PEDAL POWER GENERATOR

A dissertation

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EXAMINATION COMMITTEE

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ABSTRACT

Goal of this project is to design and administer the bicycle power generator to produce ample electricity to charge batteries. This project can supply reliable power to billions of people around the globe, who do not have electricity, especially in rural areas. This quarry can be achieved by fabricating a safe and sturdy human powered bicycle generator which can produce DC signal and can be hoard in batteries. Later on these batteries can be used to power up appliances in daily use. Bicycle power generator is not a new concept, many people had built it for small scale production in their house. We aim to expand the scope of this project and make it safer and efficient. If it is produced commercially, it is necessary that it should meet all the safety parameters.

ACKNOWLEDGMENT

Success and achievement is possible only through hard work, determination and strong will. We are grateful to Almighty Allah who gave us the strength to think, plan and act accordingly which made possible for us to complete our Final Year Project, "Pedal Power Generator" at National University of Sciences and Technology – NUST Islamabad. Though it is literally tradition to acknowledge the contribution and help by different people and department in the completion of the project, but as a matter of fact some words cannot express my gratitude to the various helping hands. It is very difficult to appreciate each and every person for his contribution, but there is a standing contribution of my supervisors; Assistant professor Mr. Muhammad Adnan Hanif and Assistant Professor Mr. Muhammad Usman Bhutta and Dr. Riaz Ahmad Mufti for their guidance. The technical and practical knowledge imparted by them to us will always help us in our life. Special thanks to Mr. Tajwar (student froms SEECS-NUST for helping us in understanding of arduino), Mr. Faizan Ahmad (ME-03 for helping us in ABAQUS Analysis) for their unconditional help toward the completion of this Project.

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CHAPTER 1

INTRODUCTION

Need of the project

The Earth as we know it today will no longer last the same, because the energy is devoured at a drastic Rate on this planet which is causing environmental issues, health issues and many others. These dangers are not because of the consumption of energy, but it is due to the methods through which energy is produced. The oil is mostly used fossil fuel to get the energy supply while the coal is used after that. The top producers of the oil, are Russia and Middle East, and based on their current producing capacity and worlds consuming capacity they will be hitting the bottom of the earth with no oil in the next decade. To make the situation worse than the already, the cost of oil is rising very rapidly due to the issues in the Middle East. Coal can be thought of an alternative of oil, but it is much dangerous for the environment. Because it produces the CO_2, solid, liquid, and hazard gaseous waste products. In 2007, the energy Information administration estimated that the primary sources of energy consists of petroleum 36%, coal 27.4%, and natural gas 23%, which are 86.4% of the total energy consumed. This sum of 86.4% is made up of fossil fuels [1].

Alternatives to fossil fuels

Seeing this much big figure of consumption of fossil fuels, the alternatives to the use of fossil fuels and non-renewable energy sources, should be found. Renew able energy technologies are preferred for the clean production of power and also due to their one time investment. In 2006 renewable energy technologies included, hydroelectric 6.3%, nuclear 8.5%, and others (like geothermal, solar, wind, tidal, biomass) amounting up to the 0.9% of the total production of electricity [2] [3]. According to the Renewable Energy Policy Network for the 21st Century (REN21), in 2014 they released a report mentioning

that 19% of our energy consumption needs were fulfilled by renewable sources in 2012. Similarly 22% of electricity generation was done using renewable energy technologies in 2013 [4].

In 2013, more than US$214 billion were invested in renewable energy technologies to produce clean and cheap power by the countries like China and United States. Power produced by the means of renewable technologies is much clean and cheap. It includes solar energy, hydro energy, wind energy, tidal energy, and energy from bio mass. The world had recognize the need of the renewable power generation and now they are investing in it. Power and energy engineers are developing the ways to produce clean and sustainable power to meet the current energy requirement and reduce the carbon and greenhouse gas emissions from fossil fuels.

In the attempt of doing, so power and energy engineers have developed some ways successfully. That makes sure that there is always ample energy when it is needed. There are a number of options to store the electricity but the most popular and technologically matured option is batteries. In batteries power can be stored either using solar panels or UPS. But, both technologies have their limitations. Solar panel is costly because the panel which generates electricity using sun rays is not a matured technology and costs most of the price. Also it provides power when the day is sunny. In cloudy or partially cloudy days the power produced by solar panel is less. So we have to find another way to store energy in the battery which is cheap and easily can be purchase. The main purpose of this study is to design and implement a product which can be used to charge batteries and then later on these batteries can be used to run the appliances. For this purpose a bicycle generator is considered as it is cost efficient and easy to use.

Bicycle Generator

This project is a good step towards bringing the green and reliable power to the billions of people of the world who do not have electricity at their disposal. To do so a safe and sturdy human powered stationary bicycle generator is built that will make DC energy. The DC power generated by pedaling can be then stored into battery and later on it can be

used to turn the appliances on. Power generation using a bicycle is not a new idea in itself, many hobbyist build such generators to produce power on small scale for residential usage. Here the idea is to expand and develop a bicycle generator that can produce DC power more efficiently and safely.

