International Journal of Electrical and Power Engineering 3 (4): 238-241, 2009
ISSN: 1990-7958

Comparative Analysis of the Insulation Resistance of Some Nigerian Wood Species with Imported Class B Insulating Materials

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

Abstract: Ambient temperatures in tropical countries across the equatorial belt are adversely high. Thus, the operating temperatures of electrical machines in these countries are uncomfortably high even when, the machines operate at rated load. Nigeria as a tropical and developing country has had to contend with this unfavorable thermal condition for electrical machines. Most of the drive motors in Nigeria are imported and many of them come with class B insulation. In this study, eight sample varieties of Nigerian wood species-Mahogany, Obeche, Iroko, Afara, Danta, Opepe, Abeza and Aper and the two most commonly imported class B insulating materials-fiber glass and leatheroid are experimented with to compare their ability to maintain insulation integrity at higher temperatures. Impregnated samples of the eight wood species and samples of leatheroid and fiber glass were subjected to a heat-run in a sealed industrial oven. The insulation resistance of each sample was measured at regular temperature intervals, until the sample burns out. Tables show the values of weight, insulation resistance and temperature. The results show that at the class B limiting temperature of 130°C, leatheroid had an insulation resistance of 6 MΩ, while that of fiber glass was 8 MΩ. The eight wood samples had insulation resistance above 30 MΩ. At the higher temperature of 150°C, the insulation resistances of leatheroid and fiber glass collapsed to 1 and 1.4 MΩ, respectively while that of the wood species was a minimum of 15 MΩ. At a much elevated temperature of 170°C, both leatheroid and fiber glass were burnt but, the insulation resistances of the eight wood species were up to 8 MΩ. Thus, the wood species exhibited higher insulation integrity at higher temperatures than leatheroid and fiber glass. These wood species through some careful chemical synthesis could be made more malleable and consequently, serve as alternative and cheaper machine insulating materials to the imported leatheroid and fiber glass.

Key words: Insulation, class B, temperature, wood, fiber glass, leatheroid

INTRODUCTION

The effect of temperature on insulation of a machine is of great importance and is a limiting factor in design. The behavior of insulating materials under different thermal and environmental conditions is an important subject of investigation. For example, Peng *et al.* (2007) Wieck *et al.* (2007), Kannus and Lahti (2007) and Berlijn *et al.* (2007) examined the flashover performance of insulators and breakers under iced conditions while, Abderrazzaq (2008), Du (2005), Lan and Gorur (2008) Yousfi *et al.* (2005) investigated the influence of dryness, wetness, atmospheric pressure and heat on the dielectric characteristics of insulators. Mayoux (2000), Oraee (2000), Nelson *et al.* (2000), Hudon *et al.* (2000) and Crine (2005) examined the degradation of insulating materials under electrical stress and the problem of aging and life expectancy of motor insulation. In their research, Paraskevas *et al.* (2006), Fu *et al.* (2007), Kikuchi *et al.* (2008), Rui-Jin *et al.* (2008) and Ishikawa *et al.* (2009) investigated the influence of ambient and operating temperatures on the dielectric properties and aging of insulating materials while, the influence of water absorption on the dielectric quality of insulators was studied by Kyritsis *et al.* (2000) and Hong *et al.* (2009a, b). In their own contributions, Ohki and Hirai (2007) examined the electrical conduction and breakdown properties of several biodegradable polymers, while D.C ramp test is used to determine the dielectric response of a stator winding insulation (David *et al.*, 2007; Ohki and Hirai, 2007). Chakradhar and Ramu (2008), Murakami *et al.* (2008) and Maity *et al.* (2008) investigated the thermal breakdown of polymer nanocomposites as insulation for HVDC cables; the electrical breakdown properties of magnesium oxide/low-density, polyethylene (MgO/LDPE) nanocomposites, as well as the degradation of polymer dielectrics with nanometric metal oxide fillers due to surface discharges.

