PIEZOELECTRIC WHEEL

A MINOR PROJECT - III/VI REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this **18ECP105/106L - Minor Project III/IV** report “PIEZOELECTRIC WHEEL**”** is the bonafide work of GOKUL S C (20BEC4042), ARUN KUMAR N (20BEC4011), BALAJI P(20BEC4016), GOWSHIK N (20BEC4046) who carried out the project work under my supervision in the academic year <<**YYYY-YYYY - ODD/EVEN**>>.

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PROJECT COORDINATOR

INSTITUTION VISION AND MISSION

Vision

To emerge as a leader among the top institutions in the field of technical education.

Mission

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges.

M2: Create a diverse, fully -engaged, learner -centric campus environment to provide quality education to the students.

M3: Maintain mutually beneficial partnerships with our alumni, industry and professional associations

DEPARTMENT VISION, MISSION, PEO, PO AND PSO

Vision

To empower the Electronics and Communication Engineering students with emerging technologies, professionalism, innovative research and social responsibility.

Mission

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives

PEO1: **Core Competence:** Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering

PEO2: **Professionalism:** Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: **Lifelong Learning:** Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality

Program Outcomes

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO1: Applying knowledge in various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of Engineering application.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations.

Abstract	Matching with POs, PSOs
Piezoelectric materials, , road power generation , Energy conversion , Kinetic harvesting	**All POs and PSOs**

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ABSTRACT

A piezoelectric wheel is a novel device that utilizes the piezoelectric effect to convert mechanical energy into electrical energy. The device consists of a wheel with embedded piezoelectric materials that generate electrical energy when subjected to mechanical stress. The generated electrical energy can be used to power various electronic devices and systems, such as sensors, actuators, and wireless communication modules. The piezoelectric wheel has the potential to be used in various applications, such as in the automotive industry, where it can generate electricity from the rotational motion of wheels and reduce the load on the vehicle's battery. The device also has potential applications in the field of renewable energy, where it can be used to harvest energy from wind turbines, water turbines, and other rotating machinery. Overall, the piezoelectric wheel is a promising technology with a wide range of potential applications in various fields.

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LIST OF ABBREVIATIONS

ACRONYM		ABBREVIATION
PZT	-	Lead Zincornate
BMS	-	Battery Management System
CDC	-	Carbine-Dervied Carbon
AWP	-	Alumina Wear Plates
PT	-	Piezoelectric Tubes
AR	-	Acoustic Roads
SFT	-	Spherical Focusing Transducer

CHAPTER 1

INTRODUCTION

The word “piezo” is derived from the Greek word pie-zein, meaning “to press tightly”. Piezoelectricity is the ability of a material to convert mechanical energy (pressing) into electric energy (polarization) and vice versa. The direct piezoelectric effect is the generation of electric polarization in response to an applied stress. The directionality and the magnitude of polarization is proportional to the stress applied, and the polarization can have components in the parallel and perpendicular directions. The opposite phenomenon, the inverse piezoelectric effect, is the generation of a mechanical deformation in response to an applied electrical field. Piezoelectricity is a property of certain dielectric materials to physically deform in the presence of an electric field, or conversely, to produce an electrical charge when mechanically deformed. Piezoelectricity, also called the piezoelectric effect, is the ability of certain materials to generate an AC (alternating current) voltage when subjected to mechanical stress or vibration, or to vibrate when subjected to an AC voltage, or both.

1.1 OBJECTIVE

The objective of a piezoelectric wheel in an electric vehicle (EV) is to generate electrical energy from the vibrations and mechanical stress experienced by the wheel as it rotates on the road surface. The piezoelectric material, which is embedded in the wheel, produces an electric charge when subjected to mechanical stress or pressure. This charge can be harvested and used to power various components of the EV, such as the battery, motor, or other electrical systems. The piezoelectric wheel can help to increase the overall efficiency of the EV by reducing the reliance on the battery and other external power sources. By generating electricity from the vibrations and mechanical stress of the wheel, the piezoelectric system can help to extend the range of the EV and reduce the need for frequent recharging. Overall, the objective of a piezoelectric wheel in an EV is to improve the efficiency, range, and safety of the vehicle by harnessing the electrical energy generated by the wheel as it moves on the road.

