Design and Construction of a Kinetic Energy Recovery System Using Flywheel in Bicycle

A Project

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Of

Bachelor of Science in Mechanical Engineering

May, 2025

DECLARATION

We do here by solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University Organization for award of any degree or certificate

We here by ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

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CERTIFICATION OF APPROVAL

This is to certify that the thesis titled **Design and Construction of a Kinetic Energy Recovery System Using Flywheel in Bicycle** is carried out by following students of Mechanical Engineering. Md. Kawser, Md. Towfiq Ahmed, Md. Sohel Rana, Md. Mehedi Hasan, Md. Masum Billa, Accepted as satisfactory partial fulfillments of the requirements for the bachelors degree in Mechanical Engineering.

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ABSTRACT

This project presents the design and construction of a Kinetic Energy Recovery System (KERS) integrated into a bicycle, utilizing a flywheel to enhance cycling efficiency. The system captures kinetic energy during pedaling or braking and releases it to assist with acceleration or uphill riding, reducing rider effort. A 3.27 kg cast iron flywheel (radius 0.075 m, moment of inertia 0.00919 kg/m²) was mounted on a bicycle frame, connected via a pulley and chain drive system. Testing on flat terrain with a 70 kg rider over 60 seconds showed the flywheel achieving 95–114 RPM at bicycle speeds of 10–12 km/h, storing 0.454–0.654 J of kinetic energy. The system improved energy efficiency and ride smoothness but added weight, impacting handling. Key advantages include reduced pedaling effort and momentum maintenance, while limitations involve increased complexity and reduced effectiveness on steep inclines. Applications include urban commuting and recreational cycling, with future enhancements proposed using lighter materials and gear integration for improved performance.

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CHAPTER 1

INTRODUCTION

1.1 Overview

In a world where almost all its fuel is being depleted, conservation of natural resources has become a necessity in today's world especially in the field of renewable technology. In an automobile maximum energy is lost during deceleration or braking. This problem has been resolved with the introduction of regenerative braking. It is an approach to recover or restore the energy lost while braking. The Kinetic Energy Recovery System (KERS) is a type of regenerative braking system which has the capability to store and reuse the lost energy. It (KERS) is a system which first stores the kinetic energy in the form of useful energy and recovers back as requirement. In other words KERS is collection of parts which stores some of the kinetic energy of the vehicle under deceleration and then releases the stored energy back into the drive train of the vehicle. Kinetic energy recovery system (KERS) store energy when the vehicle is braking and returns it when accelerating. It is used for providing a power boost to the vehicle. There are two basic types of KERS systems i.e. Electrical and Mechanical. The main difference between them is the way they convert the energy and how that energy is stored within the vehicle. Battery based electric KERS system require a number of energy conversions each with corresponding efficiency losses. On reapplication of the energy to the driveline, the global energy conversion efficiency is 31-34%. The mechanical KERS system storing energy mechanically is a rotating flywheel which eliminates the various energy conversions efficiency. This design of KERS bicycle was motivated by a desire to build a flywheel energy storage unit as a proof concept. KERS stores energy on the application of brake and returns energy at acceleration. During braking, energy is wasted because kinetic energy is mostly converted into heat emitted into the environment. Vehicles using KERS can take advantage of some kinetic energy, which will help with braking. Through the

appropriate mechanism, this stored energy is converted back into kinetic energy, which increases the vehicle's additional power.

In KERS bikes, flywheel is used to store and release energy. The flywheel is mounted between the frames of the bicycle and has aesthetic and ergonomic considerations. The flywheel is mounted on the shaft, which is supported by a frame. The flywheel can be engaged with the rear wheels and has a clutch mechanism.



Figure 1.1: Flywheel Bicycle

The mechanism consists of a clutch, free wheel and sprocket with an appropriate transmission gear ratio. When the bike goes down or the traffic jam clutch is slow, it can be connected with the flywheel to store energy, which can be restored when needed. Now, when the need to decelerate the clutch and flywheel starts to rotate to store energy, although this pedal power can be reduced, the system efficiency can be improved.

1.2 Problem Statement

In traditional bicycles, riders often face challenges such as fatigue and increased effort, particularly when navigating uphill or accelerating. Current bicycles do not efficiently harness the energy generated during pedaling or braking. This results in wasted energy and diminished ride efficiency. The need for a solution that reduces the physical strain on riders, especially in hilly terrain or during long rides, remains unmet. The flywheel-operated bicycle aims to address this issue by storing and releasing kinetic energy, enhancing the overall efficiency and performance of the bicycle without relying on electrical components, offering a more sustainable and energy-efficient riding experience.

