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Prototype of Electromagnetic Braking System

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ABSTRACT: An electromagnetic braking system (EM braking system) is a new and revolutionary concept. Irrespective of hydraulic fluid in disc and drum brakes, EM brakes use magnetic power to engage the brake. Therefore, electromagnetic brakes work on electric and magnetic power. Unlike the conventional braking system which is often referred to as bulky, EM braking system is compact and offers high degree of safety. These brakes have various names like electromechanical brakes, eddy current brakes, frictionless brakes, non-contact brakes and many more. This system works under the principle of electromagnetism. This braking system is frictionless, hence there is no wear and tear of the system parts. This phenomenon is governed by Faraday's Law of Electromagnetic induction and Lenz' Law. Eddy current is generated by the relative motion between a metal, an alloy conductor, and a magnet. Now when the magnetic flux passes through and perpendicular to the rotating wheel, eddy current flows opposite to the rotating wheel/ rotor direction. This eddy current tries to stop the rotating wheel/rotor. Therefore, the rotating wheel/rotor comes to rest position. This type of braking system is generally used in trains and trams. EM braking system is better in performance and also has low maintenance as compared to conventional braking system.

KEYWORDS: Electromagnetism, Faraday's Law of Electromagnetic induction and Lenz' Law.

I. INTRODUCTION

Electromagnetic brakes are simply an mechanical brakes which bring about retardation by applying electromagnetic induction in the disc brake in direction opposite to the rotation of the actual disc i.e. If vehicle is moving forward then rotation of disc will be clockwise (Frame of reference is from left hand side of vehicle) then the magnetic field will be counter clockwise. By this way the motion of the brake is retarded by the brakes but there is no physical contact in any case. This is a revolutionary concept. Hence electrical energy from the appropriate power source is used to the purpose. As any type of brake the heat energy is generated in the brakes which have to be exhausted into environment but wear and tear is minimized. Brakes are imperative for any vehicle and a substantial vehicle by and large uses grating brakes alongside Electromagnetic brakes. This venture primarily concentrates on building a slowing mechanism, which can be material in bike at fast and low upkeep cost. This framework utilizes an electromagnet connected directly to vehicle's battery. Electromagnetic brakes are likewise called electro-mechanical brakes or EM brakes and moderate or stop movement utilizing electromagnetic constrain to apply mechanical resistance. Electromagnetic brakes were invented by an African- American self-taught engineer known as Granville Taylor Woods. They were originally called as electro-mechanical brakes, but as time passed by, people were used to call it electromagnetic brakes. These EM brakes are used widely in locomotive industries especially in trains and trams. These trains and trams EM brakes for safe and efficient travel on tracks. They are also used as emergency braking system when electronic brakes fail to function.

In a study, it was found that these EM brakes develops a negative power, which constitutes about twice the maximum power output of a typical engine, and at least three times the braking power of an exhaust break (Reverdin 1994). The working principle of the EM brake is based in formation of magnetic field within a mutual disc rotating between two electromagnets. This sets up a force opposing the rotation of the disc. As mentioned earlier, both Faraday's Law and Lenz' Law govern this phenomenon. Faraday's Law of electromagnetic induction states that "the induced voltage in a circuit is directly proportional to the rate of change of time of the magnetic flux throughout the circuit".



II. RELATED WORK

The design of the brakes is based upon the phenomenon of electromagnetic induction and eddy currents. The design basically consists of very strong magnet and rotating metallic wheel. The wheel develops eddy currents due to the change in magnetic flux associated to the wheel due to its rotation. The eddy current development obeys Maxwell's law of electromagnetic induction and Lenz's law of direction of induced current.

