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Design of Piezoelectric Car

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ABSTRACT

I have the developed of the project design piezoelectric car by using CREO software. The growth in power consumption of portable electronic gadgets and the idea of harvesting renewable energy in human surrounding arouses a renewed hobby. This technical paper specializes in one such advanced approach of power harvesting the use of piezoelectric car. Piezoelectric substances can be used as mechanisms to switch mechanical energy, normally ambient vibration, into electrical energy that may be stored and used to power other gadgets. A piezoelectric substance is one that produces an electric powered feed while a mechanical stress is carried out. Conversely, a mechanical deformation is produced whilst an electric powered field is carried out. Piezo-film can generate enough electrical density that can be stored in a rechargeable battery for later use. Cleaner, more sustainable forms of electrical power are needed in order to keep costs lower, to maintain positive and productive relationships with neighbours and to insure a healthier environment for future generations. The use of piezoelectric devices installed in terminals will enable the capturing of kinetic energy from foot traffic. Electrical energy can also be generated from traffic vibrations (vibrations in the road surface) using piezoelectric material.

Keywords: piezoelectric car, CREO software, substance, vibration, piezo-film, electrical energy.

I. INTRODUCTION

PIEZOELECTRIC AUTOMOTIVE DEVICES

As now a day's automobiles comprise more and more sophisticated driving aids and sensing generation era, industrial piezoelectric additives have become more and more crucial to producers. In reality, automotive era is currently the second-biggest market for piezoelectric ceramic merchandise. APC International is proud to help the automotive enterprise broaden smarter and more secure vehicles with implemented piezoelectric automotive sensor generation. We provide a number of answers for producers and subcontractors, from piezoelectric powders to finish sensor assemblies. Contact our team at once to discover what we will do for you.

Consider the two types:

Direct: Directly applied piezoelectric materials are those that are incorporated into a vehicle for a variety of functions. These can be actuators, injectors and sensors controlling, adjusting and sensing a wide range of systems. Our piezoelectric materials are used to manufacture the equipment that goes into your vehicle, and they allow for precise, reliable control with repeatability and accuracy after billions of cycles. This is a huge advantage for automotive applications, especially in systems related to fuel economy, performance and safety, where failure could lead to major problems.

Indirect: Indirect uses of piezoelectric materials in the automotive industry include machines and robots that are used to design, manufacture and test vehicles. The high accuracy and precision of our piezoelectric materials that go into a wide range of transducers, sensors and actuators makes them perfect for indirect automotive applications. From the equipment that's used to aim the headlights to the precise positioning of a robotic arm for the installation of components, piezoelectric technology has an important role to play in the automotive industry.

1.3 PIEZO CAR ACTUATORS

Piezo auto actuators play a large role in a number of different vehicle components. An actuator converts an electrical signal into a precise physical movement called a stroke. This stroke can finely adjust lenses, mirrors and other components, and it can act as a small volume pump or trigger a hydraulic valve. You'll find piezoelectric car actuators in any application where simplicity and reliability are required; piezo actuators are maintenance-free and can be operated billions of times without incurring wear or deterioration. APC International manufactures a variety of actuators used in automobiles.

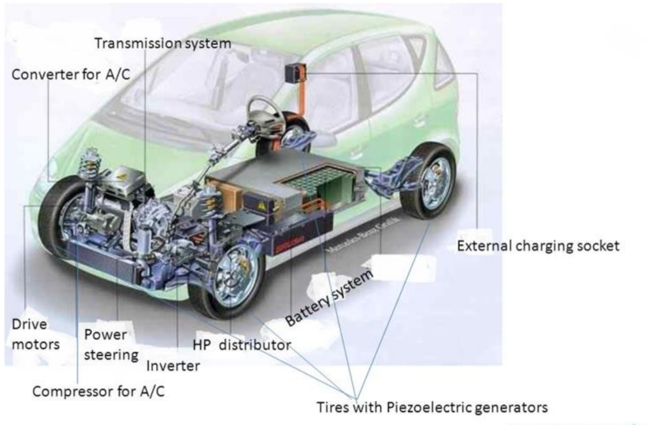


Figure – 1.1 Block diagram of piezo car

II. POWER GENERATION

Today's electric vehicles use batteries to supply energy to make the vehicle move. The problem is that the batteries have limited power, which means that battery powered vehicles can only be used for short trips. However, hybrids include an internal combustion engine that uses conventional fuels, which recharge the batteries extending the vehicle's range. This approach challenges the purpose of having an electrical vehicle, which would reduce environmental impact using renewable energy. There is still a need to generate more clean power that allows the maximum range of a vehicle to be extended with minimal environmental concerns.To do this, a piezoelectric array is mounted in one or more tires of the vehicle. As the vehicle drives down the road, the tire is flexed during each revolution to distort the piezoelectric elements and generate electricity. An electric circuit delivers the energy to the electrical system of the vehicle.

