**DESIGN AND FABRICATION OF PEDAL OPERATED WATER PUMP CUM POWER GENERATOR**

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***Abstract***

Energy is the most vital aspect in the development of modern technological civilization. The conventional energy sources are being scarce, so alternative energy sources are found which must be cheap, easily available and must satisfy the technical requirements.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 and it can also be used to lift water by using a suitable pump. In the present work, a human powered multipurpose machine is developed which lifts water to a height 10 meter and generates 14 Volt, 4 ampere of electricity in most effective way. Power required for pedaling is well below the capacity of an average healthy human being.

**Introduction**

We all know that energy can neither be created nor destroyed but can be transformed from one form to another. With the ever increasing the cost and decreasing sources of conventional energy like fossil fuels, finding the alternative non-conventional energy resources is the need of present time. Apart of other renewable energy resources, human power is one of the effective and readily available sources of energy. Human being generates energy from the calorific contains of the food they eat. Human beings are able to generate 250W and above of power while riding bicycle [1]. However this power goes waste without use. If we can make use of this energy, we would be able to power many electronic and mechanical devices.

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 and also water pumps. 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 alternator which is connected to the bicycle, whereas he can also pump out water from wells by connecting the set up to the centrifugal pump by using a belt drive.

In present study, a pedal powered multipurpose machinehas been developed which comprises of pedal powered generator for generating electricity and pedal powered pump for lifting the water of desired quantity at desired height without use of electricity or any other power. An attempt is made to make this multipurpose device low cost.

**Pedaling Rate**

Humanbeings are very adaptable and can produce powerover a wide range of pedaling speeds. However,people can produce more power--or the sameamount of power for a longer time--if they pedal ata certain rate. This rate varies from person toperson depending on their physical condition, butfor each individual there is a pedaling speedsomewhere between straining and flailing that isthe most comfortable, and the most efficient interms of power production. (For centuries, this fact was apparently not recognized.

The predominant method of human power production was to strain with maximum strength against a slowly yielding resistance. This is neither comfortable nor efficient. Neither is the opposite extreme of flailing at full speed against a very small resistance.

A simple rule is that most people engaged in delivering power continuously for an hour or more will be most efficient when pedaling in the range of 50 to 70 revolutions per minute (rpm) [2]. The relation of human pedal power produced with respect to time is presented in Table-1.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Age  (Years) | Human power by Duration of effort(watt) | | | | | | | | | | |
| Time Duration | | | | | | | | | | |
| 5  min | | 10  min | | 15  min | | 30  min | | 60  min | | 180  min |
| 20 | 220 | 210 | | 200 | | 180 | | 160 | | 90 | |
| 35 | 210 | 200 | | 180 | | 160 | | 135 | | 75 | |
| 60 | 180 | 160 | | 150 | | 130 | | 110 | | 60 | |

**Gear Ratios**

The relationship between the rotating speed of whatever is being driven and the pedaling rate (both expressed in revolutions per minute) is called the gear ratio. Most practical applications of Pedal power will use bicycle-chain drives, which on bicycles range from 1:1 (the rear wheel turns at the same speed as the turns at five times the speed of the cranks) for high gears.

**Methodology**

The multipurpose machine which was basically used by common man has been modified for water lifting and generation of electricity. The consideration for designing was to lift water to the height of 10 meter and to generate 14 volts, 4 ampere of electricity in most efficient way. Source of power utilized for above purpose is pedal power. Selecting normal bicycle for this application is due to its low cost, availability and design simplicity. Various types of pumps and generators are available in the market namely: Reciprocating, Rotary, Centrifugal Pumps and AC and DC generators respectively. In this scenario, Centrifugal pump and DC generator are selected as they are compact in size, simplicity in design, relatively low cost, light weight, and easy availability of spare parts.

**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.

**Dynamo:**

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

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 devices including mobile phones and iPods can be powered using this. These devices can be charged while either riding the bi-cycle or gym keeping the bi-cycle stationary and pedaling. Dynamo is small light weight and is best to use in bi-cycles.

**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 both advantages and disadvantages over dynamo, but alternator generates more power than dynamo with lesser time and effort. Alternator is larger in size compared to dynamo and it would seize more space. One way to connect an alternator with the bicycle is to place it behind the seat by removing the carrier. The shaft 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.

**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.

**Setup for power generation:**



Figure: Line diagram for working of the system

Figure shows the system setup we used to charge the batteries. In this, an alternator is attached to the bicycle’s tire for power generation. When the person gives the motion to the pedals, that pedal motion transferred to the driver, and this driver is directly connected to the pedals, and this driver is also in contact with the driver/follower and this follower is directly connected to the alternator, with this alternator results in the rotational motion of the follower (of the alternator). This motion causes the alternator to produce electrical energy (AC). The alternator output can be given to the rectifier circuit, filter and then to voltage regulator and hence the DC regulated output can be used for charging batteries. The entire setup can be fixed on the bicycle and the batteries can be charged while the user rides the bicycle.

