POWER TRANSFORMERS FOR SUSTAINABLE NATIONAL DEVELOPMENT

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ABSTRACT
Transformers are electromagnetic energy transformation devices which operate on the principles of electromagnetic induction. The devices transform alternating current voltage from one value to another at a constant frequency. This work reviews the development of these functional devices using locally available materials in Nigeria. The design stages, material selection, manufacturing techniques, performance parameters such as efficiency, voltage regulation and power factor were also discussed. Some applications of the locally developed transformers were presented. The possibilities of producing larger power transformers for electrical power transmission and distribution systems using the similar approach for sustainable national development in Nigeria are also discussed.
KEYWORDS: Transformer, Production, Capacity Building, Sustainable Development.

Introduction

Transformer operates on the principle of electromagnetic induction (Theraja and Theraja,1997). Transformers are widely used in power system network for transmission and distribution of electric power. The numbers of transformers in power system network are enormous.

Apart from generation inadequacy, most of the crises in the Nigerian electricity industry are transformer related. These may be due to overloading, faults condition and ageing. The power grid failures in Nigeria had been predominantly due to transmission disturbances of which transformer is the major component(Ekeh and Evbogbai, 2005)

A study on transformer loading rate in Nigeria revealed that some of the transformers on the network are overloaded(Edokpa and Evbogbai, 2004). Most transformer substations in Nigeria are outdoors, thereby exposing them to various hazardous, atmospheric and weather conditions. A study on transformer failure rate revealed that Lightning, poor earthing and overloading are the major causes of transformer (Okonigene, Evbogbai and Alli, 2005). The failure of one transformer in network means all consumers feeding from it will be out of supply and the amount of loss of revenue will depends on the downtime.

The agitations against the staff of the electricity industry in Nigeria are due to transformer related problems. Apart from the transmission and distribution network, there are other devices such as electric arc wielding machines, power supply units, battery charger, inverters, static converters, uninterruptible power supply and consumer electronics where transformer is a basic component. The successful development of some of these devices using locally available materials in Nigeria had been reported. Some of these devices includes small power transformer (Evbogbai, Obiazi, and Edokpa, 2004), electric arc wielding machines (Evbogbai and Obiazi, 2002; Evbogbai, 2004; Evbogbai, Obiazi, Okonigene, Ibhaze and Oseyomon, 2004), Static converter (Evbogbai, Ekeh, Akhadelor and Ejodamen, 2004).

This work reviews the design stages involved in the successful development of practical transformers with a view of using similar approach for the manufacturing of large power transformers for electric power transmission and distribution networks. The work is also intended to stimulate government, corporate and individual entrepreneurs to invest on small and medium scale transformer manufacturing for capacity building.

Materials

The materials needed for the construction of transformers includes:
The laminated core, Conductors (copper) for the primary and secondary windings, Bobbin (former), Insulation material, High current diodes for rectification, Angle bar cut to size, bolts and nuts for clamping of core.

Methods

Design Specifications

The following are the specifications which the design work strives to achieve:
Power rating,Input voltage ,Output voltages, Frequency,
Max, flux density, Current density, Constant, c ,Space factor kw

- **Design Calculations**
- The voltage per turn
- Calculation for Core Area, Ai
- Calculating for flux, θ
- Calculating for the diameter of circumscribing circle, d
- Calculating for the width of lamination
- Calculating for window area; Aw
- Calculating for core dimensions
- Calculating for the stack height,
- Calculating for the number of laminations
- Calculating for both Primary and Secondary circuits (windings)
- Current flowing at the primary and secondary windings.
- Calculating for the conductor section of the primary & secondary windings
- Calculating for the diameters.
- Calculating for window space factor, kw
- Calculating the mean length per turn, for both primary and secondary coils.
- Calculating for the resistance of the primary
- Calculating for the resistance of the secondary
- Calculating for the weight of the core

Procedures For Construction

The transformer is a comparatively simple structure, since there are no rotating parts or bearings. The main elements of the construction of this design are

Magnetic circuit, comprising limbs, yokes and damping structure.

Electric circuits, the primary and secondary windings formers, insulation and tracing devices.

Terminals, tapings and leads.

Core Construction

In constructing the core, we used laminated mild steel sheets. These are special iron sheets of high resistance and low hysteretic loss. Laminated sheets were used because of the pulsating nature of the flux.