When bicycle is pedaled the alternator starts producing AC signal which is converted into DC power with the help of rectifier built in the alternator. Then this DC voltage can be stored into battery. This project will help those who do not have electricity in their area or they have frequent load shedding of electricity specially. It is man powered so there is no need of fuel and it will cost only installation cost.

From where the Electricity is supplied to the consumer is called a grid. This grid is usually administered by the government but in case of some developed countries grid are also administer privately. To run a grid, government must have enough financial resources and significant investment to provide electricity to the consumer.

It is reported that 80% of the world's population in third world countries do not have electricity. This is an estimated 1.5 billion people with no electricity. And according to the US Energy Administration's International Energy Outlook Report for 2010 they said that world energy consumption growth rate is 49%, or 1.4% per year [5].

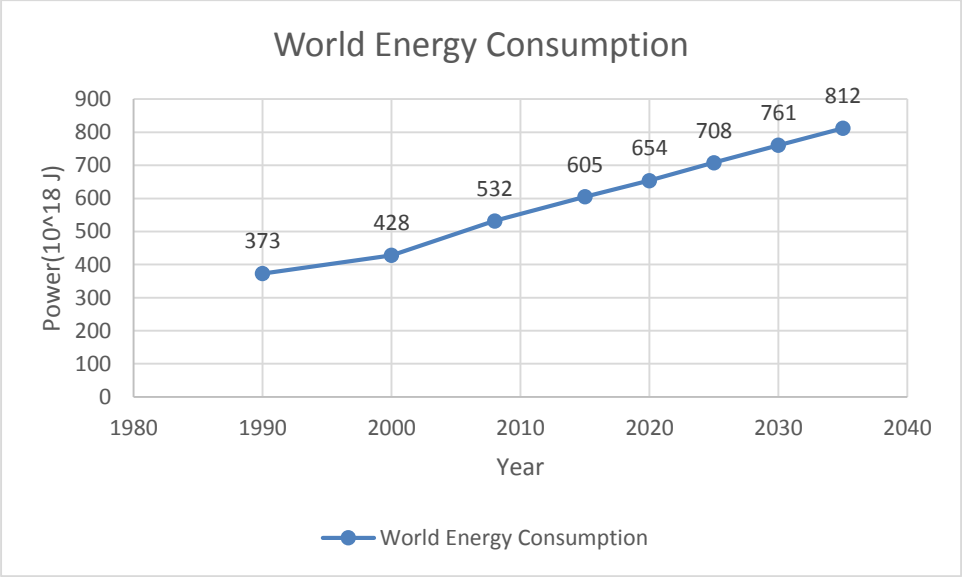

Figure 1: World Energy Consumption

CHAPTER 2

LITERATURE REVIEW

Human powered bicycle generator is not a new idea. Here are some glimpse in the past to the rotatory motion and its uses. In early 19th century human powered machines and tools were used and built. But ever since the electricity is produced from the fossil fuels the human powered machines and tools had become an obsolete technology. [6]

In late 19th century a most efficient mechanism to harvest human energy was harvested, it was pedaling. Stationary pedal powered machines and tools got their fame in 20th century but development in the production of electricity made these machines and tools obsolete.

In 1980 Carl Nowiszewski, a mechanical engineering student at MIT, worked out with professor David Gordon Wilson a design for a pedal powered generator, which when built would be used for auxiliary control functions in a sailboat in an Atlantic crossing. The energy storage was primarily for automatic steering while the pilot slept, and the pedaling was a way to keep warm and avoid boredom. [7]

Similarly pedal powered generators are being used for different purposes like to provide light to the farms in night, to charge your cell phones, laptops or to turn on your television etc.

It comprises the production of DC Voltage, storing it in batteries, converting it into AC form for direct utilization in domestic appliances.

CHAPTER 3

METHODOLOGY

Cost Estimate

The purpose of this project is to develop a product which can make electricity and this electricity will be available to every one, espacially in rural areas of Pakistan. To get the goal, different designs were studied. After doing the literature review, it was concluded that a bicycle will be more suitable than the exercise bike. After doing the market survey here are Prices of different components which team find and then made a temporary budget. Following table will show the figures

Table 1: Estimated Budget

Item	Price (PKR)
Bicycle	9000
Alternator	3000
Belts	1000
Supporting Stand	2000
Welding Rods	1200
Chain	500
Bolts	150
Welding cost	1000
Clips	250
Socket	500
Total	18,500

Note:

- There is price for two alternators in table because mostly there is a chance to burn the alternator.
- All of these prices are not actual to see maximum limit of our budget

Hardware Design and Methodology

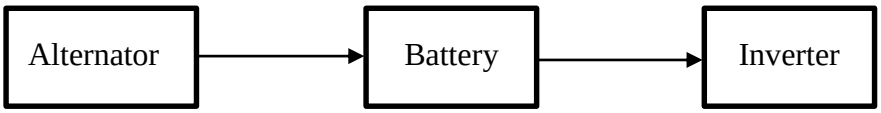

Figure 2: Hardware

- **12 V Alternator:** It gives 12 V DC voltages when driven at 1500 rpm
- **Battery:** It is a lead acid battery of 28 Ah rating
- **Inverter:** It is of square wave type of rating 150 VA with backup of 3 to 5 Hrs.