The piezoelectric effect occurs when the charge balance within a material's crystal matrix is disturbed. When there is no applied stress on the material, the positive and negative charges are evenly distributed so there is no potential difference. When the lattice is changed slightly, the charge imbalance creates a difference. This current is extremely small and would only cause a small electric shock. A piezoelectric array is mounted inside a pneumatic tire of a motor vehicle and flexed or distorted during each revolution of the tire. The outputs of the piezoelectric devices are connected to an electric circuit to transfer the high voltage, low amperage electricity produced by the piezoelectric devices into low voltage, high amperage electricity that is compatible with the electrical system of motor vehicles.

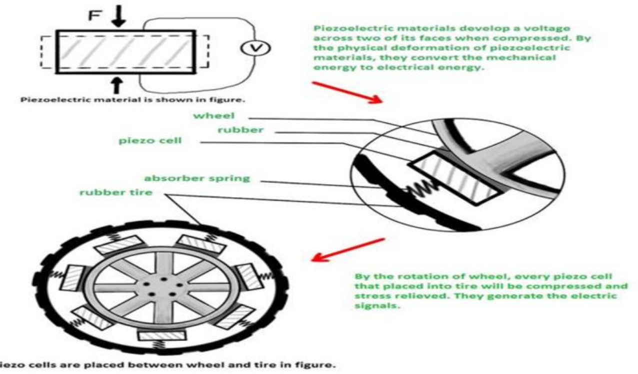


Figure – 1.2 Power creators

Piezoelectric materials can convert mechanical energy to electrical energy, and vice versa. To accomplish this, piezoelectric units are bonded to the inner liners of tires. As the wheels rotate, the tires repeatedly distort and slacken as they interact with the road. This causes the piezoelectric units to produce a periodic voltage with a speed-dependent frequency. The energy that is generated can be used as auxiliary power to prolong the life of batteries.

A tire maintains its circular shape when not moving. Movement of the vehicle causes a section of the tire to conform to the shape of the road—it flattens out. The sidewall just above the contact area also undergoes deformation by bulging out. As the vehicle moves, a new area of the tire continually deforms and relaxes in a cyclic pattern whose frequency is dependent upon the speed of the vehicle. The piezoelectric bender elements would deform and relax with the tire. This deformation allows for the collection of energy.

To send energy to the battery, engineers could use a connection running from the tire to the hub and on to the battery. Or they could transfer energy with an induction current. Power is obtained from the tire/wheel system using an assembly that constantly maintains the electrical contact between the chassis and the wheel while letting the wheel spin freely. Such a setup allows the extraction of tire-generated power to run the onboard electronics.

These sensors would need some special characteristics, such as being able to operate on miniscule pulses of power, and the ability to be powered by the motion and pressure of the tires and the vehicle's interaction with the road.The amount of pressure that we are dealing with is only transitory, since the vehicle is a moving object. The piezoelectric energy harvesting will need to be done just under the tread. A crystalline layer sandwiched between two different tread layers would serve the purpose.

III. PIEZOELECTRIC PRESSURE SENSORS, PIEZO LEVEL SENSORS & AIR TRANSDUCERS

Ultrasonic sensors are another important piezoelectric automotive product used in several different applications. Sensors respond to pressure, acceleration or other input by producing an electrical signal. This signal can be used to relay vital information to a vehicle's computer about a range of different factors. Examples include piezoelectric tire pressure sensors, engine knock sensors, backup sensors, dynamic pressure sensors, and many of the other important safety features found on most of today's vehicles. APC International offers complete turnkey solutions for the design and production of custom piezoelectric pressure sensors in our Pennsylvania facility. Custom orders are built to exacting tolerances and rigorously tested to ensure the highest level of quality.

