DESIGN OF TRANSFORMER PERIPHERALS BY COMPUTER AIDED DESIGN DRAFTING (CADD)

B. Phani Ranga Raja¹, K.JyothiSree², J.Gayatri³, J.Bhavani⁴

Assistant Professor in Usha Rama College of Engineering and Technology¹²³ & V R Siddhartha College of Engineering⁴

Department of Electrical and Electronics Engineering

1phaniboyina@gmail.com, 2jyothisree461@gmail.com, jaladig@gmail.com3 bhavani.jaladi@gmail.com4

ABSTRACT.

Computer Aided Design and Drafting (CADD), is the use of computer technology for design and design documentation. CAD software replaces manual drafting with an automated process. Electrical Transformer is a static device which is used to transform the electricity from primary winding to secondary winding without change in frequency and power. A three phase 100 KVA distribution transformer is designed in AUTOCAD mechanical by using particular dimensions. Power-100KVA, Primary Voltage-11KV, Primary Current-5A, Secondary Voltage-415V, Secondary Current-139A, which are derived by substituting the primary voltage, primary current, secondary voltage and secondary current in specific formulae to find out the calculations like core area, window area, stack height, limb width, and gross core area. By using these calculations in the basic level the length breadth and height of the core is calculated accurately which are utilized to make perfect design.

Index Terms— Computer-Aided Design and Drafting (CADD), Software. NET Framework.

I. INTRODUCTION

Computer-aided design and drafting (CADD) is the process of using a computer with CADD software to design and produce drawings and models according to specific industry and company standards. The terms computer-aided design (CAD) and computer-aided drafting (CAD) refer to specific aspects of the CADD process. AutoCAD is a commercial software application for 2D and 3D computer-aided design (CAD) and drafting, available since 1982 as a desktop application and since 2010 as a mobile web- and cloud-based app marketed as AutoCAD 360. Developed and marketed by Autodesk AutoCAD was first released in December 1982, running on microcomputers with internal graphics controllers Prior to the introduction of AutoCAD, most commercial CAD programs ran on mainframe computers or minicomputers, with each CAD operator (user) working at a separate graphics terminal. Autodesk has also developed a few vertical programs (AutoCAD Architecture, AutoCAD Civil 3D, AutoCAD Electrical, AutoCAD Map 3D, AutoCAD Mechanical, AutoCAD MEP, AutoCAD Structural Detailing, AutoCAD Utility Design, AutoCAD P&ID and AutoCAD Plant 3D) for discipline-specific enhancements. For example, AutoCAD Architecture (formerly Architectural Desktop) permits architectural designers to draw 3D objects, such as walls, doors and windows, with more intelligent data associated with them rather than simple objects, such as lines and circles. The data can be programmed to represent specific architectural products sold in the construction industry, or extracted into a data file for pricing, materials estimation, and other values related to the objects represented.

Additional tools generate standard 2D drawings, such as elevations and sections, from a 3D architectural model. Similarly, Civil Design, Civil Design 3D, and Civil Design Professional support data-specific objects, facilitating easy standard civil engineering calculations and representations. Civil 3D was originally developed as an AutoCAD add-on by a company in New Hampshire called Soft desk (originally DCA). Soft desk was acquired by Autodesk, and civil 3D was further evolved. AutoCAD commands and options allow you to draw objects of any size or shape. Use AutoCAD to prepare two-dimensional (2D) drawings, three-dimensional (3D) models, and animations. AutoCAD is a universal CADD software program that applies to any drafting, design, or engineering discipline. For example, use AutoCAD to design and document mechanical parts and assemblies, architectural buildings, civil and structural engineering projects.

II. REQUIREMENTS TO DESIGN DISTRIBUTION TRANSFORMER PERIPHERALS

Distribution transformers are made using a core from laminations of sheet steel stacked and either glued together with resin or banded together with steel straps. Where large numbers of transformers are made to standard designs, a wound C-shaped core is economic to manufacture. A steel strip is wrapped around a former, pressed into shape and then cut into two C-shaped halves, which are re-assembled on the copper windings. A three phase 100 KVA distribution transformer is designed in AUTOCAD mechanical, by using particular dimensions.

Transformer basic information for design is shown in the following table.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>POWER</td>
<td>100 KVA</td>
</tr>
<tr>
<td>PRIMARY VOLTAGE</td>
<td>11000 V</td>
</tr>
<tr>
<td>PRIMARY CURRENT</td>
<td>5 A</td>
</tr>
<tr>
<td>SECONDARY VOLTAGE</td>
<td>415V</td>
</tr>
<tr>
<td>SECONDARY CURRENT</td>
<td>139 A</td>
</tr>
</tbody>
</table>

Table: 1

We know that it’s simply a device used for either stepping-up or stepping down an applied input AC through magnetic induction in between its two windings.

Basically a transformer will have the following main components:

1. Iron core stampings (configured either as U/T or E/I, generally the latter is used more extensively).
2. Central plastic or ceramic bobbin surrounded by the above iron core stampings.
3. Two windings (electrically isolated and magnetically coupled) using super enameled copper wire made over the bobbin.
4. Normally the winding which is designated to receive the input supply is termed as the “Primary” and the winding which in response to this input produces the required induced voltage as the output is termed as the “secondary” winding.

