



Parametric Variation of Magnetically Coupled Coils Wound on Iron Core using Al- Enclosure

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Abstract: A copper wire wound on an iron rod called as an iron cored inductor. The impedance of an iron cored inductor can be varied by the different methods. In those, one of the methods is, placing an iron cored coil in the aluminium enclosure. Due to this, the effective impedance of an iron cored inductor is de-creased. If another coil is wound on the same core and placed in the aluminium enclosure, the induced EMF in another coil has increased. The detailed study of this effect is presented with numerical analysis in this paper.

Keywords : Aluminium Enclosure, Induced EMF, Impedance, Iron Core, Solenoid.

I. INTRODUCTION

Two copper coils wound on an iron core are said to be mutually coupled through magnetic field. When supply is given to one of the coil, EMF is induced in second coil due to faradays law of electromagnetic induction. In [1] it is observed that by placing two separate iron cored coils in an aluminium enclosure, will results in the increase of induced EMF in the second coil when the other coil is excited by Alternating Current source. In [2] various methods are discussed for decreasing effective impedance of an iron cored inductor. In [3]-[7] various properties of a conductor (variation of conductivity & resistivity) wound on different Ferro magnetic materials. The effect of temperature [8] on various circuit parameters including induced EMF and magnetizing current. It is proved that the circuit parameters will change with degree of magnetization [9].

II. EXPERIMENTAL SETUP

A copper wire having 22 gauge wound on an iron rod with diameter of 2cm and length of 20cms. The copper wire is wound one on the other. The coil near to the core called is as inner coil and while the other is called as outer coil. The coils having different number of turns are tested with and without aluminium enclosure. At first the coil with 500/500 turns is wound on the iron core. Later the outer turns increased to 1000, 1500 for verifying the effect of aluminium enclosure.

III. EXPERIMENTAL RESULTS

A 500/500 turns coil as described above is kept inside aluminium enclosure of diameter 4cm and length 20cm. The decrease in inductance L_{AL} and effective resistance R_{AL} are measured using LCR-meter. These values are presented in the Table 1. Where L_{Al} , R_{Al} is the inductance and resistance of a coil when the other coil is open circuited, $L_{Al/sc}$, $R_{Al/sc}$ is the inductance and resistance of a coil when the other coil is short circuited.

Table 1 500/500 Turns coil

Coil type	L (mH)	L _{Al} (mH)	L _{Al/sc} (mH)	R (Ω)	R _{Al} (Ω)	R _{Al/sc} (Ω)
Inner coil	10.93	7.72	3.163	8.73	6.68	6.52
Outer coil	8.213	4.03	2.096	8.77	6.02	5.93

Similarly the resistance and inductance of 500/1000 turns coils with and without aluminium enclosures are presented in the Table 2.

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Table 2. 500/1000 Turns coil

Coil type	L (mH)	L _{Al} (mH)	L _{Al/sc} (mH)	R (Ω)	R _{Al} (Ω)	R _{Al/sc} (Ω)
Inner coil	10.95	7.74	4.032	8.74	6.68	7.028
Outer coil	29.65	14.55	7.571	25.59	17.57	17.33

Similarly the resistance and inductance of 500/1500 turns coils with and without aluminium enclosures are presented in the Table 3.

Table 3. 500/1500 Turns coil

Coil type	L (mH)	L _{Al} (mH)	L _{Al/sc} (mH)	R (Ω)	R _{Al} (Ω)	R _{Al/sc} (Ω)
Inner coil	10.6	9.862	5.422	9.15	7.54	7.54
Outer coil	63.04	51.45	29.51	53.55	38.7	37.4

From all the tables shown above when the coil is placed in aluminium enclosure the inductance and resistance are decreasing. For 500/500 turns coil, Fig.1 shown the variation of I1 with V1 when the secondary coil is open circuited, as the iron cored coils are placed in aluminium enclosure the current drawn by the coil will increase. Fig.2 shown the variation of I2 with V2 when the primary coil is open circuited. Fig.3 & Fig.6 shown the variation of the V1 with V2 when the other coil is open circuited. Fig.4 & Fig.5 shown the variation of the I1 with V1 when the other coil is short circuited.

