Study of Zero Friction Electromagnetic Braking System by Varying the Disc Material

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Abstract --- With the exponential hike in technologies, it is now mandatory for the improvisation in the existing system to not only be efficient than its ancestors but also be competent with the next generation. This is now being made possible through interdisciplinary incorporation of technologies. As of braking in automobiles is considered, the conventional braking mechanism always falls short in achieving its full potential due to frictional loss and wearing of brake shoe material whose vapors, produced due to heat generation, are also toxic in nature. Hence this is the process to device an eco-friendly braking system that's more reliable and functions similar to ABS (Anti-Lock Braking System) established using a control unit.

Keywords:- *contactless braking system, electromagnetism, eddy current, eco-friendly, functions similar to ABS.*

1. INTRODUCTION

The electromagnetic braking system works on the principle of electromagnetism, which is, when the magnetic flux passes through and perpendicular to the rotating wheel the eddy current flows opposite to the rotating wheel or rotor thereby producing torque necessary to stop the wheel. Since this is frictionless, they are more durable, require less maintenance and have higher life span. This can be an excellent replacement of conventional brakes due to their many advantages that includes reduction in temperature produced as which could even go as high as 500°C, brake wear is un-predictable and worn out brakes can cause catastrophic failure in braking and requires lubrication from Ref 1,2.

So if we could make electromagnetic braking operate more efficiently like that of Anti-Lock Braking System (ABS) then they could function much better than the conventional brakes as their response time is very minimal, higher brake force, power transmission is more reliable and easier and this project is the visualization of the above said concept which also addresses the present innovation of being inter-disciplinary.

2. CONSTRUCTION

The arrangement of electromagnetic braking system as in Ref.3,4 is as shown in Fig.1 which is much simpler than the conventional braking system whose specifications are mentioned in Table1, since they have lesser mechanical components and does not require any lubrication. It consists of a DC motor coupled with the drive shaft that is mounted on a bracket via the transmission chain. The free wheel is kept variable so as to step-up the speed if required. A slack adjuster is provided to guide the transmission chain in-line with the drive wheel. Two different materials of disc are used, namely Mild Steel and Aluminum so as to give a comparative study of variations that occur in the braking due to change of materials.

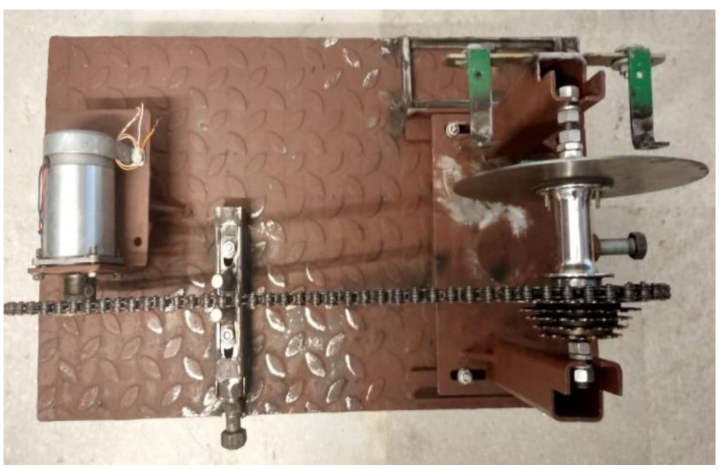

Figure 1: Hardware Arrangement

The electromagnets are screwed along the brackets and are held perpendicular to the disc with an air gap of 1 – 1.5 mm, which are energized using a separate electronic setup so as to make the braking function similar to ABS. This line diagram of electronic setup as shown in Fig.2 consists of battery to supply DC current, step-down converter, relay module to provide intermittent current supply for timed energization of the electromagnet coils made possible by Arduino IDE coding. Further, a potentiometer that would help in directly varying the speed of the DC motor, just an alternative to speed variations that could also be brought about by changing the gear ratio of the drive and the free wheel. The practical electronic setup is as shown in Fig.3

