MARATHA VIDYA PRASARAK SAMAJ'S

KARMAVEER ADV. BABURAO GANPATRAO THAKARE COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Presents

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Institute Vision

To be internationally accredited, Multidisciplinary, and Multi-collaborative institute working on technology enabled platform fostering innovations and patents through state-of-art academic system designed by highly qualified faculty for the development of common masses at large

Institute Mission

To educate and train common masses through undergraduate, post graduate, research programs by inculcating the values for discipline, quality, transparency and foster career and professional development for employment thereby contributing to the development of society

Department Vision

To be the centre for excellence and centre of learning for innovation, incubation and research in the domain of product design, thermal engineering and manufacturing technology thereby path finder for professionalism, entrepreneurship and new knowledge contributing to the common masses.

Department Mission

To educate and train undergraduate and post graduate students in Mechanical Engineering by inculcating the values for discipline, quality and transparency and profession development in the job and self-employment emphasis industry-based practices.

Program Education Objectives (PEO's)

PEO1: To prepare technocrats that can satisfy the need of mechanical and allied industries.

PEO2: To develop critical thinking, problem solving skills, research aptitude and career and professionalism among the students.

PEO3: To improve and expand technical and professional skills of students through effective teaching-learning and industry interaction.

Program Specific Outcomes (PSOs)

PSO1: Ability to design, analysis and problem-solving skills using basic principle of mechanical engineering.

PSO2: Ability to impart technical and professional skills through industry institute interaction

PSO3: Develop practical skills for the benefits of society.

Objectives of Magazine

1. Primary objective of the magazine is to provide a wide platform to the aspiring engineers to showcase their technical knowledge and to explore innovative ideas.
2. This magazine is intended to bring out the hidden literary talents in the students and teachers to inculcate strong technical skills among them.
3. Share the latest developments, trends, and innovations in engineering, including new technologies, methodologies, and industry standards.
4. Encourage creativity and innovation within the engineering community by highlighting groundbreaking research, new inventions, and novel solutions to existing challenges.

Mechanical and Tribological properties of the Lead-Free Composite-A review

This review article explores the mechanical and tribological properties of lead-free composites, highlighting their importance in sustainable engineering. It covers various materials and their performance characteristics, focusing on their wear resistance, friction behavior, and overall durability. The shift towards lead-free alternatives is driven by environmental concerns and the need for safer, non-toxic materials in industrial applications. The review provides a comprehensive analysis of the current advancements, challenges, and future directions in the development of lead-free composite materials.

Introduction

Environmental concerns regarding the use of hazardous materials have become crucial in material selection, especially in bearing applications where lead has traditionally been used due to its exceptional dry lubrication and anti-friction properties. However, the detrimental effects of lead on both human and environmental health have driven the search for safer, eco-friendly alternatives. Journal bearings, essential components in many machines and automotive systems, have become a focal point for researchers seeking lead-free options. Recent studies have explored advanced nanocomposites and cutting-edge manufacturing techniques, such as additive manufacturing, which have shown promising results in improving the efficiency and sustainability of lead-free composite journal bearings. These innovations not only reduce the use of harmful substances but also enhance mechanical properties like tensile strength and wear resistance, resulting in longer bearing lifespans, reduced maintenance, and improved system performance. This review provides an in-depth exploration of lead-free composites, focusing on their mechanical, tribological, and microstructural properties relevant to journal bearings.

1.1 Factors to be Considered in Selecting Journal Bearing Materials

Selecting the right bearing material for journal bearings is crucial for optimal system performance. Journal bearings, which support rotating shafts in various industrial machines, rely on factors such as embeddability, compatibility, conformability, fatigue strength, and resistance to corrosion and cavitation erosion. These materials must strike a balance among these properties, as no single material can fulfill all requirements. Important mechanical properties include low friction, high compressive strength, and good thermal conductivity. Additionally, lubrication type—

such as hydrodynamic or boundary lubrication—plays a significant role in reducing wear and ensuring long-lasting performance. Proper material choice ensures reduced friction and effective function in machinery such as engines, turbines, and compressors.