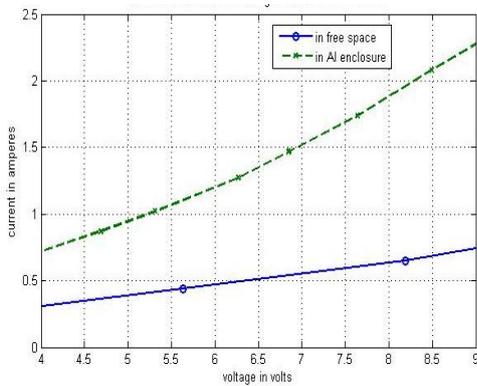


Fig. 1. V-I characteristics of inner 500T coil

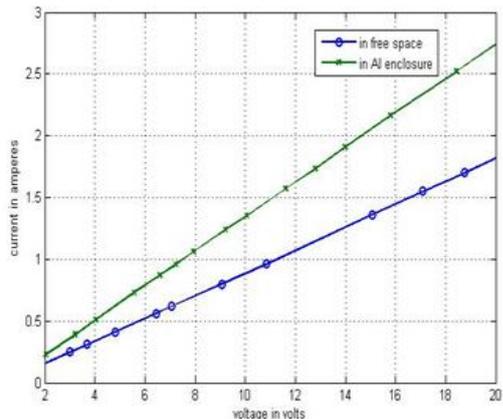


Fig. 2. V-I characteristics of outer 500T coil

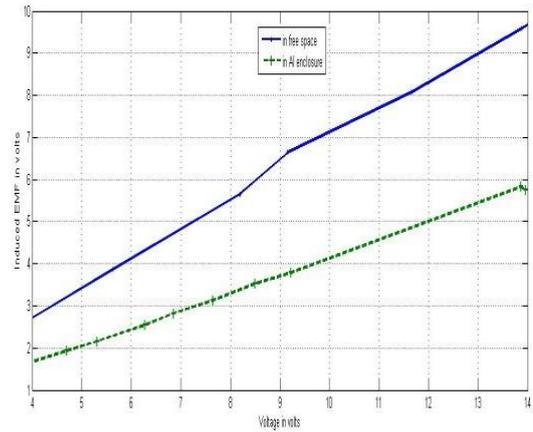


Fig. 3. Variation of EMF in outer coil with input voltage to inner coil.

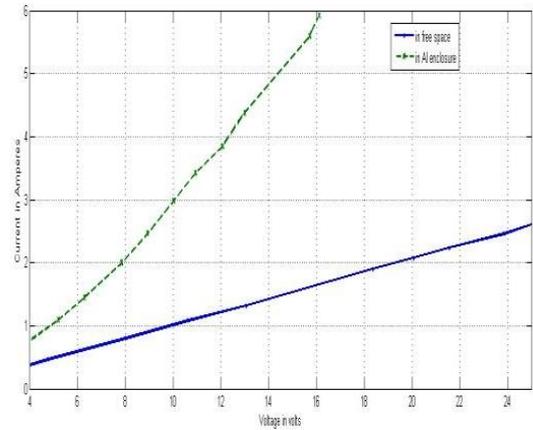


Fig. 4. V-I characteristics of inner coil when outer coil shorted

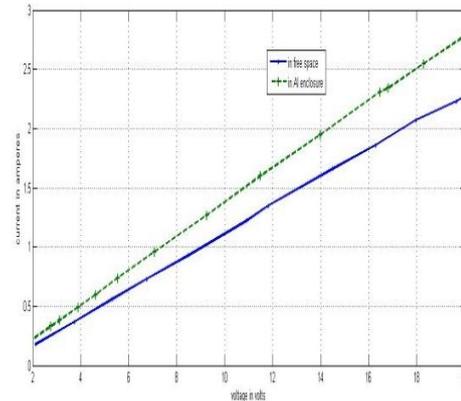


Fig. 5. V-I characteristics of outer coil when inner coil shorted

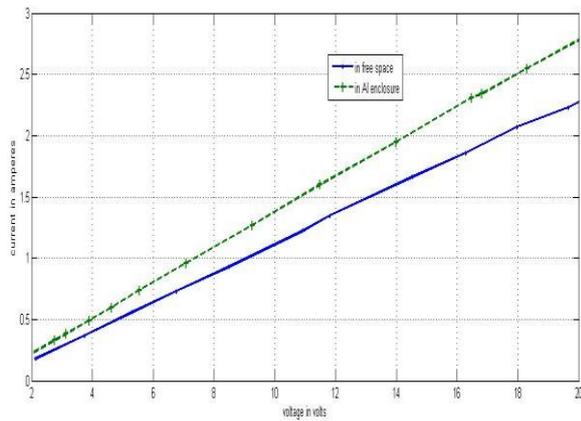


Fig. 6. Variation of EMF in inner coil with input voltage to outer coil

From the above graphs, the input current to inner or outer coil is increasing when the coils are placed in aluminium enclosure. The induced EMF in the second coil is reduced when the coils are placed in the aluminium enclosure.

Table III shown the values of induced EMF in the inner coil when it is placed in free space and aluminium enclosure. By seeing the values the value of induced EMF is reducing when the coil placed in the aluminium enclosure.