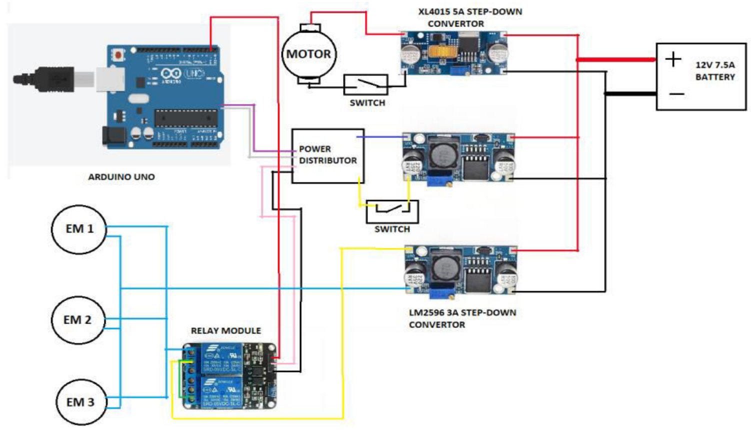

Figure 2: Circuit Assembly

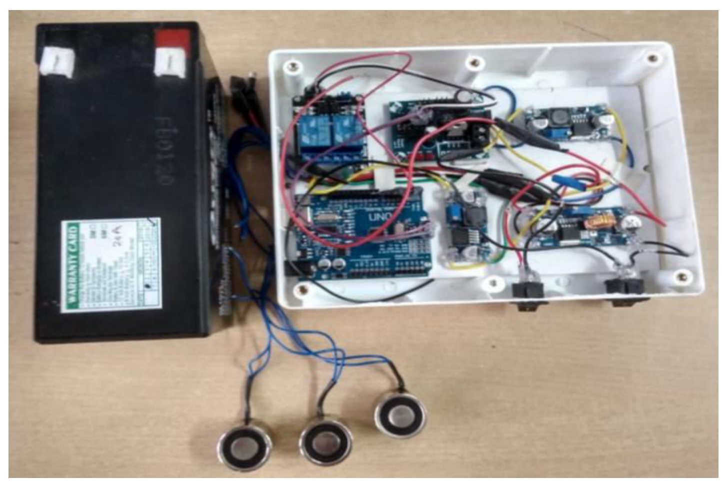

Figure 3: Circuit Arrangement

Table 1: Component Details

COMPONENTS	SPECIFICATIONS
Base (Cast Iron)	750 x 450 mm
Disc (Mild Steel & Aluminum)	Dia. 178 mm Thickness 1.5 mm
Drive Wheel	Dia. 96.5 mm
Free Wheel	Dia. 86.4 – 53.4 mm
Hub	Dia. 35 mm
DC Motor	12 V, 2200 RPM
Battery	12 V , 7.5 A
Electro-Magnet	24 V, 80 Nm
Relay	10 A

3. WORKING

The Arduino IDE coding is fed into the Arduino UNO board. The timed pulses are generated, transmitted by the relay module and the electro-magnets are energized in sequence to the pulses and produce Eddy current in the disc which retards the rotational motion of the disc. This braking system when used for supplementary braking utilizes both the swirl current and attraction power of magnet whose action is visualized in Fig.4 to stop vehicle. Swirl current is utilized to hinder the vehicle while attractive power is accustomed to convey vehicle to rest. This braking depends on attraction property of magnets. The more powerful the electromagnet and greater the impulse the shorter will be the time taken for the disc to come to rest. When the disc rotates between the brackets, the electromagnets mounted in the brackets pull in the lasting magnet in disc. Since, electromagnets in bracket are settled, they endeavor to turn the disc in the opposite direction thereby decelerating it. The deceleration is finished by expanding attractive field by expanding current supply to the electromagnets.

