Pedal Power Generation

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***Abstract*—Bicycle is the main mode of transportation for many Indian villagers. Most of these villages are un-electrified. Power generated by pedaling can be converted from mechanical to electrical energy by using either dynamo or alternator. Small powered lighting devices can be charged using dynamo and can be used in the night by students for study purposes. This principle can be extended to power mobiles, iPods, laptops etc. Power can be also generated from the rotation of the wheels of alternator vehicles like bikes and cars, where there is a possibility of generating more power. The generated power can be either used in the same vehicle or can be stored in a battery for powering some other devices. Riding bicycle helps in maintaining a good physic and along with it power can be also generated.This paper presents methods in generating electricity by pedaling a bicycle. It also explains in detail the method using bottle dynamo to generate power. A detailed analysis of using pedal power is also presented.**

***Keywords*—Alternator; dynamo; bicycle; rechargeable batteries.**

I. INTRODUCTION

World is a storehouse of energy. We all know that energy canneither be created nor destroyed but can be transformed from one form to another. But we are wasting resources that can produce energy as if they are limitless. If we can renew and reuse the energy we waste, it would help in some way to the problem of scarcity of energy, which is the major threat of present world. Humans are able to generate approximately 150W of power while riding bicycle. However, this power goes waste without any use. If we can make use of this energy,we would be able to power many electronic devices. A dynamo or an alternator can be used for harvesting the energy generated by a cycle rider while riding. We can charge mobile phones or a small lighting device with this power. Not only in bicycles but also in alternator bikes, cars, and exercise bikes we can use this principle.

People use bicycles as the main medium of transportation in villages. In addition, in cities, where most people use exercise bikes, the energy can be productively used to power electronic gadgets, which require less power.In India, many of the villages are still without electricity and most of them use bicycle as their medium of transportation. In such places, our system will be of great help. Charging of the battery can be done by a layman by just connecting the circuit to the output of the dynamo which is connected to the bicycle. This would charge the NiMH batteries.

II. ELECTRIFIED INDIA

In reference to the report [6], number of Towns and Villages Electrified in India by IIFL, it can be seen that even after 65 years of independence 17.7 percent of India is still in dark during nights. All of the 5161 towns in India are electrified, i.e. cent percent in the case of towns. However, in India villages are more than towns and development of India is only possible by the development of those villages. Out of 593732 villages in India only 488439 villages are electrified, i.e. 105293 villages are un-electrified. Andhra Pradesh, Goa, Kerala, Punjab, Tamil Nadu,Haryana, and Delhi are the few of the states that are 100% electrified. Arunachal Pradesh, Bihar,Jharkhand, Orissa, Meghalaya,and Tripura are the states where less than 60% of the villages are electrified. The worst situation is in Jharkhand where only 31.1 %villages are electrified.

The consumption of electricity in the country is increasing at the rate of 10% per year. The energy usage has been increasing through years, but there has been no sufficient increase in the production. In the case of electricity, this leads to load shedding and increase in prices.

III. TURNING SWEAT INTO WATTS

In the July-2011 [7] issue of IEEE Spectrum, a detailed study and analysis of pedal power energy generation, its usage, feasibility, and economics is presented. The power is produced from the exercise bikes used in gyms by means of a small generator. This article presents a case where in it looks at the overall feasibility of including the pedal power technology in the mainstream. To be in the mainstream means, this technology has to produce lot of power. In addition, it lists many household devices and the pedaling time required to operate each of the devices for an hour. For CFL it takes 18 minutes of pedaling. For laptops, it takes 30 minutes. For fan, it takes 1 hour. However, for cloth dryer it takes 40 hours. From this, we can conclude that power produced from such machines will not be enough for powering high-powered devices. But in our case where we want to make use of the pedal power in un-electrified villages, the scenario is entirely different.

IV. PEDAL POWER GENERATION USING BICYCLE

There are various renewable energy sources such solar, wind, hydropower etc. In addition, people use fossil fuels, which are non-renewable. These resources are very expensive.