Table 3 Induced EMF in the inner 500T coil with and without aluminium enclosure

S. No	Without aluminium enclosure			With aluminium enclosure		
	V ₂ in volts	I ₂ in amps	V ₁ in volts	V ₂ in volts	I ₂ in amps	V ₁ in volts
1	1.475	0.11	1	2.049	0.23	0.875
2	2.991	0.25	2.07	3.197	0.39	1.372
3	3.688	0.31	2.578	4.03	0.51	1.774
4	4.82	0.41	3.367	5.55	0.73	2.464
5	6.46	0.56	4.51	6.59	0.87	2.919
6	7.07	0.62	4.96	7.22	0.96	3.186
7	9.06	0.8	6.41	7.92	1.06	3.513
8	10.84	0.96	7.68	9.21	1.24	4.06
9	15.09	1.36	10.59	10.06	1.35	4.41
10	17.1	1.55	11.86	11.61	1.57	5.13
11	18.75	1.7	12.88	12.79	1.73	5.64
12	22.82	2.09	15.46	13.99	1.91	6.02
13	25.03	2.74	17.16	15.8	2.16	7.16
14	28.49	2.67	19.33	18.42	2.52	8.11
15	31.12	2.92	20.67	20.93	2.87	4.22

Fig. 7 shows the variation of different secondary currents when the other coil is open circuited. Fig. 8 shows the variation of different secondary currents when the other coil is short circuited. Fig. 9 shows the variation of different inner coil voltages when the outer coil is supplied by a voltage source. Fig. 10 shows the variation of different inner coil currents when the outer coil is supplied by a voltage source.

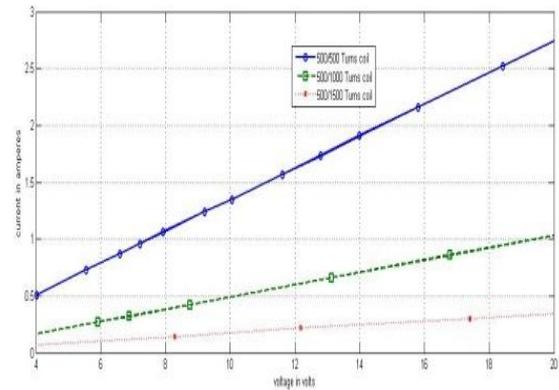


Fig. 7. V-I characteristics of voltage to outer coil when inner coil open

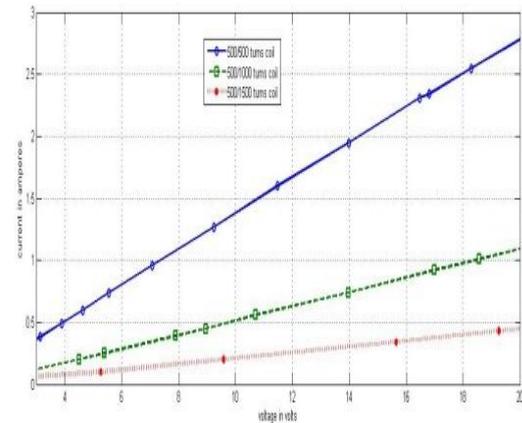


Fig. 8. V-I characteristics of outer coil when inner coil short.

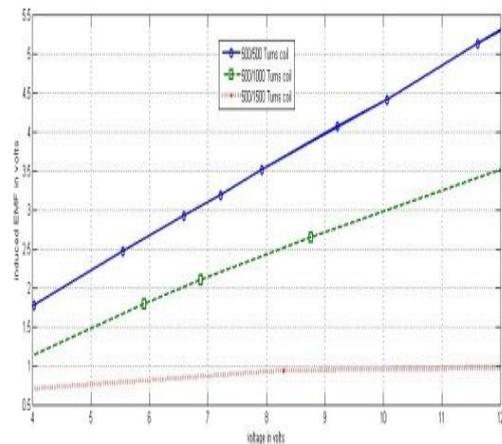


Fig. 9. Induced EMF in the inner coil for different turns of outer coil.

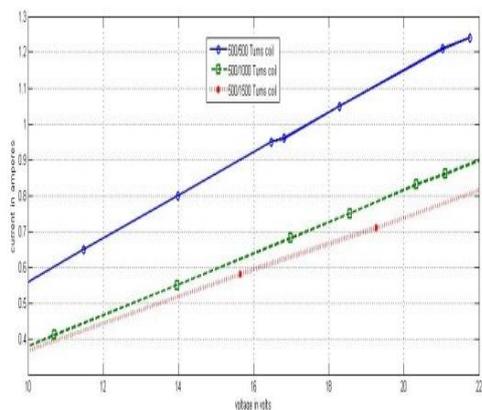


Fig. 10. Current in the inner coil for different turns of outer coil.

From the above figures it is concluded that the current drawn for higher number of turns is less hence the induced EMF in the inner coil is also less.

IV. CONCLUSION

From the above observations, the effective resistance and inductance of two coils wound on same core is decreasing when it is placed in aluminium enclosure. The decrease in inductance is mainly due to the change in permeability of the iron core. But the increase in induced EMF in the second coil when the iron core (two coils wound on the same core) is placed in the aluminium enclosure is not possible. In addition to that the primary coil will draw more amounts of current leads to higher loss there by low efficient. If two coils placed on two different cores then the induced EMF in the other coil gets doubled..

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