1.1.1 On-Road Noise Measurement:

Smooth paved road and electric vehicle (Coms, ZAD-TAK30-DS, Toyota Auto Body Co., Ltd., Aichi, Japan). To measure the road noise, a wireless acceleration sensor (MVP-RF3-J, Micro Stone Corporation, Nagano, Japan) with a response frequency of 1–1000 Hz is installed on the front suspension of the vehicle. In low speed range conditions where the vehicle travels on a smooth paved road, it indicates that the power spectral density of the accelerations remains identical by analyses of the measured signal. Therefore be derived. Calculation of the Kramer’s rate reveals that resonance readily occurs at an angular velocity lower than 40.6 rad/s (6.5 Hz).

1.1.2 Actual – Vehicle Experiment:

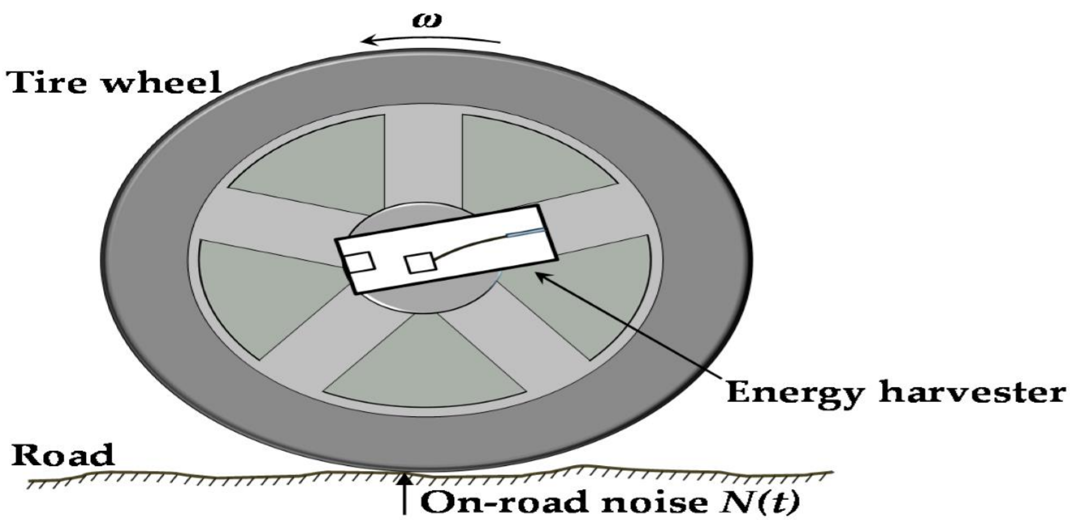
The proposed energy harvester is attached to the front tire wheel of the electric vehicle to verify the power generation performance in real-world road environment. The center of the cantilever tip mass is precisely located at the rotational center of the wheel to eliminate the centrifugal force's effect on the balance of the wheel and stiffness of the cantilever beam. The wireless accelerometer is mounted on the wheel for measuring the on-road noise excitation and tangential gravity acceleration, and a data acquisition system (DSO Nano v3, Seed Studio, Shenzhen, China) is used to continuously measure real-time output voltage across a matched load resistor. It should be noted that when the energy harvester is rotating as the vehicle drives, considering the dynamic effect of rotation on the on-road noise that is forced on the cantilever, the expression of the on-road noise becomes N(t) sin(wt.) instead of N(t). Then the intensity of N(t) is weakened to stimulate the phenomenon of stochastic resonance at an angular velocity lower than 22.5 rad/s (23.5 km/h). The validation experiment is implemented on real-world road, in which the vehicle travels at four different speeds of 10 km/h, 20 km/h, 30 km/h, and 40 km/h. The power generation performances are given under four different vehicle speeds, and the red solid line represents the average value of power. The experimental results indicate that the power can be boosted to a higher level at the speed of 20 km/h, due to the occurrence of stochastic resonance. It is approximated to the calculated Kramer’s rate value of 23.5 km/h. As presented for the increasing vehicle speeds of the 30 km/h and 40 km/h