Therefore, there is a need for cheap, renewable energy source. As long as we are pedaling and the system is working fine, we can get the power whenever needed. Power generation using bicycle is very cheap and eco-friendly. Even though people have been using pedal power for various day-to-day chores, generating electricity from pedaling was not in vogue until few decades back. Today dynamo equipped bicycles are common which power the incandescent headlights during night.

The rotational energy that is generated when the tire rotates because of the application of force on the pedals can be used in two ways. This energy can also be used in dynamo/alternator,which is then converted to electrical energy. Rotational energy of the tire can be used to pump water out from the well, to drive a washing machine, to operate blender/grinder etc.These applications can be of very great use in un-electrified places. Refrigerators can also be powered by pedaling, which are used to preserve the food during a bicycle trip. Pedal powered pump can pump water from wells and bore wells, which are very deep and can be used for irrigation and drinking water purposes. In pedal powered washing machine,the plastic barrel rotates as we pedal. Thus, water consumption can be also reduced. Using exercise bikes also power can be generated. Particularly for people living in cities, it is an added advantage that no separate time is needed and along with exercise, our effort will not go waste.

V. DYNAMO

Bicycle Dynamos are alternators equipped with permanent magnets, which produce ac current. Two types of dynamos available are the hub dynamo and the bottle dynamo. Hub dynamo is built into the hub of a bicycle wheel. Here generation of electricity is done by using the rotation of the bicycle wheel. A bottle dynamo is also small electric generator like hub dynamo. It is generally placed to the rear wheel of the bicycle. A bottle dynamo acts like a small alternator.

A. Why dynamo?

Dynamo can be used to convert mechanical energy to electrical energy. Alternating current can be produced normally using the dynamo. This current can power devices, which work on ac directly and can be converted and used for devices working on dc.The amount of power generated from a dynamo by pedaling is sufficient to power the devices, which require low power. Most of the electronic gadgets including mobile phones and iPods can be powered using this.These devices can be charged while either riding the bicycle or by keeping the bicycle stationary and pedaling. Dynamo is small, light weight, and is therefore best to use in bicycles.

B. Advantages of hub dynamo over bottle dynamo

- Slippage: In rainy seasons or wet conditions, the roller on the bottle dynamo can slip against the surface of the tire resulting in interruption in the generation of electricity.
- Resistance: The bottle dynamo offers resistance when it is engaged. It rather creates more drag than hub dynamo. There is no resistance when the bottle dynamo is disengaged.
- Tire wear: As the bottle dynamo rub against the circumference of the tire (sidewall) to generate electricity, it causes added wear of the tire. However, it is not so in the case of hub dynamo.
- Positioning: The positioning of the bottle dynamo also is one of the disadvantages. If not placed correctly, it would lead to some interruption in the generation of electricity or sometimes improper positioning would lead to no generation.
- Hub dynamo has more voltage output than the bottle dynamo.

C. Advantages of bottle dynamo over hub dynamo

- The hub dynamo cannot be attached to an existing bicycle. For the installation of hub dynamo, the bicycle tire has to be replaced with a specially designed tirehavinghub dynamo already attached to its hub. But for bottle dynamo, it can be directly attached to rear or front tire.
- Hub dynamo are heavier than bottle dynamo and adds to the weight of the bicycle.
- Installation of hub dynamo is more expensive than that of bottle dynamo. Bottle dynamo costs ranges from Rs 75/- to Rs 160/-.
- Installation of bottle dynamo can be done manually without any sophistication in its installation.

VI. ALTERNATOR

The output energy from the dynamo is very low. Only three 1.2V NiMH batteries can be charged using this power, which can be used for low power applications like small led lights. Also, it takes a lot of time in charging these batteries. It is definite that the dynamo output will be insufficient for high power applications and an alternative is needed.

A dynamo can be replaced with an alternator since it is capable of producing more power in less time. Alternator has bothpros and cons over dynamo, but alternatorgenerates more power than dynamo withlesser time and effort.

