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RESEARCH ARTICLE

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IMPLEMENTATION OF REVERSE DESIGN METHODOLOGY FOR THE DESIGN OF LOW VOLTAGE TRANSFORMER

RAJENDRA MUHARE[1],ALKA THAKUR[2]
[1]Department of Electrical Engineering, SSSIST, Sehore, India
[2]Department of Electrical Engineering, SSSIST,Sehore, India

ABSTRACT

Transformers are the heart of electrical transmission and distribution systems. The purpose of transformer design is to ensure that the transformer parameters meet system needs and to familiarize users as to how specifications affect the design and the cost. The transformer should be designed initiate new or evolving innovations in transformer design and manufacture for the reduction of cost without compromising the performance. From a manufacturer's perspective it is convenient to design and produce a set range of transformer sizes. Usually, the terminal voltages, VA rating and frequency are specified. Reverse design approach is presented here, whereby the physical characteristics and dimensions of the windings and core are the specifications. By manipulating the amount and type of material actually to be used in the construction of the transformer, its performance can be determined. Such an approach lends itself to designing transformers using what is available from suppliers

Keywords— transformer; Reverse design, simulation; MATLAB

INTRODUCTION

Design of transformer, based on reverse design approach is presented in the same series a comparison between reverse design approach & conventional design method is given in Again, Reverse design approach is compared with finite element analysis in Transformer design optimization is present here based on geometric programming .

1) Research dedicated to specific transformer characteristics
2) Transformer Design Optimization

Transformer design optimization The difficulty in achieving the optimum balance between the transformer cost and performance is a complicated task[2],[3], and the techniques that are employed for its solution must be able to deal with the design considerations of Section 3, so as to provide a design optimum, while remaining cost-effective and flexible. optimization methods. Techniques that include mathematical models employing [13]. Analytical formulas, based on design constants and approximations for the calculation of the transformer parameters are often the base of the design process adopted by transformer manufacturers

Manufacturing cost minimization

- Artificial Intelligence techniques have been used in order to cope with the complex problem of transformer design optimization[6], such as genetic algorithms

(GAs) that have been used for transformer cost minimization.

- Performance optimization of cast-resin distribution transformers with stack core technology or toroidal core transformers.
- Deterministic methods may also provide robust solutions to the transformer design optimization problem. Furthermore the complex optimum overall transformer design problem which is formulated as a mixed integer non linear programming problem[12], by introducing as integrated design optimization methodology based on evolutionary algorithms and numerical.

Operating cost minimization

Apart from the transformer manufacturing cost, another criterion used for transformer evaluation and optimization is the Total Owing Cost (TOC) taking into account the cost of purchase as well as the cost of energy losses throughout the transformer lifetime Another aspect of transformer design optimization consists in providing design solutions in order to maintain certain aspects of transformer performance within the limits imposed by the technical specifications

Description of Reverse Design Method

A transformer profile showing known material characteristics and dimensions is depicted [5],[6] In the reverse design method, the transformer is built up from the core outwards. The core cross-section dimensions (diameter for a circular core and side lengths for a rectangular core) are selected from catalogues of available materials based on stamping used in conventional design[13].

In the reverse design method, the transformer is built up from the core outwards. The core cross-section dimensions (diameter for a circular core and side lengths for a rectangular core) are selected from catalogues of available materials based on stamping used in conventional design[1]. A core length is chosen. Laminations that are available can be specified in thickness.

A core stacking factor can be estimated from the ratio of iron to total volume. The winding and core material resistivity and permeability become specifications. Given the core length and diameter, the inside winding (usually the low voltage winding) is wound on layer by layer. The wire size can be selected from catalogues. They also specify insulation thickness. The designer can then specify how many layers of each winding are wound Insulation is placed between the core and the inside winding and between each layer for high voltage applications. Insulation can also be placed between each winding. The outer winding (usually the HV winding) is wound over the inside winding, with insulation between layers according to the voltage between them. Instead of 'guessing' the values of SF1, SF2 and WWF, as required in the conventional approach, these can be accounted for by knowledge of the actual dimensions of materials used. Also winding current densities and volts per turn become a consequence of the design, rather than a design specification.

The only rating requirements are the primary voltage and frequency. The secondary voltage and transformer VA rating are a consequence of the construction of the transformer. This calculation assumes that the winding length is equal to the core length. The core length may be substituted for actual winding lengths if the primary and secondary winding lengths are different or if the windings do not fully occupy the winding window height.

In reverse design first the core dimensions are selected. After the selecting the dimensions the primary current is calculated as

Is = VA/J

Where,

VA is volt ampere rating of transformer

J is current density.

Based on Is, Ip can given with the help of turn ratio. After this all the data is calculated as in conventional design. Reverse approach for small transformer is can easily explain with in below.