CHAPTER 2
LITERATURE REVIEW

2.1 Importance of piezoelctric wheel

The wheel with the increasing requirements of advanced driving assistance systems, researchers have developed a tire-pressure monitoring system that can provide the driver with the tire condition via wireless transmission [1,2,3]. However, because it is inconvenient to replace or recharge the batteries of a monitoring system, there is a desire to establish an effective energy harvesting system [4]. The present paper therefore proposes a piezoelectric energy harvester for rotating automobile wheels, and focuses on experimental testing under on-road noise excitations to improve the harvesting efficiency through the application of stochastic resonance. Several attempts have been made to exploit energy harvesters for rotating environments. Specifically, a linearly piezoelectric energy harvester using a cantilever beam has been proposed, where the centrifugal force is used to stimulate the natural frequency of the energy harvester system matching the rotational frequency [5]. A linear MEMS energy harvester using tire shock excitations was proposed for automotive applications; however, it can extract more energy only in the case of high-speed driving, and the energy harvesting efficiency depends on the concave-convex condition of the road surface [6]. A nanogenerator layer was attached on the inner surface of the tire, and the energy was harvested by the bending of the piezoelectric film; however, the energy harvesting performance was investigated using a bicycle tire instead of a real vehicle tire [7]. Moreover, a linear energy harvester was presented to optimize the frequency band of operation based on a feedback loop control system [8].

2.2 Mathematical model :



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To eliminate the effect of the centrifugal forces, the center of the cantilever tip mass is located at the rotational center of the wheel due to the sensitivity of cantilever beam stiffness to centrifugal force, To obtain the restoring force between the two magnets of the energy harvester, a mathematical model is first derived for the interaction forces of the magnets. The dipole model is used to represent the interaction forces, and the potential energy of the movable tip magnet can be where k is the spring constant of the beam. As shown in with the distance between the two magnets increasing from 19.5 to 25.5 mm, there are two stable states, and the distance between the two stable points gradually becomes small. When the separation of the magnets exceeds 25.5 mm, the cantilever beam cannot be stimulated as being bistable, and it becomes a monostable system around the equilibrium position. gives the numerical parameters used to investigate the effect of the distance between the two magnets on the steady state of the system.

2.3 Piezo-Electric research trends :

Piezoelectric wheels are an emerging technology in the field of electric vehicles (EVs). The technology involves the use of piezoelectric materials to convert mechanical energy into electrical energy, which can be used to power the vehicle's electrical systems. Research in this area is focused on improving the efficiency of piezoelectric materials, increasing their durability and lifespan, and integrating them into existing EV designs. Some researchers are also exploring the possibility of using piezoelectric wheels to generate energy from the motion of the vehicle, which could help to increase the vehicle's range and reduce its reliance on external power sources. Overall, the use of piezoelectric wheels in EVs is still a relatively new area of research, but it has the potential to significantly improve the efficiency and sustainability of electric vehicles in the future. Increasing Efficiency: One of the primary research goals related to piezoelectric wheels is to improve the overall efficiency of EVs. Piezoelectric materials can generate electricity when subjected to mechanical stress, and by incorporating these materials into the wheels of an EV, researchers hope to harness the energy generated during braking and other driving conditions to power the vehicle's electrical systems. Lightweight Materials: To maximize the energy generated by piezoelectric wheels, researchers are exploring the use of lightweight materials such as carbon fiber and aluminum alloys for the wheel's construction. These materials are not only strong and durable but also reduce the overall weight of the vehicle, which can increase its range. Advanced Piezoelectric Materials: While the use of piezoelectric materials is not new, recent research has focused on developing more advanced materials that can generate higher amounts of electricity. Some of the most promising materials include lead-free piezoelectric ceramics, polymer-based piezoelectric materials, and single-crystal piezoelectric materials.