**Pedal power 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.

There are many different types of pumps available in the market. But the pumps which are suitable for our project are the centrifugal pump and the reciprocating pump.

**Reciprocating pump**

Typical reciprocating pumps include plunger pumps, diaphragm pumps. Plunger pumps comprise of a cylinder with a reciprocating plunger in it. In the head of the cylinder the suction and discharge valves are mounted. In the suction stroke the plunger retracts and the suction valves opens causing suction of fluid into the cylinder. In the forward stroke the plunger push the liquid out the discharge valve.

With only one cylinder the fluid flow varies between maximum flow when the plunger moves through the middle position and zero flow when the plunger is in the end positions. A lot of energy is wasted when the fluid is accelerated in the piping system. Vibration and "water hammers" may be a serious problem. In general the problems are compensated by using two or more cylinders not working in phase with each other.

There are two main types of diaphragm pump design: - hydraulically flexed, where a plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder, or mechanically flexed where the diaphragm is connected to a solenoid or a conrod.

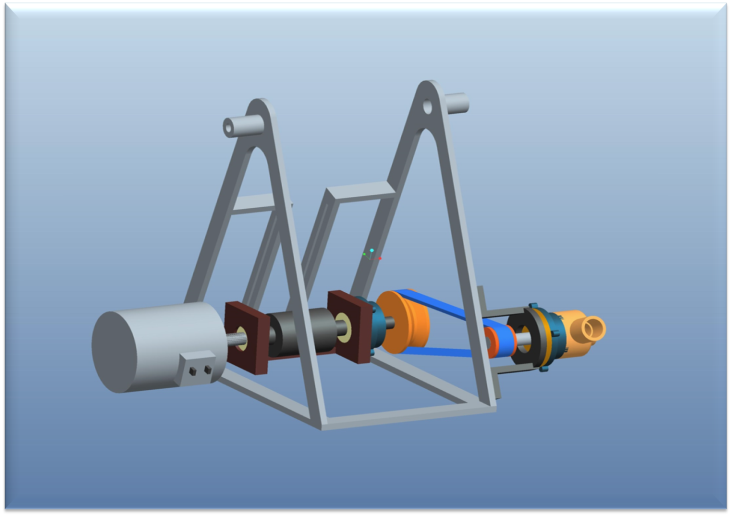
**Centrifugal pump**

Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow. The rotational energy typically comes from an engine or electric motor. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or [volute](http://en.wikipedia.org/wiki/Volute_(pump)) chamber (casing), from where it exits. The outlet pressure is a reflection of the pressure that applies the [centripetal force](http://en.wikipedia.org/wiki/Centripetal_force) that curves the path of the water to move circularly inside the pump. On the other hand, the statement that the "outward force generated within the wheel is to be understood as being produced entirely by the medium of centrifugal force" is best understood in terms of centrifugal force as a [fictional force](http://en.wikipedia.org/wiki/Fictional_force) in the frame of reference of the rotating impeller; the actual forces on the water are inward, or centripetal, since that is the direction of force needed to make the water move in circles. This force is supplied by a pressure gradient that is set up by the rotation, where the pressure at the outside, at the wall of the volute, can be taken as a [reactive centrifugal force](http://en.wikipedia.org/wiki/Reactive_centrifugal_force). This was typical of nineteenth and early twentieth century writings, mixing the concepts of centrifugal force in informal descriptions of effects, such as those in the centrifugal pump.

**Why centrifugal pump**

**Model development**

The working principle of pedal operated multipurpose machine is based on flywheel driven belt and pulley system. The Peddler using his physical power for pedaling the flywheel rotates with the help of chain drive. The rotational motion of flywheel is transferred to the intermediate shaft and then to the main shaft and this power at main shaft is used drive either pump or generator with the help of shifting mechanism. When the main shaft rotates the impeller of centrifugal pump imparts energy to water because of which it can lift the water at high head. The shifting mechanism so arrange that the main shaft engaged with rotor of the generator by using dog clutch mechanism. The CAD illustration design shown in figure



**Conclusion**

The working of human powered multipurpose machine is quite satisfactory for long duration of time. At the average head 6 m condition time required for filling a water tank of capacity of 1000 lit. is 33.33 min. Also the generator was working satisfactory by which we can charge a battery of 40 Ah within 10 hours, when fully discharged.

Power required for pedaling is well below the capacity of an average healthy human being. The system is also useful for the work out purpose because pedaling will act as a health exercise and also doing a useful work. Considering today’s busy life this is going to be an important machine. This system was working properly satisfying the requirements of a user and this might be the future of devices used for pumping water and electricity i.e. for domestic and other purposes.

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