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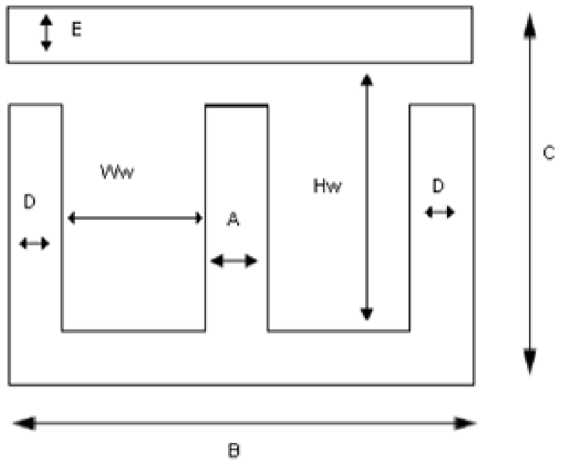


STEPS FOR DESIGN

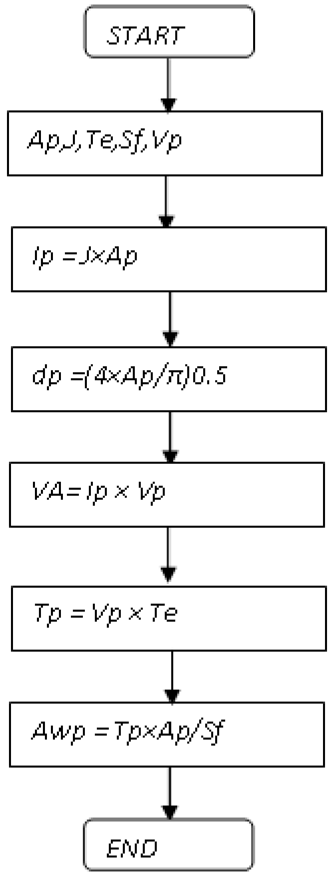
Stamping Size

1. Selecting core diminutions from appendixB (A,B,C,D,E) for particular rating according to experience.
2. Width of window (Ww) = (B-A-2D)/2 √ & height of window (Hw) = C-2E
3. Window area provided (Awpro) = Ww×Hw

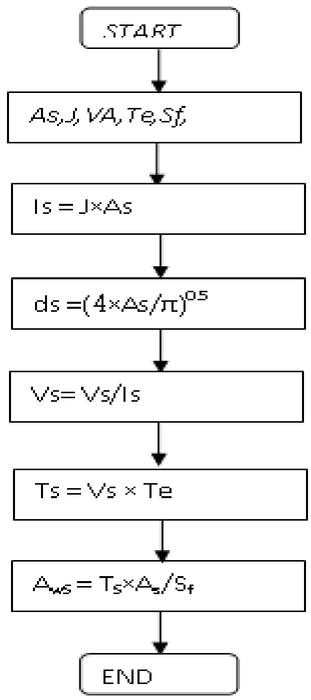
   "Primary winding calculation"
4. Select area of primary conductor & current density
5. Primary winding current (Ip) = J×Ap
6. Primary conductor diameter (dp) $=(4\times Ap/\pi)^{0.5}$
7. Volt Ampere rating (VA) = Ip × Vp
8. No of turns in primary winding (Tp) = Vp × Te
9. Window area for primary winding (Awp) = Tp×Ap/S_f *"Secondary winding calculation"*
10. Select area of secondary conductor & J
11. Secondary current (Is) = J × As
12. Secondary conductor diameter (ds) $=(4\times Ap/\pi)^{0.5}$
13. Voltage of secondary winding (Vs) =VA/I_s
14. No of turns in secondary winding (Ts) = Vs × Te
15. Window area for secondary winding (Aws) = Ts×As/S_f
16. Window width factor (WWF)=Hw/Ww
17. Window area required (Aw_{req}) $=(Awp+Aws)^{0.5}$

    "Core design"
18. Gross area of centre core (Agi) = $(A)^{0.5}$
19. Net area of centre core (A_i) = $A_{gi}\times S_f$
20. Maximum flux (Øm) = ¼.44×f×Te
21. Maximum flux density (Bm) = Øm/Ai

