Enhancement of Electromagnetic Braking System

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Abstract*- We know that today's braking system works on principle of dissipation of kinetic energy into heat energy that is through friction.[1] As this method has wearing effects hence must be replaced with a method which has low or no wearing effect with enhanced effectiveness.[2] In this project design of electromagnetic braking system along with optimization for various operational parameters has been done. These parameters have been previously iterated in cited projects and papers. Simulation models are to be cross checked with experimental setup. An attempt is made through this project to calculate the braking time.*

Keywords- Current, braking torque, opposing torque, no. of turns, air gap

I. INTRODUCTION

Modern braking techniques focused on safety, comfort and environmental protection. With the increase in driving speed and load conventional braking systems does not give satisfactory performance.[4] Electromagnetic brakes can be applied separately, completely without the use of friction brakes. Due their specific method of installation electromagnetic brakes can avoid problems that friction brakes face. Working principle of electric retarder (solenoid ring) is based on creation of eddy current within a coil which is mounted parallel to flywheel. The force developed by eddy current opposes the flywheel. [6]

Therefore, practically it is found that electromagnetic brakes depend on electrical parameters like flux density, axial distance between solenoid coil, current etc. This electromagnetic braking system eliminates drawback of wear and tear which exist in conventional braking system. This system is applicable for only high speed application.

II. METHODOLOGY

Initially designing of setup is done with help of solid works. Then calculations regarding various components involved in it like shaft, flywheel etc are done. So the method involves taking actual readings over the setup and then comparing it with theoretical values which are calculated with the help of standard formulas.

CAD Model:-

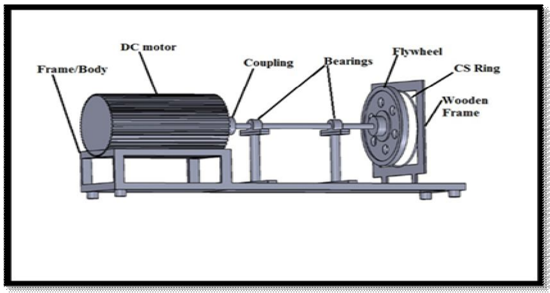


Fig.2.1:- CAD model of experimental setup

Flywheel:-

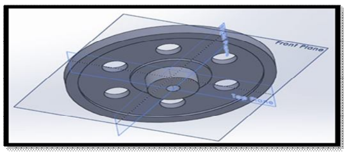


Fig no 2.2 Flywheel

Total weight of flywheel (M) = 8.94kg
Weight of flywheel with 6 holes= 7.95kg
Radius of flywheel (R)= 152mm
Radius of holes (r) = 18.5mm
Distance of centre of hole from distance of flywheel (h) = 95mm
Mass moment of inertia of flywheel without hole (I) = $MR^2/2$
$=0.10327$ kg.m^2
Mass moment of inertia of holes (Ih) = $I_o+m.h^2$
$= (mr^2/2)+m*h^2$
$=1.50816*10^{-3}$ kg.m^2
$I_{flywheel} = I-I_h$
$=0.09422$kg.m^2

Solenoid ring:-

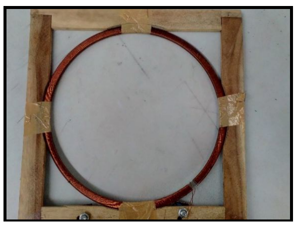


Fig no.2.3:- Solenoid ring

Details of solenoid ring:-

1) Material: - Carbon steel
2) Permeability:-$1.26*10^{-4}$ H/m
3) Relative permeability: - 100
4) Copper wire diameter: - 0.5 mm
5) No. Of turns: - 1500

Actual setup:-

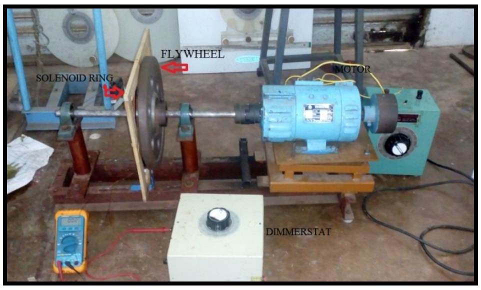


Fig no.2.4:- Experimental setup

Experiments are performed on above setup which comprises D.C. motor (0.5KW) to which flywheel is connected with the help of shaft. A braking arrangement is shown in fig 2.3 which is termed as solenoid ring. To supply controlled voltage dimmer stat is connected to dc motor as well as to solenoid ring but where ammeter is connected to it in series. Experiments are performed on setup within the range of 400 to 1100 RPM with 5mm and 3 mm air gap.