Alternator

Working Principle

Alternator works on the principle of Faraday's electromagnetic induction law, which says "If a conductor is placed inside a magnetic field, either the conductor or magnetic field is in motion then the current is induced in the conductor". To understand the Phrase consider the figure below [8]:

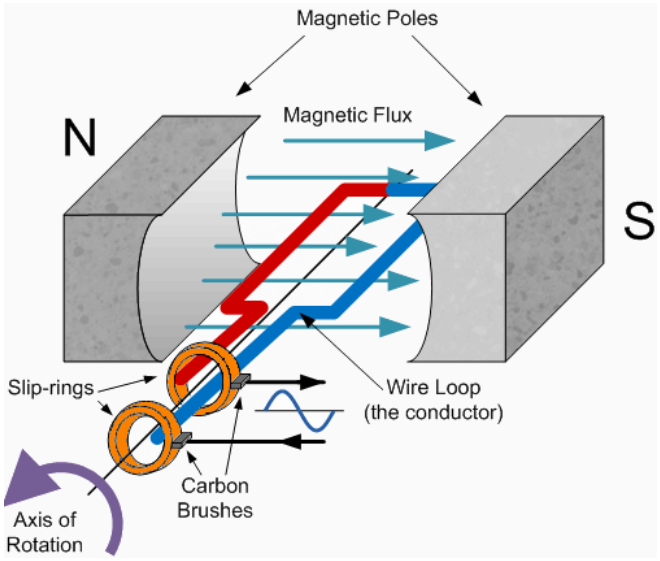

Figure 3: Faraday's Law

What an alternator is?

An alternator has no permanent magnet in it while a DC motor does. In an alternator there are wounded coils namely stator and rotor. Stator suggest that this coil is stationary and does not move white the rotor suggest that it is in motion and it rotates. Rotor is attached to the pulley of alternator. Rotor is also called field of the alternator. If current is passed through the rotor of an alternator then an electromagnet is created say for temporarily. The amount of current passed is proportional to the strength of the field through rotor. As the rotor moves, electricity is generated in the stator coil. Because rotor is moving it cause a sweeping magnetic field through the stator coil, this results in alternating current. The frequency of thus produced alternating current is equal to the no of rotation of revolution at which pulley of alternator is rotating. There are some main components of an alternator namely

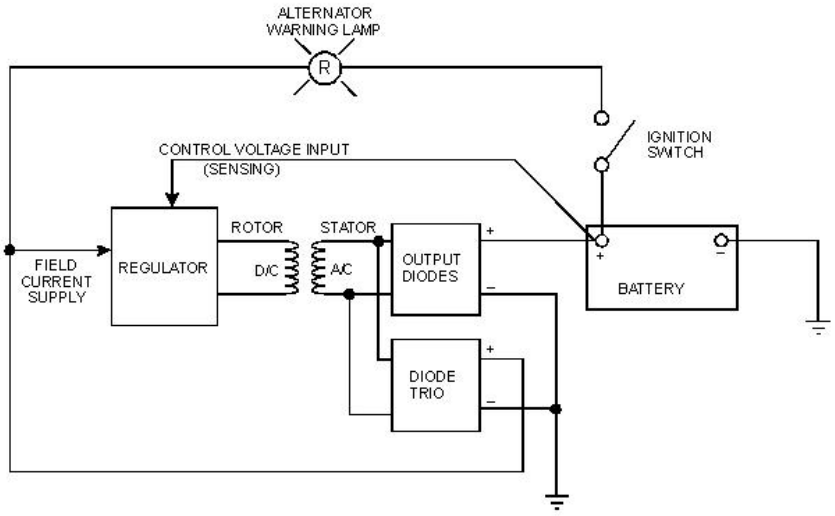

Figure 4: Alternator Functional Diagram [11]

- Rotor

  A coil of wire wrapped around an iron core is called rotor. When the current is passed through the wire magnetic field is produce whose strength depends on amount of current. The rotor is driven by alternator pulley.

- Stator

  A set of three coils surrounding the rotor and attached to alternator are called stator. When rotor turns the magnetic field of the rotor induces current in these three coils. The stator coils are 120 degree apart from each other and produces the voltage as shown in figure.