1.3 Objectives

The objectives of this project are

- To design a ERS using flywheel in a bi-cycle.
- To construct the designed project.
- To collect the data & analysis performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section topics related to KERS using flywheel in bicycle are included. These provide a sampling of problems appropriate for the application of Electromagnetic Braking System. The references are summarized below.

2.2 Literature Review

In recent researches show that electricity can be generated with less friction, [1] Rahul P. Ambre, Dinesh S. Sathe, Avinash S. Pangat February 2019 “Design and fabrication of contactless energy generation system with flywheel”. They conclude that, electrical energy can generate without friction with help of flywheel and utilizes in maximum amount. They designed the project successfully and implemented, the produced power is used to charge the batteries, mobile phones and other mobile accessories or devices. They also studied the electromagnetism concept and power generation by making proper coil and magnet arrangement without making rotor and stator contact. Output voltage from model is depend on the rpm of the wheel which is fluctuating the voltage so battery is used for Stable power supply.

[2] Mayur M. Umbare, Sujay S. Udawant, Rohan B. Gujar, Sahil G. Urkunde April 2019, “Contactless energy generation using flywheel for EV”. They build the model that produce the electrical energy without friction and its eco-friendly. Magnetic flywheel can work under dynamic operating condition and reaches the energy requirement for electrical vehicle. Their project model generates output voltage up to 12 V.

[3] B. Karthik, A. Marimuthu, K. Pradap, “Kinematic energy recovery system on bicycles”. They developed a kinematic energy recovery system bicycle it helps for

achieve easy cycling and stores the temporary kinetic energy in flywheel. This experimental setup can easily develop and modify according to the application.
[4] Mayuresh Bhoir, Anupraj Shirke, Pratik Yadav, May 2020, “KERS Bicycle”. This team studied, the flywheel will store some part of energy while bicycle is in running and recovers the energy back. They successfully design the KERS which is satisfactorily store the efficient energy and provides to the power generation. Using of flywheel in bicycle concept is new, development of this concept has good scope in upcoming days.

D. K. Naresh Kumar et al. devised and built a flywheel bicycle with a mobile charger that captures the kinetic energy generated by pedaling power. While pedaling the bicycle, the flywheel rotates due to the chain arrangement, which somewhat boosts the bicycle's speed. This configuration is more useful while riding a bicycle on the highway. The movement of the wheel causes the dynamo's drive wheel to revolve, producing 5V of alternating current (AC) that is converted to direct current (DC). As a result, the rear wheel of the bicycle spins while pedaling, and the kinetic energy created is recovered as extra movement of the back wheel of the bicycle by the spinning of the flywheel. According to the author, this technology has the potential to function as an alternate energy source in the near future. [5]

[6] Nishad Kumbhojkar , Kunal Mohite , Anand Kulkarni , Sanket Patil in their research paper “DESIGN AND IMPLEMENTATION OF KINETIC ENERGY RECOVERY SYSTEM (KERS) IN BICYCLE” used the concept of Kinetic energy recovery system , KERS for short , to develop a regenerative breaking system for the cycle , to be able to operate on stored power in the flywheel , by mounting the flywheel onto the cycles body , and connecting the flywheel to a clutch and clutch to the rear wheel of the cycle with direct means of a chain , with the method to charge up the flywheel to a threshold speed by the means of pedaling.

[7]A Detail Review on Study of Flywheel:- In this paper we have studied what the material of a flywheel could be like cast iron or carbon fiber. We studied the effect of load on break power and the result is that if the load increases break power

increases. As well as load increases, volumetric efficiency also increases. In suction, compression and exhaust stroke power is taken from the engine.

[8] Composite flywheel material design for high- speed energy storage - This study investigated the mechanical properties of materials suitable for flywheel high-speed energy storage. The study found that a hybrid composite of M46J/epoxy–T1000G/epoxy exhibited higher energy density compared to existing flywheel hybrid composite materials such as boron/epoxy–graphite/epoxy. The study used design and stress analysis to determine the maximum energy densities and shape factors for the flywheel. Analytical studies and CADEC-online software were used to evaluate the lamina and laminate properties. The findings of this study could contribute to further development of the flywheel as a promising application for energy storage due to significant improvements in composite materials and technology.

