

Design And Development of Fluid Frictionless Clutch For Vehicles

Gaurav Kailas Jadhav¹, Yogesh Iranna Meralwar², Shubham Pandurang Gachande³,
Sahil Ravindra Kadam⁴, Dr. S. N. Shinde⁵

^{1, 2, 3, 4, 5} Dept of Mechanical Engineering

^{1, 2, 3, 4, 5} Brahma Valley College of Engineering & Research Institute, Anjaneri, Nashik - 422 213
Savitribai Phule Pune University, India

Abstract- Friction clutches are vital mechanical components that transmit torque and power between two rotating shafts. They are widely used in various applications including automobiles, industrial machinery, and power tools. Traditional friction clutches operate on the principle of frictional force, where two surfaces are pressed together to transfer torque. This mechanism, however, leads to significant torque losses, wear and tear of clutch plates, maintenance issues, and thermal heating of engine components. This paper presents the design, development, and experimental evaluation of a fluid frictionless clutch system that replaces mechanical contact with fluid-based torque transmission using electromagnetic and viscous fluid principles. The proposed system employs a 2 mm oil gap between drive and driven plates, eliminating direct surface contact and thereby reducing friction to near-zero. The system significantly reduces vibration, noise, and maintenance requirements while improving clutch life and power transmission efficiency. Experimental results confirm smooth clutch operation, negligible vibration levels, and improved torque transfer characteristics.

Keywords: frictionless clutch; fluid clutch; electromagnetic clutch; torque transmission; wear reduction; automotive systems; viscous fluid coupling

I. INTRODUCTION

A clutch is a mechanical device that allows an output shaft to be disconnected from a rotating input shaft. The clutch's input shaft is typically attached to a motor, while the output shaft is connected to the mechanism that performs the work. In a motor vehicle, the clutch acts as a mechanical linkage between the engine and transmission, enabling the driver to disengage engine power during gear changes or vehicle standstill.

Traditional friction clutches have served automotive applications for over a century. However, they are inherently prone to wear and degradation due to the direct mechanical contact between friction surfaces. The slipping of a friction

clutch during engagement generates heat, accelerates material wear, and reduces the overall efficiency of the power transmission system. Studies have shown that friction losses in conventional clutch systems can account for a measurable reduction in driveline efficiency, especially during frequent engagement cycles typical of urban driving conditions.

Dry clutches, used in most manual transmission vehicles, transfer power via a friction disc pressed against the engine flywheel by a spring mechanism. While functionally effective, these systems suffer from noise, vibration, and harshness (NVH) issues, contamination sensitivity, and a finite service life dictated by friction material degradation. Wet clutches, though offering improved cooling and longevity, introduce energy losses due to fluid drag and require careful management of the oil medium.

The concept of a fluid frictionless clutch addresses these limitations by introducing a non-contact torque transfer mechanism. By maintaining a controlled oil gap between the driving and driven members, direct surface contact is eliminated, friction is reduced to near-zero, and the system operates with significantly lower wear rates and noise levels. The fluid viscosity can be adjusted or engineered to match the torque transfer requirements of specific applications, offering a versatile and adaptable solution for both automotive and industrial use.

This paper presents the complete design, component selection, manufacturing process, and experimental evaluation of a prototype fluid frictionless clutch system developed for vehicles. The system was designed and modeled using Solid Edge CAD software and fabricated using standard manufacturing processes including turning, welding, drilling, and precision assembly.

II. PROBLEM DEFINITION AND OBJECTIVES

A. Problems in Conventional Friction Clutches

Conventional friction clutches exhibit several well-documented failure modes and operational problems. The primary signs of clutch failure or degradation include:

- Clutch slipping due to worn friction material, preventing effective torque transfer.
- Spongy, sticky, or loose clutch pedal feel caused by hydraulic or mechanical linkage faults.
- Grinding or squeaking noises during clutch engagement due to bearing wear or dry lubrication points.
- Difficulty in acceleration despite engine revving, indicating inadequate friction engagement.
- Fluid leakage around the gearbox or clutch assembly from damaged seals.
- Difficulty changing gears resulting from clutch drag or incomplete disengagement.

The root causes of these problems include worn friction material, weakened or warped pressure plates, oil contamination of the clutch assembly, bent or misaligned linkage components, and prolonged clutch slippage or abuse. As clutch components are wear-and-tear items, replacement is inevitable with conventional designs, incurring maintenance cost and vehicle downtime.

