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Techniques of Enhancing Induced Secondary Voltage

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Abstract

Two cylindrical copper coils (inductors) are kept one inside the other. A ferromagnetic cylindrical road (core) is kept inside the inner coil. AC voltage given to the inner coil (primary) induces voltage in the outer coil (secondary). The amount of voltage induced is given by faraday's law of induction. It is observed that instead of using a single primary coil if multiple primaries are used and the same voltage applied to the single primary is applied to all primaries connected in series, the voltage induced in the secondary increases while the current through the primary decreases. This saves a lot of electrical energy. Detailed studies on the use of multiple primaries are reported in this paper. This Principle is used to redesign the transformer.

Keywords: Induced secondary voltage; Ferro magnetic Core; Inductance; Primary Coil; Secondary Coil

Introduction

The author is investigating several techniques to get more induced secondary voltage than given by Faradays law. He observed that the induced secondary voltage in an iron cored copper coil can be increased 1. By increasing the temperature of the core and 2. By enclosing the iron cored coil in an aluminium tube [1,2]. Another method for increasing induced secondary voltage by using multiple primaries is described in this paper.

Description of Experimental Setup

Primaries

APoly vinyal chloride cylindrical tube of length 22 cms and diameter 4 cm is wound with an insulated copper wire of gauge number 19. Ten CRGO laminations of rectangular in shape are passed through the tube. The width, thickness and length of lamination are 3.8 cms, 0.3 cms and 50 cm. These act as cores. This entire assembly act as primary. This is shown in figure 1 six such primaries are assembled. The DC resistance of each coil is 0.8 ohms. The AC impedance of each coil is 4.2 ohms.

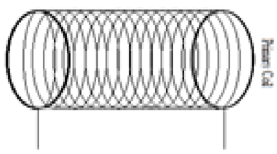

Figure 1: Primary Coil

Secondary

A Poly vinyal chloride tube of length 22 cms and diameter 16 cms is wound with an insulated copper wire of gauge number 26.The number of turns are 500. This is shown in figure 2. The DC resistance of the secondary is 22.4 ohms. The AC impedance of the secondary is 130 ohms.

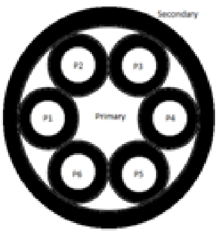

Figure 2: Secondary Coil

All the six primary coils are kept inside the secondary. The 10 CRGO laminations in each tube are connected end to end. As the ends are connected they enclose the secondary turns also. This is shown in figure 3. This is repeated for the remaining five coils.

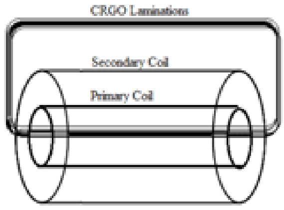

Figure 3: Arrangement of Primary and Secondary Coils

Load

A Poly vinyal chloride tube of length 22 cms and diameter 8cm is wound with an insulated copper wire of gauge number 28. The DC resistance of the coil is 12 ohms. The AC impedance of the coil is 13 ohms.

The voltage to primary coils is supplied by a variac of 220V and 15 amps. The voltages and currents in primary and secondary circuits are measured using digital multimeter.

Experimental Procedure

Measurement of Induced Secondary Voltage and Current

AC voltage (V_P) is applied to single primary coil P_1. The primary current I_P, the secondary voltage VS and the secondary current IS are measured. I_P' is the primary current corresponding to the secondary current I_S. The second primary P_2 is connected in series with the first primary P_1. The same primary voltage is applied to the combination of P_1 and P_2. The corresponding primary current I_P, secondary voltage V_S and the secondary current I_S are measured. The procedure is repeated for the remaining four primary coils.

Measurement of Load Voltage and Load Current

The load inductor is connected in series with the secondary. A voltage V_P is given to the primary coil P_1. The primary current I_P the load voltage V_L and current through load I_L are measured. The above procedure is repeated for primaries (P_1+P_2), $(P_1+P_2+P_3)$, $(P_1+P_2+P_3+P_4)$, $(P_1+P_2+P_3+P_4+P_5)$, $(P_1+P_2+P_3+P_4+P_5+P_6)$.

Measurement of Power Factor

Open circuit and short circuit tests are performed for all the primaries connecting one by one in series.

Observations & Calculations

Table I: Variation of secondary Emf for multiple primary cores

Core Number	V_P(volts)	I_P(Amperes)	V_S(volts)	I_S(Amperes)	I_P'(Amperes)	$\cos\phi$	$P_P=V_PI_P\cos\Phi$(watts)	$P_P'=V_PI_P'\cos\Phi$(watts)	$\alpha=P_P/V_S$ (jouls/volt)	$\beta=P_P'/I_S$(jolus/Ampere)
P_1	15	12.17	15.8	0.0151	11.8	1	190.5	177	12.05	11800
P_1+P_2	15	3.94	33.0	0.037	3.9	0.57	33.687	33.34	0.7	901
$P_1+P_2+P_3$	15	1.24	45.1	0.2	1.6	0.86	16.163	20.856	0.36	104
$P_1+P_2+P_3+P_4$	15	0.59	49.7	0.4	1.62	0.79	6.99	19.2	0.14	48
$P_1+P_2+P_3+P_4+P_5$	15	0.23	51.5	0.52	1.94	0.65	2.24	18.9	0.043	36.34
$P_1+P_2+P_3+P_4+P_5+P_6$	15	0.15	52.5	0.59	2.11	0.41	0.922	12.97	0.017	1.56

In Table I is shown the variation of I_P, V_S, I_S and I_P' as the primary cores are increasing from P_1 to P_6 for a primary voltage of 15 volts. The power in the primary P_P is calculated using the formula PP=$V_{PIPcos\Phi}$. The ratio between P_P and V_S gives the primary power required to produce one volt in the secondary. This is represented by α. Similarly β is the primary power required to get a current of 1ampere in secondary.