2.4 Piezo- Electric foams:

In recent years, researchers have begun investigating the piezoelectric-like response of cellular polymer foam material for use in harvesting vibration energy. The development of piezoelectric foam, also called ferroelectric foam, began in Finland in the 1980s . This class of material is known as an electret; a dielectric material containing permanent electric charge (much like permanent magnets which contain permanent magnetic fields). While these materials are ferroelectric, as opposed to conventional piezoelectric materials which are ferroelectric, they exhibit piezoelectric-like behaviour, therefore, are considered appropriate for inclusion in this review. Ferroelectric foam exhibits piezoelectric-like behaviour thanks to the permanently charged internal voids of the structure. During fabrication of this material, a polarization process deposits the charge, which then becomes trapped in the voids. The application of mechanical or electrical stimuli causes the charged voids to act as macroscopic diploes, thus yielding piezoelectric-like properties. When compared to conventional piezoelectric polymer materials. One potential application of piezoelectric wheels in EVs is in the development of foam-based tires that contain embedded piezoelectric materials. These tires would generate electricity as they deform under the weight of the vehicle, effectively converting some of the mechanical energy of the car's motion into electrical energy. This could potentially increase the range of the EV by providing additional power to the battery. However, there are some challenges associated with the development and implementation of piezoelectric wheels in EVs. For example, the amount of electricity generated by piezoelectric materials is typically quite small, and it may be difficult to generate enough power to make a significant impact on the vehicle's overall efficiency. Additionally, the cost of incorporating piezoelectric materials into tires or other components may be prohibitive, especially in the early stages of development.

2.5 Railways adapated with piezoeletric devices:

The generation of electricity through the train tracks are an adaptation of the application for power generation from roads by means of pavements with piezoelectric elements [16]. The advantage with the application in the railways is that it is guaranteed that pressure will be exerted at the same point repeatedly [14]. This is because the deformable piezoelectric devices are in the joints that make up the support of the rails, which are connected to the rest of the equipment so that the energy collected can be used [4, 9]. Whether for power supply of trains, for signals of the road or even for supply toward the general power grid, each one may be possible because with the passage of the trains it is estimated that it could generate at least some 120kWh of clean energy and at the same time provide information such as speed, weight and number of wheels [17]. Finally, this type of transport emits inevitably vibration and pressure to specific points of the rails, thus reaching self-sustaining signaling pathway, or even better yet, if they are electric trains, it may reduce the requirements for the electricity network and in such case provide power to the grid [14]. Considering this, we have Proposition 3: Adapting piezoelectric devices to railways as energy harvesters might help for power generation support. The wave energy is a huge source of potential energy, clean, which can be exploited by piezoelectric devices. In addition, given the large number of coastal areas, since 70% of our planet is made of oceans, it is a great amount of electricity which is calculated could be obtained through the waves, you can even install devices on buoys or floats offshore, but to be profitable these devices .