Alternator is larger in size compared to dynamo and it would seize more space. One wayto connect analternator with the bicycle is to place it behind the seat by removing the carrier. Theshaft of the alternator should be connected to the tire with a belt that rolls over shaft on one end and other end rolls over a cylindrical structure attached to its rear tire's hub. In this way when the bicycle moves, the structure rotates and thereby facilitates rotation of alternator's shaft.The other way to connect the alternator with the bicycle is by making the shaft directly roll over the tire. A rubber cap placed on the

shaft is used to provide grip and to facilitate roll without slipping. Among the two ways, the first way will be more power efficient but the bicycle is needed to be pedaled in stationary mode.

As alternator would produce more power, a rechargeable battery of high voltage rating is required. The rectifier (conventional bridge rectifier) and filter will not undergo any alterations. However, in the regulator part, a regulated voltage of 15v has to be maintained using a regulator IC 7815. Also while travelling there is a possibility of alternator to be get stolen. To avoid this, alternator can be attached to the bicycle through welding or can be kept in a separate box which can be locked.

VII. Application of Alternators in Bikes and Cars

Power can be produced from bicycle and be used to power some electronic instruments with low power rating such as- tail light and head light in bikes and cars, for charging mobile phones, etc. Similarly power can be produced from bikes alternator and be stored for backup or some other purpose. In cars, dynamo can be placed onto more than one tire in order to produce more power with less effort. This in turn can be used to power many electronic based parts in the cars.

VIII. Circuit for Power Generation

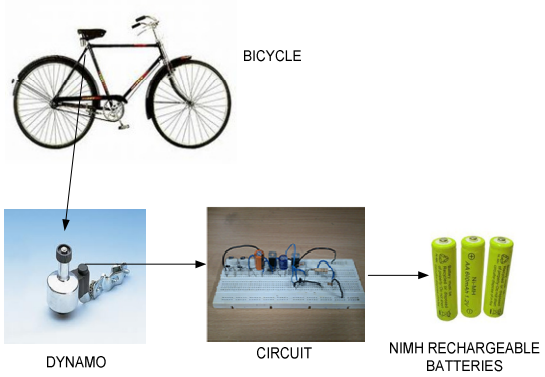

Fig1. Charging NiMH batteries using dynamo

Figure 1, shows the system setup we used in the lab to charge the batteries. In this, a dynamo is attached to the bicycle's tire for power generation. When the rider pedals, the motion of the tire in contact with the dynamo results in the rotational motion of the roller (of the dynamo). This motion causes the dynamo to produce electrical energy (AC). The dynamo output is given to the rectifier circuit, filter and then to voltage regulator and hence the DC regulated output is used for charging NiMH batteries.

Figure 2, shows the circuit setup which consisted of bridge rectifier, filter and voltage regulator. The entire setup can be fixed on the bicycle and the batteries can be charged while the user rides the bicycle for any day-to-day activity. For example, most people in villages use cycle for short distance travel of one to few kilometers for their daily work or children travel to schools in cycles. The circuit is designed in such a way that it can be fixed and charged even while the user rides it on the road. By this way, the energy spent in riding the bicycle can be used for charging the batteries. Alternatively, a user can ride the bicycle in stationary mode and charge the batteries.

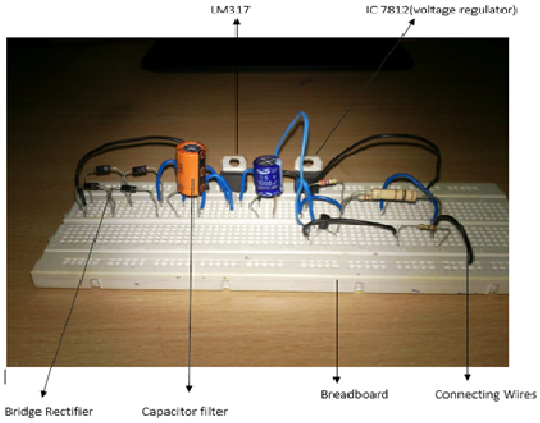

Fig2. Charging circuit

IX. Batteries/Super Capacitors

Batteries store charge chemically, where as capacitors store them electro-statically. Ultra-capacitors are costlier than the rechargeable batteries. Ultra-capacitors will discharge suddenly if short circuited.