2. Development of Bearing Materials and Current Trends

Bearing materials are available in a variety of types, tailored for specific applications, and can be classified into metallic and non-metallic categories. Metallic bearings include materials such as aluminium-based alloys, lead and tin-based white metals, porous metals, and copper-based bronzes, while non-metallic bearings are made from ceramics, composites, and polymers. Bearings can also be categorized by geometry, with full round sleeves referred to as "bushes" and half round sleeves called "bearings." Metals like gold, copper, iron, and silver are commonly used in metallic bearings, with lead-based alloys, known as Babbitt metals, being particularly notable. However, environmental and health concerns have led to a decline in the use of lead-based bearings, with tin-based alternatives becoming more common. Tin Babbitt alloys offer good embeddability and adhesion but are limited by their weak fatigue strength. Recent research is focused on minimizing or eliminating lead in bearing materials to improve sustainability and performance.

Non-metallic bearings are used in light-duty applications where chemical durability, self-lubrication, and high-temperature resistance are needed, such as in space and food processing. They offer benefits like vibration absorption and corrosion resistance but have limitations like low melting points and high thermal expansion. Composite bearings, which combine metal and polymer matrices, improve strength and wear resistance. Advancements in fiber-reinforced plastics further enhance their performance in various industrial uses.

3. Properties of Lead-Free Composites

3.1 Mechanical Properties of various Lead-free composites

The incorporation of silicon nitride (Si_3N_4) particles into materials at varying rates of 0, 0.25, 0.5, 0.75, and 1.0 wt.% significantly impacted the mechanical properties, with a 0.75% Si_3N_4 addition enhancing shear strength by 25.6%. Various studies on lead-free composites have shown that the inclusion of different particles, such as bismuth, titanium, graphene, and carbon nanotubes, influences properties like tensile strength, hardness, and machining efficiency. Notably, composites with 15% bismuth or 0.05% single-walled carbon nanotubes exhibited notable improvements in strength. Additionally, the hardness of these composites, ranging from 13.5 HV to 380 HV, can be adjusted based on the specific requirements of journal bearing applications.

3.2 Tribological Properties of various Lead-free composites

Tribological properties are crucial for the performance of lead-free composites, particularly in reducing friction, wear, and heat generation in moving components. These composites often exhibit superior tribological behavior, leading to energy savings, lower maintenance costs, and enhanced system efficiency. Many formulations, including those with self-lubricating properties, reduce reliance on external lubrication. Research has focused on improving these properties by combining different matrix materials and reinforcing agents for applications across various industries like automotive, aerospace, and renewable energy. Studies have demonstrated significant reductions in friction and wear, such as a 29% decrease in friction and 73.2% in wear for FeS/Cu-Bi composites. Other studies have highlighted improvements in materials like phosphorous-aluminum-copper and aluminum-nickel-copper composites, with wear rates reduced by up to 73.2% and friction coefficients by 29%. Surface modification, mechanical alloying, and the addition of materials like MoS2 or Ca compounds have been key factors in these improvements, leading to more durable, efficient lead-free composites.

3.3 Micro-structural characteristics of various Lead-free composites

One critical microstructural property of lead-free composites is grain size, which influences their mechanical strength and toughness. Smaller grains generally lead to stronger materials, and lead-free composites can be engineered with fine grains to enhance their properties. Additionally, the size and distribution of diamond particles in these composites play a significant role in thermal conductivity. Smaller diamond particles form sharp polygonal carbides, while larger particles result in uniform carbide coverage, improving thermal conductivity. The diamond volume fraction also affects thermal properties, with optimal conductivity achieved at 50-60% volume fraction.