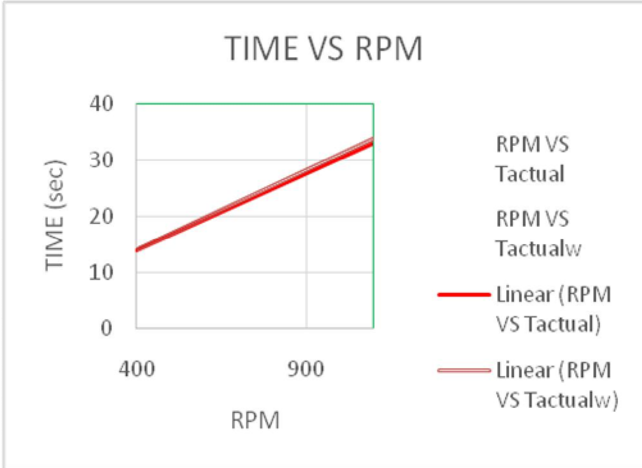
III. PRACTICAL OBSERVATIONS

Terms involved:-

Tactw = Actual time without braking
Tactb = Actual time with braking
Tthw = Theoretical time without braking
Tthb = Theoretical time with braking
ζcoil = Opposing torque by solenoid ring = 0.1576 N.m
ζMotor = Torque of motor
αw and αw = Deceleration of flywheel with and without braking

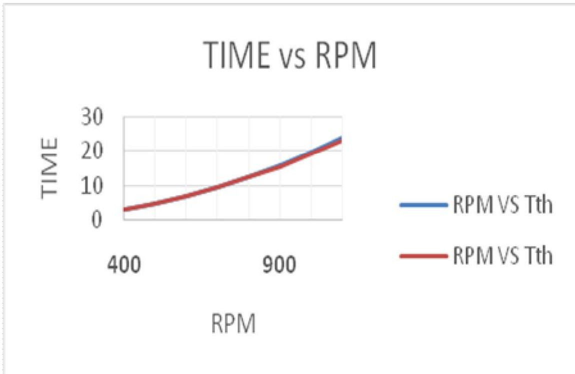
Table no. 3.1 For 3mm air gap and 5 A current

RPM	Tactw(s)	Tactb(s)	ζMotor (N.m)	αw(rad/sec^2)	Tthw(sec)	αb(rad/sec^2)	Tthb (sec)
1100	34.59	31.34	4.34	46.062	23.88	47.73	23.04
1000	30.37	30.11	4.77	50.62	19.75	52.29	19.12
900	27.82	26.7	5.3	56.25	15.99	57.9	15.53
800	25.53	25.13	5.96	63.25	12.64	64.92	12.32
700	23.1	22.92	6.82	72.38	9.67	74.05	9.45
600	20.8	19.47	7.95	84.37	7.11	86.04	6.97
500	17.1	15.93	9.54	101.25	4.93	102.92	4.8
400	13.73	13.43	11.93	126.6	3.15	128.29	3.11



Graph 3.1:- For actual reading with and without braking

The above graph shows the variation of time with respect to RPM , with and without braking for practical readings for 3mm air gap.

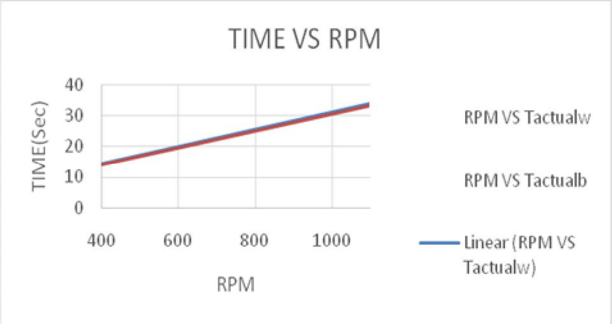


Graph 3.2:- For theoretical reading with and without braking

The above graph shows the variation of time with respect to RPM , with and without braking for theoretical readings for 3 mm air gap.