- Output Diodes

The alternating current produced in the stator is then filtered out as DC using the BRIDGE RECTIFIER. Diodes in bridge rectifier allow only in one direction. The output voltage thus produced is not pure DC signal but it is pulsating DC as shown in

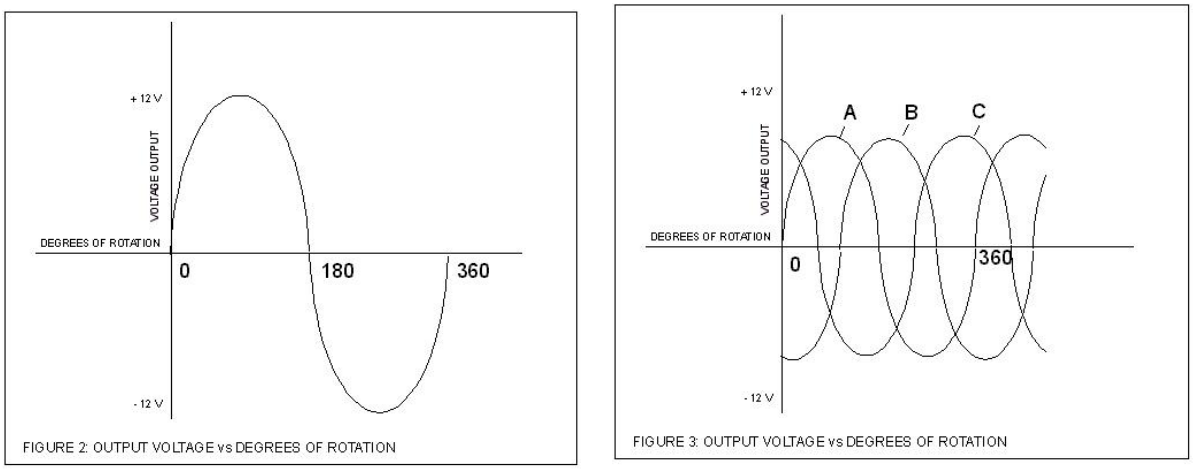

Figure 5: Alternator Output Form

the figure

- Regulator

The regulator has two inputs and one input. The inputs are the field current supply and control voltage input, and the output is the field current to the rotor.

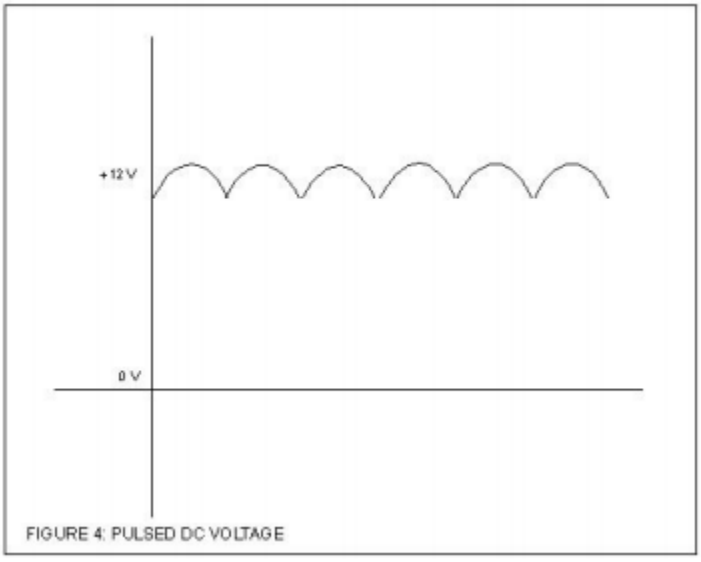

Figure 6: Rectified Signal

Terminals of an alternator

There are four terminals of the alternator which are as follow

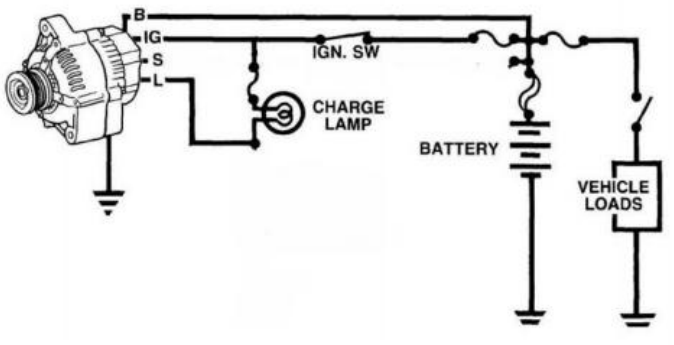

Figure 7: Terminals of Alternator

S Terminal

S terminal of the alternator serves the purpose of the basic control of the output of alternator. This terminal is always connected to the positive terminal of the battery.

L Terminal

This pin is used to turn the alternator charge warning light ON/OFF. If the alternator regulator detects that the alternator has failed it can indicate this to the driver so action can be taken. This pin is grounded by the regulator as required to turn the alternator charge warning light ON. Light ON=Error Condition, light OFF=Normal.

IG Terminal

This pin is used to determine if the ignition is ON. The alternator regulator is turned on by this signal. This pin is connected to battery voltage when the ignition switch is in RUN and CRANK positions. When the switch is on, initial current is provided to the field coil through the battery till the alternator becomes self-sustaining.

B Terminal (Alternator Output)

This is the output terminal of the alternator and it is directly connected to the positive terminal of the battery. The output voltage of the alternator is controlled by the regulator and it is used to the charge the battery and also to run different electrical components of the car. The battery is used to provide the initial juice to the alternator until it becomes self-sustaining.

Market Survey

Power is the best indicator of how well a cyclist will perform in terms of maximizing their speed. An elite cyclist can produce about 5 watts (5W) of power for every kilogram of bodyweight for a 1-hour event. For example, a 70kg cyclist who is able to maintain a power output of 350W for 1 hour would be considered to be in the elite category. A very powerful cyclist might be able to produce 1200W or more for a few seconds.