Designing your own transformer as per specific application can be interesting, but not feasible without calculating the various parameters typically involved with them. The following discussion will take you through a few important steps and formulas and explain how to make a transformer.

III. CALCULATIONS OF VARIOUS PARAMETERS

CALCULATING THE CORE AREA (CA) OF THE TRANSFORMER: The Core Area is calculated through the formula given below:

\[ CA = 1.152 \times \sqrt{(\text{Output Voltage} \times \text{Output Current})} \]
CALCULATING TURNS PER VOLT (TPV): It is done with the following formula:

\[ TPV = \frac{1}{(4.44 \times 10^4 \times CA \times Flux \ Density \times AC \ frequency)} \]

where the frequency will depend on the particular country's specifications (either 60 or 50 Hz), the standard value for the flux density of normal steel stampings may be taken as 1 Weber/sq.m, for ordinary steel material the value is 1.3 Weber/sq.m.

PRIMARY WINDING CALCULATIONS: Basically three important parameters needs to be figured out while calculating the primary winding of a transformer, they are as follows:

- Current through the primary winding
- Number of turns of the primary winding
- Area of the primary winding

Let’s trace out each of the above expressions:

**Primary Winding Current** = \( \frac{\text{Secondary Volts} \times \text{Secondary Current}}{\text{Primary Volts} \times \text{Efficiency}} \).

The average value for the efficiency of any transformer may be presumed to be 0.9 as a standard figure.

**Number of Turns** = TPV \times Primary Volts. **Primary Winding Area** = Number of Turns / Turns per Sq. cm.

SECONDARY WINDING CALCULATIONS:

The Number of turns for the secondary winding is also calculated as explained for the primary winding, however considering high loading conditions of this winding, 4 % extra turns is preferably added to the overall number of turns. Therefore the formula becomes:

Secondary Number of Turns = 1.04 \times (TPV \times secondary voltage). Also secondary winding area = Secondary Turns / Turns per sq. cm.

CALCULATING THE CORE SIZE OF THE STEEL LAMINATIONS OR THE STAMPINGS:

The core size of the steel stampings to be used may be easily found by suitably matching the relevant information with Total Winding Area of the transformer. The Total Winding Area thus needs to be calculated first, as follows:

Total Winding Area = (Primary Winding Area + Total Secondary Winding Area) \times Space for External Insulation. The third parameter i.e. the space for the insulation/former etc. may be taken approximately 25 to 35 % of the sum of the first two parameters. Therefore, the above formula becomes: Total Winding Area = (Primary Winding Area + Total Secondary Winding Area) \times 1.3. Normally, a core having a square central pillar is preferred and used, other factors involved are also appropriately illustrated in the adjoining figure and calculated as follows: Gross Core Area = Core Area from / 0.9 (sq.cm.) Tongue Width = \sqrt{\text{Gross Core Area (cm)}}.
After calculating the Tongue Width, it may be used as a reference value and matched appropriately to acquire the actual CORE TYPE. Your quest regarding how to make a transformer gets over when you finally finish calculating the stack height, using the formula by the above fig:

\[
\text{Stack Height} = \frac{\text{Gross Core Area}}{\text{Tongue Width}}
\]

IV. CALCULATIONS OF TRANSFORMER CONSTRUCTION

Transformer construction:
Ratings of transformer: 3∅- 100 KVA, 11000/415V
Distribution transformer
Primary voltage = 11000V
Primary current= 5.25A
Power = \(\sqrt{3} \times 11000 \times 5.25\) = 100KVA
Secondary voltage=415 V
Secondary current=139.1V
Power = \(\sqrt{3}VI\) = \(\sqrt{3} \times 415 \times 139.1\) = 99.99KVA

CONSTRUCTION OF CORE, PRIMARY&SECONDARY WINDINGS

1. Core area of transformer = \(1.152 \times \sqrt{(Output \ \text{Voltage} \times \text{Output Current})}\)
   \[
   CA = 1.152 \times \sqrt{(415 \times 139.1)} = 276.78 \text{ cm}^2
   \]

2. Turns per volt = \(\frac{1}{(4.44 \times 10^{-4} \times CA \times \text{Flux Density} \times \text{AC frequency})}\) (FD = flux density taking 1)
   \[
   \text{TPV} = \frac{1}{(4.44 \times 10^{-4} \times 276.783433 \times 1 \times 50)}
   \text{TPV} = 0.1627447296
   \]

3. Primary Winding Current = \(\frac{(Secondary \ \text{Volts} \times \text{Secondary Current})}{(Primary \ \text{Volts} \times \text{Efficiency})}\) (Efficiency=0.9)
   \[
   = \frac{(415 \times 139.1)}{(11000 \times 0.9)}
   = 5.8309A
   \]

Number of turns = TPV × Primary volt
   = 0.1627447296 \times 11000
   = 1790.1920 turns.