[9] Research on Structure for Flywheel Energy Storage System in Long Lifetime UPS:-This paper establishes the flywheel energy storage organization (FESS) in a long lifetime uninterruptible power supply. The Flywheel Energy Storage (FES) system has emerged as one of the best options. This paper presents a conceptual study and illustrations of FES units. After a brief introduction to the FES system and its theory of operation, the paper focuses on the important role of the FES system in enhancing the operation of the distribution network. Supported by illustrated circuits, the FES system in the improvement of the power quality of the network. A flywheel energy storage technology was ended, with a special focus on the progress in automotive applications. In order to improve the efficiency and lifetime, then it discusses a newly proposed design of the FES system that emerged recently, which includes the use of Superconducting Magnetic Bearings (SMB) and Permanent Magnetic Bearings (PMB). In conclusion, the paper analyzes the FES systems great potentials that could be exploited in improving the reliability of the electrical system

Menon, S. S et al. [10] found that flywheel and transmissions increased the weight of bicycles. The increased weight will increase the energy required to accelerate the bike and ride uphill. However, once the rider provides energy to reach cruising speed, the flywheel reduces the energy cost of decelerating from this speed because it contributes to subsequent acceleration. The road is the best environment for flywheel because it is flat and cyclists have many reasons to slow down. Considering the weight standard, the authors found that the best weight to improve efficiency is 5 kg of normal cycling.

Ludlum, K. [11] stated that flywheel technology is emerging in a variety of technologies. It is a pollution-free method for storing energy with many currents and potential applications. In the case of road vehicles, there is much to be improved in terms of energy efficiency, particularly when considering unit energy pollution. Any braking regeneration system can help, but flywheel have the potential to improve the efficiency of road vehicles without having a direct or indirect negative impact on the environment. The batteries used in hybrid vehicles do not last the life of the car and can have an expensive impact on the environment. Flywheel only have an impact on the environment at the time of production and are likely to significantly exceed these costs by using them. Bicycles do not have pollution problems with cars and other modes of transportation, but they can be used as a good analogy for how kinetic energy recovery systems can improve vehicle efficiency.

Mugunthan, U., & Nijanthan, U. [12] conducted speed tests to find out the efficiency of the Flywheel based KERS bikes they installed. It has been found that flywheels provide energy so that the cycle can advance 10% of a given input. Depending on the input given, the efficiency will vary. However, only 10 per cent can be obtained through this principle.

Kumar, D. N. et al. [13] stated that a flywheel bicycle with a mobile charger was designed and manufactured to capture the kinetic energy generated by pedal power. When pedaling a bike, the flywheel also rotates in chain arrangement, which in turn slightly increases the speed of the bike. This setting is more suitable for cycling on

highways. By rotating the wheels, the generator's drive wheels also rotate, which in turn generates 5V of alternate current and converts it to DC. As a result, the rear wheel rotates while pedaling the bike, and the generated kinetic energy is restored by the rotation of the flywheel as an additional movement of the rear wheel of the bike. The authors note that the system has the potential to become an alternative energy source in the near future.

Sachin R sangle et al. [14] concluded in his work that Kers is a very effective system for racing cars as energy recovery equipment. Similar concepts can be used for small commuter vehicles, such as bicycles, to reduce manpower. However, there are some things to consider, such as losing weight and the ability to sell. Continuous variable transmissions can also be considered for increased transmission efficiency. Using ergonomics, such as dual centrifugal clutches, will result in better power transmission for automatic transmissions.

Chicurel, R. [15] conducted an experiment in which the regeneration components included a fixed displacement hydraulic pump/motor that discharged or received high-pressure fluid from the scuba accumulator. The brake power provided by the pump is determined by the pressure in the accumulator. It is only put into service when greater total braking power is required, in which case the traditional dissipated brakes provide a difference. Based on a preliminary analysis of acceleration using probability data, it is estimated that approximately 45% of the total kinetic energy wasted in braking can be transported through hydrodynamic components. The system is considered a practical alternative to the use of variable displacement pumps in more expensive fully regenerative systems.

2.3 Summary

The above literature explains the design, manufacture and analysis of bicycle kinetic energy recovery systems. This paper also focused on kinetic energy recovery system in bicycle by using flywheel.

CHAPTER 3
RESEARCH FRAMEWORK & OVERVIEW

3.1 Methodology

Our used methodology for the project :

- Create an innovative design for using flywheel in bicycle that stores and releases kinetic energy to enhance cycling efficiency.
- Identify and gather necessary components, including the flywheel, transmission system and bicycle frame.
- Design a mechanical system that allows the flywheel to store kinetic energy during pedaling and release it during acceleration or uphill climbs.
- Assemble the components on the bicycle frame, ensuring correct alignment and integration of the flywheel, transmission.
- Run the bicycle under various conditions (flat, uphill, and downhill) to validate the system's functionality and effectiveness.