What's Next for the Automotive Industry?

As the push continues for further improvements in terms of fuel economy, safety and connectivity, the demand for piezoelectric materials and components for the automotive industry will only continue to grow. We see focus within the industry in these major areas:

Fuel Economy: Increasing fuel economy can be accomplished in many ways. Lighter vehicles with more compact sensors and equipment can help increase fuel mileage. More accurate monitoring of speeds, fuel rates and operating parameters and real-time adjustments can all be made possible with continued improvements of our piezoelectric materials.

Safety: Increasing automotive safety comes down to creating more reliable and faster-acting controls for braking, crash avoidance and safety devices, like airbags. The ever-increasing reliability and repeatability of piezoelectric materials means they will continue to push automotive safety in the future and allow for further advances.

Connectivity: Automotive connectivity is giving drivers a new way to experience their cars. Piezoelectric sensors and actuators are a key component in proximity sensors and automated driving features. As automakers move towards fully autonomous vehicles, our piezoelectric materials will continue to prove their importance.

IV. THEORY OF CREO INTRODUCTION

Creo is a family or suite of Computer-aided design (CAD) apps supporting product design for discrete manufacturers and is developed by PTC. The suite consists of apps, each delivering a distinct set of capabilities for a user role within product development. Creo runs on Microsoft Windows and provides apps for 3D CAD parametric feature solid modeling, 3D direct modeling, 2D orthographic views, Finite Element Analysis and simulation, schematic design, technical illustrations, and viewing and visualization. Creo Elements and Creo Parametric compete directly with CATIA, Siemens NX/Solid edge, and SolidWorks. The Creo suites of apps replace and supersede PTC's products formerly known as Pro/ENGINEER, Co Create, and Product View.

PTC began developing Creo in 2009, and announced it using the code name Project Lightning at Planet PTC Live, in Las Vegas, in June 2010. In October 2010, PTC unveiled the product name for Project Lightning to be Creo.PTC released Creo 1.0 in June 2011. Creo apps are available in English, German, Russian, French, Italian, Spanish, Japanese, Korean, Chinese Simplified, and Chinese Traditional. The extent of localization varies from full translation of the product (including Help) to user interface only. Creo is part of a broader product development system developed by PTC. It connects to PTC's other solutions that aid product development, including Windchill for Product Lifecycle Management (PLM), Mathcad for engineering calculations and Arbortext for enterprise publishing software.

Get up to speed quickly on Creo Parametric with five real-world tutorials. This series of exercises will take you through parts and assembly modeling, motion analysis and creating drawings. Start today and see how easy it is to get started designing with Creo Parametric.

Release history

Table – 3.1 Release history

Version	Release date
Creo 1.0	6 January 2011
Creo 2.0	27 March 2012
Creo 3.0	17 March 2014
Creo 4.0	15 December 2016
Creo 5.0	19 March 2018
Creo 6.0	19 March 2019
Creo 7.0	14 April 2020

WHAT IS CREO

Creo, the shorthand name for Creo Parametric, (formerly known as Pro Engineer) is a powerful and intuitive 3D CAD software optimized to address the challenges organizations face as they design, analyze, and share information with downstream partners. Developed by PTC, the original pioneers of parametric CAD, Creo is powerful foundational software supporting an integrated family of product design tools used by thousands of manufacturers worldwide.

Creo Parametric 3D CAD software can easily be customized and extended through the addition of modules and extensions, but the product family also contains stand-alone purpose build design applications such as Creo Simulate, Creo Direct, Creo Layout & Creo Options Modeler. Each stand-alone app serves a different purpose in the product development process. From concept to design to analysis, to effectively sharing your information with downstream partners (such as manufacturing and technical publications), Creo is a rock-solid foundation for any design group. It supports the needs of modern manufacturing and product development organizations.

The way Creo works is that it is made up of individual apps, including:

- Creo Parametric
- Creo Simulate
- Creo Direct
- Creo Layout
- Creo Options Modeler

Each Creo app serves a different purpose in the product development process. This means that Creo takes you through every stage, including concept design work, design and analysis. Then it also enables you to communicate effectively with downstream partners, for instance manufacturing and technical publications.