B. Project Objectives

The primary objectives of this project are as follows:

- To reduce friction and wear in the clutch system used in automotive and industrial applications.
- To increase the power transfer efficiency of engines and motors by minimizing frictional losses.
- To reduce vibration and noise levels in the engine power transmission system.
- To develop an affordable and efficient mechanization solution for a fluid frictionless clutch.
- To improve clutch service life and reduce maintenance intervals through non-contact torque transmission.
- To demonstrate smooth clutch operation using fluid viscosity as the medium of torque transfer.

III. LITERATURE REVIEW

Several research works have been carried out in the domain of non-friction and electromagnetic clutch systems, contributing to the theoretical and practical foundation of this project.

Piao et al. [4] conducted a torque analysis and shape optimization study of an electromagnetic clutch,

demonstrating that the geometric configuration of the electromagnetic core significantly influences the achievable torque density. Their work established analytical methods for predicting torque output as a function of design parameters, which were applied in the conceptual design phase of the present project.

The design and control of electromagnetic clutch actuation systems for automated manual transmissions were investigated in [1], where the authors developed a closed-loop control strategy that allows precise modulation of clutch engagement torque. This research highlighted the importance of control algorithms in achieving smooth engagement, particularly during vehicle launch from rest.

Krasil and Krasil [2] analyzed torque calculation methods for end magnetic clutches, providing complementary formulas applicable to the design of non-contact drive systems. Their torque equations for permanent magnet-based couplings formed a reference for estimating fluid clutch torque capacity in this work.

Karthik et al. [3] explored the concept of a regenerative clutch for power generation applications, demonstrating that non-contact clutch mechanisms could be adapted for energy recovery purposes. This broadens the potential application scope of frictionless clutch technology beyond pure power transmission.

Diez-Jimenez et al. [5] reviewed passive electromagnetic devices for vibration damping applications and established a quantitative basis for comparing non-contact force transmission in mechanical systems. Their review confirmed that fluid and electromagnetic coupling can achieve vibration isolation properties unattainable by mechanical friction contacts.

Collectively, the literature establishes that non-contact clutch systems leveraging electromagnetic principles and fluid coupling can achieve high torque efficiency, reduced wear, and lower NVH levels compared to conventional friction clutches. The present work builds upon these findings to develop a practical, low-cost prototype demonstration model suitable for automotive application.

IV. SYSTEM DESIGN AND WORKING PRINCIPLE

A. Working Principle

The fluid frictionless clutch operates on the principle of electromagnetic coupling combined with viscous fluid torque transmission. The driving member is connected to the

engine (prime mover), and the driven member is connected to the transmission shaft. Unlike a conventional clutch, the driving and driven plates do not make physical contact. Instead, a precisely controlled oil gap of 2 mm is maintained between them.

When the driving member rotates, it generates a viscous drag force in the oil medium filling the gap. This viscous force is transmitted to the driven member, causing it to rotate and transfer torque. The magnitude of torque that can be transmitted is a function of the fluid viscosity, the gap width, the rotational speed differential, and the surface area of the coupling faces. By selecting appropriate fluid viscosity and gap geometry, the system can be tuned to match the torque requirements of specific vehicle applications.

Additionally, electromagnetic effects from the motor and field interactions contribute to the coupling force, enabling smooth and controllable engagement without mechanical shock or friction-induced heat generation. The absence of physical contact means that there is no friction material to wear, no heat generated from slipping surfaces, and no degradation of the coupling interface over time.

B. System Architecture

The prototype system consists of a 24V DC motor as the prime mover (engine simulator), driving a shaft supported by precision ball bearings mounted in ABS plastic bearing holders. The driving disc and driven disc are separated by the 2 mm oil gap maintained by the fluid medium and controlled geometry. An LM2596 adjustable step-down DC-DC buck converter is used to vary the motor supply voltage and thus simulate different engine speeds. A 12V, 15A SMPS provides regulated DC power to the system. The entire assembly is mounted on a fabricated steel frame manufactured using welding, turning, and drilling operations.

V. COMPONENT DETAILS AND SPECIFICATIONS

A. 12V / 15A SMPS Power Supply

A switched-mode power supply (SMPS) rated at 12V DC and 15A maximum output current is used to provide regulated power to the system. Key specifications are listed in Table I.

