American Journal of Electrical and Electronic Engineering, 2013, Vol. 1, No. 3, 42-45
Available online at http://pubs.sciepub.com/ajeee/1/3/2

DOI:10.12691/ajeee-1-3-2

The Humidity Effect on Machines in the Coastal Area of the Niger Delta

John Tarilanyo Afa*

Department of Electrical Engineering, Niger Delta University, Wilberforce Island, Nigeria
*Corresponding author: jhnafa@yahoo.co.uk

Received March 09, 2013; Revised April 29, 2013; Accepted July 20, 2013

Abstract The environmental condition of Niger Delta is harsh with average humidity of about 85 percent (relative), and rainfall of about 2500mm. Some of the factors may affect the machine directly or indirectly. It is necessary to take a critical study to identify the effect of humidity so that proper selection could be made for safe operation and for longer life of the equipment.From the results, humidity was the most severe environmental factor that affect the machine. It was also seen that a motor stored in that environment for a year looses 15 percent of its life span due to humidity The humid effect is more severe in the rainy season therefore proper selection of machine and frequent check and drying is necessary to keep a longer life of the machine.

Keywords: *dielectric strength, insulating materials, humidity, environmental condition, partial discharges*

Cite This Article: Afa, John Tarilanyo, "The Humidity Effect on Machines in the Coastal Area of the Niger Delta." *American Journal of Electrical and Electronic Engineering* 1, no. 3 (2013): 42-45. doi: 10.12691/ajeee-1-3-2.

1. Introduction

A machine is a device that does useful work in a predictable way according to physical laws. A machine could be referred to a motor or a generator and in most cases is reversible; therefore electro-mechanical energy conversion devices are necessary [1,2].

Electro-mechanical energy conversion device is a link between an electrical and mechanical system and electromagnetic system needs the presence of natural phenomena which inter-relate electrical and magnetic fields on one hand and mechanical force on the other hand.

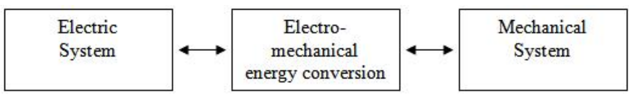


Figure 1. Electro-mechanical Energy Conversion (Reversible system)

For this category of continuous energy conversion equipment the magnetic medium is best suited. With magnetic field more than a million joules can be stored in a cubic meter of air [1,3].

2. Forces and Torques in Magnetic Field Systems

According to Lorentz Force Equation

$$f = q(E + V \times B) \tag{1}$$

Where f is the force in Newton on a particle of charge q coulombs in presence of Electric and Magnetic fields,

E is volt per meter, B in Tesla and V is the velocity of the particle relative to the magnetic field in m|s.

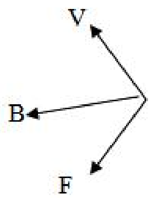
In magnetic field system the force is given as:

$$f = q(v + B) \tag{2}$$

That is, it is determined by the magnitude of the charge on the particles and the magnitude of flux density B as well the velocity of the particles. The direction of force is always perpendicular to both the direction of particle motion and the direction of magnetic field.

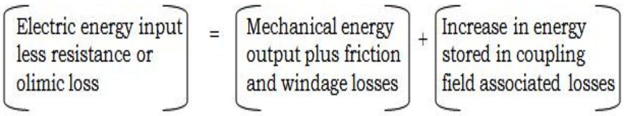
For situations where large numbers of charge particles are in motion it is convenient to write the equation (2) in terms of current density J, which is

$$f = J \times B\, N|m^3 \tag{3}$$



The mass of the materials used in the construction of electrical machines remains constant under the condition of operations, therefore the principle of conservation of energy can be applied in the energy conversion [4,5].

The input energy must therefore be equal to the summation of the useful output energy, the energy converted into heat and the change in the energy stored in the magnetic field. The energy balance equation may be written as follow:



This can diagrammatically be represented as shown in Figure 2.

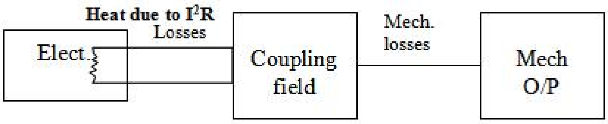


Figure 2. Electrical Energy Converted to Mechanical Output

The left hand side of equation (4) can be express in terms of current and voltages as

$$dW_{elect} = eidt = vidt - i^2rdt \quad (4)$$

Generally, the equation (4) can be represented as

$$dW_{elect} = eidt = dW_{field} + dW_{mech} \quad (5)$$

Where dW_{mech} is the differential energy converted into mechanical form, dW_{field} is the differential energy absorbed by coupling field.