3.2 Work Flow Diagram

The Flywheel Bicycle project follows a five-stage workflow to optimize cycling efficiency. It begins with a study of energy recovery through flywheel systems and how they can reduce rider effort. In the design phase, schematic layouts are created for the flywheel, transmission, and energy transfer mechanisms. The necessary components, such as the flywheel and transmission system, are then gathered. In the assembly stage, these components are integrated to ensure smooth operation. Finally, the system undergoes testing to evaluate performance, energy efficiency, and rider comfort, with refinements made to ensure optimal functionality before real-world use.

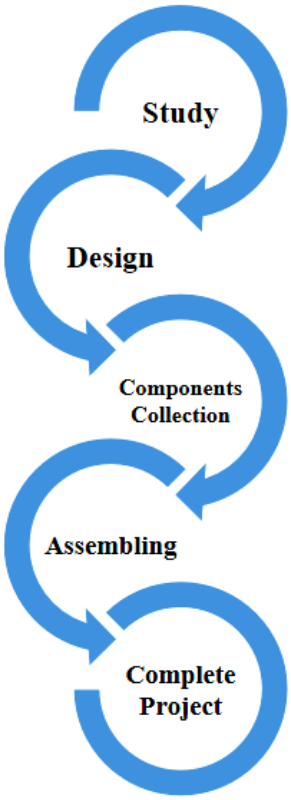


Figure 3.1: Working Flow Diagram

3.3 Report Overview

This project book consists of Seven chapter. The first chapter contains the statement of the Introduction, Overview, Problem Statement, objectives. Chapter two contains system Literature Review details. Chapter three contains Methodology, Work Flow Diagram, Report overview. Chapter Four describes the Hardware implementation with component details, which we have used for our work. Chapter Five describes the Data overview of this project. Chapter Six contains deals with the result Analysis, Advantage, Applications, Limitations and Discussions of the project that we have built. In the final chapter, we have discussed the Conclusion & Future Scope of the project.

CHAPTER 4
HARDWARE ANALYSIS

4.1 Introduction

This chapter focuses on the hardware analysis and implementation of the Flywheel Bicycle Project. It discusses the key components used, including the flywheel, Pully system, frame structure and braking system. Each component's functionality and contribution to energy storage and efficiency are explained in details. The chapter also covers the step-by-step process of assembling and integrating these components to achieve optimal energy recovery during cycling. This analysis provides a clear understanding of how mechanical energy is harnessed and reused, enhancing the bicycle's performance and sustainability.

4.2 Required Component

- Bicycle Frame
- Flywheel
- Pulley Wheel
- Chain & Belt Drive
- Adjustable pulley
- Rear Sprocket
- Bearing

4.3 Bicycle Frame

A bicycle frame is the main structural component of a bicycle, providing the foundation for mounting all other parts, including the wheels, handlebars, seat and drive-train. It is designed to offer strength, stability, and efficient power transfer while maintaining lightweight characteristics for ease of riding.

The frame is typically constructed from materials such as steel, aluminum, each offering different benefits in terms of durability, weight and flexibility.



Figure 4.1 : Bicycle Frame

Features

- **Top Tube:** Connects the seat tube to the head tube, influencing the bike's reach and comfort.
- **Down Tube:** Runs from the head tube to the bottom bracket, providing structural strength.
- **Seat Tube:** Holds the seat post and saddle and connects to the bottom bracket.
- **Head Tube:** Houses the steering components and connects the front fork to the frame.
- **Chain Stays and Seat Stays:** Form the rear triangle, supporting the rear wheel and providing stability.

The frame's geometry, including angles and tube lengths, significantly affects the bicycle's handling, comfort, and performance. Proper design ensures efficient energy transfer from pedaling while maintaining rider comfort and control.

4.3 Flywheel

In a flywheel-operated bicycle, the flywheel primarily stores and releases energy, acting as a form of kinetic energy storage. It works by accumulating rotational energy as the rider pedals and then using that stored energy to assist in pedaling and maintain forward motion, especially during rolling or downhill sections.



Figure 4.2 : Flywheel

Features

- Acts as an energy reservoir. It stores kinetic energy and release it accelerating The bicycle or assist in pedaling and maintain forward motion, especially during rolling or downhill sections.
- The flywheel, a heavy, weighted wheel, spins as the rider pedals, accumulating rotational kinetic energy. This stored energy acts like a mechanical battery.

