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General Study of Materials used for the design of Underground Cable

Mabrouki. Hichem[1] *Hadj Abdallah .Hsan*[2]
Command and Energy Management Laboratory,
in Engineering National School of Sfax.
Sfax University; Tunisia.

[1]hichemmabrouki@gmail.com

[2]hajabdallahhsann@gmail.com

Abstract: An efficient working of a system, a component or electric equipment depends essentially on the quality of the material with which it is conceived. Seen the big diversity and the importance of materials used in the manufacturing of the electric systems, it turns out to be necessary to make a general study concerning its materials with the aim of knowing the physical and electric properties of every material. As well as, material influence for the working of an electric system. Especially, the case of the frequency and the temperature variation. We are going to take exactly the case of the electric coaxial cable which presents an essential element in the chain of transport and distribution of electrical energy in various powers.

Keywords: Underground cable, Materials properties, Finite Element Magnetic Method.

I. INTRODUCTION

In this paper, we are going to concentrate on the study of materials used in the conception of electric cables, as well as the various electric parameters of these materials (permeability, permittivity and resistivity). Secondly, we will study the influence of frequency and temperature for each material using in the conceived of electric cable (cooper, aluminum, PVC and XLPE…) [1,2,3]. This study is achieved using FEMM software in order to know exactly the comportment of these different materials in function of frequency and temperature.

II. MAIN MATERIALS USED IN THE CONCEPTION OF THE ELECTRICAL POWER CABLE

To know materials used in the conception of electrical power cable, we are going to begin describing the most important element which is the conductive core.

A. The core

This element insures the main circulation of the current. Generally, the conductive core is copper or aluminum in order to guarantee better the current passage; because its two materials are good drivers

B. Semiconducting interior screen on the core

The role of this screen is to standardize the electric field on the surface of the core; it is realized for cables with synthetic insulation by a layer of extruded synthetic material in charge of black carbon [4].

C. Insulating Envelope

The material must be insulating, this insulating material has to allow a high temperature of functioning. The energy which can be transmitted by a cable is limited by the acceptable maximal temperature on the core [5,6]. Generally, materials used for the conception of the insulating envelope are:

- ✓ LDPE : Low-density Polyethylene
- ✓ HDPE : High-density polyethylene
- ✓ PE : Cross-lined polyethylene

D. Semiconducting Exterior Screen

This screen surrounds the insulating envelope and forms a second cylindrical electrode assuring a radial electric field.

E. Metallic Screen

This screen performs essentially three functions:

- ✓ Ensure the return of current of short circuit during a defect of cable.
- ✓ Protect the cable against the possible penetration of humidity which causes reduction of the dielectric quality of some insulating material and can cause a breakdown of the dielectric.
- ✓ Give a good mechanical protection for the cable.

F. *Outside Protective Sheath*

Serves to avoid the contact between the metallic screen with the outside. It so eliminates the problems of corrosion and problems of direct earthling of the screen. It is generally constituted by an extruded mixture with polyvinyl chloride (PVC) or with polyethylene (PE).

III. ELECTRIC PARAMETERS OF MATERIALS USED FOR CABLE CONCEPTION

The electric behavior of a conductive environment is characterized by the following three sizes:

A. *Permittivity*

More exactly dielectric permittivity is a physical property which describes the answer of an environment given to an applied electric field.

B. *Permeability*

In electromagnetism, permeability is the degree of magnetization of a material in response to a magnetic field.

C. *Resistivity*

This is an intrinsic property that quantifies how strongly a given material opposes the flow of electric current.

Tab1: Typical values for the resistivity of some materials.

Material	Copper	Aluminum	Silver	Graphite	Gold
Resistivity ($nano\Omega m$)	16.9	26.7	16.3	13.75	22

D. *Dielectric*

A material is dielectric if it does not contain electrical charges susceptible to move in a macroscopic way. The environment cannot thus lead the electric current, and is by definition an electrical insulator.

IV. BEHAVIOR OF A BNC CABLE DURING A VARIATION OF LENGTH

A. *Structure*

BNC coaxial cable is composed by a central core (D), dielectric insulator (C), metallic shield (B) and plastic jacket (A) (figure 1).

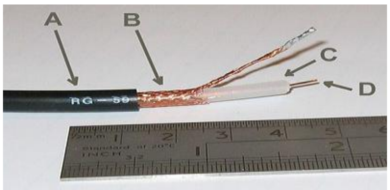

Fig. 1 Coaxial cable constitution

To study the behavior of the already presented materials, we exploited the **FEM** software to appear the influence of the variation of the frequency on its materials.