Machine insulations are the most venerable and are subject to electric, thermal and mechanical stresses. The three fundamental properties of materials of utmost importance in the operation of electrical machines are insulation resistance, dielectric strength and dielectric loss angle. Others are mechanical strength, heat resistance, hydroscopicity and it must be capable of withstanding repeated heat cycle without deterioration. Insulation in machine is continuously subject to vibration and impact, when mechanical load is in operation, therefore it must possess high mechanical strength and monolithicness [6,7,8].

Dielectric characteristics of insulation of rotating machines can be affected by operational and environmental conditions.

Humidity, Temperature and Contaminations affect dielectric parameters such as insulation resistance, polarization index and dissipation factor in certain degree. In large machines the effect of partial discharge due to some recognized factors including ageing has become an area of interest.

Partial discharges are small electric sparks that occur within the electric insulation of large machines [9,10]. Common insulating materials such as epoxy, polyester and polyethylene have very high dielectric strengths. Conversely air has a relatively low dielectric strength. Electric breakdown in air causes an extremely brief electric current to flow through the air pocket. The measurement of partial discharge is the measurement of this breakdown current [11,12].

In all cases, these stresses caused as a result, will weaken the bonding properties of the insulating materials of the windings. Heat is developed in all electrical machines due to losses in the various part of the machine. The temperature rise depends on (i) the amount of heat produced (ii) the amount of heat dissipated per 1°C rise of the surface of a machine.

According to Newton Law of cooling [1,13], the rate of lose of energy of a hot body is proportional to the difference in temperature between that body and its surroundings. Heat balance equation can be put in the following way.

Energy converted into heat = Heat absorbed + Heat dissipated

$$P_{dt} = m\,C_r d + Sdt \quad (5)$$

P = Power converted into heat.
m = Mass of active part of machine.
C_r = Specific heat of material.
S = Surface area of cooling.
α = Coefficient of cooling.
θ = Rise in temperature.

Due to this energy balance the type of enclosure, the duty cycle and the environmental factors are of great importance in the selection of the machine type.

For proper selection and performance of electrical equipment, it was necessary to study the environmental problems in relation to the operation of rotating electrical machines.

3. Methodology

Due to the prevailing condition nine (9) sites were selected from the Niger Delta Zone and the Relative Humidity, mean annual Rainfall and Mean Annual Temperature were taken in the two main seasons (rainy and dry). Due to seasonal variation, previous records were compared and other seasonal records of the Niger Delta environment were also collected and compared. The results are shown in Table 1.

Table 1. Relative Humidity, Annual Rainfall, temperature and Lightning days

S/N	Place/ Location	Season	Relative Humidity	Mean Annual Rainfall	Main Annual Temp. (°C)
1.	OPOBO	w d	90-95 61-65	3816.8	26 33.5
2.	BONNY	w d	80-85 55-60	2425	27 33
3.	ONNE	w d	85-90 60-65	2438.4	26.2 33.5
4.	PORT HARCOURT	w d	75-78 48-54	2370.5	28 34
5.	BRASS	w d	84-89 54-62	2512.2	25 33
6.	SAGBAMA	w d	87-91 56-62	2452.7	26 34.4
7.	AKASSA	w d	89-93 61-65	2951.3	24.8 34
8.	OLOIBIRI	w d	80-90 56-61	2354.6	27 33.7
9.	WARRI	w d	19-84 50-55	2289.1	26.5 34.6

w = Wet (Rainy Season) d = Dry (Dry Season)

It was not possible to determine the marine environment by its effect but it is severe within the costal areas up to 3km inland. In areas where the sea goes inland its influence can be experienced.

Various Machines were examined and the fault conditions were analysed. Their life span was also examined. This was done on single phase motors of various sizes and rating. In Table 2, the records are shown for some commercial machines.

Tests were carried out with 1 hp motors in three different locations of Brass, Port Harcourt and Onne. The results are shown with the average life span on Figure 4.