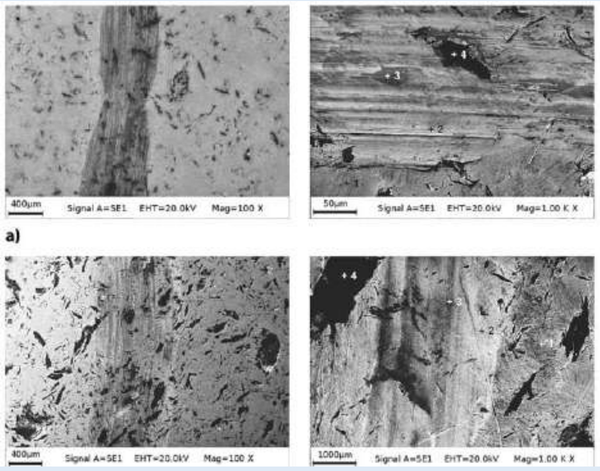

Fig shows Copper-based diamond composites

Furthermore, phase distribution within the composite matrix is crucial for mechanical performance. The uniformity of phases, such as in Tin/bronze composites with graphite reinforcement, can reduce wear and friction. These microstructural factors—grain size, diamond particle size and fraction, and phase distribution—are essential in designing lead-free composites with desirable mechanical and thermal properties.

4. Challenges in implementation of lead-free composites

The current engineering landscape faces significant challenges in replacing lead-based materials with eco-friendly alternatives for journal bearings. Finding materials with comparable or superior mechanical and tribological properties is difficult, especially for applications involving heavy loads and rapid sliding, which require low friction and high wear resistance. Design complexities and lubrication requirements must be carefully analyzed to ensure new materials maintain performance and durability. Moreover, lead-free bearings must balance performance with cost-effectiveness, while considering the lifecycle environmental impacts of alternative materials. Compliance with international standards and rigorous testing is essential for ensuring the environmental footprint of production, use, and disposal. Continuous research, education, and knowledge sharing are crucial for driving innovation and keeping industries competitive as they transition to sustainable solutions.

5. Conclusion

This review highlights the significant progress made in developing lead-free composites for journal bearings, emphasizing the urgent need for sustainable engineering solutions that align with global environmental goals. The promising tribological and mechanical properties of these materials offer a potential eco-friendly alternative to traditional lead-based options. However, the study also points out the gaps in research, particularly in real-world applications, where factors such as varying loads, speeds, and lubrication conditions need to be considered.

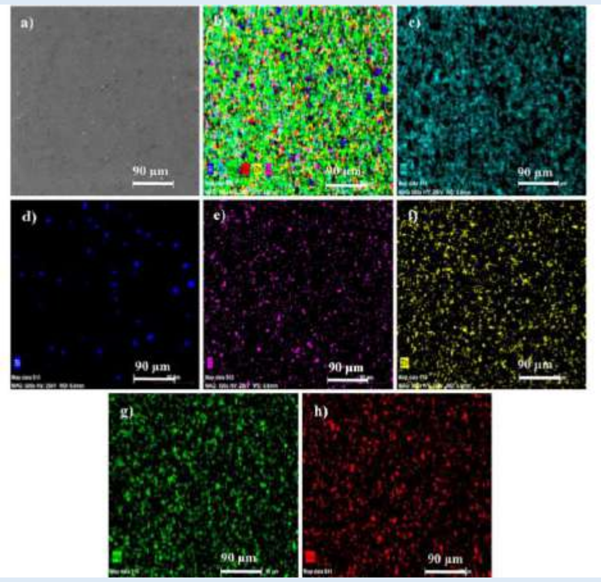

Figure 3 SEM images of aluminum-based ceramic-reinforced composite of the sample containing 6% Zn a) Sem image b) All elements c) Al particles d) Si particles e) C particles f) Zn particles g) Mg particles h) Cu particles

To fully realize the potential of lead-free composites, further research focusing on their long-term durability, optimization, and comparative performance under different conditions is crucial for advancing their practical use in industrial settings.

