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Design Of Electromagnetic Friction Less Clutch

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I. ABSTRACT

Our project friction less clutch using electromagnetic locking principal with minimal air gap between drive and driver plates, with torque transfer control electronically through V-I Drives. The construction of friction less clutch involves calculation of MMF Force for amount of K-N Torque transfer, design of magnetic plate study of critical factor such as plate diameters, gauge of copper conductor for electromagnet, drive and drives plates. The power source we are planning to use is a constant speed electric motor same as IC Engines. The output speed and torque control through electromagnetic coupling and practically no mechanical contact between will ensure friction less power transfer between engine and Gearbox or load. The amount of noise reduction, amount of friction and wear reduction and practical scalability of this technology, in automotive and other industrial applications, through hardware modal implementation will be analyzed in this project.

II. Introduction

A clutch is a mechanical device that allows an output shaft to be disconnected from a rotating input shaft.[1] The clutch's input shaft is typically attached to a motor, while the clutch's output shaft is connected to the mechanism that does the work. In a motor vehicle, the clutch acts as a mechanical linkage between the engine and transmission. By disengaging the clutch, the engine speed (RPM) is no longer determined by the speed of the driven wheels.

Another example of clutch usage is in electric drills. [2] The clutch's input shaft is driven by a motor and the output shaft is connected to the drill bit (via several intermediate components). The clutch allows the drill bit to either spin at the same speed as the motor (clutch engaged), spin at a lower speed than the motor (clutch slipping) or remain stationary while the motor is spinning (clutch disengaged).

dry clutch uses dry friction to transfer power from the input shaft to the output shaft, for example a friction disk presses against a car engine's flywheel by a spring mechanism. The wheels of the vehicle only rotate when the flywheel is in contact with the friction disk. To stop the transfer of power, the friction disk is moved away from the flywheel by means of a lever mechanism. The majority of automotive clutches on manual transmissions are dry clutches. [citation needed] Slippage of a friction clutch (where the clutch is partially engaged but the shafts are rotating at different speeds) is sometimes required, such as when a motor vehicle accelerates from a standstill; however, the slippage should be minimized to avoid increased wear rates

III. LITERATURE REVIEW

[1] Design and Analysis of an Electro-Magnetic Clutch

Abhishek Chowdhary, Anupam Kumar, Sanket Kumar Singh Student, Department of Mechanical Engineering, Birla Institute of Technology, this paper presents the designing and analysis of an

Electromagnetic Clutch. Engagement and disengagement of clutch is operated electrically but the torque is transmitted mechanically. It overcomes the problem of higher response time of mechanical clutches. In this paper we have discussed, in detail, various steps we followed to design an electromagnetic clutch -calculations, CAD, and analysis of parts of electromagnetic clutch. Static analysis is done on designed parts to ensure the safe operation of clutch and also fatigue analysis is done for estimating life of components. This paper also demonstrates about Magneto-static Analysis to know about Electromagnet characteristics like Magnetic Flux density and Force density.

[2] A Comprehensive Study on Friction less or Electromagnetic Braking System

Mohamed Faizal S Mechanical Engineering in Department of Production Technology, MIT Campus, Anna University, Chennai, India system is friction less, 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.

[3] Friction less Electromagnetic Braking System

The working rule of this technique is that when the magnetic flux passes through and perpendicular to the rotating wheel the eddy Current flows opposite to the rotating wheel/rotor direction. This eddy current trying to prevent the rotating wheel or rotor. This results in the rotating wheel or rotor comes to rest/ neutral these are totally friction less. Due to this, they are more durable have longer life spangles maintenance is there. These brakes are a superb replacement on the convectional Sandip University, Nashik, M. Tech. Mechanical Engineering 8 brakes thanks to their many advantages. The reason for implementing this brake in automobiles is to scale back wear in brakes because it friction less. Therefore, there will also be no heat loss. The

electromagnetic brakes are much effective than conventional brakes the time taken for application of brakes is also smaller.