The operating temperatures of electrical machines in tropical countries are uncomfortably high. Nigeria as a tropical and developing country has had to contend with this unfavorable thermal condition for electrical machines. Most of the drive motors in Nigeria are imported and many of them come with class B insulation. The permissible maximum temperature for class B insulation is 130°C. Leatheroid and fiber glass are very common imported class B insulating materials used in electrical machine winding and slot insulation in Nigeria. The wood species of Abeza, Afara, Aper, Danta, Iroko, Mahogany, Obeche and Opepe are abundantly available in Nigeria. The research experimented with these wood species as well as leatheroid and fiber glass to compare their ability to maintain insulation integrity at higher temperatures. The research also evaluated if these wood species can serve as viable alternative and cheaper machine insulating materials to the imported leatheroid and fiber glass.

MATERIALS AND METHODS

The eight wood species used in the experimental research were:

- Abeza
- Afara
- Aper
- Danta
- Iroko
- Mahogany
- Obeche
- Opepe

The two imported class B insulating materials were;

- Fiber glass
- Leatheroid

Preparation of the samples: Each of the eight wood species was cut into a sample measuring 10×5×0.5 cm. They were impregnated by immersing in a hot insulating varnish for 20 h and then slowly dried for 3 days. Both leatheroid and fiber glass were cut into samples measuring 10×5 cm. But, the thickness of each sample was maintained as manufactured in order not to alter the material integrity of the sample. The weight of the samples before impregnation, immediately after impregnation and after drying as well as the initial insulation resistances (at room temperature) of each sample material are shown in Table 1.

Table 1: Initial parameters of samples

	Weight of samples (g)			
Material	Before varnishing	Immediately after varnishing	After drying	Insulation resistance (MΩ)
Abeza	11.918	13.261	12.262	200
Afara	15.277	18.127	16.632	200
Aper	24.293	26.204	25.041	200
Danta	14.623	16.224	15.871	200
Iroko	14.649	15.000	14.710	200
Mahogany	16.523	18.830	17.760	200
Obeche	28.367	31.276	30.176	200
Opepe	17.989	19.680	18.798	200
Fiber glass	1.417	-	-	200
Leatheroid	2.166	-	-	200

Table 2: Heat run and insulation resistance measurement of sample materials (MΩ)

	Temperature (°C)							
Material	30	50	70	90	110	130	150	170
Abeza	200	200	180	150	80	40	15.0	8
Afara	200	180	150	110	75	30	15.0	8
Aper	200	200	180	150	100	50	20.0	9
Danta	200	200	180	140	90	40	18.0	9
Iroko	200	200	180	150	100	50	20.0	9
Mahogany	200	180	150	110	80	40	15.0	8
Obeche	200	200	150	110	75	40	18.0	8
Opepe	200	200	150	130	80	40	18.0	9
Fiber glass	200	180	100	60	20	8	1.4	-
Leatheroid	200	180	100	50	20	6	1.0	-

Heat-run: Each sample of the eight wood species as well as samples pf leatheroid and fiber glass were subjected to heat run in a well-lagged industrial oven. 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 samples during the heat-run.

RESULTS AND DISCUSSION

Table 2 presents, some fascinating results. Fibreglass and leatheroid are the two most commonly imported class B insulating materials for electrical machine winding and slot insulation in Nigeria. At the class B limiting temperature of 130°C, leatheroid had an insulation resistance of 6 MΩ, while that of fiber glass is 8 MΩ. The insulation resistance of impregnated samples of the eight wood species at this temperature was a minimum of 30 MΩ. Aper and Iroko each had an insulation resistance of 50 MΩ at this temperature. When, the oven temperature was raised to 150°C, the insulation resistances of leatheroid and fiber glass collapsed to 1 and 1.4 MΩ, respectively. But, the insulation resistance of the wood samples was a minimum of 15 MΩ. In fact, Aper and Iroko each had an interesting figure of 20 MΩ. At an elevated oven temperature of 170°C, both leatheroid and fiber glass were burnt. Of the eight wood species, four (Abeza, Afara, Mahogany, Obeche) had an insulation

resistance of 8 MΩ while, Aper, Danta, Iroko and Opepe had an insulation resistance of 9 MΩ. Thus, the wood samples exhibited higher insulation resistances at higher temperatures than leatheroid and fiber glass, the imported class B insulating materials.