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“Ishrae student members won Third prize in Project exhibition cumcompetition - Innovate X Celebrating Innovation and Excellence”

Ishrae student members of Final year Mechanical Engineering viz. Mr. Raj Dongare, Mr. Abhishek Patil, Mr. Prathmesh Khelukar, Mr. Kshitij Chaudhary presented their Final year project “IoT based Indoor Air Quality Monitoring and Management system” in a Project exhibition cum competition ‘Innovate X - Celebrating Innovation and Excellence’. Our students got Second Runner-up position (Third prize worth Rs.10000/) in this competition at Zonal level.

An IoT-based Indoor Air Quality (IAQ) Monitoring and Management System is a technology-driven solution designed to continuously monitor and manage the quality of air inside indoor environments like homes, offices, or industrial spaces. The system uses a network of IoT (Internet of Things) sensors to measure various air quality parameters such as: CO2 levels, PM2.5 (Particulate Matter), Temperature and humidity, VOC (Volatile Organic Compounds), Carbon monoxide (CO).

Performance Evaluation of Polymer Based Hybrid Composite Under High Impact

Most applications today require materials with high-velocity impact resistance, which traditional polymer composites cannot provide. This project aims to develop a hybrid composite material capable of withstanding high-velocity impacts by selecting suitable reinforcing materials. The process includes software analysis, specimen manufacturing, and experimental testing using mechanical

methods to validate the material's performance.

Introduction

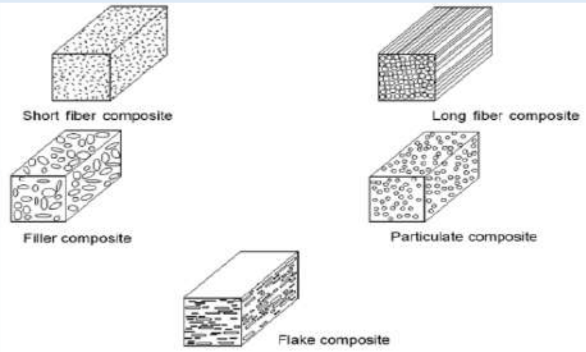

Fig. 2. Types of composites

Composite materials combine two or more distinct materials to create a new material with unique properties. They are widely used in construction, automotive, and marine industries. Hybrid composites, which mix different fibers, offer advantages like improved strength, reduced weight, and better fatigue resistance. Kevlar fiber-reinforced composites are known for impact resistance, though research is focused on improving their stiffness and other properties for broader applications.

Methodology

The methodology for this project involves several key steps. Initially, a project is selected based on its alignment with the research objectives. Data is collected through literature review and mechanical testing, followed by analysis of the results. Samples are prepared, and materials are procured before conducting the necessary mechanical tests to determine material properties. Software tools may also be used for simulations and analysis. After selecting the most suitable material based on test outcomes, a comprehensive report is prepared, detailing the findings.

Material Selection

A polymer matrix composite (PMC) due to its numerous advantages, including lightweight, high strength, design flexibility, and resistance to abrasion and corrosion. Among the various PMCs, we selected epoxy for its heat resistance, availability, high tensile strength, and resistance to fatigue. The reinforcement material chosen is Kevlar fiber because it offers high strength, lightweight, flame resistance, and excellent chemical and dimensional stability, while avoiding the health hazards associated with carbon fiber.

To enhance the mechanical properties, we opted for a hybrid composite material, combining polymer with carbide materials. Carbide materials, such as cemented and boron carbides, are known for their high impact strength, wear resistance, thermal stability, and corrosion resistance. After evaluating several options, we selected Tungsten carbide due to its high melting point, strength, and suitability for high-impact applications, making it the ideal choice for our project's hybrid material.

Processes Used for Manufacturing of the Sample

The Hand Lay-Up Process is a simple and cost-effective method used to fabricate composite materials, where dry fibers are manually placed into a mold and resin is applied with a brush. The process is low-cost, easy to learn, and doesn't have size or shape limitations. However, it has disadvantages like uneven resin distribution, low production efficiency, and a higher chance of voids.