To select the alternator different markets were visited. Then the alternator of 40A at a nominal 12V which is 480W, was selected from the local market of Islamabad. It is featured with the automatic adjustment of current supply according to the requirement by the appliance. Below are some snaps from our survey and purchase. It costs 2100 PKR.

These are the findings of the online research,

Table 2: Online Findings

Type (ISKRA Brand)	Voltage (V)	Current (A)	Min. Speed (rpm)	Picture
AAG	14V	33	1150	
AAk	14	45	1000	
AAK Compact	14	70	1000	

AAN Compact	14	100	1050	
AAT	28	75	1000	

Why this alternator?

Alternator has electromagnet in it. Electromagnet has many advantages over the permanent magnets. Some of the following are listed here

Magnetic Strength

The strength of an electromagnet can be adjusted by adjusting the amount of current to magnetize the core. If current is increased the magnetism will also increase. On the contrary magnetism of permanent magnet depends upon the type of material it is made of.

Loss of Magnetic Properties

If a permanent magnet is heated at higher temperature it loses its magnetic properties and it is worthless. To recover its magnetic properties it must be re-magnetized. While the electromagnet loses its magnetic properties when the current is stopped. Contrarily, an electromagnet loses its magnetic power every time an electric current is removed and becomes magnetic once again when the electric field is introduced.

Belt

Belt drives are called frictional drives because they transmit power by friction contact. Following parameters should keep in mind for best services

- Select belts according to the job nature
- Check, if the belt is installed properly

Belt selection consideration

While choosing a belt keep in mind following parameters in mind

- Environmental conditions in which belt will operate
- Type of drive required
- Driver/Driven Revolutions Per Minute
- Horsepower
- Pulley diameter and center distance
- Pulsating or shock load conditions

Belt Drive Principles

If the grip of a belt on the pulley is good then it will transmit power efficiently, there are three major factors that tells the potential of grip of belt

- Area of contact
- Belt tension
- Friction between belt and pulley or sheave surface (co efficient of friction)

Why V-Belt?

The alternator used in our case has V shaped pulley. For V shaped grooves of pulleys, V belts are used for power transmission. V belts operate at low tension and low bearing load as compared to the other belt types. There are standards for the manufacturing of V belts, set by the Rubber Manufacturers Association (RMA). There are a number of other reasons to choose V belts

- V belt drives provides compactness
- Slip between pulley groove and belt is negligible, so the drive is positive
- Drive is smooth because there is no joint in belt.
- Easy to install and remove, long life and no noise
- High velocity ratio can be obtained
- Wedging effect of the V belt gives high value of power [9].

Bike

A bicycle is designed to convert human energy into mechanical energy for transportation purposes. The mechanical energy is then translated into electrical energy. To maximize the efficiency of both conversions it is essential to obtain the maximum power output. The first conversion is from human energy or muscle energy into mechanical energy. The bicycle is an efficient and robust method to convert between the two types of energy. As published in the International Journal of Industrial Ergonomics, ―Pedaling is the most efficient way of utilizing power from human muscles. The human musculature is concentrated in our legs and the bicycle set-up allows for harnessing the maximum output. The article also explains that stationary power generation on bicycles has been skipped over in past research but with the rising cost of other power generation, reliance on human power generation will become more important; furthermore, the bicycle is a universal symbol of transportation in all types of countries especially developing ones. We can find bicycles everywhere.

The rear wheel therefore becomes an ideal prime mover for electrical generation; we would need to connect an alternator and rear wheel, through either direct contact or a belt system.

In developing countries, people use bicycles more often than motor vehicles.

While a bike is the ideal tool to harness human power, there are a few difficulties when trying to use a bicycle. A bicycle is only stable when in movement; it will fall over if not moving forward or braced. A stand or brace has to be built in order to remain stationary when trying to generate power. This bracing, if done haphazardly, could result in injury to the user.

Design for Stand

To support the bicycle so it would stay stable while pedaling, many structures were considered. While making the stand some parameteres were consiered. i.e.

- Portability

- Stability
- Compact design
- Deattachable
- Price

First a rectangular frame was considered to make. When the stress analysis was performed it came out that this is not stable. Then a semi circle strucre was considered. Then again after analysis it was found that this structure is not stable. Finally a triangular

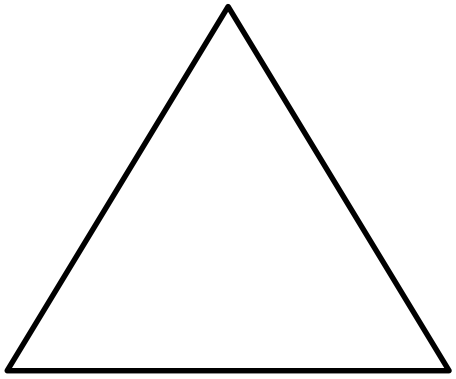

Figure 8: Concept Designs

truss was considered to be the most stable form.