Combined benefits of both parametric and direct modeling

PTC Creo integrates the power of both 3D CAD modeling approaches into a single system, so you get the power and control of parametric modeling combined with the speed and flexibility that's only available through direct modeling.

SIMULATION

PTC's simulation software is designed uniquely for the engineer, complete with the common Creo user interface, engineering terminology, and seamless integration between CAD and CAE data, allowing for a more streamlined process. Best of all, the results are accurate and reliable and can be easily calculated with very little input from non-simulation experts.

STEPS IN FOLLOW CREO PARAMETRIC

When you work with Creo Simulate, your goal is to create a simulation model that reflects both the physical nature and the real world environment of a part or assembly, analyze the model, and evaluate the results of the analysis. To help you complete these tasks efficiently, Creo Simulate provides a tool—Process Guide—that leads you through each step in the simulation process. Process Guide is available for 3D Structure modeling in both native mode and FEM mode. You can use Process Guide for both parts and assemblies.

Process Guide also provides the user interface to Creo Simulate Lite, the free limited functionality version of Creo Simulate. In its simplest form, it leads you through the process and workflow and prompts you to complete the following steps involved in successfully creating and analyzing a basic simulation model:

- Modeling phase—Guides you through assigning materials, defining constraints, and assigning loads.
- Analysis phase—Lets you create structural analyses for your model.
- Results phase—Opens the Results user interface so you can define results windows and review the analysis results you are interested in.

For complex applications, expert users can enhance the Process Guide by creating unique templates that capture a specific series of modeling and analysis activities and instruct users in how to perform those activities to a given standard

- ✓ Click Tools > Run Session.
- ✓ Set the simulation_process_prompt configuration option to automatically invoke Process Guide whenever you enter Creo Simulate.
- ✓ Start Creo Simulate in Creo Simulate Lite mode.

ADVANTAGES OF CREO PARAMETRIC

The release of Creo Parametric is imminent. You may be watching closely, ready to buy and install it, or you might be wondering whether it is right software for you. To try and help you make your decision, we've rounded up 7 advantages of the upgrade.

Optimised For Model-Based Enterprises

Creo has many added features to help more manufacturing businesses transition into model-based enterprises. There is a greater focus on authoring features such as ASME and ISO standard support, and the calculation of enterprise consumption with the STEP AP 242 and JT Creo View Printing features.

Increased Engineer Productivity

Several features are now optimised to increase the productivity of users. Geometry based selection, a new mini toolbar and WSYIWIG customisation will all help users design faster. In addition, with advanced rendering, users no longer have to wait a long time for images to be produced or have to work with poor quality renders

Increased Engineering Capabilities

The update has a whole new set of capabilities for engineers. Users can model sheet metal directly, build accurate solid weld geometry in both parts and assemblies and reuse components through the intelligent mirror tool. New capabilities also allow for greater 3D design ability; engineer

Design Capabilities For Additive Manufacturing

The ability to model both 2.5D and 3D structures as well as analyse and optimise them along with increased design capabilities for 3D printing, users have much more additive manufacturing capability. Tools also allow for lattice thicknesses to be varied for the improvement of strength in any specific region of a model

LIMITATIONS OF CREO

GD&T Advisor is an application to be used in conjunction with Creo to correctly define the dimensioning and tolerancing on a part. Intelligent GD&T filtering has been developed to guide and advise the user based on the selected tolerancing standard (ASME Y14.5-2009 or ISO 1101:2012).

By understanding the limitations of the application, you can avoid trying to make it do things that it is not designed to support. However, it is important to understand that GD&T Advisor is a tool that is used to make GD&T annotation creation in Creo fast, easy, and correct (per the selected tolerancing standard). For some parts, you may be able to use GD&T Advisor to create most, but not all, of the necessary annotations. The remaining annotations can often be created using native Creo functionality.

- **Assembly-Level Geometric Tolerances**

  GD&T Advisor works only with individual parts. It does not support dimensioning and tolerancing of assemblies.

- **Associating to CAD Dimensions**

  GD&T Advisor helps you properly define GD&T and associate dimensions for each part feature, and then automatically creates native Creo annotations. GD&T Advisor provides tools for visualizing the completeness of the dimensioning and tolerancing. It also evaluates the conformance with the rules of the selected tolerancing standard and best practices, providing feedback in the form of informational, warning, and error messages.