Table 2. Faults in motors due to Climatic condition

Symptom	Resist. Meas.	Likely cause	Phases	Usage
Arm. Hot all over	Low resistance	Dampness	1ph	Grinding
Burnt out winding	Low resistance	Dampness	1ph	Water pumping
Short at in fields	Low resistance	Dampness	1ph	Water pumping
Sparking at brush	Very low winding resistance	Brush not at neutral point	1ph	Grinding
Partial short circuit in field windings	Very low resistance	Moisture in coil	1ph	Compressor motor
Hot and smoking at windings	All winding low	Moisture on winding	1ph	Lathe motor

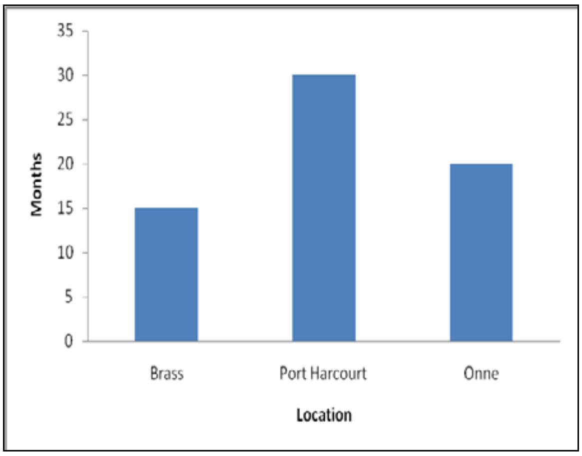


Figure 3. Average Lifespan of motor in three locations

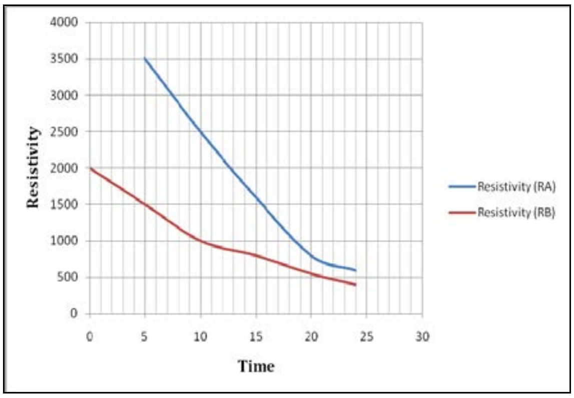


Figure 4. Effect of Moisture with time in Brass

4. Discussion

From Table 2, the major cause of fault in the motors was due to the humidity. The humidity range was from 45 to 92 in some coastal areas during the different seasons. For outdoor machines the consistent rain affects the humidity of the place. For small machines these effects cause dampness of the windings, thereby causing short circuit, and burning of windings, grounding of machine windings. For motors, it gradually starts from partial discharge and develops to burning of the insulation winding. The test carried out in the Brass, Port Harcourt and Onne sites gave the average life of the motor. Most single phase motor last for an average life span of 2 years but that also depends on the duty it is called for and the maintenance schedule. The reason for this short life span may be attributed to the high humidity throughout the year, the humid and salt spray from the ocean.

Figure 3 shows two machines of the same rating tested, within 4 years. One was put in use after 18 months of storage while one was put in use immediately. The tests show that within the storage period the resistivity dropped by about 15 percent and the life span of the machine was shorter Due to the high humidity of the area the windings absorb traces of moisture thereby reducing the resistivity of the windings.

Partial Discharge: Dielectric characteristics of insulation of large rotating machines are easily affected by operational and environmental conditions. In humid condition like the Niger Delta area partial discharge activities or coronization in machines will be frequent.

Partial discharges are locally confined electrical breakdown within the high voltage insulating system, which may occur internal to the insulation or on the surface or a sharp point. Several factors are responsible for partial discharge in a H.V rotating machine including agency of the insulation but humidity is a major factor. Though partial discharges are localized but may cause progressive deterioration of the insulation which may eventually lead to breakdown [3].

Marine Effect: The marine environmental is humid and sea air contains chlorides, traces of sulphur, carbondioxide and other elements that over a period of time may become concentrated on metal surfaces. In areas immediately adjacent to the shore, the salt spray from the ocean thrown up by strong breeze contributes to the buildup of sea salt deposit on metal which keeps them wet due to the high humidity in the area. These effects may be on the casing of rotating machines, bearings and all metal parts including windings. If the machine is kept from operation for a long period of time the insulation may become strong and bristle and rust on bearings. The copper winding at the surface and at the terminal end forms the greenish patina (Copper oxide).

Due to this marine effect the life span of motor in such areas as Brass is very short.

5. Conclusion

From the available records the main problems in the small motors is the moisture content in the air especially those machines that are operated in damp areas. From statistics it was seen that those machines that are used for water pumping undergoes repairs almost every six months.

Another problem is rusting on the metal bodies. When a machine is not operated for six months to one year most rotating part become stiff and shows sign of rust in some areas. This is due to the coastal effect and the level of humidity in the environment.