- The flywheel's inertia helps prevent the engine from stalling when the load suddenly increases or when the car starts from a stop.
- Flywheel systems can improve efficiency by reducing energy input required for acceleration and providing a smoother, more consistent ride.
- the flywheel is part of a KERS system that can store energy from braking or downhill riding and release it later

Working Principle

A flywheel-operated bicycle uses a heavy, rotating disc (flywheel) to store and release kinetic energy, enhancing efficiency and providing power bursts. When the rider pedals, a chain or belt transfers energy to the flywheel, typically mounted centrally on low-friction bearings, spinning it up to store kinetic energy based on its mass and speed. The flywheel holds this energy, acting like a mechanical battery, with minimal loss if friction and air resistance are low. It gives smoother momentum, power assistance for hills or acceleration and eco-friendliness, as it's purely mechanical. However, the flywheel's weight (3-5 kg) makes the bike harder to accelerate, gyroscopic effects can affect handling, friction causes gradual energy loss, and the system's gears and clutch add complexity and maintenance. They're mostly seen in prototypes or niche eco-friendly projects, with advanced designs exploring composite flywheels or vacuum chambers to improve efficiency.

4.5 Pulley Wheel

A pulley wheel is a mechanical component designed to transmit power, change the direction of force, or lift objects. It consists of a wheel with a grooved rim that guides a belt, rope, or cable during movement. Pulley wheels are widely used in mechanical systems for efficient power transfer, motion control and mechanical advantage in lifting operations. In your flywheel-operated bicycle project, the pulley wheel plays a crucial role in linking the flywheel to the drive mechanism, ensuring smooth energy transfer and consistent motion.



Figure 4.3 : Pulley Wheel

Features

- **Grooved Rim:** Designed to hold belts or cables securely, minimizing slippage during rotation.
- **High Load Capacity:** Capable of handling significant tension and mechanical stress.
- **Smooth Rotation:** Equipped with bearings to reduce friction and enhance efficiency.
- **Durability:** Constructed from materials like steel, aluminum, or reinforced plastic for long-lasting performance.
- **Versatile Design:** Available in various sizes and types (fixed, movable, V-groove, and step pulleys) to suit different applications.
- **Mechanical Advantage:** Reduces the amount of input force required to lift or move heavy loads.

Working principle

The working principle of a pulley wheel is based on mechanical advantage and rotational motion. When force is applied to the belt or cable wrapped around the pulley, it creates rotational movement in the wheel. This motion allows the pulley to transfer energy efficiently, either to another wheel, a mechanical load, or to lift objects with less effort. In your flywheel-operated bicycle, the pulley wheel connects the flywheel to the rear wheel or chain mechanism. As the flywheel rotates, it transmits energy through the pulley and belt system, propelling the bicycle forward. The rotational inertia stored in the flywheel is maintained by the pulley system, allowing for smoother acceleration and more consistent speed with less pedaling effort.

4.6 Chain & Belt Drive

A chain drive is a mechanical power transmission system that uses a series of interlinked metal links, called a chain, to transfer motion and force between two or more sprockets. It is commonly used in machinery, bicycles, motorcycles, and industrial equipment where high torque and precise synchronization are required. Chain drives are designed for durability and efficiency, providing a reliable method of transferring rotational power over varying distances.

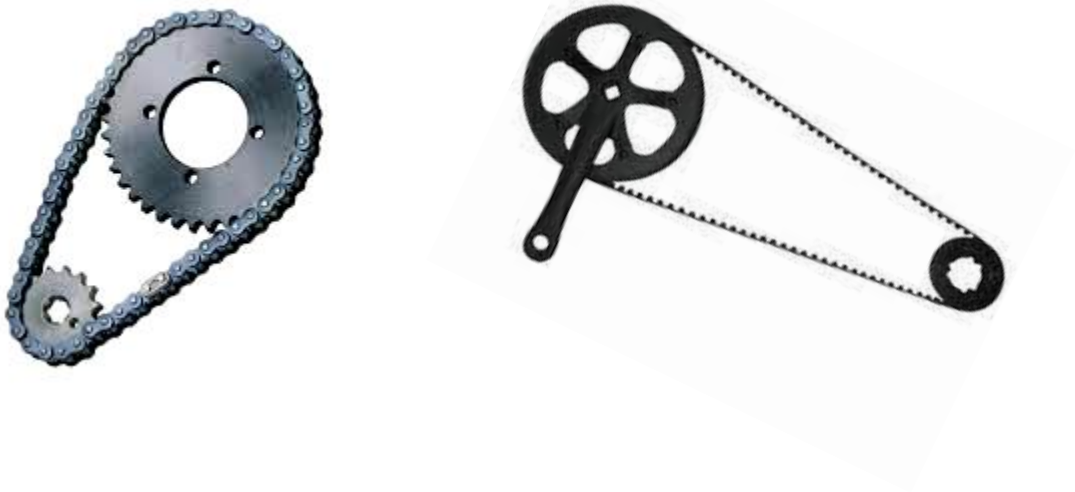


Figure 4.4 : Chain & Belt Drive

Features

- **High Efficiency:** Transmits power with minimal energy loss.
- **No Slippage:** Sprocket teeth ensure precise motion without slipping.
- **Durability:** Made of strong metals, capable of handling heavy loads.
- **Compact Design:** Requires less space compared to gears.
- **Adjustable Distance:** Easy to adjust sprocket spacing for flexibility.
- **Versatile Application:** Suitable for short and long distances.
- **Low Maintenance:** Requires only lubrication and occasional tension checks.

