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Analysis of Thermal withstanding capacity of three phase squirrel cage induction motor coated with SiO_2 & TiO_2 nanocomposite filled enamel

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Abstract — **It has been examined that the addition of nanocomposites to the enamel can greatly improve the thermal, mechanical and electrical properties of enamel. In electrical machines, enamel was used mainly in three different ways: impregnation, coating and adhesion. 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. Heat run test was performed on electrical machines to determine the total loss of energy dissipated as heat. It was a well-known fact that the operating temperature of an electric machine has a very strong relationship with the life duration of the insulation. The insulating enamel mostly used for coating the machine windings were organic in nature, and were adversely affected by thermal decomposition. But the addition of nanocomposites to the enamel has increased the temperature withstanding capacity of the induction motor.**

Keywords— **Induction Motor, Enamel, Nanocomposites, Sem, Sio_2, Tio_2, Thermal Ageing.**

I. INTRODUCTION

In the last few years, a great deal of attention has been given to the applications of nano dielectrics in the field of electrical insulating materials. It has been reported that the use of nano composites to the enamel can greatly improve the thermal, mechanical and electrical properties of it [1]. In electrical machines, insulating enamel was used mainly in three different ways: impregnation, coating and adhesion. A heat run test was performed on electric machines to determine the total loss of energy dissipated as heat. It was a well-known fact that the operating temperature of an electric machine has a very strong relationship with the life duration of the insulation. The insulating enamel used for coating the machine windings were organic in nature and were adversely affected by thermal decomposition.

I. Synthesisation And Characterization Of Nano Particles

A. *Ball Mill Method*

Ball mill was an efficient tool for converting micro powder into nano powder [1]. There are two ways of grinding: dry process and the wet process. The Silicon dioxide and titanium oxide nano filler was synthesized by this method. The pulverization planetary ball mill was universally applicable for quick dry or wet grinding of inorganic and organic samples.

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B. Characterization Of SiO_2 And TiO_2

Hitachi SU1510 was a compact, high performance scanning electron microscope. It was used for analyzing the particle size of SiO_2 and TiO_2 micro and nano particles. High resolution imaging was provided by this electron microscope. The SiO_2 and TiO_2 particles were subjected to scanning electron microscopy to analyze the particle size and structure of the nano particles.

The figures 1 and 2 show the SEM analysis of micro range of SiO_2 and TiO_2 before ball mill synthesization method.