[4] Analysis and Design of a Permanent Magnet Bi-Stable Electro-Magnetic Clutch Unit for In Wheel Electric Vehicle Drives Clutches have been used in internal combustion vehicles and concentrated electric vehicles (EVs) to smoother impulsion while starting and shifting. This paper proposes a permanent magnet bi-stable electromagnetic clutch unit (PMBECU) which is specially introduced into in-wheel EVs to make the rigid connection between hub and wheel more flexible. Firstly, the operation principle of the PMBECU is illustrated. Then, the basic magnetic circuit model is presented and analyzed, followed by optimal design of the main structural parameters by investigating the PM leakage flux coefficient. Further, according to the basic electromagnetic characteristics of the PMBECU, the current pulse supply is put forward, and the minimum pulse width which enables the operation of the PMBECU and its dynamic characteristics are analyzed by an improved finite element method. Finally, a prototype machine is manufactured and tested to validate all the analysis results.

[5] Dynamic coordinated control strategy of a dual-motor hybrid electric vehicle based on clutch friction torque observer.

The hybrid power system with dual motors and multiple clutches experiences significant torque fluctuation during mode switching process due to the different torque response characteristics of the motor and engine. To address this issue, this paper focuses on the estimation of clutch friction torque and the development of dynamic coordinated control strategies for the components. Firstly, based on the dynamic model of the novel dual-motor hybrid electric vehicle, a torque observer based on the Kalman filter algorithm is developed to predict the friction torque generated in the clutch sliding friction stage. Secondly, the control strategies are developed for the mode switching process from single-motor to dual-motor and from dual-motor to parallel drive on a co-simulation platform. Thirdly, a power level Hardware-In-the-Loop test platform is built, and the performance of the designed control strategies is verified by the HIL platform. The results show that for the mode switching process from dual-motor to parallel drive, compared with the control strategy using the engine target speed, the control strategy

based on engine idle speed proposed in this paper reduces the clutch sliding friction work and the maximum longitudinal jerk of the vehicle by 42.5% and 25.4%, respectively.

IV. Scope

Electromagnetic clutches are expected to play a significant role in the future of automotive technology, particularly in electric and hybrid vehicles. They offer several advantages, including:

- Precision control

Electromagnetic clutches can provide precise control and adaptability, which are essential in the evolving automotive landscape.

- Smooth power transmission

Electromagnetic clutches can be used as a flexible link between the motor and wheel hub, which can result in smooth power transmission and high levels of comfort.

- Energy savings

Electromagnetic clutches can help reduce energy consumption. For example, a mechanical decoupling system can improve fuel economy by up to 4.73% during urban driving.

- Reduced wear

Electromagnetic clutches can reduce wear on pumps.

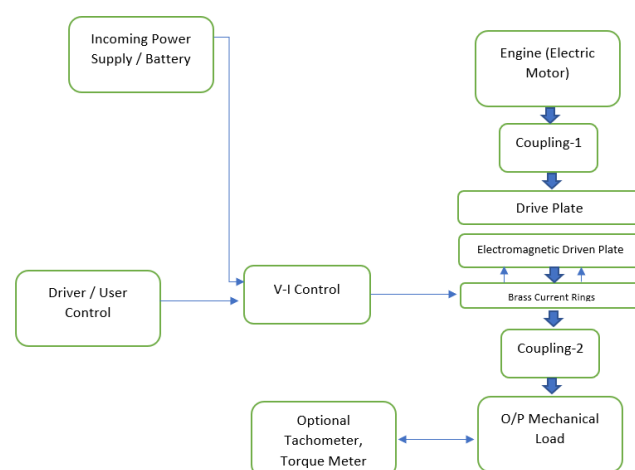
- Emergency-off function

Electromagnetic clutches can immediately stop the hydraulic system in an emergency. Electromagnetic clutches are mechanical elements that can transmit and cut power on the driven side using an electromagnetic force. They can connect and disconnect power without stopping the power.