The laminars were cut to I shape to avoid sheet wastage. The smaller the thickness of the laminars sheets the better for the construction because eddy current loss is reduced. We used Red oxide and varnish for the insulation of the laminars. After setting the laminars to form the core, we now used the angle bar that is cut to size together with the bolts and nuts to clamp the core to make it firm. Figures 1 and 2 shows the dimensions and setting of the laminars to form the core of a typical welding transformer. Weight of the laminated core of the transformer.

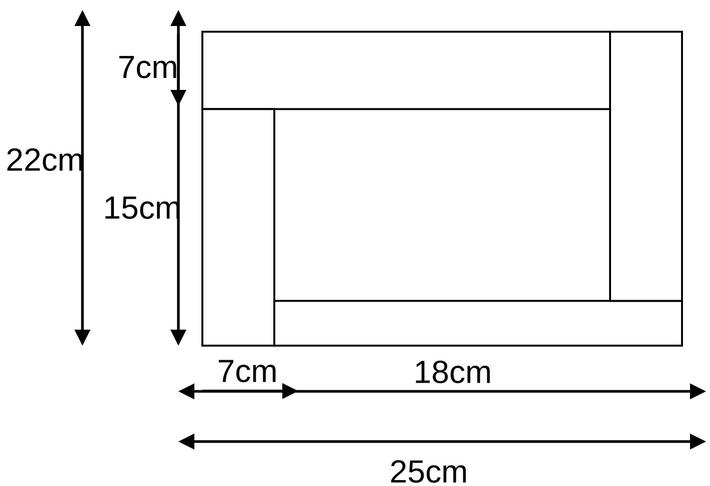

Figure 1: dimension and setting of lamina

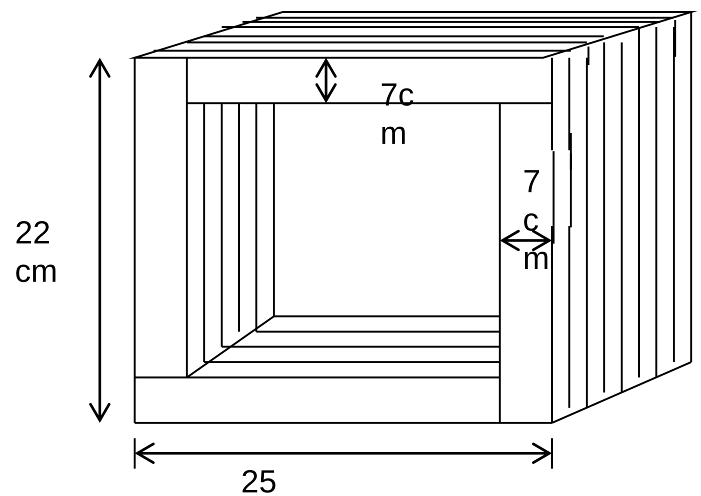

Figure 2: Laminated core of transformer with window dimension

Bobbin

The material used for the bobbin was obtained from hardboard and a sheet of plank (wood). The dimensions of the bobbin depend on the dimension of the core. This is shown in figure 3.

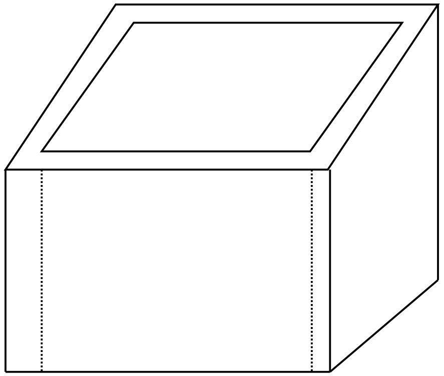

Figure 3: Shape of Bobbin

Windings

Varnished copper conductor was used for the windings. The gauges of the copper conductors depend on the power ratings, which is a function of the primary and secondary current.

Assembling The Windings And Core

In the assembly process, the metal sheet attached to the side of the bobbin was first removed. The bobbins themselves with the windings wound on them were then slotted into the core. The rectangular openings on the bobbins were dimensioned relative to the core size, which made the bobbins fit firmly to the core and hold it together. It was after this arrangement that we now used the angle bar iron cut to size with the bolts and nuts to hold the core more firmly.

Coolant

Natural air was used for cooling the small capacity transformer, while transformer oil was used for those of higher ratings. The oil also served as insulating medium for the windings. Other insulating material used includes wood, masking tape, insulating wrapper and cord for binding.

