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Construction and Experimental Analysis of an Electromagnetic Braking Clutch

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Abstract-*Over the decades, there have been many changes in the use of clutch and clutch design has experienced startlingly variation but basic operation has remained same. An electromagnetic braking clutch is the new era of automobile industry and other sectors like air conditioning, locomotives, and food processing machinery etc. To slow or stop the motion electromagnetic braking system using magnetic force to apply mechanical resistance. The objectives of this paper are to construct an electromagnetic braking clutch and analyze the power transmission by measuring torque with load and unload condition. This work also investigates the speed change between driving shaft and driven shaft. In this project a shaft is attached with friction plate and motor is placed in the structure. The diagonal of the armature is evolved with a magnetic field when voltage is adopted to the motor as armature and this output start to accelerate. The contrary process (when voltage is not applied) is initiated which results in deceleration of the motion. The period of this appropriate action is absolutely trivial and it happens in a second. This paper proposed the mechanism which implements this phenomenon in developing an electromagnetic clutch and braking system. The results show, for without load condition, torque in driving shaft and driven shaft is same that implies the loss of power is small in magnitude. When the speed of driving shaft decreases, torque increases for without load condition and hence efficiency increases. The results also show, for with load condition, with increase in load, speed decreases abruptly, which depicts slip increases.*

Key words: Electromagnetic, Braking Clutch, Torque, efficiency, Slip.

1.1INTRODUCTION

Though the transmission of torque automatically electromagnetic clutches is electrically driven. They are referred to as electromechanical clutches for that rationality. For years EM turned into electromagnetic in opposition to electro mechanical, mentioning moreover their actuation process against physical activation. Electromagnetic clutches appear simple, but complicated alterations suitable those for multifarious implementations. Without perceiving it, general public utilize electromagnetic (EM) clutches day after day. It is common for anyone who switches on photostat, a tractor or refrigeration device may be using an EM clutch. Electromagnetic clutches turn in various features, with claw, multiplex disk, hysteresis, and magnetic fragment. Despite that single-face design is copiously used version. [6].

1.2 METHODOLOGY

The AC motor is powered by an alternate current in an electromagnetic brake. It contains two parts where the magnetic field is produced with the aid of AC current by a stationary stator with coils. The braking is then applied by the magnetic field due to the retardation and energy absorbed causing the coil to be heated. This high strength magnetic field overcomes the air gap and most of the energy is utilized to pull in the armature. Field, rotor, armature and hub are the integral parts of the electromagnetic braking clutch. The magnetic flux starts to pass through the rotor as soon as the voltage is applied which in turns pulls the armature in contact with the rotor. Disengagement occurs smoothly. Once the field starts to deteriorate, flux fades away thereby disconnecting the armature. Multiple springs held the armature away from the rotor.

1.3 LITERATURE REVIEW

Arthur Pratt Warner is the founder of electromagnetic braking clutch. He established a company named of Warner Electric Brake Corporation in 1927, it is based on innovation of brake design using electricity. At one time, more than 75% of all mobile homes made were equipped with the Warner Electric brake design. Shortly after the end of World War II, the first industrial electric brake was developed for high-speed engine lathes. In 1950 the first industrial electric clutch was developed for use on large turret lathes. During the 50's and 60's the range of applications quickly expanded to include packaging machines, computer printers, textile machinery, farm combines, conveyor systems and plant automation equipment. More recent developments include packaged designs - foot mounted, shaft mounted and C-face designs for direct mounting to standard reducers and motors highlighted by the industry's first clutch/brake modules - the leading choice of designers today.[9]

By using brake Pad Actuation in electromagnetic Coils there are many advantages. Firstly, it prevents brake failure, secondly it reduces the frequent need of maintenance of the braking system. Moreover, this system can be compatible to any kind of vehicle with slight modification.[1]

A moving body's kinetic energy is converted into heat that is degenerated by the braking pads; mostly the braking systems exploit abrasion forces. The intensity of heat of the braking pads augments when resistance-nature braking systems is extreme used, conversely decreases the productiveness of the system. It also reduces the preservation of braking method. A positive impact of this system is that with insignificant revision to the communication and electrical systems, it can be applied on any vehicle.[2]

In 2009 a research conducted by Fleming, Frank; Shapiro, Jessica focusing on the electromagnetic braking system. The paramount objective of the braking system is to ensure the safety and comfort of the passenger, driver and other road user as well as to perform braking efficient than the conventional brakes. This modernized braking system can be used in small & heavy vehicle like car, jeep, truck, busses etc. This paper mainly focuses on the reducing accidents caused by brake failure.

This drastically reduces the complex maintenance procedure without limiting the effectiveness of the braking system. The proper cooling of brake ensures anti fade character and smooth operation. The response time for emergency situation is typically short and in general this system keeps the friction brake working longer and safer.[3]

2. CONSTRUCTION

Construction of Electromagnetic Braking clutch

2.1 DRIVING MOTOR

It is the DC motor which is used to rotate the shaft. It consists of a magnetic field and armature. It is connected between the e shaft and clutch plate. It is rotated with 2000 RPM. But practically in this project it is rotated with the 1400-1500 RPM. It is clamped by screw nut and bolt. RATING: - Power 40-watt, 220 volts.