Compression Molding is a more advanced technique that uses heat and pressure to shape polymer composite materials. The material is loaded into a mold, and pressure and heat are applied until it cures. This process is good for small production runs and large parts, with lower tooling costs. However, it comes with drawbacks like greater material waste, higher labor costs, slower cycle times, and challenges with complex molds.

Testing

Fig shows Barcol Hardness Test

The Barcol hardness test (ASTM D2583) measures a material's resistance to indentation by comparing the depth of an indenter's penetration into the sample. It is commonly used for rigid plastics and composite materials. The test involves applying uniform pressure to a specimen until a maximum dial reading is reached, which is then converted into Barcol hardness numbers. This method is essential for quality control, especially in materials like aluminum and plastics, and is quick, cost-effective, and widely used in industries requiring precise material evaluation.

Conclusion

Without the tungsten carbide layer, the deformation of the specimen is greater compared to the deformation of the specimen with the tungsten carbide layer. With the tungsten carbide layer, the specimen can sustain high impact. The impact strength of the specimen is increased. The mechanical properties are enhanced due to the tungsten carbide layer. It is observed that the hardness of the simple composite material (epoxy and Kevlar) is increased by adding an additional reinforcement material (tungsten carbide) to the composite.

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Guided By: Prof. N. S. Gaikwad

Smart Phone Operated Car

Nowadays, smartphones are becoming increasingly powerful with enhanced processors, larger storage, and advanced entertainment and communication features. Bluetooth is commonly used for data exchange, while technologies like ESP8266 WIFI are expanding smartphone capabilities. With the growing number of smartphone users, devices are evolving into all-purpose tools for daily life. This paper focuses on providing a simplified hardware architecture with efficient computational platforms, allowing designers to concentrate on research and testing instead of managing complex ESP8266 WIFI connections. The proposed system enables remote control of a robotic vehicle through the BLYNK app, using features like vibration detection, obstacle avoidance with ultrasonic sensors, and automatic airbag deployment for accident prevention. The entire vehicle control process is streamlined through an Android smartphone interface.

Introduction

The project aims to design a robot that can be operated wirelessly through an Android smartphone via Bluetooth. In this setup, the smartphone serves as a remote control, leveraging Android's versatile operating system, which supports multiple connectivity options like Bluetooth. Bluetooth technology enables short-range, wireless communication, making it ideal for controlling the robot. A microcontroller acts as the central controller, interfacing with the Bluetooth module and DC motors to execute commands received from the smartphone. The controller's program, written in Embedded C, processes the input and drives the robot's movement. Bluetooth-controlled robots like this one simplify day-to-day tasks and have broad applications in fields like mobile surveillance, assistive devices, and home automation. This innovation represents a step toward future technologies, such as driverless cars, offering convenience and accessibility to user

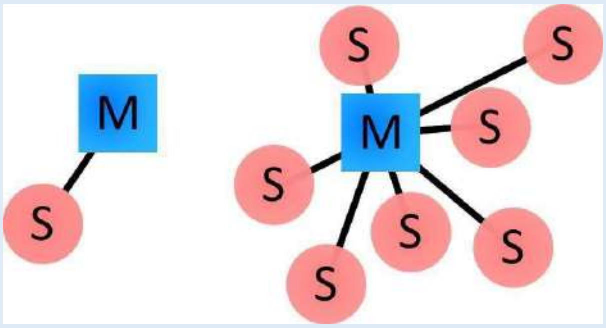

Fig. shows Examples of Bluetooth master/slave Piconet topologies

Methodology

The methodology for designing a Smartphone Operated Car follows a structured approach to ensure systematic development. The process begins with a survey to identify key issues, followed by defining the problem and setting clear objectives. A comprehensive review of related research papers is conducted to gather essential insights, forming the foundation for the project. Afterward, the most suitable solutions are selected, and a detailed plan is developed. Next, raw materials and components are chosen based on quality and cost. The individual components are then assembled, culminating in the construction of the final model. Finally, the car undergoes rigorous testing in various environments to ensure it functions as intended. This structured methodology ensures efficient project execution, meeting the required standards and timelines.