CONCLUSION

The experiments showed that the impregnated samples of the eight wood species-Abeza, Afara, Aper, Danta, Iroko, Mahogany, Obeche and Opepe exhibited higher insulation integrity at higher temperature than leatheroid and fiber glass, the imported class B insulating materials. These wood species through some careful chemical synthesis could be made malleable and consequently, serve as alternative and cheaper machine insulating materials to the imported leatheroid and fiber glass.

REFERENCES

Abderrazzaq, M.H., 2008. Characterizing the internal strain in composite insulation under dry and wet conditions. IEEE. Trans. Dielectrics and Elect. Insulation, 15 (5): 1353-1359. DOI: 10.1109/TDEI.2008.4656244. PMID: 10291011.

Berlijn, S.M., I. Gutman, K.A. Halsan, M. Eilertsten and I.Y.H. Gu, 2007. Laboratory tests and web-based surveillance to determine the ice-and snow performance of insulators. Ibid, 14 (6): 1373-1380. DOI: 10.1109/TDEI.2007.4401219. PMID: 9900581.

Chakradhar, R.C. and T.S. Ramu, 2008. Polymer nanocomposites as insulation for HVDC cables-Investigations on the thermal breakdown. Ibid, 15 (1): 221-227. DOI: 10.1109/T-DEI.2008.4446754. PMID: 9901381.

Crine, J.P., 2005. Influence of electromechanical stress on electrical properties of dielectric polymers. Ibid, 12 (4): 791-800. DOI: 10.1109/TDEI.2005.1511104. PMID: 8574903.

David, E., T. Godwin, J. Bellemare and L. Lamarre, 2007. Modeling of the dielectric response of a stator winding insulation from a DC ramp test. Ibid, 14(6): 1548-1558. DOI: 10.1109/TDEI.2007.4401239. PMID: 9695239.

Du, B.X., 2005. Effects of atmospheric pressure on DC resistance to tracking of polymer insulating materials. Ibid, 12 (6): 1162-1171. DOI: 10.1109/TDEI.2005.1561796. PMID: 8691774.

Fu, M., G. Chen, L.A. Dissado and J.C. Fothergill, 2007. Influence of thermal treatment and residues on space charge accumulation in XLPE for DC power cable application. Ibid, 14 (1): 53-64. DOI: 10.1109/TDEI.2007.302872. PMID: 9298528.

Hong, T.P., O. Lesaint and P. Gonon, 2009a. Water absorption in a glass-mica-epoxy composite-(I:Influence on electrical properties). Ibid, 16 (1): 1-10. DOI: 10.1109/TDEI.2009.4784545. PMID: 10476235.

Hong, T.P., P. Gonon and O. Lesaint, 2009b. Water absorption in a glass-mica-epoxy composite (II: Field distribution and diagnostic in a stator bar geometry). Ibid, 16 (1): 11-16. DOI: 10.1109/TDEI.2009.4784546. PMID: 10479167.

Hudon, C., N. Amyot, T. Lebey, P. Castelan and N. Kandev, 2000. Testing of low voltage motor turn insulation intended for pulse-width modulated applications. Ibid, 7 (6): 783-789. DOI: 10.1109/94.891989. PMID: 6797115.

Ishikawa, T., K. Yasuda, T. Igarashi, S. Yanabu, G. Ueta and S. Okabe, 2009. Effect of temperature on the streaming electrification characteristics of silicone oil. Ibid, 16 (1): 273-280. DOI: 10.1109/TDEI.2009.4784577. PMID: 10476260.

Kannus, K. and K. Lahti, 2007. Laboratory investigations of the electrical performance of iced-covered insulators and a metal-oxide surge arrester. Ibid, 14(6): 1357-1372. DOI: 10.1109/TDEI.2007.4401218. PMID: 9711616.