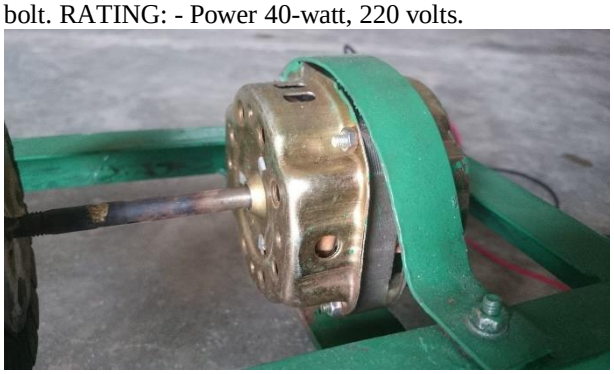

Fig 1: Driving Motor

2.2 CAPACITOR

Main function of capacitor is to store the energy in form of voltage and release the energy at appropriate time. It is connected with the motor and main sources. Rating: - Model C B61, 400 volt, 50 ~ 60 Hz, capacity 6μF ± 5%

Fig 2: Capacitor

2.3 CLUTCH PLATE OR FRICTION MATERIAL

In this project 'Asbestos' material is used as clutch plate or friction plate. Clutch plate is connected with one end of motor shaft in place of the engine shaft. Clutch plate is rotated at same as the motor speed. The friction material is attached to the outer periphery of the clutch plate. Pressure plate is connected with one end of driven shaft. There is a clearance between pressure plate and clutch plate while clutch is disengaged. The pressure plate rotated at the same speed as the clutch plate when clutch is fully engaged. The RPM of the pressure plate varies according to the engaging condition.

Fig 3: Clutch plate

2.4 STEEL SHAFT & BEARINGS

The shaft material is mild steel. It is connected with clutch plate and two bearings. Plane surface bearings are used in this project. It contains a driving pulley with belt. It is rotated with same speed of driving motor shaft speed. The shaft size is $\frac{1}{4}$ inch and Bearing size is $\frac{1}{4}$ + (.002 ~ 0.0025) inch.

Fig 4: Bearing and shaft

2.5 PULLEY AND BELT

In this project mild steel is used to fabricate pulley. Pulley size is .25 +.001 in. Pulley is connected with driven shaft. Belt model is HM-26, made in china. Belt is attached with pulley. It can be transmitted power from driven shaft to another shaft.

Figure 5: Pulley and belt

2.6 FRAME AND CLAMP

Frame is constructed by iron angles and it is joined by Arc welding. Its length is 20 in, width is 5.5 in. Clamp is also fabricated by iron angles. Motor, bearings are clamped by nut and bolts.

Here, figure 6 shows the constructed electromagnetic braking clutch.

Fig 6: Constructed electromagnetic braking clutch

3. EQUATIONS

The connections amid voltage, current and resistance addresses ohm's law which is the most significant law of physics. This law states that the direct current through the conductors is commensurate with the employed voltage and the law is explicated as,

$$I = V/R \quad (7)$$

Here V- potential difference or voltage (volts); I- current (amperes); R- conductor's resistance (ohm);

The input motor power is calculated according to this formula:

$$Pin = I * V \quad (7)$$

Where Pin – input motor power (watts); I- current, (amperes); V- voltage (volts);

The output motor power is calculated according to this formula:

$$Pout = T * \omega \quad (5)$$

Here Pout – amount of produced power(watts); T – Torque, (newton meter); ω – angular speed (radians per second);

The calculation of the angular speed of motor determined by this relevance formula:

$$\omega = N*2\pi/60 \quad (5)$$

Where ω – angular speed (radians per second); N –speed, (revolution per minute); π- constant;

The ratio of output power to the input power indicates the efficiency of the motor:

$$\eta = Pout/Pin \quad (5)$$

after substitution of we get,

$$T * N * 2\Pi / 60 = Pin * \eta$$

So Torque will be, $T = (Pin * \eta * 60) / (N * 2\Pi)$;

Speed difference is defined as the interval of two speed. The speed difference divided by the simultaneous speed and multiplied by 100 is denominated as slip speed of a motor. This speed commonly varies from 0.4% to 6% based on its design criteria and speed is inherently illustrated in percentage.