Design and Components

The system consists of several key components:

1. Arduino UNO: A versatile open-source microcontroller board featuring the ATmega328P chip. It offers 14 digital I/O pins, 6 analog I/O pins, and is programmable via the Arduino IDE. It can be powered through USB or an external 9V battery, providing flexibility for various applications.

2. L298N Motor Driver Module: This module is designed to control the speed and direction of two motors simultaneously, utilizing the L298N IC to drive motors with voltages ranging from 5V to 36V.

3. HC-05 Bluetooth Module: A wireless serial Bluetooth module that communicates via UART, allowing the system to send and receive data over Bluetooth. It facilitates wireless control of the device from smartphones or computers.

4. 4 x 5V Geared Motors: These motors operate at a rated voltage of 5V and offer a torque of 0.8kg/cm, with a no-load speed of 200rpm. They are suitable for driving various mechanical systems within the project.

5. Connecting Wires: Essential for connecting all components on a breadboard or prototype circuit, these wires facilitate the transmission of electrical signals between components without the need for soldering.

6. Android Phone: Used to send commands to the system, this smartphone acts as a controller via Bluetooth, enabling wireless operation.

7. Bluetooth Controller App: The app communicates via Bluetooth to control the system, simplifying interaction by allowing the user to send commands wirelessly.

Working

The wiring diagram shows a power source of four 1.5V batteries connected to the L298

Motor Driver and Arduino UNO. Digital pins of the Arduino control the Motor Driver's inputs, which drive the motors connected to the outputs. The HC05 Bluetooth module is powered by the Arduino’s 5V pin, with communication between the Arduino and Bluetooth via TXD and RXD. After uploading the program, power is turned on, and the Bluetooth module allows control of the motors through commands sent from an Android device.

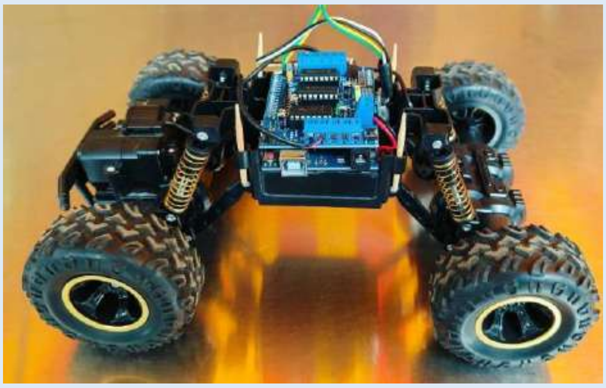

Fig shows Assembly of Smart Phone Operated Car

Result and Conclusion

The Android-guided Arduino car has been successfully created, and thorough testing has been conducted to cover all known usage cases. We developed an easy-to-use Android application that allows users to control the Arduino-powered car via Bluetooth, providing real-time feedback from the Arduino microprocessor. The Arduino program was successfully written, compiled, and uploaded to the microcontroller, ensuring proper logic to minimize hardware damage. Additionally, we integrated an ultrasonic sensor with a servo motor to prevent collisions, meeting the project's goal of designing an interactive Android interface and an autonomous car with basic mobility features. The car, powered by 4 DC motors driven by an H-bridge, can be controlled via Bluetooth or infrared. Future enhancements, such as improved line tracking and custom modes, are possible through further software updates and sensor integrations. This project lays the foundation for future advancements, such as using the car for surveillance or transforming it into a robot with self-monitoring capabilities.