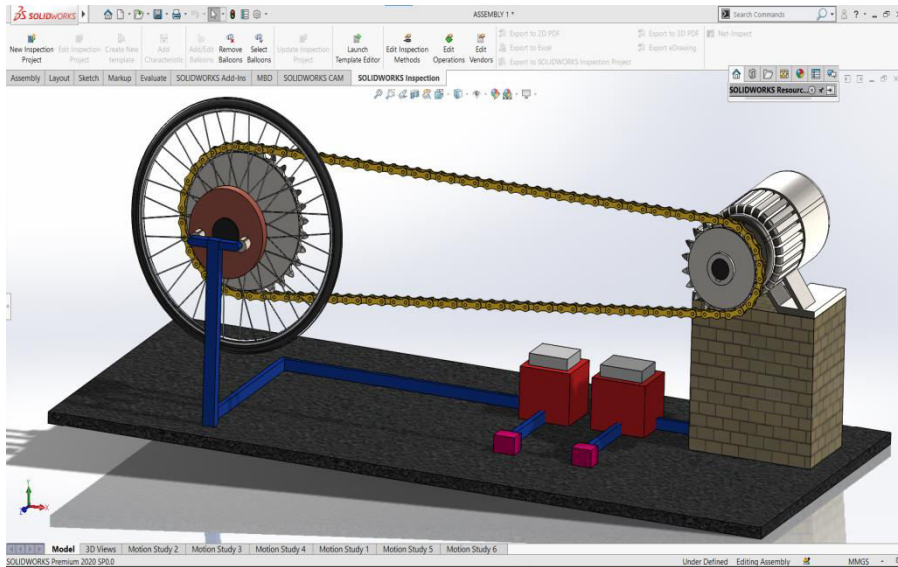
III. METHODOLOGY

The wheel is rotated by chain drive sprocket which is powered by a motor connected to a 12V battery. The electromagnets are connected to another 12V battery in series combination. Now to apply brakes first let wheel be rotated at its optimal speed almost approx for few seconds. Now when the wheel is at its optimal speed suddenly switch of the motor and switch on the electromagnets powered by another battery. In this way transmission given to the wheel will be stopped and brakes will be applied to the wheel through electromagnets. To increase intensity of braking power, we can make a little advancement that is increasing thickness of the iron plate. As thickness is increased, Eddy current induced will be more. Hence braking time will be reduced increasing more intensity of braking power.

IV. EXPERIMENTAL WORKING

As we are using electromagnets which are being given DC current, so due coiling in electromagnet and DC charge in it magnetic field generated will be constant. It will create fixed strong magnetic field. As wheel is moving /rotating in front of it, so the wheel is cutting magnetic lines of force. Thus, as a result voltage will be induced in the iron plate which is on the wheel and as voltage is induced, the wheel's plate is behaving like one solid piece due to short circuit; current will be induced in it. This current is called as Eddy Current. So due to this Eddy Current wheel's iron plate will also produce magnetic field and due to this wheel will apply brake.

V. DESIGN



VI. SPECIFICATION

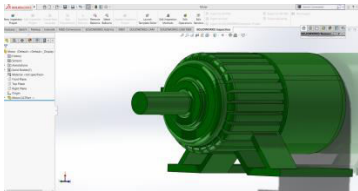


Figure-1 DC Motor

Type: 12 Volt.
RPM: 1500
Width: 127mm
Height: 120mm

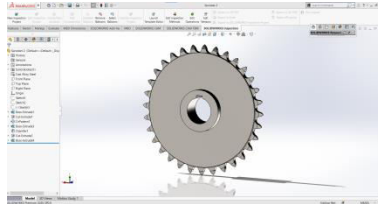


Figure-2 Wheel Sprocket

No of teeth: 32
Outer diameter: 117mm
Inner diameter: 28mm

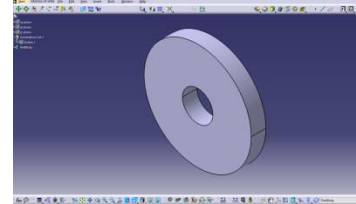


Figure-3 Iron Disc

Thickness: 20mm
Inner Diameter: 27mm
Outer Diameter: 95mm

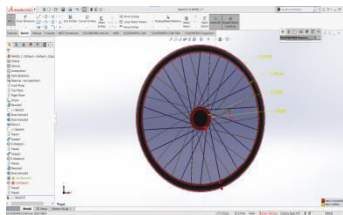


Figure-4 Wheel

Wheel Diameter: 218.39mm
Wheel Outer Rim Diameter: 198.44mm
Wheel Inner Rim Diameter: 27mm
Wheel Circumference: 685.74mm

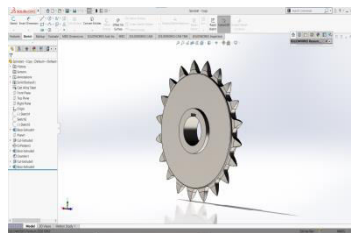


Figure-5 Motor Sprocket

No of teeth: 20
Outer diameter: 69.30mm
Inner Diameter: 42.80mm

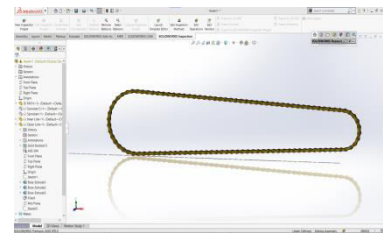


Figure-6 Chain

Distance between sprockets: 499.82mm
Length of Chain: 1326mm
Diameter of motor sprocket: 69.30mm
Diameter of Wheel sprocket: 117.80mm