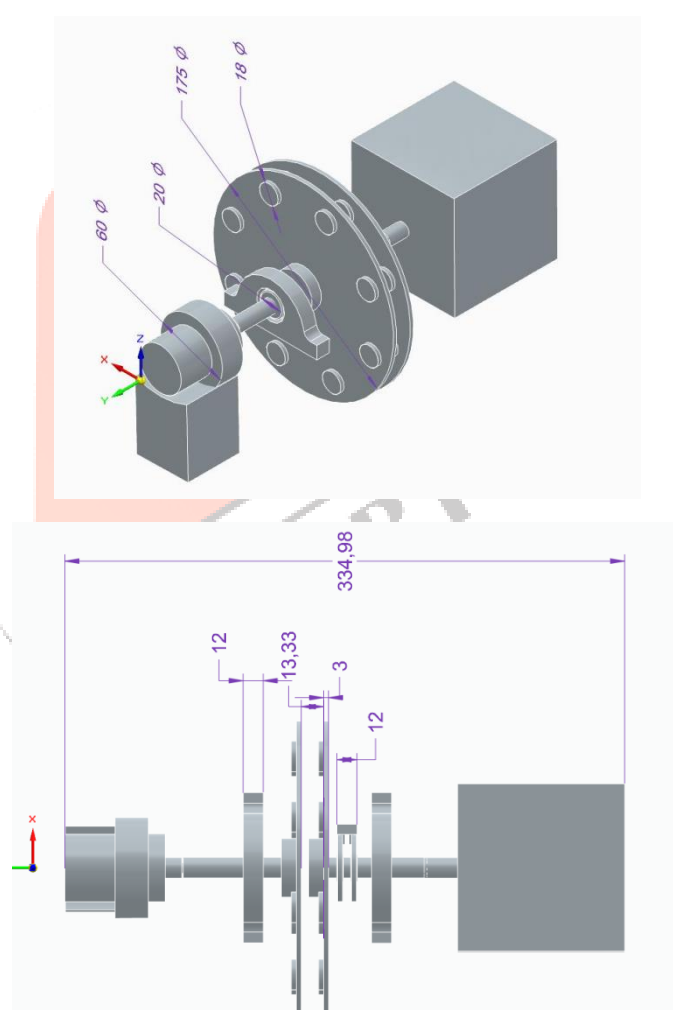
V. Methodology

An electromagnetic clutch is a device used in various mechanical systems to engage and disengage power transmission between two rotating shafts. It operates through electromagnetic force to facilitate the engagement and disengagement of the clutch mechanism in various applications. Additionally, this type of clutch is a subset of automobile clutches, functioning based on friction principles. Its design offers precise control over power transmission and finds use in a wide array of industries, including automotive, industrial, and manufacturing sectors.

VI. Process Design



VII. Experimental Setup



VIII. Problem Identification

gearbox: Clutch faults

Your vehicle's transmission, or gearbox, is a complex and vital system that ensures seamless gear transitions during your drives. However, when you encounter less-than-smooth gear shifts, you might find yourself asking, "What's gone wrong with my gearbox?" Quite often, the answer to this question

lies in the realm of clutch faults. In this article, we'll explore the intricacies of clutch-related issues and shed light on the world of gearbox repairs. Whether you've experienced hesitant or jerky gear changes, we're here to guide you towards diagnosing and resolving these problems, helping you get your vehicle back on the road in optimal condition.

Signs of clutch failure: Clutch pedal makes noises when engaging and disengaging. If you can hear a noise when you press the clutch pedal or release it, while the engine is off, then there is a high likelihood that there is a problem with the clutch release mechanism or clutch fork. The clutch fork is a hydraulic or mechanical device that helps engage and disengage the clutch. You will also hear noises when lubricant dries out and the mechanism wears down. A cable or connection may also cause a squeak or clunk sound.

Before we ask if there's something wrong with your clutch we need to understand what all a traditional clutch assembly is made up of?