Material

Material to make the stand is choosed steel. There are certain resons to that.

- Light weight
- Strength to weight
- Anti corroision property

Stand

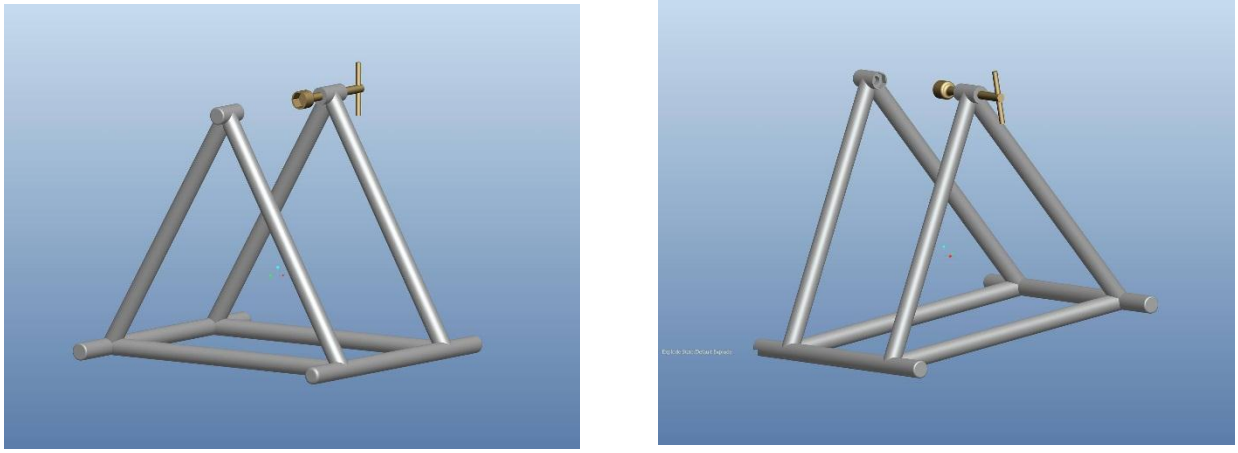

Figure 9: Final Design

To make a pedal power generator, the stand on which bicycle will be supported is very important. A bicycle is a very important mean of transportation in underdeveloped and third world countries, so we tried to design a stand that will not distort the original purpose of the bicycle. Our design for the stand is just plug and play type. A permanent attachment of bicycle to the stand is not installed.

To make our stand for bicycle generator the steel pipes are used rather than wood or any other material. There are many reasons for this choice but the durability and strength of the steel is major one. The negative aspect of a wood frame is the issues of breakability and corrosion from the user or the environment or both.

Numerical Analysis

To fabricate the stand a numerical analysis was performed on the steel pipes to check how much load they can bear.

Fabrication of stand

For the stand to be able to handle the vertical and lateral motions of the users, a wide and solid base is necessary. To design the base of the stand two pipes of dimension 41cm were cut and two of the dimension 26cm. Then these pipes were welded together to form the base of the stand. Pipes on the sides are a little bit in side because to support the

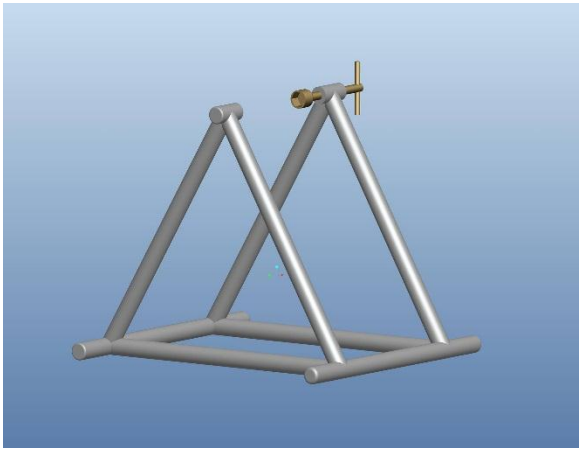

Figure 10: Fabricated Design

lateral load. Once the base is complete the sides of the stand were fabricated. To fabricate the sides of the stand, four pipes of the length 41cm were cut. These pipes in a triangular shape were welded on the base. Once this process is complete a socket was welded on the stand to hold the axil of the wheel in it. All of it was fabricated in the workshop available within campus.

The main frame for the bike stand is now complete; however, a front wheel holder must be constructed to hold the front tire in place. This will keep the user from turning the tire and possibly shifting too much weight to one side of the stand. Once the bike stand is completed we can mount the bike and other hardware on the frame.

The bike stand frame design was made to withstand a great amount of force from the user and still maintain its performance and form. This is necessary in the bike to allow the user to pedal much faster if more energy is required in a shorter amount of time.

Another factor that needs to be addressed is the issue of corrosion. This bike is intended to be used by people in developing and third world countries, so it is safe to assume the

entire system will be outside in the elements for the majority of its working lifetime. It will corrode if left unprotected in the environment for an extended period of time; however, there are many protective coatings in the market. If cost is too much of a factor, the stand should still hold up quite well in an exposed environment if it is kept out of direct contact with rain, water and other liquids.