Casing

The machine casing was quite simple. It was constructed with a metal sheet bent to suitable shape and welded together, and the transformer was bolted to the cover. The metal sheet is provided with vent on top to allow flow of air, which assist in the cooling.

Movement

For easy movement the casing is provided with double handles for easy lifting and lowering. In some cases rollers are attached to the base of those with heavy weight.

Results And Discussion

After the construction, open circuit and short circuit tests were carried out in order to determine the efficiency, voltage regulation and power factor. The physical working of the machine was also carried out.

The open circuit test enables us to determine the no load current, voltage and the losses that accompany it as a result of the presence of air gap. Figures 4 is a circuit diagram to demonstrate open circuit test, while Figure 5 is for the short circuit test. The efficiencies of the transformers manufactured using locally available materials were over 90%, power factor of about 80% and Voltage regulations of 86%.

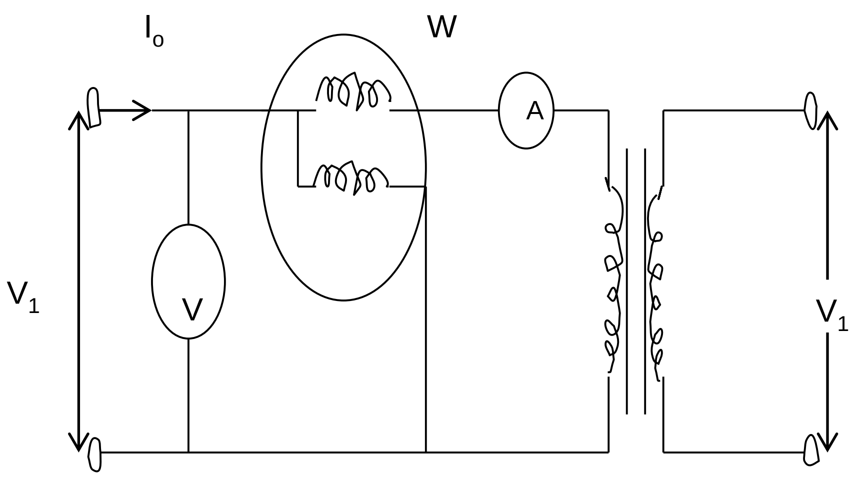

Figure 4:Open Circuit Test

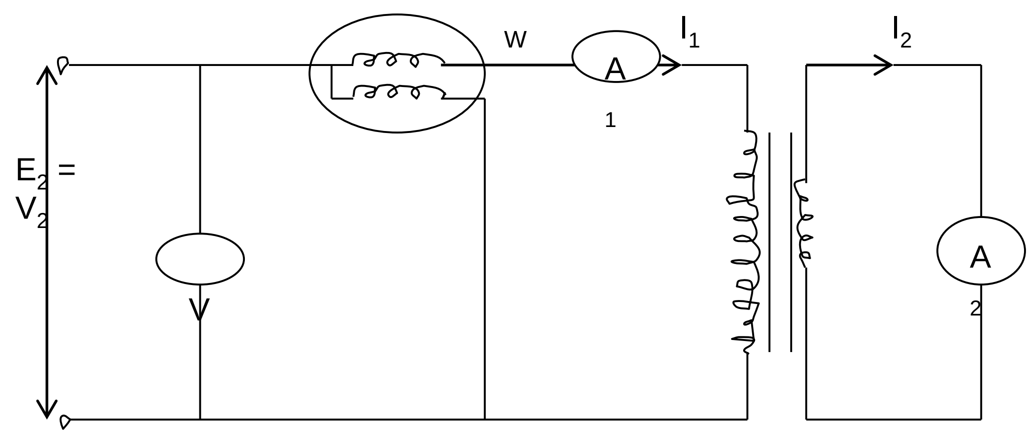

Figure 5: Short Circuit Test.

Conclusion

The manufacturing of transformers for various applications using locally available materials in Nigeria has been reviewed. The results revealed that these transformers and transformer based devices are still functioning till date. Therefore the mystery behind transformer construction has been broken hence larger capacity transformer can equally be manufactured locally using the similar approach.

Nigeria has the potential) for commercial production of these functional devices, hence the government, co-operate bodies and individuals entrepreneurs should focus the desired attention in these direction enhance research and capacity building.

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