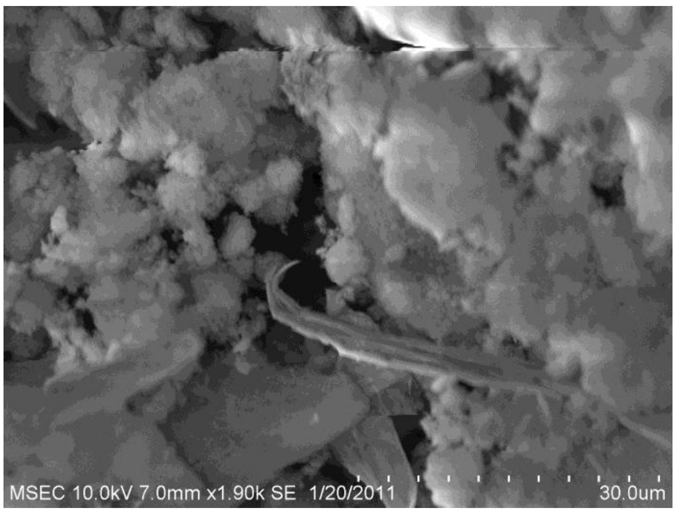

Figure 1 SEM analysis of SiO_2 at 30 μm

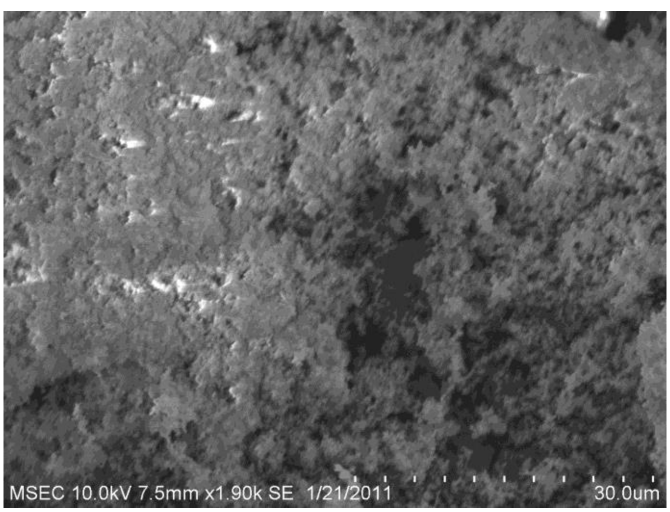

Figure 2 SEM analysis of TiO_2 at 30 μm

The figures 3 and 4 show the SEM analysis of SiO_2 and TiO_2 after ball mill synthesization method.

The micro size particle are converted into nano size with the help of Ball Mill .The SEM results show that the particles were in the form of nano metric range varies. The sizes of the particles were in the range from 40 to 100 nm size.

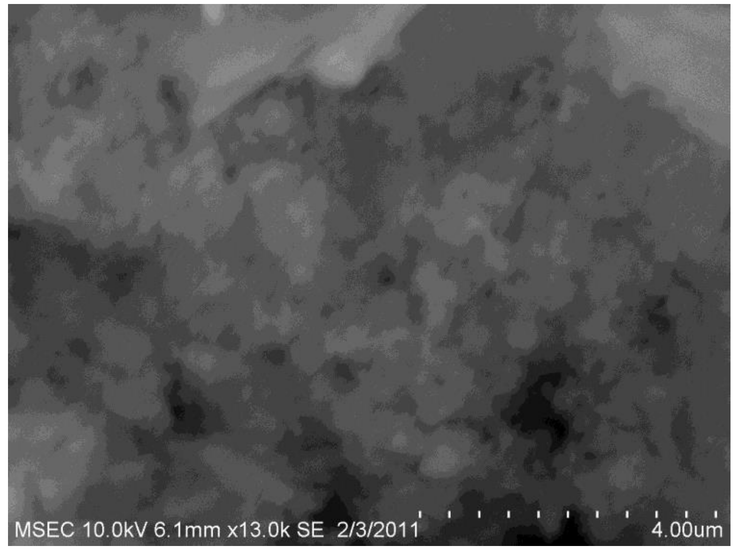

Figure 3 SEM analysis of SiO_2at 4 μm

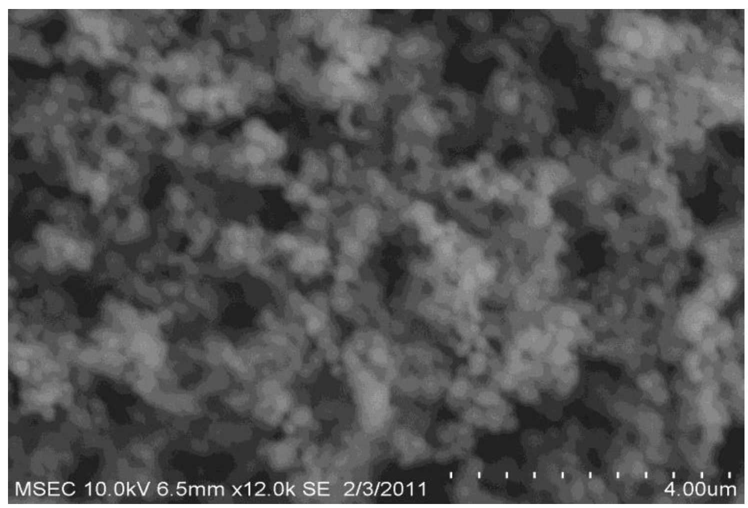

Figure 4 SEM analysis of TiO_2 at 4 μm

C. Coating of nanocomposite filled enamel

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 as shown in figure 5.