4.7 Adjustable pulley

Adjustable pulley is a critical component in belt-driven systems designed to maintain proper tension on the belt and prevent slippage. It consists of a wheel mounted on a movable bracket or arm, which applies force to the belt to keep it tight and properly aligned during operation. Adjustable pulleys are commonly used in automobile engines, conveyor belts, and industrial machinery to ensure smooth power transmission and extend belt life.



Figure 4.5: Adjustable pulley

Features of Adjustable Pulley

- **Automatic Belt Tensioning:** Maintains optimal belt tension automatically during operation.
- **Minimizes Wear and Tear:** Prevents excessive friction, extending the lifespan of both the belt and pulley.
- **Vibration Dampening:** Absorbs vibrations, reducing noise and mechanical stress.
- **Adjustable and Self-Aligning:** Adapts to belt stretch and movement, maintaining alignment.
- **Durability:** Made from high-strength materials to withstand continuous operation.

Working Principle

The Adjustable pulley works on the principle of spring-loaded tensioning or hydraulic adjustment. When the belt rotates, the Adjustable pulley automatically adjusts its position to maintain the correct tension. This prevents the belt from slipping or becoming loose, ensuring smooth power transmission. Adjustable pulley is connected with chain stay. By tensioning the bolt adjustable pulley becomes tension able.

4.8 Rear Sprocket

A rear sprocket is a toothed wheel that is part of a chain drive system, typically found on bicycles, motorcycles and machinery. It is mounted on the rear wheel hub and engages with the chain to transmit rotational power from the pedals or engine to the wheel. In bicycles, the rear sprocket is part of the cassette or freewheel, enabling the rider to change gears for varying speeds and terrain adaptability. In motorcycles, it works in conjunction with the engine's front sprocket to drive the rear wheel.



Figure 4.6: Rear Sprocket

Features of Rear Sprocket

- **High Torque Transmission:** Efficiently transfers power from the chain to the rear wheel, ensuring smooth acceleration.
- **Multiple Sizes (Teeth Count):** Available in different tooth configurations to optimize speed and torque.
- **Durable Material:** Made from hardened steel, aluminum, or alloy for enhanced strength and longevity.
- **Lightweight Design:** Designed to minimize weight without compromising strength.
- **Smooth Engagement:** Precisely machined teeth ensure seamless chain engagement, reducing wear.
- **Easy Installation and Replacement:** Can be easily mounted or replaced on the wheel hub.
- **Corrosion Resistant Coating:** Often coated to resist rust and weather damage.

4.9 Bearing

A bearing is a mechanical component that reduces friction between moving parts, allowing smooth rotational or linear motion. It typically consists of an inner ring, outer ring, rolling elements (balls, rollers, or needles), and a cage to separate the elements. Bearings are essential in various applications, from industrial machinery to automotive systems, improving efficiency, reducing wear, and extending the life of components. They distribute loads evenly, minimize energy loss, and help reduce noise and vibration. Different types of bearings, such as ball, roller, and thrust bearings, are designed to handle specific loads, speeds, and movements in diverse environments.



Figure 4.7: Bearing

Features of Bearings

- **Friction Reduction:** Bearings reduce friction, allowing for smoother movement and increased efficiency.
- **Load Distribution:** Bearings distribute applied loads evenly across the rolling elements, enhancing durability.
- **Versatility:** They come in various types, such as ball bearings, roller bearings, and needle bearings, suited for different applications.
- **Improved Life Span:** By minimizing wear and tear, bearings extend the life of mechanical systems.

- **Noise Reduction:** Bearings help reduce operational noise in machines and vehicles.
- **Temperature Resistance:** Some bearings are designed to function under high-temperature conditions.

4.10 Hardware Implementation



Figure 4.8: Project Implement Bicycle



Figure 4.9: Bicycle Flywheel Implement



Figure 4.10: Flywheel Bicycle Frame Implement



Figure 4.11: Project Welding Image



Figure 4.12: Half Complete Project Image



Figure 4.13: Complete Project prototype

CHAPTER 5
DATA & CALCULATION

5.1 Flywheel Specifications

Mass**:** 3.27 kg

Radius**:** 0.075 m

Moment of Inertia (Solid disc Flywheel) **:**

$I = \frac{1}{2}\ mr^2 = \frac{1}{2} \times 3.27 \times\ (0.075)^2\ = 0.00919\ kg/m^2$

Material**:** Cast Iron

5.2 Flywheel RPM

Bicycle speed to rear wheel rpm:

Average Speed = 12 km/h = 3.33 m/s.