Rechargeable battery is used to store the energy produced by pedaling. Rechargeable batteries are made up of one or more electrochemical cell used to store energy in the form of electrical energy. The only reason why batteries are preferred over capacitor is its easy usage i.e. the batteries after recharging can be easily removed from the charging case and can be used for desired purpose like for lighting up torch, etc. On the other hand, super-capacitors cannot be taken out from the circuit after recharging and be used boost a device. Also, 'case' for placing the super-capacitors are not available.

At first NiCd (Nickel Cadmium),batteries were used but later were changed to NiMH (Nickel Metal Hydride). NiMH has got many advantages over NiCd battery:

- More charge capacity (about twice as that of NiCd)
- Has no hazardous effect on the environment
- Has no memory effect (generally occurs due to overcharging or due to full drainage of battery)

X. Applications of Pedal Power

A. Charging mobile phones

For this we need a mobile charging circuit which would give the appropriate voltage and current required for charging the mobile. Here, the difference will be the input to charging circuit. In normal chargers, the input is from ac main 230V. However,in our case the voltage will be of lower value. Correspondingly, some changes are required to be made in the

mobile charging circuit. Here two types of chargers are possible:

- The first, in which the mobile phone battery is charged by connecting the charger output to mobile phone directly.
- The second in which battery of the mobile phone is charged separately.

In the case of connecting charger to the mobile directly, the battery level indicator is not required, as the battery level will be shown on the mobile screen itself. However, if we are charging the battery separately then a battery level indicator will be required. Battery level indicator is necessary as it avoids overcharging of the batteries, which may lead to battery damage. Even if there a village is un-electrified, people there use mobile phones. At such places, our design will be of great use.

B. Pedal powered laptops

Laptops powered using solar energy is available, but not everyone can afford to buy it. A simpler way will be to pedal and charge it. This already exists in Afghanistan and they claim that even a third grader will be able to use it without any difficulty. Here the pedal is fitted to the laptop table so that while using the laptop one could charge it.

C. Pedal powered washing machine

Pedal power can be used to operate washing machine. It agitates, cleans and rinses the clothes. Already existing models uses pedal power in two different ways. In one of the model, plastic barrel filled with water, soap powder and clothes are put and lid is closed. This plastic barrel itself is rotated by pedaling. In the other model also plastic barrel is used. But one person can sit on that barrel and pedal the foot pedal provided at the bottom of the plastic barrel.

D. Pedal powered refrigerators

To keep the food fresh and cool without being spoiled during a bicycle tour, pedal power refrigerators are used. In villages, particularly in India there are many street vendors for selling vegetables and fruits. Many of these vendors use bicycle or tricycle for this purpose. Pedal powered refrigerators would be of great use to them.In addition, it can keepvaccines and medicines safe without getting spoiled. According to World Health Organization,about 50 percent of vaccines go waste in developing countries. Because of this, both lives and money are lost. The human powered refrigerator uses a manual turning device which turns a small generator and it charges a battery. In turn it powers the thermoelectric cooling.

E. Pedal powered water pump

There are places where wells and bore wells are very deep and to fetch water manually is cumbersome and strenuous.At such places, pedal powered pump can be used.Also at a higher level it can be used for irrigation and drinking water purposes. For pumping more water, electric pump is needed, but where electricity is not there pedal-powered water pump can be of great use.

F. Pedal powered lawnmowers

Lawnmowers are used to cut the grass at an even height. There is a blade rotating in a vertical axis which cuts the lawn. This blade can be rotated using pedal power. For small area like gardens in houses, instead of human driven, the lawnmower can be driven by pedal power.

G. Blenders

Drive coupling of the blender is connected to the bicycle tire, which would rotate the blades of the blender. Electric blenders are high-powered devices, which work at about 500watts power. If blenders can be operated mechanically it would save electricity as well as money.

