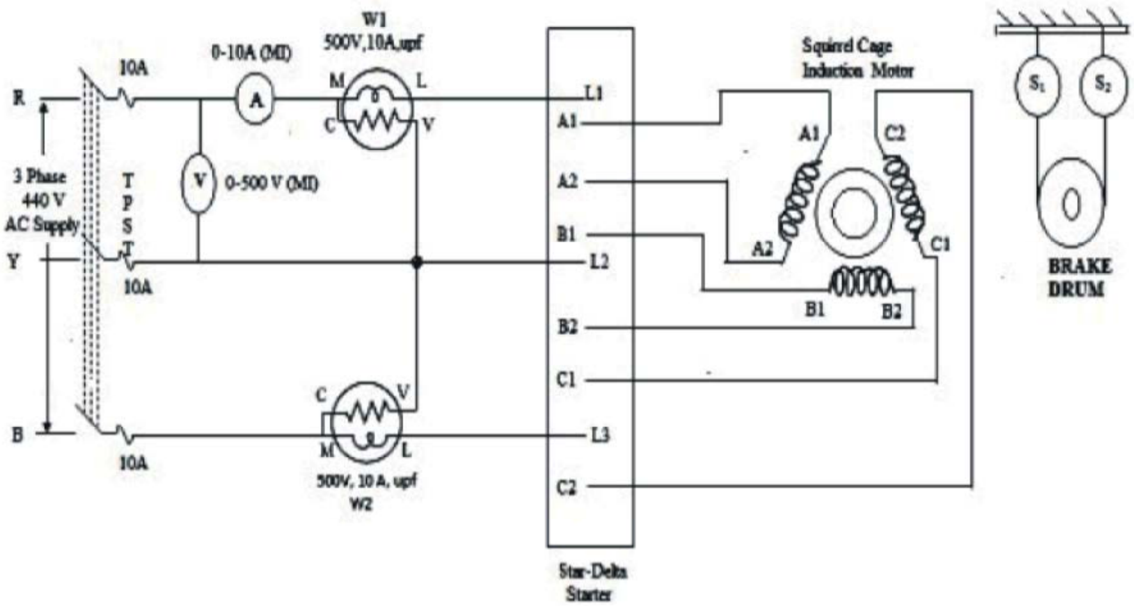

Fig. 4: Ciruit diagram for load test on 3? induction motor

Table 8: Load Test on 3Φ Induction motor

Motor without nano coating		Motor with nano coating	
Current (A)	Efficiency (%)	Current (A)	Efficiency (%)
1.2	73	1.2	77
1.4	70	1.4	74
1.8	66	1.8	69
2.2	61	2.2	64
3	58	3	62

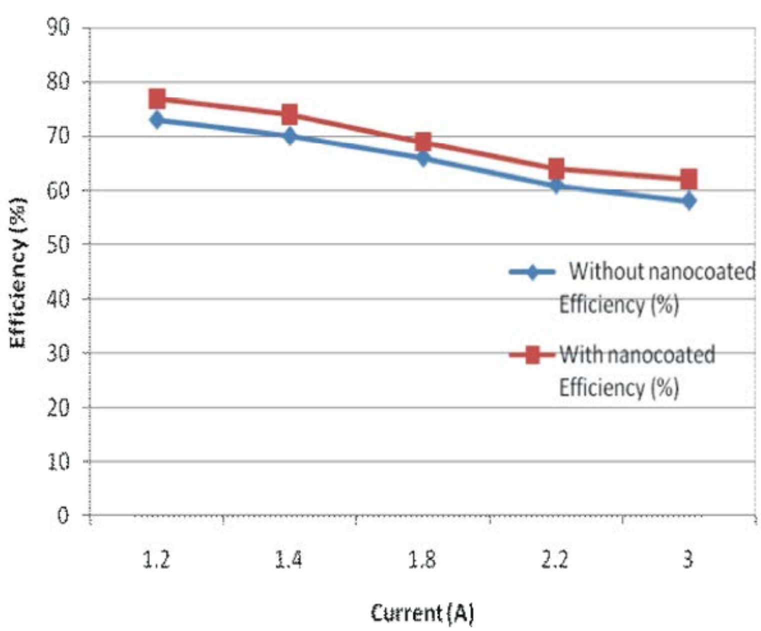

Fig. 5: Efficiency Comparison of with and without nanocoated induction motor

CONCLUSION

In this paper, Al_2O_3 nanoparticle was selected in the composition of 1:3 with enamel and this composition coated on winding of three phase squirrel cage induction motor. The following observations are studied,

- The efficiency of induction motor was increased by 3 - 4 % by adding the nanoparticle to the coating for the wounding of three phase squirrel cage induction motor which can be tested by using load test.
- The speed fluctuations were also less and smooth when compared to the ordinary three phase induction motor.

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