  In all cases, dimensions must be created in Creo. In some cases, those dimensions can be associated with the GD&T Advisor features, in which case they will be considered in the visualization and evaluation of the scheme. In other cases, such as offset angular dimensions, they cannot be associated with the GD&T Advisor feature but can still be shown as part of the completed dimensioning scheme.

- **Size Dimensions**

  All size dimensions must be defined in the CAD model (either as parametric or annotation dimensions). GD&T Advisor supports the ability to associate the size dimensions of a feature to the related feature of size. In some cases, the size dimensions are inherent to the feature (e.g., hole, tapered slab, etc.). However, there may also be a size dimension between opposing elements on separate features. The table below shows the possible combinations of features for defining a size dimension. The values in each cell in the table indicate whether GD&T Advisor supports applying a size dimension between that pair of features.

V. METHODOLOGY

The feature-based parametric modelling technique enables the designer to incorporate the original design intent into the construction of the model. The word parametric means the geometric definitions of the design, such as dimensions, can be varied at any time in the design process. Parametric modelling is accomplished by identifying and creating the key features of the design with the aid of computer software. The design variables, described in the sketches and features, can be used to quickly modify/update the design.

OBJECTIVE

- Create Simple Extruded Solid Models.
- Understand the Basic Parametric Modeling Process.
- Create 2-D Sketches.
- Understand the "Shape before Size" approach.
- Create and Modify Parametric Dimensions.

In Creo Parametric, the parametric part modeling process involves the following steps:

1. Set up Units and Basic Datum Geometry.
2. Determine the type of the base feature, the first solid feature, of the design.
   Note that Extrude, Revolve, or Sweep operations are the most common types of base features.
3. Create a rough two-dimensional sketch of the basic shape of the base feature of the design.
4. Apply/modify constraints and dimensions to the two-dimensional sketch.
5. Transform the two-dimensional parametric sketch into a 3D feature.
6. Add additional parametric features by identifying feature relations and complete the design.
7. Perform analyses/simulations, such as finite element analysis (FEA) or cutter path generation (CNC), on the computer model and refine the design as needed.
8. Document the design by creating the desired 2D/3D drawings.

DESIGN OF SELF-CHARGING POWER CELLS

The typically think of energy generation and energy storage as two different processes requiring two separate devices, but recent advances have revealed that we can, in fact, do both with just one device. Research into self-charging power cells and batteries continues to accelerate as the cells become more efficient and the power consumption demands of electronics decrease.

These self-charging power cells works by converting mechanical energy, the energy related to an object’s motion and position, into chemical energy. The technologies can release the converted energy as an electric current that can power other devices..

WHAT IS ENERGY HARVESTING?

Critical to self-charging power cell technology is the concept of energy harvesting, which is the collection of “free” energy that a process generated.

We can also harvest energy from environmental sources, such as the sun and the wind. Smaller scale examples include heat from furnaces and mechanical energy created by walking or driving. Much of the work with energy harvesting has so far been done with smaller scale applications, such as batteries for small devices. When you use your smartphone, for instance, some of the energy gets wasted in the form of heat.

THE ROLE OF PIEZOELECTRIC THEORY IN ENERGY HARVESTING

Piezoelectric power has been used in a variety of prototypes, proof-of-concept projects and small-scale applications related to energy harvesting. This technology is still young, but it offers some exciting prospects for the future. How, though, do these materials generate energy?

The inverse of this effect is also true. When the crystals come into contact with an electric field, they lengthen or shorten according to the field's strength and polarity. The piezoelectric effect creates generator actions, while its inverse creates motor actions. The piezoelectric effect transforms mechanical energy to electrical and can be used in solid-state batteries, fuel-igniting devices, force-sensing devices and other applications. The inverse piezoelectric effect changes electrical energy to mechanical energy and can be used in piezoelectric motors, sound or ultrasound generating devices and other instruments.

The voltages and forces of the piezoelectric effect are relatively small, but they can still be used for a wide range of applications, such as displacement sensing, actuation applications in motors that require precise positioning control and producing sonic signals. Most piezoelectric devices designed for energy harvesting use two layers of piezoelectric material attached to a non-piezoelectric layer, known as a bimorph, with a cantilever geometry architecture. Some also use a unimorph, which consists of just one layer, although this produces half as much energy with a relatively small decrease in volume.Sometimes, off-resonance energy harvesters might be used as an alternative architecture for energy harvesters.