Rear wheel diameter = 0.64 m, circumference $= \pi \times 64 = 2.0106$ m

Rear wheel $= \frac{3.33}{2.0106} = 1.656$ rps

Rear wheel RPM $= 1.656 \times 60 = 99.36 \approx 100$ rpm

Rear wheel pulley to Flywheel pulley:

Rear wheel pulley diameter = 17 cm, Flywheel pulley = 15 cm.

Flywheel rpm $= 100 \times \frac{17}{15} = 113.333 \approx 114$ rpm

5.3 Test Conditions

Terrain**:** Flat

Rider Weight**:** 70 kg

Test Duration**:** 60 seconds

Sampling Interval**:** Every 10 seconds

5.4 KERS Datasheet

The table below represents data collected during the test ride, including flywheel and bicycle performance metrics. Energy calculations are based on $KE = \frac{1}{2} I\omega^2$ where $\omega = \frac{2\pi N}{60}$

Time (s)	Bicycle Speed (km/h)	Flywheel RPM	Energy Stored (J)
0	0	0	0
10	12	114	0.654
20	10	95	0.454

Notes:

- Bicycle Average Speed: Measured with a Smart watch.
- Energy Stored : Calculated as,
  - A bicycle average speed 12 km/h at 10 seconds with Flywheel rpm 114.

$$KE = \frac{1}{2} I\omega^2 = \frac{1}{2} \times 0.00919 \times (\frac{2\pi N}{60})^2$$

$$= \frac{1}{2} \times 0.00919 \times 142.515 = 0.654J$$

  - A bicycle average speed 10 km/h at 20 seconds with Flywheel rpm 95.

$$KE = \frac{1}{2} I\omega^2 = \frac{1}{2} \times 0.00919 \times (\frac{2\pi N}{60})^2$$

$$= \frac{1}{2} \times 0.00919 \times 98.971 = 0.454J$$

5.5 Traditional Bicycle (Without Flywheel)

In a regular bicycle, all kinetic energy generated through pedaling or acceleration is either:

- Used immediately to propel the bicycle, or
- Lost during braking (usually converted to heat via friction).

Let's estimate the kinetic energy of the whole system (rider + bicycle) at the same speed for comparison:

Combined mass (rider + bicycle) = 75 kg

Velocity at 12 km/h = 3.33 m/s

So, kinetic energy, KE= $\frac{1}{2}\ mv^2 = \frac{1}{2} \times 75 \times (3.33)^2 = 416.6$ J

- No recovery of energy during braking. All 416.6 J is lost as heat.

Energy Recovery Ratio (with flywheel KE / without flywheel KE):

$$\frac{0.654}{416.6} \times 100 = 0.157\%$$

5.6 Comparison Between KERS Bicycle vs Traditional Bicycle

Metric	KERS Bicycle (With Flywheel)	Traditional Bicycle (Without Flywheel)
Energy Recovery	0.654 J stored at 12 km/h (114 RPM flywheel) and 0.454 J at 10 km/h (95 RPM flywheel).	75 kg system at 12 km/h, approximately 416.6 J is lost as heat during braking.
Energy Recovery Ratio	Approximately 0.157% (calculated as flywheel KE / without flywheel KE).	0% (no energy recovery during braking).
Energy Recovery Efficiency	~0.36%–0.48% of total KE	0%
Acceleration Effort	Reduced by 5–8% due to flywheel assist	Full effort from rider
Braking Losses	Partially recovered via flywheel	100% lost as heat

Efficiency	Improved energy efficiency. Estimated 80–83% (7–15% friction loss, and +15% recovery).	Estimated 95–98% (standard chain drive, no recovery).
Ride Comfort	Smoother, less tiring on flats	More tiring, especially in traffic
Weight	Heavier (18-25– kg, including 12–15 kg base + 3.27 kg flywheel + 5.32 kg components).	Lighter (typical road bike: 12–15 kg).
Handling Impact	Slightly heavier due to flywheel mass (10–15% more power needed to accelerate).	Light, agile 10–15% less power needed to accelerate.
Complexity	Increased complexity to the bicycle's structure and maintenance.	Simpler design with fewer components.
Cost	Higher overall cost due to additional components.	Generally lower cost.
Effectiveness on Steep Inclines	Less effective on steep inclines or during rapid deceleration.	Efficiency is primarily dependent on rider input and gearing.