VII. NOMENCLATURE

- Z1 = No. of teeth on driving sprocket
- Z2 = No. of teeth on driven sprocket
- N1 = Motor RPM
- N2 = Wheel RPM
- w = Width of Keyway
- h = Height of keyway
- P = Chain Pitch
- i = Speed Ratio
- V = Average Velocity
- γ = Pitch Angle
- M = No. of Links
- L = Length of Chain
- C = Centred distance between wheel and motor



VIII. CALCULATIONS

Motor rpm= 1500rpm, Motor Sprocket= 20 Teeth, Wheel Sprocket= 32 Teeth

We know,

Output teeth/Input Teeth=Input rpm/Output rpm

$$32/20=1500/\text{Output rpm}$$

Thus by solving above equation:-

$$\text{Output rpm} = 937.5 \text{ rpm} = 938 \text{ rpm}$$

Keyway of Sprocket-

Motor-

$$w = d/4 = 18/4 = 4.5$$

$$h = 2/3 * w = 2/3 * 4.5$$

$$h = 3$$

Wheel-

$$w = d/4 = 27/4 = 6.75$$

$$h = 2/3 * w = 2/3 * 6.75$$

$$h = 4.5$$

Average Velocity (V)-

$$V = z * p * N1 / 60 * 1000$$

$$= 20 * 12.5 * 1500 / 60 * 1000$$

$$= 6.255 \text{ m/sec}$$

Pitch Angle-

$$\gamma = 360 / Z1 = 360 / 20$$

$$= 18 \text{ degree}$$

Speed Ratio (i)-

$$N1 / N2 = Z2 / Z1$$

$$1500 / 938 = 32 / 20$$

$$i = 1.6$$

Minimum Chain Speed-

$$V(\text{min}) = \pi * D * N1 * \cos(\gamma/2) / 60 * 1000$$

$$= \pi * 80 * 1500 * \cos(18/2) / 60 * 1000$$

$$= 6.20 \text{ m/sec}$$

Maximum Chain Speed-

$$V(\text{max}) = \pi * D * N1 / 60 * 1000$$

$$= \pi * 80 * 1500 / 60 * 1000$$

$$= 6.283 \text{ m/sec}$$

Maximum Chain Speed-

$$V(\text{max}) = \pi * D * (N1/60) * 1000$$

$$V(\text{max}) = \pi * 80 * (1500/60) * 1000$$

$$V(\text{min}) = 6.283 \text{ m/sec.}$$

Percentage Speed Variation of Chain-

$$V(\text{max}) - (V(\text{min}) / V * 100)$$

$$6.273 - 6 - (6.20 / 6.255 * 100)$$

$$= 1.326$$

Number of Links (M)-

$$2(C/P) + (Z1 - Z2/2) + (Z1 - Z2/2\pi)^2 * (P/C)$$

$$2(500/12.5) + (20 + 32/2) + (32 - 20/2\pi)^2 * (12.5/500)$$

$$106.021$$

$$M = 106 \text{ mm}$$

$$C = 500 \text{ mm (consider).}$$



Corrected Center Distance-

$$P/4 \{ [M-(Z1+Z2)/2] + \sqrt{[M-(Z1+Z2)/2]^2 - 8[Z2-Z1/2\pi]^2} \}$$
$$12.51/4 \{ [105-(20+32/2)] + \sqrt{[105-(20+32/2)]^2 - 8[32-20]^2} \}$$

$$C = 499.82\text{mm.}$$

Length of Chain-

$$L = M * P$$
$$= 106 * 12.51$$
$$= 1326.06\text{mm}$$
$$L = 1326\text{mm}$$

Motor Selection-

By design data book catalogue
12V DC Motor
Motor RPM = 1500

IX. CONCLUSION

Brake linings would last considerably longer before requiring maintenance and potentially “brake fade” problem could be avoided. Can be used some aircrafts Aeroflux brakes uses electromagnetic braking to stop an aircraft without friction and therefore without wear. The electromagnetic repulsion between these surface currents and the applied magnetic field creates a drag force on the disc that results in a braking torque. Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicle. Electromagnetic Braking system experiences less maintenance as compared to disc brake and drum brake. To increase intensity of braking power, we can make a little advancement that is increasing thickness of the iron plate. As thickness is increased, Eddy current induced will be more. Hence braking time will be reduced increasing more intensity of braking power. We have 20mm thickness Width of Iron Plate in our Prototype.

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