- Macro- and mesoscale
- MEMS scale
- Nanoscale

DESIGN OF POWER CELL ON CREO

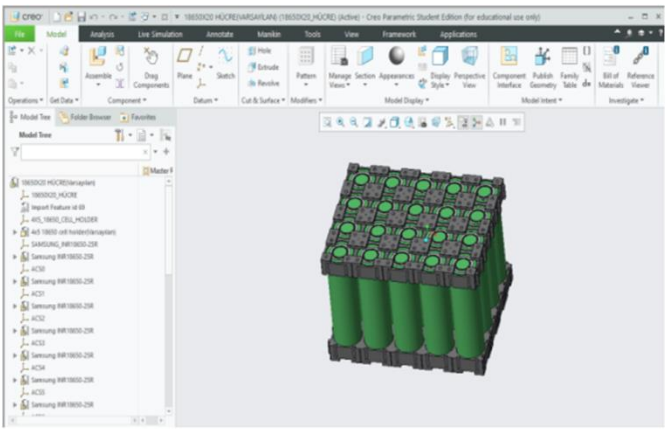


Figure – 5.1 Power cell in piezoelectric car

THE ROLE OF PIEZOELECTRIC MATERIALS IN ENERGY HARVESTING

Metal oxide-based piezoelectric ceramics are human-made materials that allow the piezoelectric effect to be applied to many different applications. We can adjust the shape, dimensions and composition of these materials to better fit the needs of individual projects.

A conventional piezoelectric ceramic is a group of perovskite ceramic crystals that consists of a small tetravalent metal ion, typically zirconium or titanium, within a lattice of larger divalent metal ions, typically barium or lead, and O2 ions.

PZT, or lead zirconate titanate, is currently one of the most commonly used piezoelectric ceramic elements. We offer five proprietary piezo materials — APC 880, APC 855, APC 850, APC 841 and APC 840.

HOW DO PIEZOELECTRIC SELF-CHARGING BATTERIES COMPARE TO CURRENT LITHIUM-ION BATTERIES?

The voltage provided by both lithium-ion batteries and self-charging piezoelectric batteries can vary from cell to cell, but lithium ions provide a stronger current than today's piezoelectric designs across the board. A typically nominal cell voltage for a lithium-ion battery might be around 3.6 volts. The piezoelectric self-charging battery is still a young technology, meaning they will likely become more efficient in the future.

WHAT IS THE FUTURE FOR PIEZOELECTRIC SELF-CHARGING POWER CELLS?

The future of the self-charging piezoelectric battery is promising. We will continue to see advancements in performance and efficiency as well as the introduction of new applications.

The Georgia Institute of Technology researchers have predicted that they can improve their cell's performance with several modifications, including using a more flexible casing so that the piezoelectric material can expand further. Other self-charging technologies will also likely both emerge and continue to improve, and combining them with piezoelectric substances could yield useful results

PIEZOELECTRIC SYSTEMS & SOLUTIONS

At APC international, we supply piezo products and services required for energy harvesting applications as well as for many other uses. As mentioned earlier, we suggest our APC 850 PZT element for use in energy harvesting.

Energy collection isn't the only thing our customers use our piezo products for. In fact, it's a relatively rare application because the technology is so new. We offer a wide variety of piezo elements, products and services including piezo discs, rings, plates and cylinders, stack actuators, amplifiers, igniters and much more. We also offer custom piezoelectric solutions and information resources such as our over-100-page textbook on the principles and applications of piezoelectric ceram

DESIGN OF PIEZOELECTRIC CAR

With the increase in the concern for the alarming depletion of fossil fuel reserves and its adverse effects on the surrounding environment, the alternative non-conventional sources of energy have gained popularity in the society. Starting from the well-known solar cells to the wind turbines, hydroelectric power generation, biodiesel and biogas plants have already being successfully proven and implemented for the same. For power supply needs of the portable gadgets the human use, new ways have been found out to cater the need. Piezoelectric materials and the effect itself have played a major role in solving such problems. Energy harvested from the vibrations is one of the easiest and omni-usable techniques. These vibrations can be from human motion, vehicular motion, machines and any other surface under vibrations. The conversion of mechanical energy into electrical energy can be done by the use of piezoelectric materials. Some of the natural piezoelectric materials already in use is quartz. Some artificial piezoelectric materials like BaTiO3, Lead Zirconium Titanate etc. find their applications in modern electronic circuits.