Arduino

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer [10].

A complete code was written to run the arduino in order to show rpm on LCD. Here is the code;

```
// include the library code:
#include <LiquidCrystal.h>

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup() {
  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("hello, world!");
}

void loop() {
  // set the cursor to column 0, line 1
  // (note: line 1 is the second row, since counting begins with 0):
  lcd.setCursor(0, 1);
  // print the number of seconds since reset:
```

```
  lcd.print("03122663663");
}

long startTime = 0;
int state, prevState = 0;
int sensor = 0;
long counter = 0;

void setup()
{
  Serial.begin(9600);
  pinMode(A2, OUTPUT);
  pinMode(A1,OUTPUT);

  //LCD init - off, on, rest cursor to 0,0
  Serial.write(21); //off
  Serial.write(22); //on
  Serial.write(12); //clear display
  Serial.write(17); //turn backlight on

}

void loop()
{
  //reset variables.
  sensor = 0;
  state = 0;
  prevState = 0;
  counter = 0;
  startTime = millis();
```

```
//enable sensor and turn on LED, LCD.
digitalWrite(A1, HIGH);
digitalWrite(A2,HIGH);
Serial.write(12); Serial.print("Measuring...");

//Loop for sample duration of 1 minute
while((millis() - startTime) < 60000)
{
  sensor =  analogRead(0);
  if (sensor > 750)
  state = 1;
  else
  state = 0;

  //On change of state increment counter.
  //A change in state twice represents one revolution
  if(state != prevState)
  {
    counter++;
    prevState = state;
  }
}

counter = counter / 2;

//Trun off Sensor and LED
digitalWrite(A2,LOW);
digitalWrite(A1, LOW);
//Display RPM
```

```
  Serial.write(12);
  Serial.print("RPM = "); Serial.print(counter);
  delay(10000); // delay 10 seconds
}
```

CHAPTER 4

RESULTS

The results of various parameters are obtained using the arduino voltmeter and ampere meter. Arduino to show the rpm voltmeter to show the voltages and ampere meter to indicate the amperage produced by the alternator. Here are the graphs and data to show the obtained results

RPM vs. Voltage

According to the gear ratio calculations the pulley of the alternator can rotate up to the 2500 rpm at maximum. When rpm are increased initially the voltage also increases in order to charge the battery.by increasing the rpm there is a certain value of voltage, up to that value voltage increases that value is 14.4V. Once 14.4V are achieved no matter how much you pedal the voltage will not increase. Here is the graph to show the relation between rpm and voltages. Rpm are on the horizontal axis and voltage are on the vertical axis.

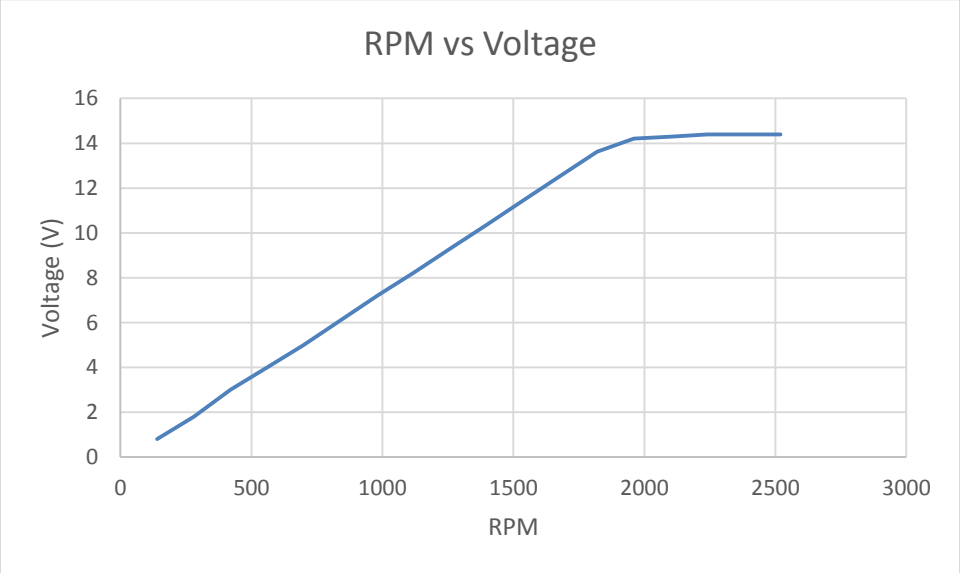

Figure 11: RPM vs Voltage

RPM vs. Current

According to the gear ratio calculations the pulley of the alternator can rotate up to the 2500 rpm at maximum. When rpm are increased initially the voltage also increases in order to charge the battery.by increasing the rpm there is a certain value of voltage, up to that value voltage increases that value is 14.4V. Once 14.4V are achieved no matter how much you pedal the voltage will not increase. The current produced by the alternator related to this rpm and voltage is variable. As the number of rpm are increased the current decreases because initially when the battery is not charged the load is maximum and more current is generated by the alternator. As the battery gets charged the current generated by the alternator decreases, but never goes to the zero.