- Clutch disc – connects to the transmission.
- The release mechanism (mechanical or hydraulic)
- Cable – connects between clutch pedal and fork.
- Linkage – connects fork to pressure plate.
- Pressure plate – connects to clutch disc
- Flywheel – connects to the engine.
- Pilot Bearing.
- Release or “throw out” bearing.
- Clutch fork – modulates force between pressure plate and clutch via linkage

IX. Applications

This type of clutch is used in some lawnmowers, copy machines, and conveyor drives. Other applications include packaging machinery, printing machinery, food processing machinery, and factory automation.

Vehicles

When the electromagnetic clutch is used in automobiles, there may be a clutch release switch inside the gear lever. The driver operates the switch by holding the gear lever to change the gear, thus cutting off current to the electromagnet and disengaging the clutch. With this mechanism, there

is no need to depress the clutch pedal. Alternatively, the switch may be replaced by a touch sensor or proximity sensor which senses the presence of the hand near the lever and cuts off the current. The advantages of using this type of clutch for automobiles are that complicated linkages are not required to actuate the clutch, and the driver needs to apply a considerably reduced force to operate the clutch. It is a type of semi-automatic transmission

X. CALCULATIONS

The prime mover is being assumed to be a 10 HP Engine that

produces a maximum torque of 20 N-m at 2600 RPM. Then,

Data known:

Torque to be transmitted (M_t) = 20 N-m

Power of Prime Mover (P) = 7460 W

Co-efficient of friction between Armature and Friction Lining

(μ) = 0.2

Permissible intensity of pressure of Friction Lining (P_a) = 0.7

N/mm²

Data Assumed:

Inner Diameter of Friction Lining (d_o) = 50 mm

1. Calculation of Outer Diameter of Friction Lining:

Let D_o be the Outer Diameter of the Friction Lining. We

know, $M_t = \pi \mu P_a D_o (D_o^2 - d_o^2) / 8$

$\therefore D_o = \sqrt[4]{\pi \mu P_a 8 M_t / d_o^2}$

Substituting the values, we get, $D_o \approx 100$ mm

2. Calculation of Normal Force required to transmit Torque:

Let P_n be the Normal Force required. We know,

$M_t = \mu P_n (D_o^2 - d_o^2) / 4$

$\therefore P_n = 4 M_t \mu / (D_o^2 - d_o^2)$

Substituting the values, we get, $P_n = 2666.67$ N

3. Calculation of Number of turns for Electromagnet:

Data known:

Current (I) = 1.2 A

Area of Friction Lining (a) = $4.71 \times 10^{-3} \text{ m}^2$

Permeability of free space (μ_0) = $4\pi \times 10^{-7} \text{ Wb/A-m}$

Air Gap (δ) = 0.2 mm

Let number of turns = N

We know,

$$P_n = \mu_0 a (N \times I)^2 / 2 \delta$$

$$\therefore N = \sqrt{2 P_n I^2 \delta / \mu_0 a}$$

Substituting the values, we get, $N \approx 1200$ turns

XI. Result

Slip speed = 0

Vibration = < 10 HZ At a speed OF 0 – 1000 RPM

Air gap = < 2 mm

Life of magnet – 6 Year as per manufacturers datasheet

Heating of magnetic coil – Around 70-90 degrees after 5 minutes of running and heat dissipation based backed driven plate can be used.

XII. Conclusion

In this project we successfully created a demonstration modal of electromagnetic frictionless clutch using magnetic repulsion principal. Vibration level and noise is almost negligible during transmission process. Friction is zero and air gap of 2mm is maintained between drive and driven plates. Electromagnetic strength affects the torque transfer and can be modifier according to the load and engine requirements. The various mechanical components of the electromagnetic clutch were successfully designed, analysed and presented in this Project. All the aspects involved in the design of the electromagnetic clutch were carefully taken into consideration. Hence, by proper analysis we verified our design and calculations. Thus, without compromising on the safe design of clutch, an endeavour was made herein to present a simplified model of electromagnetic clutch.

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