Table I. SMPS Power Supply Specifications

Parameter	Specification
Input Voltage	110V / 220V AC
Output Voltage	12V DC (adjustable $\pm 10\%$)
Output Current	15A maximum
Output Channels	Three sets
Protection	Overload, over-voltage, thermal, short-circuit
Cooling	Passive (fanless metal case with ventilation holes)

B. 24V DC Motor (Prime Mover)

A 24V DC worm gear motor simulates the engine in the prototype and drives the input shaft of the clutch assembly. Table II lists the motor specifications.

Table II. DC Motor Specifications

Parameter	Specification
Voltage	24V DC (PMDC)
Current	2.5A
No-load Speed	150 RPM
Torque	10 kg-cm
Gear Type	Right Angle Worm Gear
Motor Diameter	42.3 mm
Motor Height	66.3 mm
Output Shaft Diameter	8.5 mm
Net Weight	346 g

C. LM2596 Adjustable Step-Down DC-DC Converter

The LM2596-based buck converter module is used to adjust the motor supply voltage, enabling speed control of the driving shaft to simulate varying engine RPM conditions. The module is a non-isolated step-down converter operating at 150 kHz switching frequency, enabling compact filter components. Key specifications include an input voltage range of 4V to 35V, adjustable output voltage from 1.25V to 30V, and a rated output current of 2A (maximum 3A with heatsinking). The high switching frequency and internal thermal shutdown and current limiting features ensure reliable operation across load conditions.

D. Ball Bearing (626 RS)

Precision ball bearings are used to support the rotating shafts and ensure accurate concentricity of the driving and driven discs. Table III provides the bearing specifications.

Table III. Ball Bearing (626 RS) Specifications

Parameter	Specification
Bearing Number	626 RS
Inner Diameter	6 mm
Outer Diameter	19 mm
Basic Dynamic Load Rating	13.5 kN
Basic Static Load Rating	6.55 kN
Limiting Speed	20,000 r/min
Material	Bearing Steel
Lubrication	Not required (sealed)
Cage	Sheet Metal

E. ABS Bearing Mounting Holders

Plastic ABS bearing holders provide flange-type mounting for the ball bearings on the assembly frame. Each holder is rated for axial loads up to 20 kg and is fixed using 4 mm or 5 mm bolts. The lightweight design (approximately 30 g each) minimizes the overall system weight. Applications include conveyor belt rollers, motor mounting, free-end shaft mounting, and vehicle chassis wheel mounting, making them versatile for the prototype assembly.

F. Nitrile Rubber O-Rings

Nitrile rubber (NBR) O-rings with an inner diameter of 54 mm and cross-section thickness of 1.5 mm are used to provide fluid sealing at the clutch assembly interfaces, preventing oil leakage from the gap zone. NBR material offers excellent resistance to petroleum-based oils, which is essential for maintaining the integrity of the viscous fluid medium. Tolerance on dimensions is maintained at ± 0.05 mm.

G. Acrylic Sheet (6 mm)

A 6 mm thick transparent acrylic sheet is used for the housing panels of the prototype assembly, enabling visual inspection of the internal fluid gap and disc rotation during testing. The acrylic is cut to required dimensions from 8 x 4 feet rectangular sheets and shaped using precision cutting operations.

VI. MANUFACTURING PROCESS

The prototype fluid frictionless clutch assembly was fabricated using a combination of conventional manufacturing processes. The processes employed are as follows:

1. **Welding:** The steel frame and structural support members were assembled by MIG welding to ensure rigid and vibration-resistant mounting of all components.

2. **Turning:** Rotating shaft components and disc faces were machined on a lathe to achieve the required dimensional tolerances and surface finish necessary for maintaining the precise 2 mm oil gap.
3. **Grinding:** Mating surfaces of the drive and driven discs were ground to achieve flatness and parallelism within specified tolerances, ensuring uniform fluid gap distribution.
4. **Drilling:** Mounting holes for bearing holders, motor brackets, and frame fixtures were drilled to precise locations using a drill press.
5. **Cutting:** Acrylic sheet panels and frame components were cut to required dimensions using appropriate cutting tools.
6. **Mounting and Assembly:** All components including motor, bearing holders, shafts, discs, and control electronics were assembled and aligned on the frame.
7. **Finishing:** Surface finishing operations were performed on machined parts to remove burrs and improve the overall aesthetic and functional quality of the assembly.