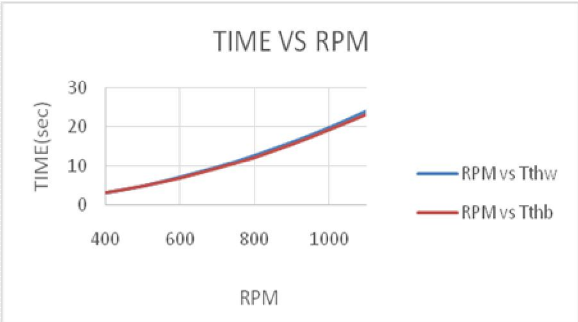
Table No. 3.2 :- For 5mm air gap and 5A current

RPM	Tactw(s)	Tactb(s)	ζMotor (N.m)	αw(rad/s^2)	Tthw(s)	αb(rad/s^2)	Tthb (sec)
1100	34.59	32.75	4.34	46.06	23.88	47.73	23.04
1000	30.37	30.23	4.77	50.62	19.75	52.29	19.12
900	27.82	26.83	5.3	56.25	15.99	57.94	15.53
800	25.53	25.46	5.96	63.25	12.64	64.92	12.32
700	23.1	23.03	6.82	72.38	9.670	74.05	9.45
600	20.8	19.78	7.95	84.37	7.110	86.04	6.97
500	17.1	16.08	9.54	101.25	4.93	102.9	4.85
400	13.73	13.4	11.9	126.61	3.15	128.1	3.11



Graph 3.3 For Actual reading with and without braking

The above graph shows the variation of time with respect to RPM , with and without braking for practical readings 5 mm air gap.



Graph 3.4 :-For theoretical reading with and without braking

The above graph shows the variation of time with respect to RPM , with and without braking for theoretical readings for 5mm air gap

IV. CONCLUSION

The purpose of study was to perform a comparative study of practical and theoretical braking time and establish practical air gap limit beyond which the electromagnetic brakes loses their effectiveness.

From theoretical calculation and experimental braking time maximum air gap limit of 3mm is obtained beyond which electromagnetic brakes are found to be ineffective. It is also found that the system is efficient for higher range of RPM (800 -1100).

V . FUTURE SCOPE

If solenoid rings are incorporated on both sides of flywheel then the braking effect would increase. It would be possible to go for different kind of materials to check braking effect. Also magnets can be positioned around the flywheel to get better braking torque distribution.

REFERENCES

[1] Lezi Ye, Desheng Li, Bingfeng Jiao. "*Three dimensional electromagnetic analysis and design of permanent magnet retarder*." ,Higher education press- Heidelberg 2010

[2] Jae Seok Choi, Jeonghoon Yoo, "*Design of Eddy current brake system using microstructures*", IEEE VOL-45, No-6, 6 June 2009

[3] H.A. Sodano, "*Non contact Eddy current excitation method for vibration testing"*, Society for experimental mechanics, 3 July 2006

[4] C.Y. Liu , K.J. Jiang, Y. Zhang, "*Design of an Eddy current retarder in an automobile*", International journal of automotive technology, Vol. 12, No. 4 (2011)

[5] V. A. Razmyslov,V. M. Kuz'min, A. V. Serikov, "*Calculations of Braking force of Electro-Dynamical railway car retarder"*, Russian electrical engineering, vol.79, No.5

[6] S. Anwar, R. C. Stevenson, "*Torque characteristics analysis for optimal design of a copper-layered Eddy current brake system*", International journal of automotive technology , Vol. 12, No. 4 (2011)

[7] Sevvel P, Nirmal Kannan V, Mars Mukesh S, "*Innovative Electro Magnetic Braking System*, Volume 3, Special Issue 2, April 2014

[8] A.A. Adly, S.K. Abd-El-Hafiz, "*Speed range based optimization of non-linear electromagnetic braking systems*", IEEE-Vol. 43, No.6- June 2007