Reduction of Electromagnetic Interference in Three Phase Squirrel Cage Induction Motor by Coating of Nano Composite Filled Enamel to the Windings of the Motor

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Abstract - It has been shown that the addition of nano composites to the enamel can greatly improve the thermal, mechanical and electrical properties of enamel. A nano composite (TiO_2+SiO_2) has been tested as nano filler. The micro particles of TiO_2 and SiO_2 are converted into nano particles with the help of ball mill. Scanning electron microscope (SEM) has been used to augment the particle size of nano composite. The nano sio_2 and tio_2 materials taken in the ratio of 1:3 were mixed with enamel by using ultrasonic vibrator. The enamel filled with nano composite was coated on the windings of a motor. The values of electromagnetic inference produced by normal induction motor and nano coated induction motor was measured and analyzed. There was a reduction of 15 to 60% in the values of the electromagnetic interference produced by the normal induction motor when compared to that of nano composite filled enamel coated induction motor at various distances. Hence, the nano composite filled enamel coated induction motor can be used to reduce the electromagnetic interference produced by the induction motor. This method can be used as one of the method to reduce the electromagnetic interference by the induction motors. This method does not require extra cost and hence, it is also an economical method of reducing electromagnetic interference produced by motors.

I. Introduction

Insulating materials are construction materials which are frequently employed in contact with metals. In equipment and installations for the supply of electricity, heat is generated by ohmic losses in conductors, through dielectric losses in insulating materials and through magnetization and eddy-current losses in the iron [1]. The dielectric losses will depend upon the dielectric properties of the insulation. These losses will depend upon the breakdown strength, partial discharge characteristics, frequency, type of applied voltage, intensity of electric field and loss tangent [2] [3].

The human body acts as an antenna for the electromagnetic waves produced by AC electrical transients, much of it in the 50 to 100 kHz range. In October of 2007 The World Health Organization recognized the danger of these frequencies and stated: high levels of exposure to electric and magnetic fields in the frequency up to 100 kilohertz can affect the nervous systems, resulting in acute health effects, including nerve stimulation. For a 60 Hz (60 oscillations per second) field with strength of three milligauss, a current is created in an adult, which is on average, one-billionth amp per square centimeter of cross-sectional area. For these currents induced by magnetic fields, the current per area increases proportional to the linear size of the organism. An AC electric field will also create a current in the body. Armed with this knowledge it only makes good sense to protect humans from these dangerous EMF frequencies.

For motors, the enamel is used for three purposes: impregnation, coating and adhesion. Varnishes are composed of a polymer matrix containing inorganic particles such as Al_2O_3, TiO_2, SiO_2 and ZnO to increase PD resistance by decreasing the PD induced erosion rate [7]. This paper focuses on the reduction of the electromagnetic interference in the induction motor by coating the enamel which is filled with nano composites of SiO_2 and TiO_2 in 1:3.

II. Design of induction motor

The design of the induction motor involves the following details:

1. Design of Main dimensions
2. Number of stator slots
3. Turns per Phase
4. Number of Coils
5. Type of winding

Design of Main dimensions

$Q = kW/n_S*\cos ø$
$= 2*0.746/0.77*0.78$
$= 2.48$ kW
Output coefficient$=11 * kW * b_{av} * ac * 10^{-3}$
$= 11*0.955*0.45*23*10^{-3}$
$C_o = 108.7$
Syn speed $= n_S = 2 * f / p = 2 * 50/4 = 25$ rps
$D^2 L = Q / C_o * n_S = 2.48 / 108.7 * 25 = 9.14 * 10^{-4}$ m^3
For a cheap design ratio, L / t = 1.5 to 2
$T = \pi*D / p$
$L / \tau *D / p = 1.5$
$L / D = 1.178$
$1.178D^3 = 9.14*10^{-4}$
$D = 0.091$ m
$0.091^2 * L = 9.14 * 10^{-4}$
$L = 0.1103$ m
$\tau = \pi * D / p = 0.07147$ m
Pole pitch = 0.07147 m
Radial duct = 10 mm
Net length $= L_t = 0.9 * 0.113 = 0.09027$m

Number of stator slots

Taking slot per pole phase $= q_S = 3$
Total no of stator slot $s_s = 3 * 4 * 3 = 36$
Stator slot pitch $= y_{ss} = \pi * D / s_s = 0.7941$ m
Total no of stator Cond $= 6 * t_s = 3195$
Conductor per slot $z_{ss} = 3195 / 36 = 89$
Actual no of turns per phase,
$t_s = 36 * 89 / 2 * 3 = 534$

Turns per phase

$ø_m = b_{av} * L * \tau = 0.45 * 0.1103 * 0.0714$
$ø_m = 3.543 * 10^{-3}$ Weber
Stator voltage per phase $E_s = 400$ V
Stator turns per phase $t_s = E_s / 4.44f\, ø_m$ kW
$t_s = 532.51$

Number of Coils

No. of coil = 36 / 2 = 18
No. of coil per phase = 18 / 3 = 6

Type of winding used for different slots

1 to 8 slot (single layer winding)
36 to 7 slot (double layer winding)

The cross-section view of the induction motor was shown in the figure 1. The winding is coated with the enamel to increase the insulation strength between the windings.