Here is the graph to show the relation between rpm and Current. Rpm are on the horizontal axis and Current on the vertical axis.

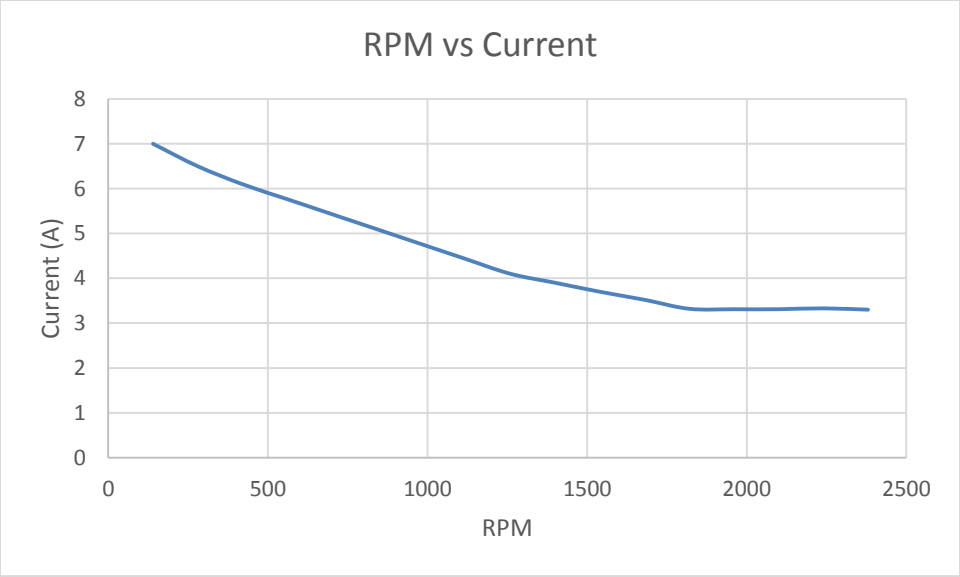

Figure 12: RPM vs. Current

Current vs. Voltage

Once the data for the current and voltage have been achieved it was easy to calculate the power generated by the alternator using

$$P = V \times I\ (watts)$$

The maximum power output was 140watts that can be generated from the alternator. Here is the graph to show the trend of power. Voltages are on the horizontal axis and current on the vertical axis.

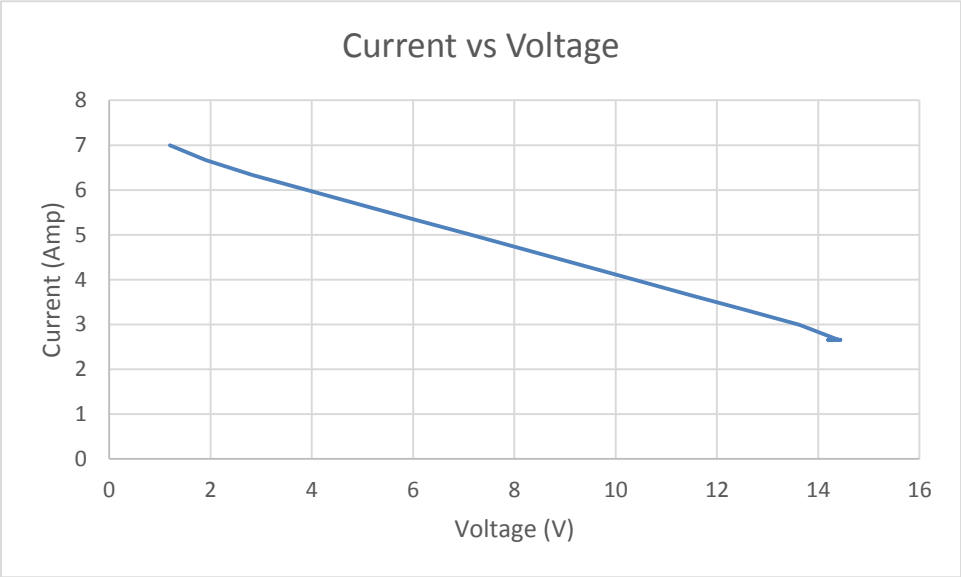

Figure 13: Current vs. Voltage

CHAPTER 4

CONCLUSION AND RECOMMENDATION

The cheap and Eco friendly Energy can be achieved using this product. There is no need for the fossil fuel to produce electricity. It is also useful for the third world and developing countries. Like Pakistan, India, Bangladesh, Sri Lanka, SA, Indonesia and Hong Kong. Almost 1.5billion people live there and 45% of them have bicycles. Using this mechanism they can have access to cheap and clean energy.

This Project aims to produce the electricity which is the urgent need of the hour. This project was aimed to make a portable and cheap system. But due to the shortage of time there are certain things which cannot be added to this system. There were a calorimeter planned to install on this bike. So when you exercise on this exercise the calories you burned can be shown on the meter. There was an inverter planned to install. Then there was a DC-DC converter was planned to install. All of these cannot be installed due to the lack of the time. I hope the later on some other people can improve this system and install these equipment to make it more efficient.

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