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Cost Effective Approach for Designing of Low Voltage Low Frequency Small Transformer

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Abstract—**the Small Transformer has a bigger contribution in the field of energy. It is used for various applications. But, Due to the Small Size concentration is very less in design modification &implementation. Small Transformer designed&manufacturedby using conventional approach. In this paper a cost effective approach is present for small transformer design & compare with conventional approach to show the effectiveness of presented approach.**

***Keywords*— Small Transformer, cost effective approach, Transformer design, conventional approach, conventional design**

I. INTRODUCTION

Small Transformers are used in various Electrical and Electronics equipment for the different purpose. For the designing of small transformer standard E-I core is available [1]. It is convenient to design and produce a set range of transformer sizes. Usually, the terminal voltages, VA rating and frequency are specified. These specifications determine the materials to be used and their dimensions. This approach to transformer design has been presented in detail in standard textbook [1]. A 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. This is essentially the opposite of the conventional transformer design method. It allows for customized design, as there is considerable flexibility in meeting the performance required for a particular application. This can allow matched rated, cost-effective solutions to power supply requirements, as against the traditional practice of over-rating the transformer component of a power supply because of batch construction and fixed size transformer ratings.

II. PROPOSED METHOD

Here, a reverse design approach is present for the design of low voltage low frequency small transformer. In reverse approach 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. This is essentially the opposite of the conventional transformer design method.

A. *Stamping Size*

Selecting core diminutions from Catalogues (A,B,C,D,E) for particular rating according to experience.

Width of window $(W_w) = \frac{B-A-2D}{2}$

Height of window (H_W) = C-2E

Window area provided $(Aw_{pro}) = W_w \times H_w$

B. *Primary winding calculation*

Select area of primary conductor & current density

Primary winding current $(I_p) = J \times A_p$

Primary conductor diameter $(d_p) = \sqrt{\frac{4\times Ap}{\pi}}$

Volt Ampere rating (VA) = $I_p \times V_p$

No of turns in primary winding $(T_p) = V_p \times T_e$

Window area for primary winding $(Aw_p) = \frac{Tp\times Ap}{Sf}$

C. *Secondary winding calculation*

Select area of secondary conductor & J

Secondary current $(I_s) = J \times A_s$

Secondary conductor diameter $(d_s) = \sqrt{\frac{4\times As}{\pi}}$

Voltage of secondary winding $(V_s) = \frac{VA}{Is}$

No of turns in secondary winding $(T_s) = Vs \times Te$

Window area for secondary winding $(Aw_s) = \frac{Ts\times As}{Sf}$

Window width factor (WWF) = $\frac{Hw}{Ww}$

Window area required $(Aw_{req}) = \sqrt{\frac{Awp+Aws}{WWF}}$

D. *Core design*

Gross area of centre core $(A_{gi}) = (A)^{0.5}$

Net area of centre core $(A_i) = Agi \times Sf$

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Maximum flux ($Ø_m$) = $\frac{1}{4.44 \times f \times Te}$

Maximum flux density (B_m) = $\frac{Øm}{Ai}$

E. Weight calculation

Mean length of turns (MLT) = ($4E+ 2H_w + \pi W_w$)

Volume of iron (V_i) = A_i ($2H_w+2W_w+4E$)

Volume of copper (V_c) = MLT × Aw_{pro}

Weight of iron (W_i) = V_i × (W_c) = V_c × copper density

Total weight of transformer (W_t) = W_i+ W_c

F. Resistance calculation

Resistance of primary (r_p) = $\frac{\rho \times MLT \times Tp}{Ap}$

Resistance of secondary (r_s) = $\frac{\rho \times MLT \times Ts}{As}$

G. Loss calculation

Iron losses (P_i) = specific loss × W_i

Copper losses (P_c) = P_{cp} + P_{cs}

Where, $P_{cp} = (I_p)^2 \times r_p$

$P_{cs} = (I_s)^2 \times r_s$

Total losses (P_t) = P_i + P_c

H. Efficiency calculation

Efficiency (η) = $\frac{VA}{VA+Pt}$ ×100

I. Design of small sample Transformer

Here Design of Small Transformer is presented by both method conventional & reverse approach. For Small Transformer design volt per turns, stamping size, and standard conductor diameter is chosen form catalogues. Data for both approaches is given is table I & II.

TABLE I
DESIGN DATA FOR CONVENTIONAL METHOD

S. No.	Design Data	
	Specifications	**Data**
1	Primary Voltage	230V
2	Secondary Voltage	50V
3	Frequency	50 Hz
4	Current density	2 A/mm2
5	Flux Density	1.2 T
6	Volts per turn	4.0

TABLE III
DESIGN DATA FOR PROPOSED METHOD

S. No.	Design Data	
	Specifications	**Data**
1	Primary Voltage	230V
2	Secondary Voltage	50V
3	Frequency	50 Hz
4	Current density	2.3 A/mm2
5	Flux Density	1.5 T
6	Volts per turn	4.0

J. Calculated Performance

The Table III show the calculated performance & comparison with the conventional design method.

TABLE IIIII
CALCULATED PERFORMANCE

S. No	Parameters	500VA, 50Hz		Difference
		Conventional Method	**Proposed Method**	
1	Ap , mm^2	1.2266	1.0930	
2	As , mm^2	2.2687	2.0096	
3	Bm , T	1.2000	1.5000	
4	J , A/mm^2	2	2.3000	
5	Pt , W	7.4443	5.8865	1.5578
6	Wt , Kg	10.2902	9.0639	1.2263
7	Eff. %	98.5330	98.8364	0.3034

III. CONCLUSIONS

The result shows that by using the present approach we can improve the design of low voltage low frequency small transformer. Such a design philosophy allows for the exploration in the design of transformers with alternative construction options, where flexibility in shape and size is required. Also, by using propose method, the cost effective design is possible for small transformer.

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