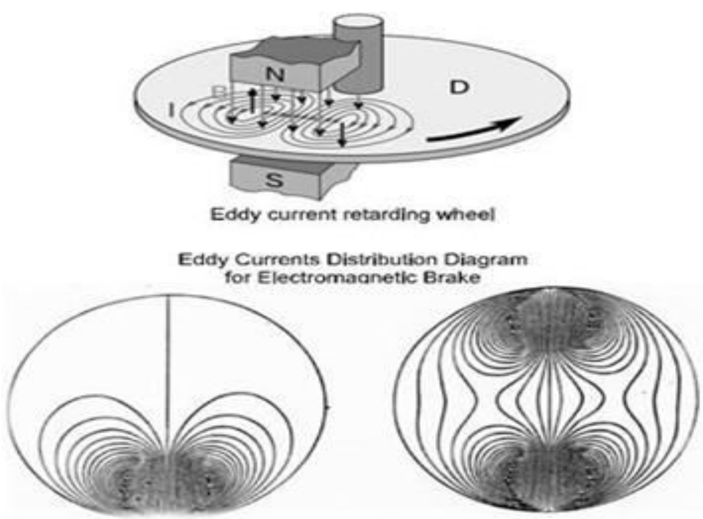

Figure 4: Eddy current distribution

Since the Arduino coded timed pulses are put up in a loop, solid electromagnet situated along the circumference of the disc is turned on, along these lines shaping an attractive motion. This attractive motion is oppositely brought into the disc. A vortex current is in this manner incited in the tweaked disc because of the Faraday's law. A Lorentz compel is created by the relative activity between the swirl current and the attractive transition, in this manner framing a braking torque. Vortex current does not decelerate vehicle at low speed. That`s why anticipated brake is blend of both attractive power and swirl current.

4. RESULTS AND DISCUSSION

Nomenclature and Formulae

Table 2: Nomenclature

NOTATION	MEANING
v	Desired Velocity Maximum
u	Desired Velocity Minimum
D	Disc Diameter
N	Disc RPM
A	Acceleration / Deceleration
BF	Braking Force
BT	Braking Torque
CF	Clamp Force
m	Rotating Mass
μ	Coefficient of Friction
t	Braking time
ρ	Density of Disc
c	Specific Heat Capacity of Disc

I. Braking Force (BF):- $V = \Pi * D * N / 60$; $A = (v - u) / t$; $BF = m*A$

II. Braking Torque (BT):- $BT = (BF \times 0.5 D) / R_{eff}$

III. Clamp Force (CF):- $CF = BT / (\mu \times R_{eff})$

IV. Brake Power (BP):- $BP = 0.5 \times m \times v^2$

V. Rotational Energy (RE):- $RE = BP / t$

VI. Fade Stop Temperature Rise (FSTR):-
$\Delta Temperature = (RE \times t) / (\rho \times c \times Volume)$

Table 3: Comparative Results

QUANTITY	MILD STEEL	ALUMINUM
N	1000 rpm	1000 rpm
c	420 J/kg °C	921 J/kg °C
ρ	7850 kg/m^3	2710 kg/m^3
t	7.38 sec	5.96 sec
BF	0.293 N	0.158 N
BT	0.532 Nm	0.287 Nm
CF	43.43 N	23.43 N
BP	12.73 J	4.39 J
RE	1.72 W	0.74 W
FSTR	0.103	0.047

By using the electromagnetic brake as supplementary retardation equipment, the friction brakes can be used less frequently, and therefore practically never reach high temperatures. Table 3 gives the experimental results derived an assumed set of conditions with regard to the done arrangement. The brake linings would last considerably longer before requiring maintenance, and the potentially "brake fade" problem could be avoided. Furthermore, the electromagnetic brake prevents the dangers that can arise from the prolonged use of brakes beyond their capability to dissipate heat. This is most likely to occur while a vehicle descending a long gradient at high speed. The installation of an electromagnetic brake is not very difficult. It does not need a subsidiary cooling system. It does not effect on the efficiency of engine making no compromise with its controllability.

5. CONCLUSION

Electromagnetic brakes have numerous preferences over frictional slowing mechanism. The blend of swirl present and attractive powers makes this brake more successful. This brake can be utilized as assistant stopping mechanism in vehicle. The utilization of abs can be dismissed by utilizing a smaller scale controlled electromagnetic framework. These brakes can be utilized as a part of wet condition, so there is no utilization of against slipping instrument. it is completely electrically controlled which brings about less mishaps. The braking power delivered in this brake is not as much as the plate brakes. Subsequently, it can be utilized as an auxiliary or crisis slowing mechanism. The electromagnetic brakes has excellent heat dissipation efficiency. From the foregoing, it is apparent that the electromagnetic brake is an attractive complement to the safe braking of heavy vehicles. Good results with current design, a larger budget would improve performance.

6. REFERENCE

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