We choose a BNC cable to demonstrate this study with the following characteristics:

TABLE I
DIMENSIONS OF CABLE ELEMENTS

Element	Core	Insulator	screen	sheath
Diameter (mm)	0.84	2.9464	3.5	4.75

B. *Simulation*

We consider that the length of the BNC cable is 20m; the core and the screen are in copper the insulator is on **PE** (polyethylene), the sheath is on **PVC** Polyvinyl chloride. To simulate this cable we have the following presentation with Finite Element Method:

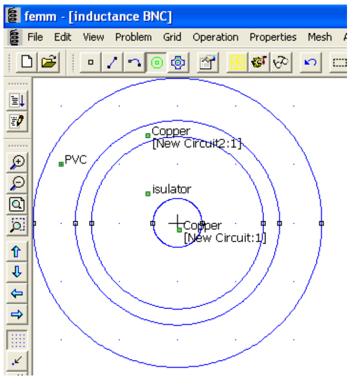

Fig. 2 Structure of BNC Cable by FEMM

In order to simulate this model we choose like a mesh size 0.015. So we have:

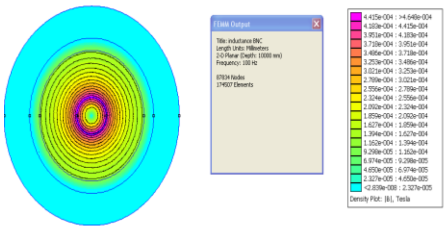

Fig. 4 System simulation

This work is doing by a frequency which equal to 50 Hz so we have like results:

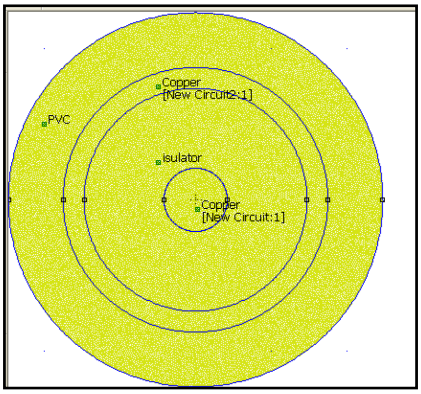

Fig. 3 Cable meshing.

Using this type of cable (special geometry and characteristics) on the FEMM software we find the following results:

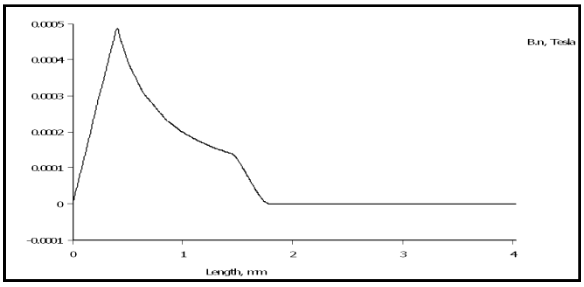

Fig. 5 Magnetic field evolution in function of distance between two points of the cable

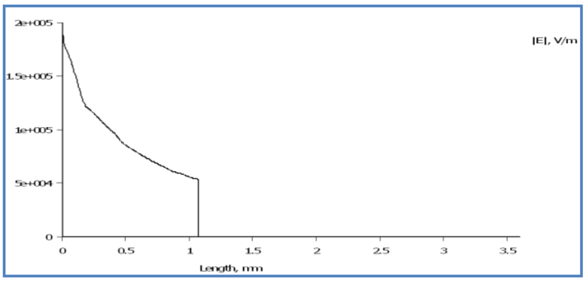

Fig. 6 Electric Evolution field between two cable points

V. CONCLUSION

In this paper we try to give a general idea about conception of power cable and the use of Finite element method (FEMM) to define the current evolution in the cable by taking into account the cable design and geometric shape. This analyze can be exploit to model cable and diagnosis monitoring. Good simulation results by FEMM are compulsory linked to the right choice of material components.

REFERENCES

[1] Han, J.; Garrett, R. Overview of polymer nanocomposites as dielectrics and electrical insulation materials for large high voltage rotating machines. NSTI-Nanotech 2008, 2, 727–732.

[2] Matthews, F.L.; Rawlings, R.D. Overview. In Composite Materials: Engineering and Science, 2nd ed.; CRC Press, Woodhead Publishing Limited: Cambridge, UK, 1999; pp. 1–28.

[3] Wikipedia—The Free Encyclopedia. Available online:https://en.wikipedia.org/wiki/Nanocomposite (accessed on 9 December 2015).

[4] Camargo, P.H.C.; Satyanarayana, K.G.; Wypych, F. Nanocomposites: Synthesis, structure, properties and new application opportunities. Mater. Res. 2009, 12, 1–39. [CrossRef]

[5] ATTAR Advanced Technology Testing and Research. Available online: http://www.attar.com.au/materialsengineering.aspx (accessed on 5 November 2015).

[6] Pyrhönen, J.; Jokinen, T.; Hrabovcová, V. Insulation of electrical machines. In Design of Rotating Electrical Machines, 2nd ed.; John Wiley & Sons Ltd.: West Sussex, UK, 2014; pp. 429–455.

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