$$Slip = \frac{Ns-N}{Ns} * 100 \quad (9)$$

4. TABLES AND FIGURES

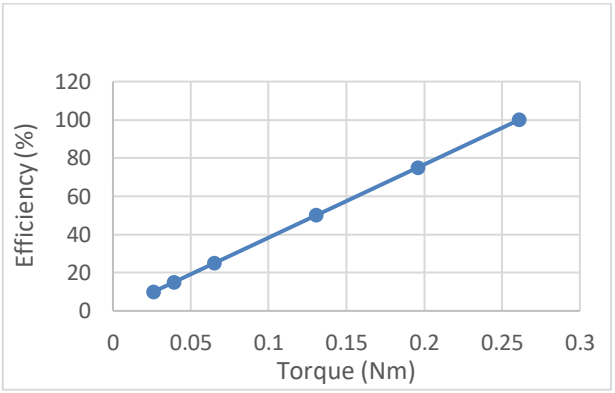

Fig 7: Torque vs Efficiency diagram without load

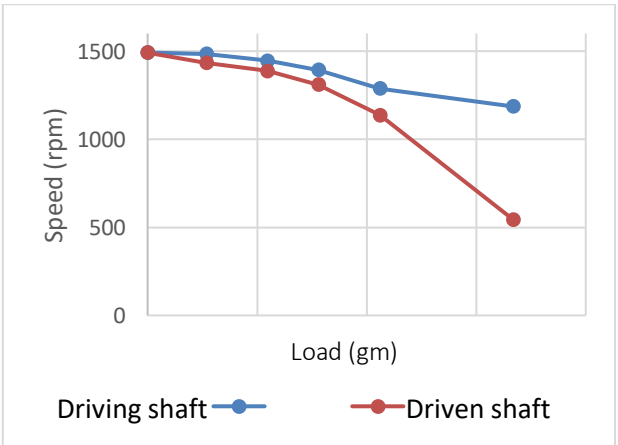

Fig 8: Load vs Speed diagram

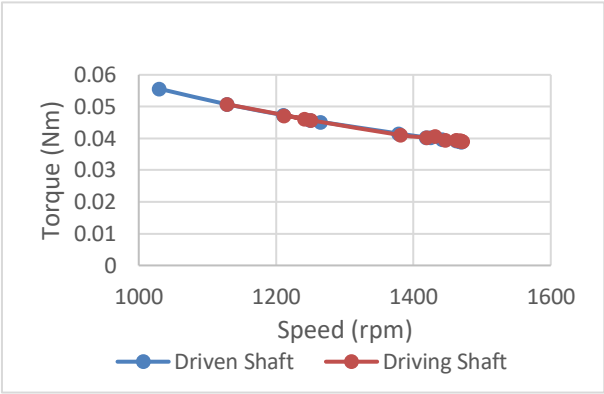

Fig 9: Speed vs Torque diagram without load

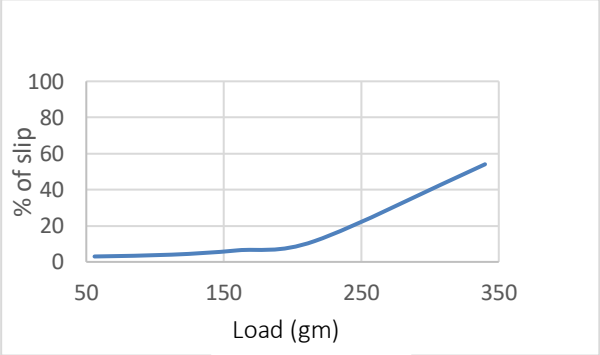

Fig 10: Load vs. % of slip diagram with load

5. RESULT AND DISCUSSION

The expectation of this project was that a prototype model would be constructed that would conceptually prove that an effective electromagnetic braking clutch. It has been widely used on heavy vehicles where the brake fading problem is so serious. The engagement and disengagement of clutch can happen very fast 1-3 seconds. In figure 9 gives information about driven shaft transmitted same torque which has come from driving shaft. So, the loss of power is small magnitude. In figure 7 illustrates if efficiency increases torque will be also increases. But if current falls, the torque or drive transmitted would be also tapered. In industry a motor can be transmitted 60% energy from electrical to mechanical. By the addition of load in driven shaft experimentally shows in figure 8&10 that speed decreases both driving and driven shaft and slipping is also occurred. Friction material selection is very important. In this project 'Asbestos' material was used which coefficient of friction is small as 0.20. Sometimes wear can be produced in two clutches hence excessive heat can be generated and slipping can be occurred. So, the brushes are necessary checked after a period of time

6. CONCLUSION

An electromagnetic braking clutch is revolutionary concept and a modern technology braking system, used in light motor and heavy motors vehicles. The number of accidents is now a days increasing due to ineffective braking system. While it is starting at no load condition there is no heavy current is required to take motor commences. With the help of enumerate of clutches a motor can accomplish variant techniques concurrently or independently. Brakes & clutches function with low wattage. At no load condition speed decreases mildly and percentage of slip is inconsiderable. Torque increases with efficiency and decreases with speed. At load condition speed decreases precipitately and percentage of slip is more elevated than before. Consequently, power transmission is slighter than the no load condition. If load is increased gradually, driven shaft will be separated from driving shaft and braking will occur automatically. Despite a vigorous attempt to analyze, more research is needed to develop electromagnetic braking system that will serve more efficient and more accurate

7. ACKOWLEDGEMENT

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8. NOMENCLATURE

Symbol	Meaning	Unit
I	Current	(A)
V	Voltage	(V)
R	Resistance	(Ω)
P_{in}	Input power	(W)
P_{out}	Output power	(W)
η	Efficiency	(-)
N	Speed	Rpm
ω	Angular speed	$Rads^{-1}$
N_s	Diving speed	Rpm
N	Driven speed	Rpm
W	Load	(N)
T	Torque	Nm