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Determination of the Insulation Classification of Nigerian Cloth Fabrics

A.M.O. Obiazi
Department of Electrical and Electronics Engineering,
Ambrose Alli University, Ekpoma, Nigeria

Abstract: The temperature-rise, which electrical machines may safely withstand is determined by the limiting temperature of the insulating materials used in them. It is therefore, a vital requirement to qualify electrical insulating materials thermally by determining their insulation class. In this study, 25 sample varieties of Nigerian cloth fabrics were experimented with to determine their insulation classification. The samples were cut into definite dimensions and weighed. Each type of cloth fabric was made into two samples; one sample left in its ordinary state, while the other sample was impregnated with insulating varnish. Both samples were subjected to a heat-run in a sealed industrial oven, while measuring the insulation resistance of the given sample at regular temperature intervals, until the sample burns out. The measured values of weight, insulation resistance and temperature are shown in tables. Curves were plotted to show the variation of insulation resistance with temperature. From the experiments, only two of the unimpregnated samples can be used for class Y insulation whose limiting temperature is 90°C, while 24 impregnated fabrics can be used for class Y insulation. Only one cloth fabric is unsuitable for class Y insulation even with impregnation.

Key words: Cloth fabrics, temperature, insulation, resistance, classification, Nigeria

INTRODUCTION

The thermal stability or limiting temperature of machine insulating materials determines the temperature rise, which the machines can withstand safely. By using materials of higher limiting temperature, machines of the same physical size may be rated for greater power output. Great efforts have been made to qualify electrical insulating materials thermally and to improve their thermal capabilities. The IEEE and IEC have developed practices and procedures for the thermal evaluation of insulation systems for electrical machines.

Modern machines using synthetic or inorganic materials such as glass and mica in a matrix of polyester, epoxy or silicon resins exhibit long life at elevated temperatures (Raja *et al*., 2007; Ali and Hackam, 2008; Lamarre and David, 2008; Takala *et al*., 2008). Insulating materials are classified thermally as Y, A, E, B, F, H and C. The allowable temperature for each of these classes is defined in NEMA, BSI and IEC standards are 90, 105, 120, 130, 155, 180 and >180°C, respectively. The tables are based on a 20 years working life under average conditions. Reddy and Ramu (2007) examined the intrinsic thermal stability in HVDC cables, while Bassapa *et al*. (2007), Berlijn *et al*. (2007), Chong *et al*. (2007), Kannus and Lahti (2007), Reddy andn Ramu (2007) and Wieck *et al*. (2007), investigated the dielectric performance of insulators under iced and hot temperature conditions while, the influence of water absorption on the dielectric quality of insulators was studied by Kyritsis *et al*. (2000) and Hong (2009a, b). High quality insulating materials are expensive and for many developing countries, they are imported. In their research, Paraskevas *et al*. (2006), Fu (2007), Kikuchi *et al*. (2008), Rui-Jin (2008) and Ishikawa (2009) investigated the influence of ambient and operating temperature on the dielectric properties and aging of insulating materials. This experimental study is an effort to thermally qualify cloth fabrics available in Nigeria.

By measuring, their maximum operating temperature, their insulation class can be determined, thus, helping to determine their level of use as insulating materials for electrical machines and if they can serve as viable alternative insulating materials to imported ones. Conducting, the experimentation with both impregnated and unimpregnated samples will help to evaluate the improvement in insulation resistance resulting from impregnation. Twenty-five sample varieties of Nigerian cloth fabrics were used in the experimental research.

MATERIALS AND METHODS

The twenty-five cloth fabrics used in the experimentation were:

- Cord lace
- Cotton
- Adire
- Taffeta lace
- Cashmier lace
- Galilia
- Satin
- Vegetable wax (abada)
- Ashoke
- Plain guinea brocade
- Chiffon
- Poplin
- UNTL wax
- AS holland wax
- London wax
- Stone lace
- Global lace
- Intorica
- Terelene
- Shakies
- George
- Paper lace
- Hollandis
- Ribbon
- Computer lace

Preparation of the sample of cloth fabrics: Each sample of the 25 types of cloth fabric measured 10×5 cm. The thickness of each fabric was maintained as manufactured in order not to alter the integrity of the fabric. Each type of fabric was made into two samples. One of the samples was impregnated by immersing in hot insulating varnish for ten hours and then dried slowly for 2 days while, the other sample was left unimpregnated.

The weights of the samples before impregnation, immediately after impregnation and after drying, as well as the initial insulation resistance (at room temperature) of both samples of each fabric are shown in Table 1.

Heat run: The two samples of each of the twenty-five cloth fabrics were subjected to heat run in a well-lagged industrial oven shown in Fig. 1. The insulation resistances of the samples were measured at regular temperature intervals of 20°C until, the given sample burns out. Table 2 shows the insulation resistance measurement of the cloth samples during the heat-run.