Kikuchi, Y., T. Murata, Y. Uozumi, N. Fukumoto, M. Nagata, Y. Wakimoto and T. Yoshimitsu, 2008. Effects of ambient humidity and temperature on partial discharge characteristics of conventional and nanocomposite enameled magnet wires. Ibid, 15(6): 1617-1625. DOI: 10.1109/TDEI.2008.4712665. PMID: 10370139.

Kyritsis, A., M. Siakantari, A. Vassilikou-Dova, P. Pissis and P. Varotsos, 2000. Dielectric and electrical properties of polycrystalline rocks at various hydration levels. Ibid, 7 (4): 493-497. DOI: 10.1109/94.868067. PMID: 6710874.

Lan, L. and R. Gorur, 2008. Computation of ac wet flashover voltage of ceramic and composite insulators. Ibid, 15 (5): 1346-1352. DOI: 10.1109/TDEI.2008.4656243. PMID: 10311368.

Maity, P., S. Basu, V. Parameswaram and N. Gupta, 2008. Degradation of polymer dielectrics with nanometric metal-oxide fillers due to surface discharges. Ibid, 15 (1): 52-62. DOI: 10.1109/T-DEI.2008.4446736. PMID: 9768535.

Mayoux, C., 2000. Degradation of insulating materials under electrical stress. Ibid, 7 (5): 590-601. DOI: 10.1109/TDEI.2000.879355. PMID: 6756523.

Murakami, Y., M. Nemoto, S. Okuzumi, S. Masuda, M. Nagao, N. Hozumi and Y. Sekiguchi, 2008. DC Conduction and Electrical Breakdown of MgO/LDPE Nanocomposites. IEEE. Trans. Dielectrics Elect. Insulation, 15 (1): 33-39.

Nelson, J.K., S. Azizi-Ghannad and Hong Li, 2000. Theory and application of dynamic aging for life estimation in machine insulation. Ibid, 7 (6): 773-782. DOI: 10.1109/94.891988. PMID: 6797114.

Ohki, Y. and N. Hirai, 2007. Electrical conduction and breakdown properties of several biodegradable polymers. Ibid, 14 (6): 1559-1566. DOI: 10.1109/TDEI.2007.4401240. PMID: 9736083.

Oraee, H., 2000. A quantitative approach to estimate the life expectancy of motor insulation systems. Ibid, 7 (6): 790-796. DOI: 10.1109/94.891990. PMID: 6807375.

Paraskevas, C.D., P. Vassiliou and C.T. Dervos, 2006. Temperature dependent dielectric spectroscopy in frequency domain of high-voltage transformer oils compared to physicochemical results. Ibid, 13 (3): 539-546. DOI: 10.1109/TDEI.2006.1657966. PMID: 9028348.

Peng, L., F. Jianbin, L. Wufeng, S. Zhiyi and Z. Jun, 2007. Flashover performance of HVDC iced insulator strings. Ibid, 14 (6): 1334-1338. DOI: 10.1109/TDEI.2007.4401215. PMID: 9695238.

Rui-Jin, L., T. Chao, Y. Li-Jun and S. Grzybowski, 2008. Thermal aging microscale analysis of power transformer pressboard. Ibid, 15 (5): 1281-1287. DOI: 10.1109/TDEI.2008.4656235. PMID: 10311366.

Wieck, H., I. Gutman and T. Ohnstad, 2007. Investigation of flashover performance of snow-covered breakers. Ibid, 14 (6): 1339-1346. DOI: 10.1109/TDEI.2007.4401216Obiazi. PMID: 9711614.

Yousfi, M., P. Robin-Jouan and Z. Kanzari, 2005. Breakdown electric field calculations of hot SF6 for high voltage circuit breaker applications. Ibid, 12 (6): 1192-1200. DOI: 10.1109/TDEI.2005.1561799. PMID: 8691777.