For big machines that are either connected directly to lines or through transformer and adequate protection from lightning is necessary for safe operation. This is due to the frequent lightning activities.

For this reason it is necessary to recommend the following methods for longer operating life of the machines.

- A standard schedule should be worked out which provides for measuring the insulation resistance of each motor at least once a year. The condition of the motor insulation resistance will determine the required treatment- internal or external drying and if possible vanishing of the insulations.
- The insulation resistance of motors that are idle for a long periods or those in general store house should be measured and ascertain their conditions before putting into usage.
- External warming methods would be used where necessary. The method uses electric-strip heater attached to the motor frame to supply external heat.
- For a motor storage facility, it is necessary to apply only enough heat to maintain the motor frame at 5°C above ambient temperature to prevent condensation.
- In all cases, the right machine should be chosen, that is, motors with moisture proof covers are needed in extreme weather conditions. These covers should be bound tightly around the shaft and motor base so as to be as airtight as possible. Some reduction in moisture may be obtained by placing a drying agent such as silica gel in porous bags inside the cover.
- Moving parts (bearings) must be adequately greased after every repair or on routine services.
- For big machines, regular partial discharge testing is necessary whether online or offline to determine the insulation condition of the machine.

If these precautionary measures are taken, the life of machine will be prolonged.

References

[1] Gupta, J.B., A Course in Electrical Power. S.K. Kataria & sons, New Delhi, 2005.

[2] Farahani, M., Borsi, H., Gockenbach, E., Dielectric Response Studies on Insulating System of High Voltage Rotating Machines, 20th International Power System Conference 98-E-WL. M-443, 2005.

[3] Tom Bishop, P.E., “Insulation Resistance Testing: How Many Megohms does it take to start a motor”. Electrical Apparatus Service Association (Spring 2008, NETA WORLD), 2008. Source: www.netaworld.org.

[4] Stone, G.C., Boulter, E.A., Culbert, I., Dhirani, H.. Electrical Insulation for Rotating Machines-Design, Evaluation, Aging, Tesing and Repair. IEEE Press, 2004. ISBN 0-471-44506-1.

[5] Zaengi, W.S., “Dielectric Spectroscopy in Time and Frequency Domain for H.V. Power Equipment, Part 1: Theoretical Consideration”. IEEE Electrical Insulation Magazine 19 (5) 5-19, 2003.

[6] Deshphande, A.S., Patil, A.S., Cheeran, A.N., “The Application of Weibull Function to Partial Discharge Analysis and Insulation Agency: A Review”. International Journal of Advanced Engineering Science and Technologies, 3 (2), 111-114, 2011.

[7] Njmbole, V., Lakdawale, V., Basappa, P., “Prediction of Partial Discharge Pulse Height Distribution Parameters using Linear Prediction Method” Conference on Electrical Insulation Dielectric Phenomena. Pp 337-340, 2008.

[8] Contin, A., Cavallini, A., Montanari, G.C., Hudon, C., Belec, M., Ngeyen, D.N., “Searching for Indixes Suitable for Rotating Machines Diagnosis”. IEEE International Symposium on Electrical Insulation. Pp 101-105, 2006.

[9] John Wilson, “Partial Discharge Analysis, Ultrasonic Technologies to Evaluate Partial Discharge in Electrical Machinery SKF Reliability Systems” U.S.A, 2004. Source: www.aptitudexchange.com

[10] Candela, R., Mirelli, G., Schifani, R., “PD Recognition by means of Statistical and Fractal Parameters and a Neural Nature”, IEEE Transaction of Elect. Insulation (7): 87-94, 2000.

[11] Vogelsang, R., Fruth, B., Frohlich, K., “Detection of Electrical Tree propagation by Partial Discharge measurements”. European Transactions on Electrical Power ETEP 15, 1-14, 2005.

[12] Birlasekan, S., Xmgzhou, Y., “Relaxation Studies on Power Equipment”. IEEE Transaction on Dielectrics and Electrical Insulation 10 (2) 1061-1077, 2003.

[13] Mousa VI Gargari, Wouters, S., Wielen, P.A.A.F, Vander, P.C.J.M., Steenrus, E., Proc. International Conference on Probabilistic Methods Applied to Power Systems Puerto Rico, 2008.

[14] Nedjar, M., Beroual, A., “Ageing under A.C Voltage of Polynethene by using weibull statistic”, International Conferences on Solid Dielectric U.K. pp. 654-657, 2004.