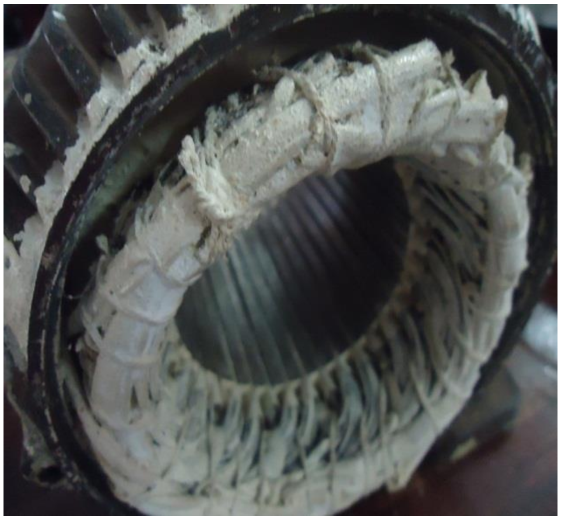

Figure 5 Nano composite motor

The specifications of the motor were given in Table I.:

TABLE I 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

II. TEMPERATURE TEST

Heat run test was performed on electric machines to determine the total loss of energy dissipated as heat. It was a well-known fact that the operating temperature of an electric machine has a very strong relationship with the life duration of the insulation. Heat run tests were conducted on this motor as per IEC 60851. The temperature of the motor was measured under different conditions and the readings were shown in the tables I to IV.

TABLE I MEASUREMENT OF TEMPERATURE ON STATOR WINDINGS OF THE MOTOR (WITHOUT ROTOR) CONNECTED TO RESISTIVE LOAD

Time in minutes	Temperature of ordinary motor	Temperature of nano coated motor
0	34	35.5
2	36	36.5
4	37.5	37
6	39	38.5
8	40	39
10	40	39.5
12	42	41
14	42	41
16	42.5	42
18	44	43
20	46	44
22	48	44
24	52	44.5
26	55	45
28	56.5	45.5
30	57	46

TABLE II MEASUREMENT OF TEMPERATURE ON STATOR WINDINGS OF THE MOTOR (WITH ROTOR) CONNECTED TO RESISTIVE LOAD

Time in minutes	Temperature of ordinary motor	Temperature of nano coated motor
0	33	31.5
2	35.5	32
4	37.5	32.5
6	38	33
8	38.5	33.5
10	39	34.5
12	40.5	35.5
14	42	36
16	42.5	37
18	43	38
20	44	39
22	45	39.5
24	45.5	40
26	46	40.5
28	47	41
30	48.5	41.5

TABLE III MEASUREMENT OF TEMPERATURE ON STATOR WINDINGS OF THE MOTOR (WITHOUT FAN) CONNECTED TO RESISTIVE LOAD

Time in minutes	Temperature of ordinary motor	Temperature of nano coated motor
0	36	36
2	39	36.5
4	42	37
6	44	38.5
8	46	40
10	48	42
12	50	45
14	52	46.5
16	54	47
18	55.5	49
20	57	49.5
22	58	50.5
24	59.5	52
26	61	53.5
28	63	55
30	64.5	56

TABLE IV MEASUREMENT OF TEMPERATURE ON STATOR WINDINGS OF THE MOTOR (WITH FAN) CONNECTED TO RESISTIVE LOAD

Time in minutes	Temperature of ordinary motor	Temperature of nano coated motor
0	33	33
2	34	33.5
4	35.5	34
6	37	34.5
8	38.5	35
10	40	35.5
12	41	36
14	42	37
16	43	38
18	44	39
20	45	39.5
22	46	40
24	47	41
26	48	42
28	49.5	43.5
30	51	44

III. CONCLUSION

It was observed that the operating temperature of an electric machine has a very strong relationship with the life duration of the insulation. The insulating materials mostly used for coating the machine windings were organic in nature, and were adversely affected by thermal decomposition. But the addition of nanocomposites to the enamel has increased the temperature withstanding capacity of the induction motor. Hence the life time of the motor will be increased.

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