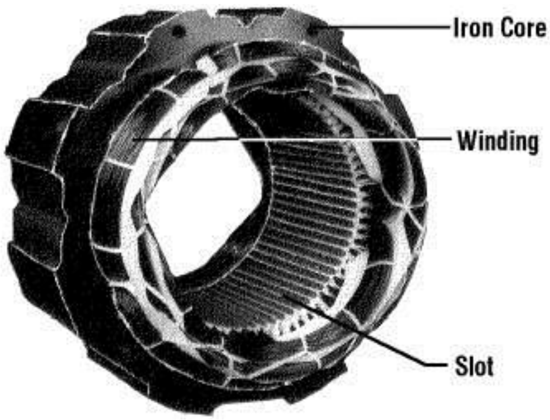

Figure 1 Induction motor

III. Preparation of Nanofillers

The micropowders of SiO_2 and TiO_2 were crushed into nanopowders by Ball Mill method [8] [12]. The SEM images of SiO_2 and TiO_2 before and after Ball Mill show the particle size of the powders. The particle size was augment by SEM images.

IV. Coating of the nanocomposite filled enamel to the windings of the motor

The nanopowders of SiO_2 and TiO_2 were taken in the proportion of 1:3. Then, the nanocomposites of SiO_2 and TiO_2 taken in 1:3 were mixed with the enamel by using ultrasonic vibrator. Further, this enamel was coated on the windings of the three phase squirrel cage induction motor. The specifications of the three phase squirrel cage induction motor were shown below in the table 1. Figure 2 shows the Nanocomposite filled enamel coated induction motor

Table 1 Specifications of the three phase squirrel cage induction motor

Quantity	Rating
Power	1.5 HP
Speed	1450 rpm
Current	3.45 A
Voltage	415 V

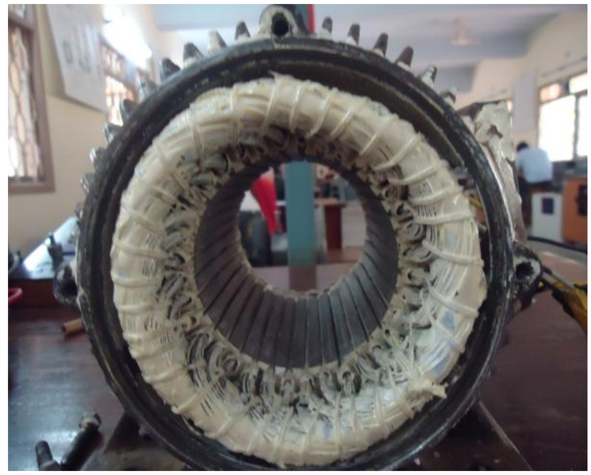

Figure 2 Nanocomposite filled enamel coated induction motor

V. Experimental Analysis of Electromagnetic Interference

The electromagnetic fields are force fields, carrying energy and capable of producing an action at a distance. These fields have characteristics of both waves and particles. An electric current flowing in a wire or coil produces its own magnetic field. The electromagnetic interference will also depend upon the dielectric and magnetic materials used in the motor. The electric field will depend upon the dielectric materials and the magnetic field will depend upon the magnetic materials. But as per Maxwell's equation, there was an inter-relation between the electric and magnetic field. Poisson's equation is called as Electrostatic governing equation and Helmholtz equation is called as Electromagnetic governing equation for the time varying field. The electromagnetic interference was measured by means of Gauss meter and Tesla meter. Table 2 shows the values of electromagnetic inference produced by normal induction motor and nano coated induction motor in terms of Gauss and Tesla. From these measurements, it was observed that there was a reduction of 15 to 60% in the values of the electromagnetic interference produced by the normal induction motor when compared to that of nanocomposite filled enamel coated induction motor at various distances. Hence, the effect of electromagnetic interference was reduced to the humans, other electrical devices, communication devices and measuring instruments.

Table 2 Measurement of Electromagnetic Interference

Distance	Ordinary motor		Nanocoated motor	
	Tesla	Gauss	Tesla	Gauss
30 cm	0.07	0.7	0.03	0.3
25 cm	0.08	0.8	0.06	0.6
15 cm	0.18	1.8	0.15	1.5
10 cm	1.18	12.3	0.80	7.9
5 cm	6.24	58.6	4.69	46.14
1 cm	19.13	189	17.14	171.5
On the casing	12.05	119.2	9 .42	98.5

VI. Conclusions

The following observations were made as per this study:

1. There was a reduction of 15 to 60% in the values of the electromagnetic interference produced by the normal induction motor when compared to that of nanocomposite filled enamel coated induction motor at various distances.
2. The nano nanocomposite filled enamel coated induction motor can be used to reduce the electromagnetic interference produced by the induction motor at the normal cost.

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