In Table II is shown variation of IP, VS, IS and IP' with variation of primary voltage for a single primary coil P1 similar results for 4 and 6 primaries are shown in Tables III and Table IV.

In Table V is shown the variation of IP, VL and IL with variation of cores from 1 to 6 for a primary voltage of 15.5 volts. The load resistance is 52 Ω. The input power PIN and output PL is calculated as shown in the table. The ratio of PL to Pin gives efficiency and it is also shown in the Table V.

In Table VI and Table VII are shown the results of OC and SC tests for all the earlier combination of cores.

Table II: Variation of Vs & Is with Vp for single primary

V_P(volts)	I_P(Amperes)	V_S(volts)	I_S(Amperes	I_P'(Amperes)
1.51	0.066	5.27	6.2	85
4.5	1.15	12.7	12.3	1.03
10.13	7.1	15.2	14.6	7.0
15.1	11.9	15.4	15.1	11.73

Table III: Variation of Vs & Is with Vp for four primary cores

V_P(volts)	I_P(Amperes)	V_S(volts)	I_S(Amperes)	I_P'(Amperes)
1.64	27.7	5.5	11.1	63.7
1.49	61.7	16.56	28.3	157
10.2	153	34.5	171.5	0.73
15.15	0.56	49.1	0.37	1.5
20.1	1.39	61.5	0.63	2.6
25.1	2.66	70.0	0.89	3.73
31.6	4.60	73.2	1.2	5.3
41.1	7.44	76.1	1.63	7.7
52.5	10.54	78.5	1.96	10.52

Table IV: Variation of V_s & I_s with V_p for six primary cores

V_P(volts)	I_P(Amperes)	V_S(volts)	I_S(Amperes)	I_P'(Amperes)
1.6	0.0214	5.6	0.0432	0.1532
4.1	0.0408	14.1	0.1051	0.46
10.5	0.0851	35.4	0.41	1.49
15.3	0.15	52.4	0.6	2.14
20.4	0.38	69.2	0.81	2.92
25.7	0.9	84.6	1.02	3.7
30.5	1.4	97.9	1.25	4.54
35.1	2.19	108	1.45	5.23
40.2	3.16	114	1.66	6.00
50.7	5.17	118	2.12	7.7
60.1	6.87	121	2.46	9.03
85.1	10.26	123.3	3.06	11.27

Table V: Variation of Efficiency with Primary Cores for a Load Resistance of 52 Ohms

No of Coils	V_P(volts)	I_P(Amperes)	$P_{in} = V_P I_P \cos\Phi$(watts)	V_L(volts)	I_L(Amperes)	$P_L = V_L I_L$ (watts)	$\eta = P_L/P_E$
P_1	16.9	17	100	0.809	0.0159	0.12	1.2
P_1+P_2	19.7	8.06	100	2.08	0.0414	0.0886	8.6
$P_1+P_2+P_3$	26.3	6.67	100	14.77	0.29	4.3	4.3
$P_1+P_2+P_3+P_4$	31.4	5.55	100	31.1	0.61	18.9	19
$P_1+P_2+P_3+P_4+P_5$	34.2	4.67	100	42.1	0.84	35.36	35
$P_1+P_2+P_3+P_4+P_5+P_6$	34.3	4.24	100	45.6	0.89	40.6	40

Table VI: Open circuit test for multiple primary coils

No of Coils	V_{OC}(volts)	I_{OC}(amperes)	Power	Power factor
2	33.6	13.74	264	0.57
3	35.6	9.37	290	0.86
4	37.3	6.44	190	0.79
5	38.4	4.4	110	0.65
6	39.3	3.1	50	0.41

Table VII: Short circuit test for multiple primary coils

No of Coils	V_{sc}	I_{sc}	Power
1	11.4	8.5	100
2	24.1	9.07	200
3	25.8	5.6	100
4	26.4	4.34	100
5	26.5	4.27	100
6	26.6	4.22	100

Results

Table I shows that α and β are decreasing as the number of cores are increasing. The electrical power required producing 1 volt and 1amp current in secondary are decreasing with increase of cores. For example in case of a single core 2.67 watts of power in primary is required to produce 1 volt in secondary. This power is reduced to 0.008 watts for six cores.

As seen from Tables II, Tables III and Tables IV the range of operation before saturation is increasing as primary cores are increasing. The maximum voltage for a single core is 15.2 volts, for four cores 52.5 volts and for six cores 85 volts.

Table V shows that the power transferred to the load increases as the number of cores are increasing (The primary is remaining constant). The efficiency increases with multiple cores.

Conclusions

Thus by using multiple cores the voltage induced in the secondary and the power delivered to the load increases compared to single core. This increase in output voltage and current is obtained not by increasing input electrical power but by decreasing the input electrical power. This helps to save lot of electrical energy. This principle can be applied to transformers thereby saving larger amounts of electrical energy.

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