4. Primary Winding Area = Number of Turns / Turns per Sq. cm
   \[
   1790.1920/26.9 = 66.549\text{cm}^2
   \]

5. Secondary number of Turns = \(1.04 \times (TPV \times \text{secondary voltage})\)
   = 67.5396 \times 1.04
   = 70.240

6. Secondary winding area = \((70.240)/0.944)\)
   = 74.406\text{cm}^2
7. Core area \( CA = 1.15 \times \sqrt{V_i} \)
Gross core area \( GCA = CA \times 1.1 = 304.458 \)
Tongue width \( = \sqrt{GCA} = 17.44872488 \)
Total area \( = PWA + SWA \)
\( A = 140.9 \text{cm}^2 \)
Window area \( = A \times 1.3 = 183.17 \text{cm}^2 \)
Stack height \( = \left( \frac{GCA}{TW} \right) = 17.44872488 \text{m} \).

For commercial use
Stack height/tongue width = 1
Length and breadth of the core are in 1:2 Ratio
So \( \frac{1}{2} = 2b \)
From the window area
Total window area = 366.34 \text{cm}^2
Total area of the window = 4b²
\( \therefore \text{Length} = 79.0680622 \text{ cm} \)
\( \text{Breadth} = 39.5340311 \text{ cm} \)
By adding the stack width to breadth \( b = 74 \text{ cm} \)

ABOUT AUTOCAD:

There’s nothing hard in using AutoCAD drawing tools. Let’s try this simple steps. You can see the screenshot below, click next/forward button to move to the next step.

1. Click the tool you want to use on the ribbon. AutoCAD drawing tools is on home tab. Let’s start with line.
2. You will see the dynamic input near your pointer. It will tell you what you need to do next. Most of drawing tools will ask you a point location. We will learn how to input the coordinate precisely later. Just click anywhere on your drawing area.
3. Again, dynamic input will tell you what to do. Another point location. Click anywhere again. Pay attention that information in dynamic input is also shown in command line.
4. AutoCAD is continuing asking you for point location. Click again.
5. When you finish drawing line segments, press [enter] to finish it. Many veteran AutoCAD users like to use [space] as an alternative.
6. Now let’s try to draw a rectangle.
7. Just like drawing lines, it will ask you for a point location. Click anywhere.
8. And just like line tool, it will ask next point. But don’t click your mouse yet. Press down arrow on your keyboard, or click the small arrow next to ‘specify other corner point or’
9. This is how you can see options for creating rectangle. The most common way is defining 2 points, but you can also define it by using other methods. If you see in the command line.
You can see the options too. You can use the option by typing the capital letters in available options.
1. Basics: Review the basic AutoCAD controls.
2. Viewing: Pan and zoom in a drawing, and control the order of overlapping objects.
3. Geometry: Create basic geometric objects such as lines, circles, and hatched areas.
4. Precision: Ensure the precision required for your models.
5. Layers: organize your drawing by assigning objects to layers.
6. Properties: You can assign properties such as color and linetype to individual objects, or as default properties assigned to layers.
7. Modifying: Perform editing operations such as erase, move, and trim on the objects in a drawing.
8. Blocks: Insert symbols and details into your drawings from commercial online sources or from your own designs.
9. Layouts: Display one or more scaled views of your design on a standard-size drawing sheet called a layout.
V. DESIGN OF TRANSFORMER PERIPHERALS

CONSERVATOR TANK:

When volume of transformer insulating oil increases due to load and ambient temperature, the vacant space above the oil level inside the conservator is partially occupied by the expanded oil. Consequently, corresponding quantity of air of that space is pushed away through breather. On other hand, when load of transformer decreases, the transformer is switched off and when the ambient temperature decreases, the oil inside the transformer contracts. This causes outside air to enter in the conservator tank of transformer through silica gel breather.

Figure 5.1: Design of Conservator Tank.

ELECTRICAL BUSHING:

An electrical bushing can be explained as an apparatus for transmitting power in or out of enclosures, i.e., barriers, of an electrical apparatus such as transformers, circuit breakers, shunt reactors and power capacitors. According to the ANSI/IEEE Standard definition an electrical bushing is “an insulating structure, including a through conductor or providing a central passage for such conductor, with provision for mounting a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and of an electrical current from one side of the barrier to the other.

Figure 5.2: Design of Electrical Bushings
TRANSFORMER RADIATOR:

Under loaded condition, warm oil increases in volume and comes to the upper portion of the main tank. Then this oil enters in the radiator through top valve and cools down by dissipating heat through the thin radiator wall. This cold oil comes back to the main tank through the bottom radiator valve. This cycle is repeated continuously till the load is connected to the transformer. Dissipation of heat in the transformer radiator; can be accelerated further by force air provided by means of fans. These fans are fitted either on the radiator bank itself or fitted nearby the bank but all the fans must be faced towards the radiator. Sometime, the convectional circulation of oil is not sufficient. That time an oil pump may be used for speeding up oil circulation.

VI. CONCLUSION

All the parameters are defined and dumped in the auto cad software and finally we constructed the transformer as shown in fig 6

REFERENCES