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Automatic Bicycle Gear Shifter

Bicycles are popular in India, but manual gear shifting can be difficult for beginners and distracting on hills. This project aims to develop an **Automatic Bicycle Gear Shifter** that changes gears based on pedal speed (RPM), reducing the need for manual control. Using a **Governor** mechanism integrated into the frame, the system automatically adjusts the gears, maintaining pedal speed between 70-90 RPM. This innovation makes cycling easier, safer, and more efficient by reducing human interference and allowing riders to focus on the road.

Terminologies

Cadence: The speed at which a rider pedals, measured in revolutions per minute (RPM).

Gears: Multiple gears on a bike that adjust pedal resistance and speed, shifted manually or automatically.

Derailleur: A mechanism that moves the chain between gears. The front derailleur shifts between chainrings, and the rear derailleur shifts between cassette gears.

Chainring: The gear attached to the pedals, with one, two, or three chainrings depending on the bike.

Cassette: A cluster of gears on the rear wheel, with 5 to 12 gears to adjust pedaling difficulty.

Shifters: Controls that allow the rider to change gears, located on the handlebars, frame, or brake levers.

Methodology/Working

The Hartnell governor is connected to the bicycle pedal via a chain-sprocket mechanism. As the pedal rotates, the governor also rotates, with its equilibrium speed set at 80 RPM. When the pedal speed increases to 90 RPM, the centrifugal force on the flyballs increases, causing them to move outward. This movement rotates the bell crank lever, which is connected to the sleeve. The sleeve, in turn, pulls the gear up-shifting wire, causing the gear to shift to a higher gear.

Conversely, when the pedal speed decreases to 70 RPM, the centrifugal force on the flyballs decreases, causing them to move inward. This inward movement rotates the bell crank lever in the opposite direction, pushing the gear down-shifting wire and shifting the gear to a lower gear. This mechanism allows for automatic gear shifting based on the rotational speed of the bicycle pedal.

Design and Calculations

The components of a Hartnell governor play essential roles in regulating engine speed. The frame houses a spring that offers support and protection, connecting to the bell crank lever, which rotates alongside the lever. The flyballs, mounted on the bell crank lever, are weighted to influence the lever's motion. The bell crank lever rotates due to the centrifugal force acting on the flyballs and connects to the frame, enabling movement. A spring applies pressure to the sleeve, adjusting its position when needed. The sleeve moves vertically in response to the lever's rotation, controlling fluid flow into the engine. The shaft connects to the flyballs and sleeve, and its rotation drives the governor's actions. These components work in concert to maintain the engine's speed by adjusting the position of the sleeve based on the centrifugal force generated by the flyballs.

Fig shows Photos of Project

Advantages and Disadvantages

The Automatic Bicycle Gear Shifter offers numerous advantages that significantly enhance the cycling experience. First and foremost, it provides ease of use by eliminating the need for manual gear changes, making cycling more accessible for individuals with limited physical abilities or coordination. Its convenience allows riders to focus on the ride itself without the distraction of shifting gears, improving both safety and enjoyment. The system optimizes gear selection based on real-time conditions like speed and terrain, ensuring efficient pedaling and performance. Smooth and seamless gear transitions are achieved through electronic or mechanical control, offering a comfortable ride. Additionally, some models offer customizable features to suit individual riding preferences, further enhancing the overall cycling experience. Finally, the automatic system increases efficiency by maintaining an optimal cadence and power output, contributing to better cycling performance in various conditions.

Conclusions

The Automatic Bicycle Gear Shifter project aimed to make cycling more accessible and enjoyable for riders of all skill levels by eliminating the need for manual gear shifting and improving safety and performance. Using a Hartnell governor, the project developed a fully mechanical automatic gear shifter designed to optimize cadence, power output, and overall cycling efficiency. By reducing rider fatigue, especially on long rides or hilly terrain, the system ensured seamless gear transitions, prolonging the lifespan of bike components by minimizing wear and tear. The project focused on affordability, compatibility with various bicycles, and thorough testing with user feedback to refine the design. Ultimately, the project advanced bicycle technology, contributing to a more sustainable and user-friendly cycling experience.

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