2.6 Economic methods of piezoelectricity :

The multidimensional relationship of renewable energy projects, no matter what kind they are, must also consider the issues from a one-dimensional perspective, such as society and the energy market [23]. Private enterprise and even the political framework of government are apparently involved for the relevant care of environment, which is extremely necessary to create an atmosphere of competitiveness against traditional forms of generation, to which countries had to stick, partially for the lack of private investment on alternative methods of harvesting energy [24]. Hence, one of the biggest challenges are the costs that have the storage from piezoelectric materials, Therefore, we present Proposition 6: Developing and clarifying public policy play a decisive role for the methods of harvesting energy not only for being innovative but friendly to all parts involved, in order to be positioned successfully. Given this, it is essential to choose investment projects that are well adapted to the frames that investment offers. Public policies that encourage investment are essential for the growth of countries, especially when it comes to the transparency of implementation processes, as well as from the support of banking institutions through financing projects with long-term return. A similar project was also installed in -Krommenie and Wormerveer, Amsterdam [31]. With such literature comparison, it is demonstrated that power generation in pavement, from piezoelectric materials are superior to solar pavement.

Chapter 3

Problem statement

Piezoelectric materials are not 100% efficient, which means that some energy will be lost during the energy conversion process. It is important to optimize the design of the system to maximize energy conversion efficiency. Integrating a piezoelectric system into an existing EV design can be challenging. Piezoelectric materials can be expensive, which could make the system prohibitively expensive for some applications. Finding cost-effective solutions will be critical to the success of this technology. The piezoelectric materials used in the system need to be durable enough to withstand the rigors of everyday driving, including the forces and vibrations generated by the wheels. Piezoelectric technology is a promising solution for harvesting energy from the movement of vehicles, particularly electric vehicles (EVs). In an EV, the rotation of the wheels generates kinetic energy that can be captured and converted into electricity using piezoelectric materials. This technology could potentially increase the range and efficiency of EVs. A challenge of piezoelectricity is that while they are efficient at optimal resonance, only a slight variation away from the optimal resonant frequency causes a significant reduction in energy generation - the bell curve is very steep. Piezoelectric roads use crystals embedded in asphalt to convert pressure and vibrations into energy. The crystals, placed about 5 cm below the surface of the asphalt, slightly deform when traffic travels across them. This produces energy.

Chapater 4
FESABILITY STUDY

4.1 EXITING METHOD :

There are currently no widely implemented methods for using a piezoelectric wheel in an EV. However, there have been several research studies and experimental projects exploring the potential of this technology. One approach involves embedding piezoelectric materials in the tire treads of the wheels to generate electricity from the deformation of the tire as it contacts the road. This concept has been explored in a few research studies, and some prototypes have been developed. For example, in 2016, researchers at the University of Wisconsin-Madison developed a prototype tire that included piezoelectric materials in the tread. The tire was able to generate enough electricity to power a small wireless sensor.

Another approach involves using piezoelectric materials to convert the vibration of the vehicle's suspension system into electricity. This concept has been explored in a few experimental projects, including a project by researchers at Stony Brook University in 2015. The project involved developing a piezoelectric energy harvester that could be mounted on the suspension of an EV to generate electricity from the vehicle's motion. While these experimental projects show promise, they are still in the early stages of development, and there are several technical and practical challenges that would need to be addressed before piezoelectric wheels could be implemented on a commercial scale. These challenges include improving the efficiency and durability of the piezoelectric materials, developing new manufacturing processes for the wheels, and integrating the system into the existing powertrain of an EV.

4.2 PROPOSED METHOD :

One proposed method for a piezoelectric wheel in an EV involves embedding piezoelectric materials in the tire treads and using the deformation of the tire as it contacts the road to generate electricity. This approach would involve developing specialized tires with piezoelectric materials integrated into the rubber. As the tire rolls over the road, the deformation of the piezoelectric material would generate an electrical charge, which could be used to power the vehicle's electronics or charge the battery. Another proposed method involves using piezoelectric materials to convert the vibration of the vehicle's suspension system into electricity. In this approach, the piezoelectric materials would be mounted on the suspension system of the vehicle, and as the vehicle moves over bumps and uneven surfaces, the vibration would generate electricity. Another possibility is to embed piezoelectric materials in the wheel rim, which could generate electricity as the wheel rotates. However, this approach would require significant modifications to the design and manufacturing of the wheel. Regardless of the approach, one of the key challenges in developing a piezoelectric wheel for an EV is improving the efficiency and durability of the piezoelectric materials, which must withstand repeated stress and vibration. Additionally, the amount of electricity generated by piezoelectric materials is relatively small, so it may not be enough to power the entire vehicle. Therefore, piezoelectric wheels may be more practical as a supplementary source of energy rather than a primary power source. they have been explored as a potential means of harvesting energy in electric vehicles. One application of piezoelectric materials is to use them to convert the vibrations produced by the rotation of the wheels in an electric vehicle into electrical energy that can be stored and used to power the vehicle's electronics or even charge its battery.