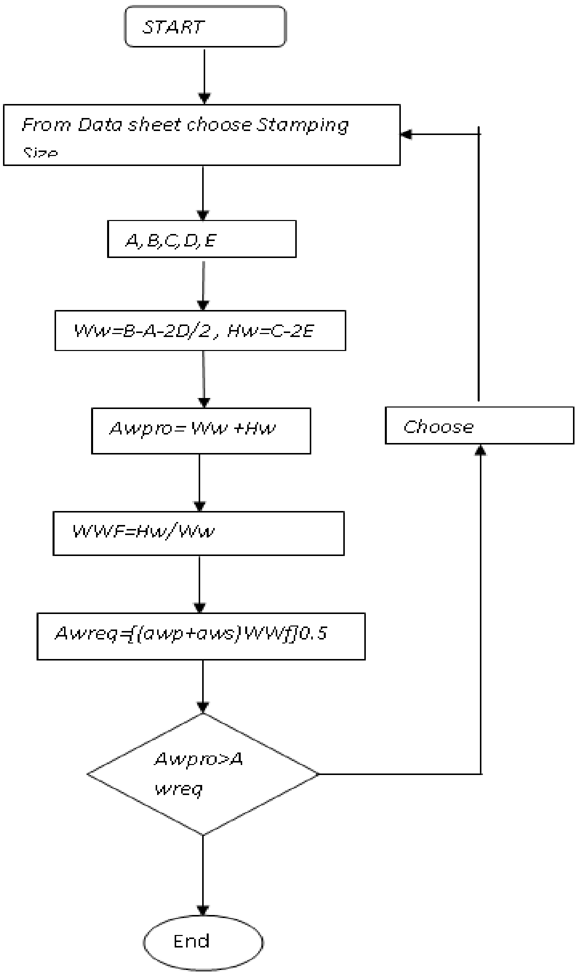
Flow sheet for primary winding design



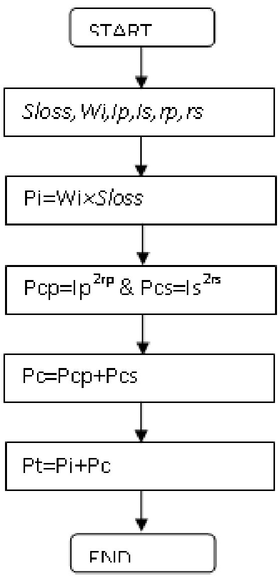
Flow sheet for secondary winding design in reverse design



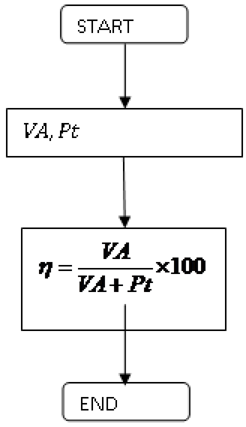
Flow sheet for stamping size



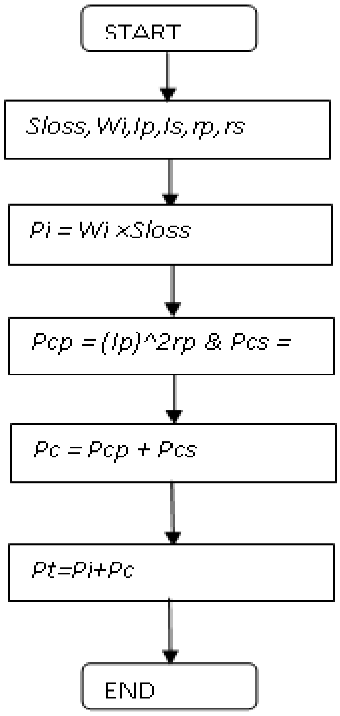
Flow sheet for losses calculation



Flow sheet for efficiency calculation



Flow sheet for losses calculation



VI. Results

S.N.	Parameters	Calculated values
1	Ts	280
2	Ip in A	0.6522
3	Tp	1288
4	TE	5.6
5	Ai in m	5.36E-04
6	VI	1.02E-04
7	F	0.804
8	Wc in Kg	1.4131
9	Wt in Kg	2.217

10	Pi in W	1.4471
11	Pt in W	38.5179
12	EFF.in %	79.568
13	A in m	2.98E-04
14	Agi in m	5.96E-04
15	Ai A.	5.36E-04
16	Ap in mm2	0.1418
17	As in mm2	1.3078
18	AwP in m2	7.56E-04
19	B	0.0953
20	Bm in T	1.5
21	C in m	0.0794
22	D in m	0.0159
23	dp in mm	0.425
24	Dpi in mm	0.493
25	Ds	1.32
26	Dsi in mm	1.42
27	E	0.0159
28	Eff in %	79.568
29	Hw in mm	0.0476
30	Ip in A	0.6522
31	Is in A	3
32	J in A/mm2	2.3
33	MLT in m	0.2086
34	MLT1 in m	2.09E-04
35	Pc	37.0708
36	Pcp in w	0.0169
37	Pcs in w	37.0539
38	Pi in w	1.4471
39	Pt in W	38.5179
40	Pym in Wb	8.04E-04
41	Sloss W	1.8
42	Spacefactor1	0.6384
43	Spacefactor	0.6923
44	SpacefactorP	0.5945
45	SpacefactorS	0.6913
46	stackingfactor	0.9
47	Te	5.6

VI. CONCLUSION

Conventional transformer design starts from a consideration of required frequency, Voltage and VA ratings. It estimates a number of factors for the core and winding The resultant design may not match specified requirement. design procedure. The dimensions of core and winding materials are entered based own whatever is available. The overall size, ratings and performance of the transformer can Sample transformers have been designed. The results highlight the problems associated with the conventional design and show the usefulness of the reverse design approach. Such a design philosophy allows for the exploration in the design of transformers with alternative construction options, where flexibility in shape and size is.

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