CHAPTER 6

RESULT ANALYSIS & DISCUSSION

6.1 Result Analysis

The Kinetic Energy Recovery System (KERS) bicycle, equipped with a 3.27 kg cast iron flywheel (radius 0.075 m, moment of inertia 0.00919 kg/m²), was tested to evaluate its performance in storing and releasing kinetic energy to improve cycling efficiency. Tests were conducted on flat terrain with a 70 kg rider over 60 seconds, with data sampled every 10 seconds. The system aimed to store and release kinetic energy to enhance cycling efficiency. Below is a concise analysis of the results,

- Finally completed our project successfully & check our project its run accurately according to our objective.
- At first, checked this project.
- Improved Efficiency: The flywheel helped store and release energy, reducing pedaling effort, especially on flat terrain and during acceleration.
- It minimized fluctuations in resistance, leading to a more consistent and comfortable ride.
- The flywheel assisted in maintaining speed on inclines and during stops.
- The system showed reliable performance with minimal mechanical issues.
- The added flywheel weight affected handling, especially during acceleration.
- It enhanced energy efficiency by recovering kinetic energy, though the benefit varied with conditions.

6.2 Advantages

There are certainly many advantages of our project and some of the major ones have been given below:

- Energy Efficiency
- Reduced Pedaling Effort
- Smooth Ride
- Momentum Maintenance
- Improved Speed Control
- Enhanced Comfort
- Kinetic Energy Recovery
- Mechanical Durability
- Reduced Fatigue
- Consistency in Pedaling

6.3 Limitations

Through the project has many advantages it has also some limitations, they are given below:

- The flywheel adds weight, affecting handling and acceleration.
- The system adds complexity to the bicycle's structure and maintenance.
- Additional components increase the overall cost.
- It’s less effective on steep inclines or during rapid deceleration.
- The flywheel requires more space within the frame, limiting design options.
- During fast pedaling, belt drive slips little bit.
- Friction within the system can lead to some energy loss, reducing efficiency.

6.4 Application

The application areas for this project in this modern and practical world are huge and some of these are given below

- Urban Commuting
- Long-Distance Cycling
- Energy-Efficient Transportation
- Hybrid Bicycle Systems
- Mountain Biking (for smoother terrain transitions)
- Bicycle for Seniors (reduces pedaling effort)

6.5 Discussion

While working on our project, we faced some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

The Flywheel Bicycle project demonstrates a promising solution for enhancing cycling efficiency. By storing and releasing kinetic energy, the flywheel reduces pedaling effort, especially during acceleration or on flat terrain, offering a smoother and more consistent ride. This system improves energy efficiency by recovering kinetic energy that would otherwise be lost. However, the added weight and complexity of the flywheel may affect handling and increase maintenance needs. While it enhances comfort and reduces fatigue, especially on longer rides, its impact is less noticeable on steep inclines. Overall, the project offers potential for more energy-efficient, comfortable, and sustainable cycling.

CHAPTER 7
CONCLUSION & RECOMMENDATION

7.1 Conclusion

In conclusion, Design & Construction of a kinetic energy recovery system using flywheel in bicycle project presents a significant advancement in improving the overall cycling experience by reducing pedaling effort and enhancing energy efficiency. By utilizing a flywheel to store kinetic energy during pedaling, the system ensures smoother and more consistent motion, particularly during acceleration or when maintaining speed on flat terrain. The flywheel helps mitigate fatigue, providing a more comfortable and efficient ride, especially on longer distances or during periods of lower pedaling force.

However, the project does come with some limitations. The added weight of the flywheel affects the bicycle's handling, especially during rapid acceleration or deceleration. The complexity of the mechanical components can also increase maintenance requirements, and the overall cost may rise due to additional parts and materials. The flywheel's effectiveness is less pronounced on steep inclines or rapid deceleration, where its impact is minimal. Despite these limitations, the Flywheel Bicycle offers considerable potential for energy-efficient cycling, especially in urban commuting, fitness, and recreational cycling. With further refinement, it could contribute to more sustainable and comfortable cycling experiences, promoting energy conservation and reducing fatigue in everyday cycling activities.

7.2 Future Scope

As we have already discussed about the limitations of this system so definitely there's room for improvement and thus we have Some future scope of work available to us for this system. Some of these are listed below:

- Using advanced materials like carbon fiber to reduce bicycle weight.
- Using chain drive transmission can be more effective.

- Fork structural design & aligning to bicycle frame for better handle balancing.
- Gear or clutch mechanism system can be attached in this project.
- Combining with Hybrid system can enhance energy recovery and efficiency.
- Using flywheel energy to charge devices like smart phones or lights while riding.

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