CHAPTER 5
CIRCUIT DIAGRAM

A piezoelectric wheel circuit typically consists of a piezoelectric material that is integrated into a wheel or a tire. As the wheel rotates or moves, the piezoelectric material generates an electrical charge due to the mechanical stress placed on it.This electrical charge can be harnessed and used to power various applications, such as sensors or wireless transmission modules. The circuit used to extract power from a piezoelectric wheel typically includes the following components.The piezoelectric material used in the wheel generates the electrical charge due to the mechanical stress placed on it.The charge amplifier is used to amplify the small electrical charge generated by the piezoelectric material. The rectifier converts the AC output of the charge amplifier into a DC output that can be used to power various applications.: The voltage regulator is used to regulate the DC output of the rectifier to a constant voltage level. The load is the application that is powered by the electrical energy generated by the piezoelectric wheel.The piezoelectric wheel circuit can be designed to operate at various frequencies and with different piezoelectric materials depending on the specific application requirements. Additionally, the circuit can be integrated with other components, such as a microcontroller, to enable more advanced functionality. It is essential to choose investment projects that are well adapted to the frames that investment offers. Public policies that encourage investment are essential for the growth of countries, especially when it comes to the transparency of implementation processes, as well as from the support of banking institutions through financing projects with long-term return. A similar project was also installed in -Krommenie and Wormerveer, Amsterdam [31]. With such literature comparison, it is demonstrated that power generation in pavement.

GILLU DIAGRAM

CHAPTER 6

RESULT AND DISSCUSSION

The use of piezoelectric wheels in energy harvesting applications has shown promising results and has been explored in various research and practical applications. Here are some potential results and discussions related to piezoelectric wheels.Energy Harvesting Efficiency: The efficiency of energy harvesting from piezoelectric wheels depends on various factors, including the type and quality of the piezoelectric material used, the design and dimensions of the wheel, the rotational speed, and the load connected to the circuit. Research studies have shown that piezoelectric wheels can achieve energy harvesting efficiencies ranging from a few percent to over 30%, depending on these factors. The efficiency can be improved through careful design and optimization of the wheel, circuitry, and load. In conclusion, piezoelectric wheels offer the potential for energy harvesting from rotational motion, providing a renewable and sustainable source of electrical power for low-power electronic devices. However, careful consideration of design, optimization, load compatibility, and limitations is necessary for successful implementation in practical applications. Further research and development in piezoelectric wheel technology may unlock new opportunities for energy harvesting and self-powered systems in the future.

CHAPATER 7

CONCULSION

In conclusion, piezoelectric wheels offer the potential for energy harvesting from rotational motion, providing a renewable and sustainable source of electrical power for low-power electronic devices. However, careful consideration of design, optimization, load compatibility, and limitations is necessary for successful implementation in practical applications. Further research and development in piezoelectric wheel technology may unlock new opportunities for energy harvesting and self-powered systems in the future.Piezoelectric wheels are a promising technology for generating energy from the movement of vehicles on roads. The piezoelectric material used in the wheels generates electricity when subjected to mechanical stress, which is produced as the wheels roll over bumps and irregularities on the road surface. The generated electricity can be used to power various devices, including streetlights, traffic signals, and electric vehicles.

CHAPATER 8

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