Table 1: Initial parameters of samples of cloth fabrics

	Weight of samples (g)			Insulation resistances (MΩ)	
Cloth samples	Before varnishing	Immediately after varnishing	After drying	Impregnated	Unimpreganted
Cord lace	1.545	2.383	2.353	200	200
Cotton	0.558	0.999	0.928	200	200
Adire	0.532	0.993	0.910	200	200
Tafeta	1.173	1.799	1.649	200	200
Cashmier	1.082	1.500	1.389	200	200
Galilia	0.570	0.912	0.862	200	200
Satin	0.280	0.612	0.552	200	200
Vegetable wax (Abada)	0.697	1.185	1.165	200	160
Ashoke	2.393	3.652	3.453	200	200
Plain guinea brocade	0.577	0.989	0.905	200	200
Chiffon	0.263	0.658	0.458	200	160
Poplin	0.437	1.002	0.723	200	200
UNTL wax	0.650	1.062	0.930	200	200
AS Holland wax	0.561	1.001	0.930	200	200
London wax	0.361	0.829	0.631	200	200
Stone wax	0.886	1.591	1.397	200	200
Global lace	1.477	2.498	2.295	200	200
Intorica	0.762	1.186	1.143	200	200
Terelene	1.038	1.500	1.440	200	200
Shakies	1.033	1.308	1.293	200	200
George	0.649	1.200	1.145	200	200
Paper lace	0.725	1.304	1.294	200	200
Holladis	0.629	1.106	0.969	200	200
Ribbon	0.201	0.401	0.358	200	200
Computer lace	1.050	2.002	1.901	200	200

Table 2: Heat run and insulation resistance measurement of samples of cloth fabrics (V = varnished, nV = non-varnished)

	30°C		50°C		70°C		90°C		110°C		130°C	
Cloth fabrics	V (MΩ)	nV (MΩ)	V (MΩ)	nV (MΩ)	V (MΩ)	nV (MΩ)	V (MΩ)	nV (MΩ)	V (MΩ)	nV (MΩ)	V (MΩ)	nV (MΩ)
Cord lace	200	200	150	100	75	40	20	9	2	0.1	-	-
Cotton	200	200	150	100	75	30	20	8	1	0.1	-	-
Adire	200	200	150	100	50	30	15	7	0.8	0.1	-	-
Tafeta	200	200	150	100	75	30	10	5	0.6	-	-	-
Cashmier	200	200	150	100	75	40	10	4	0.4	-	-	-
Galilia	200	200	150	100	75	50	9	2	0.2	-	-	-
Satin	200	200	150	100	50	30	15	6	0.3	-	-	-
Vegetable wax (Abada)	200	150	150	100	50	30	10	3	0.4	-	-	-
Ashoke	200	200	150	100	40	20	9	2.2	0.6	-	-	-
Plain guinea brocade	200	200	150	100	40	20	8	2.4	0.8	-	-	-
Chiffon	200	150	150	100	50	30	10	2.2	0.1	-	-	-
Poplin	200	200	150	100	75	40	8	2.4	0.2	-	-	-
UNIL wax	200	200	150	100	50	30	8	2.2	0.2	-	-	-
AS Holland wax	200	200	150	100	40	20	9	2.4	0.2	-	-	-
London wax	200	200	150	100	40	20	8	2.2	0.4	-	-	-
Stone lace	200	200	150	100	50	30	10	2.4	0.5	-	-	-
Global lace	200	200	150	100	50	40	8	2.3	0.3	-	-	-
Intorica	200	200	150	100	40	30	8	2.2	0.3	-	-	-
Terelene	200	200	150	100	75	40	8	2.0	0.3	-	-	-
Shakies	200	200	150	100	50	20	8	2.0	0.4	-	-	-
George	200	200	150	100	50	20	10	2.3	0.4	-	-	-
Paper lace	200	200	150	100	50	20	8	2.4	0.3	-	-	-
Holladis	200	200	150	100	40	20	9	2.2	0.2	-	-	-
Ribbon	200	200	150	100	30	15	5	1.8	0.2	-	-	-
Computer lace	200	200	150	100	40	20	8	2.1	0.2	-	-	-

Fig. 1: The inner chambers of the oven

RESULTS AND DISCUSSION

The curves of the variation of insulation resistance with temperature for the impregnated samples of the twenty-five cloth fabrics are shown in Table 2. From Table 2, it can be seen that even the impregnated samples of cloth fabrics could not withstand high temperatures. Many of the impregnated samples could barely withstand 110°C, while, at 130°C, all the samples were burnt. Only two samples of unimpregnated fabrics (Cotton and Cord Lace) had insulation resistance up to 8 MΩ at 90°C. The rest twenty-three unimpregnated samples had insulation resistances ranging from 1.8 MΩ to 7 MΩ and so are unsuitable for use at temperatures up to 90°C. For the impregnated samples, only one fabric (Ribbon) had insulation resistance below 8 MΩ at 90°C. Thus, it is unsuitable as insulating material for temperatures up to 90°C. The remaining twenty-four impregnated fabrics had insulation resistances up to and exceeding 8 MΩ at 90°C. Since 90°C is the limiting temperature for class Y insulation, these twenty-four fabrics can be used as insulating materials for class Y operation.

CONCLUSION

Out of the twenty-five types of cloth fabrics used in this experimental research, only two samples of unimpregnated materials (Cotton and Cord Lace) had insulation resistance up to 8 MΩ at 90°C. Thus, only these two cloth fabrics can be used for class Y insulation without impregnation. For the twenty-five impregnated samples, only Ribbon had insulation resistance below 8 MΩ at 90°C and so is unsuitable for class Y insulation even when impregnated. The remaining twenty-four impregnated cloth fabrics had insulation resistances up to and exceeding 8 MΩ at 90°C. Thus, apart from Cotton and Cord lace, the other twenty-two cloth fabrics would require impregnation to make them suitable for class Y insulation.

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