VII. SOFTWARE USED

Solid Edge (Siemens Digital Industries Software) was used for 3D CAD modeling, assembly design, and generation of orthographic engineering drawings for the prototype components. Solid Edge is a parametric feature-based and synchronous technology solid modeling software that supports solid modeling, assembly modeling, and 2D orthographic views for mechanical designers.

The software was used to design the bearing mounting arrangements, shaft layouts, disc geometry, and overall assembly configuration before fabrication. 3D models were generated for all primary structural and mechanical components, enabling interference checking and dimensional verification prior to manufacturing. The synchronous technology feature of Solid Edge enabled rapid design iterations during the development phase.

VIII. RESULTS AND DISCUSSION

The prototype fluid frictionless clutch was successfully assembled and subjected to operational testing using the 24V DC motor as the prime mover. The following key observations were recorded during experimental evaluation:

- **Vibration level:** Vibration levels during torque transmission were found to be almost negligible compared to a conventional friction disc clutch of similar torque capacity. The absence of direct contact

between driving and driven members eliminates the impact forces typically associated with clutch engagement.

- Noise: Acoustic noise during clutch operation was significantly reduced. No stick-slip or grinding noise characteristic of worn friction clutches was observed at any tested speed.
- Friction: Effective friction between driving and driven plates was reduced to near-zero, with torque transmission occurring entirely through the viscous fluid medium.
- Oil gap: A fluid gap of 2 mm was successfully maintained between drive and driven plates throughout the test runs, confirming the effectiveness of the O-ring sealing and disc geometry.
- Torque transfer: Fluid viscosity was confirmed to directly influence the torque transfer capacity. Higher viscosity fluids yielded higher transmitted torque at equivalent speed differentials.
- Smooth operation: Clutch engagement and disengagement were found to be smooth and progressive, without the sudden jerk or shock associated with conventional clutch engagement.

The results validate the core hypothesis of the project: that replacing mechanical contact in a clutch system with a viscous fluid medium can achieve the required torque transmission while dramatically reducing friction, wear, noise, and vibration. The adjustable voltage supply further demonstrated that the transmitted torque can be modulated by controlling the driving shaft speed, analogous to throttle control in an actual vehicle.

IX. CONCLUSION

This paper presented the design, fabrication, and experimental evaluation of a fluid frictionless clutch for vehicles. The system successfully demonstrated torque transmission between a driving and driven member using viscous fluid coupling, with a 2 mm controlled oil gap eliminating direct mechanical contact between the clutch plates.

The key conclusions drawn from this work are: (1) the fluid frictionless clutch effectively transmits torque with near-zero friction between the coupling faces; (2) vibration and acoustic noise are negligible during clutch operation compared to conventional friction clutches; (3) fluid viscosity can be used as an adjustable parameter to tune torque transfer capacity for different load and engine requirements; (4) the design significantly extends clutch service life by eliminating friction material degradation; and (5) smooth, progressive

clutch engagement is achievable without electronic control, relying solely on fluid dynamics.

Future work will focus on scaling the system to automotive torque levels, investigating the use of magnetorheological (MR) fluids for active torque control, and conducting detailed thermal analysis under sustained slip conditions. The integration of the fluid frictionless clutch with an automated transmission control unit also presents a promising direction for adaptive vehicle driveline systems.

REFERENCES

- [1] O. P. C. Series and M. Science, "Design and control of electromagnetic clutch actuation system for automated manual transmission," pp. 0–13, 2017.
- [2] A. Y. Krasil and A. A. Krasil, "Complementary products calculating the torque in an end magnetic clutch," vol. 41, no. 7, pp. 26–28, 2005.
- [3] R. Karthik, S. Ashwin, and S. Raja, "Design and working of regenerative clutch for power generation," vol. 3, no. 11, pp. 1–4, 2017.
- [4] C. H. Piao, Z. Y. Huang, J. Wang, and C. D. Cho, "Torque analysis and shape optimization of electromagnetic clutch," pp. 122–126, 2010.
- [5] E. Diez-Jimenez, R. Rizzo, and E. Corral, "Review of passive electromagnetic devices for vibration," vol. 2019, 2019.