Vehicle tires are subjected to normal and shear loads under static and dynamic conditions. The load can be used as a source of mechanical stress for the piezoelectric crystals. The piezoelectric crystals can thus be aligned along the inner lining of the tire where the air pressure does the work. In this paper, different applications of piezoelectric energy harvesting are being illustrated and an attempt has been made to conceptualise a new way of application of the same and certain calculations has been made to visualise the probable energy output from the system.

VI. AREAS OF IMPLEMENTATIONS

Piezoelectric materials have found their place in the energy harvesting sector for harnessing power ranging from nanowatts to some watts i.e. from micro-scale to macroscale energy production. There have been some implementations over the globe based on this concept. Piezoelectric floors concept utilises the footfall energy of the human population in generating electrical energy and catering the power needs.

Piezoelectric materials include quartz, BaTiO3, Lead ZirchoniumTitanate (PZTs) etc. Out of these quartz gives highest electrical output voltage w.r.t the mechanical stress applied but it is economically not feasible due to its high cost. The next is PZT which are readily available at low cost and gives impressible results. It can be seen that PZT-5H has highest d31 and d33 values then, PZT-5A and PZT-4. Also, it can be seen that the strain constants of PZT-5A and PZT-4 are consistent over different temperatures. The availability and cost of the PZT-5A is more feasible than the other PZT materials. Therefore, PZT-5A material was chosen. The module chosen is of diameter 28mm and thickness 2mm.

The piezoelectric effect is a reversible process in that materials exhibiting the direct piezoelectric effect (the internal generation of electrical charge resulting from an applied mechanical force). Also exhibit the reverse piezoelectric effect (the internal generation of a mechanical strain resulting from an applied electrical field). For example, lead zirconate titanate crystals will generate measurable piezoelectricity when their static structure is deformed by about 0.1% of the original dimension. Conversely, those same crystals will change about 0.1% of their static dimension when an external electric field is applied to the material.

VII. ANALYSIS

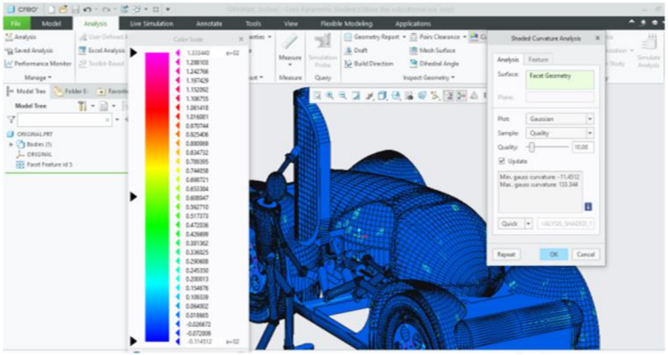


Figure – 6.3 (a) Curvature

VIII. RESULT

OVER VIEWS OF RESULTS

The rotary system with an active magnetic bearing, as shown in Figure, was investigated to obtain its dynamic behaviour with the developed measuring system. This system enabled the continuous measurement of the magnetic bearing operational parameters, such as rotating shaft strains, rotor displacements, and vibrations. During studies, strain measurements with full bridge and Quarter Bridge were registered by a wireless data acquisition (DAQ) system. The sensors were located in two cross-sections of the magnetically suspended shaft, that is, one in the middle (Node 955) and the second near the magnetic bearing (Node 954). In a classical bearing system, a full-bridge configuration allows the measurement of torsion strain, but in the magnetic bearing system, this component is absent.

Strain measurements were conducted for both cross-sections simultaneously for constant parameters of the control system and disturbance signals acting on the Ox and Oy axes. These disturbances were generated by the control system. Strain time-domain signals were acquired using a 512 Hz sampling frequency, for approximately 20 seconds of stable rotational speed. For each rotational speed, three measuring series were made with no disturbance, disturbances added in the Ox axis, and disturbances added in the Oy axis. Fast Fourier transform (FFT) analysis was performed for time-domain signals and the frequency characteristics are presented below.