H. Other mechanical applications

Rice Threshing(Threshing is the process of beating paddy plants in order to separate the seeds or grains from the straw), Winnowing, Peanut Shelling, Corn Shelling,Operating a Circular Saw, Operating a Wood Working Lathe are some of the few mechanical applications of the pedal power.

XI. ENERGY LOSSES

Energy loss cannot be avoided and is present in each stage, from production to storage. Energy loss happens in the battery, in the alternator/dynamo, in the converter (which converts ac to dc), in the voltage regulator. This means that the total energy loss in a pedal powered generator will be about 50-70 %. Losses can be minimized by reducing the number of electrical connections and use mechanical connections wherever possible. Considering the cost factor, components of maximum efficiency must be used. Like NiMH batteries can be used as they are the most efficient among the rechargeable batteries.

XII. ANALYSIS

Table I shows the lists various factors related to using an alternator and dynamo in generating pedal power. A dynamo produces less power around 3W compared to an alternator which produces power in the range of 50W to 100W depending on the rate of pedaling. Also, charging battery using dynamo causes low power efficiency due to power loss through the bridge rectifier circuits, connecting wires and through the battery (which is being charged). Due to low power efficiency, dynamo can be used to power only low power consuming devices such as LED lamps, mobile charging and LED headlights and tail lights attached to the bicycle. Dynamos are much cheaper compared to alternators and would be the best option in villages as people cannot afford to high priced cycles.

TABLE I. COMPARISON OF ALTERNATOR AND DYNAMO

Characteristics	Alternator	Dynamo
Weight	Comparatively more(>0.5kg)	Comparatively less(>270gms)
Output power	100W – 300W can be generated	Normal: 3W (6V, 500mAh)
Current	60amps and more at max RPM	22amps at max RPM
Efficiency	55%-70%	≈40%
Size	Comparatively big	Small
Loss	As heat, friction, noise, vibration Copper loss: series field & shunt field Iron loss: Hysteresis loss and eddy current loss Other losses: Armature loss and mechanical loss	As heat, friction, noise
Comparative drag	More	Less
Mounted on	With a separate stand/ In the place of the carrier	Mounted on seat stays
Applications	High power and low power devices including portable TV, DVD players, iPod etc Alternator is preferred, if more power with less effort is needed	Low power devices such as mobile phones, LED lamps, CFL etc Dynamo is preferred, only for powering small power devices, like lighting purpose
rpm	High(1000rpm)	130rpm – 170rpm
Output (dc/ac)	AC	AC
Battery used	Rechargeable batteries such as NiMH, NiCd, Li-ion NiMH is preferred since it does not possess memory effect and non toxic.	Rechargeable batteries such as NiMH, NiCd, Li-ion NiMH is preferred since it does not possess memory effect and non toxic.
At low rpm	Can't self-excite	Can self excite
cost	US $30 – US $500	US $0.5-US $3.0 / Set

A ceiling fan, which consumes 10-50 W power to function, cannot be operated using dynamo because of its low power production. Alternator produces power in the range of 50W – 100W that can be used to power devices such as a ceiling fan or a table fan. Alternators are very expensive as compared to dynamo. Also, size of the dynamo is smaller as compared to alternator which makes the dynamo suitable for attaching it on the bicycle without causing any problem to the person using the bicycle, thereby making it user-friendly.

Power loss cannot be avoided in case of both alternator and dynamo. This loss would result in the reduction of the output power. In addition, this loss is low in both the cases but for dynamo power, output is very low as compared to alternator. A dynamo-based system is less efficient than an alternator based system.

XIII. CONCLUSION

At a time when there is energy crisis casting its shadow all over the world, one has to look into alternate renewable energy resources. One such alternate way to generate power is presented in this paper. The rotational energy of the tires in the bicycle, generated by pedaling can be used to operate small powered devices. Both dynamo and alternator can be used and various options and situations where a dynamo or alternator can be used are provided. The various applications where this power could be used are also discussed in this paper. Villagers who use bicycles are going to be benefitted the most.

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