In Figures 7.1 and 7.2 fast Fourier transform (FFT) characteristics of the rotating shaft strain measured for a constant motor rotary speed equal to 25 rev/s for a quarter-bridge configuration at both shaft cross-sections, Nodes 954 and 955, are presented, respectively. These characteristics were registered without and with disturbance from the control system. In Table7.1, the list of significant values from the characteristics shown in Figures 7.1 and 7.2 is presented. Cells with peaks from the sampling frequency are marked in blue.

In Figures 7.3 and 7.4, fast Fourier transform (FFT) characteristics of the rotating shaft strain measured at the shaft front cross-section (Node 954) for a constant motor rotary speed equal to 30 rev/s for both full- and quarter-bridge configurations are presented, respectively. These characteristics were registered without and with disturbance from the control system. Significant values from obtained characteristics are presented in Table 7.2.

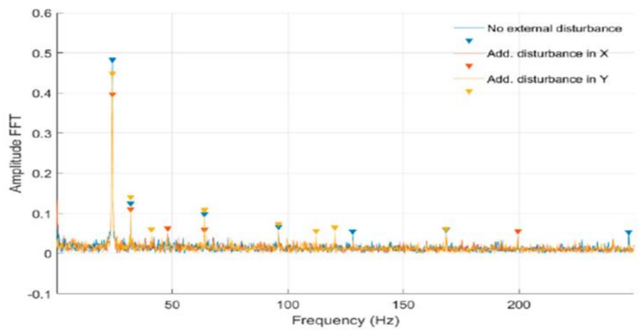
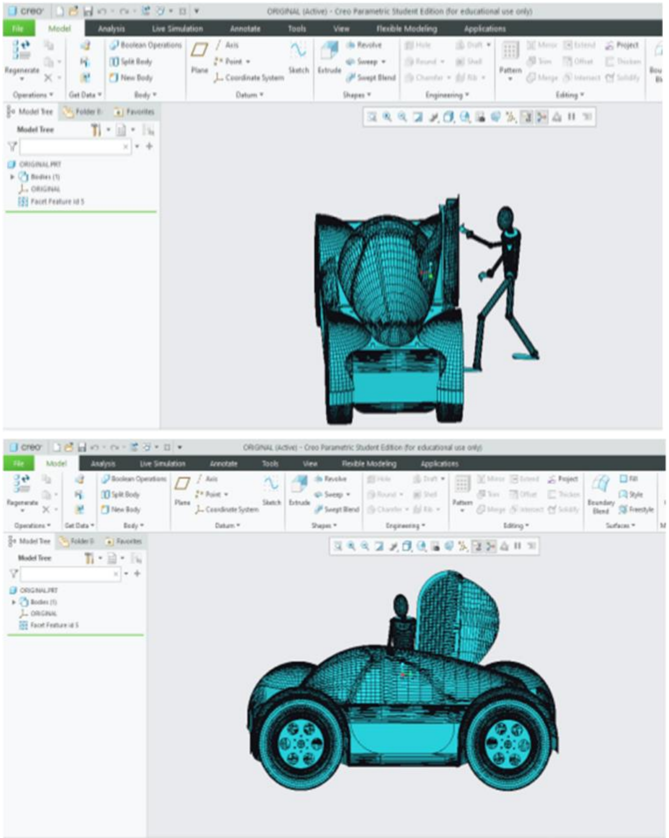


Figure – 7.1FFT of strain – level measurement for constant motor speed equal to 25 rev/s with disturbance from the control system for a quarter bridge configuration (Node 954)

PROTO TYPE MODELS OVER VIEW – PIEZOELECTRIC IMPLEMENTATION MODEL

View – 1



IX. CONCLUSION

It can be visible that the quantity of energy that can be stored from an hour of riding with the existing design of the gadget is sufficient for catering the electricity deliver desires of various digital circuits of the vehicle. Proper designing and experiments can lead to higher results. Although the performance of such systems is round 30-40 %, use of better high-quality PZT -5A materials can yield higher consequences. The calculations proven above are theoretical ones which accounts for most effective the direct load. Practically, the car tire additionally experiences shear loading that may make a contribution to the entire energy generated, contemplating the d31 and g31 constants of the material.

With the increase of recognition of non-conventional power sources the various researchers all around the global, the opportunities of energy harvesting through using piezoelectric materials paves its manner toward essential green era designs. E

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