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Solar Powered E-Bike

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Abstract: *This paper is about application of solar energy to electrical energy for running a bicycle with motor mounted on th rear wheel. This electrically powered bicycle is known as e-bike and as it is supported by a solar energy it is more efficient as it charges the electrical battery even in diffused sunlight with the help of dc to dc voltage booster.*

1.0 Introduction:

The depleting reserves of fossil fuels made the engineers and scientists to look for renewable energy sources. In addition, the environmental decay due to the combustion of fuel is alarming and justifies the design of eco-friendly system. India is spending large amount of foreign exchange to import crude oil even though we have abundant resource of solar energy. If we utilize solar power for local conveyance, a large amount of currency can be saved and we can also ensure pollution free environment and contribute to nation's economy.

The general mode of transportation for local trip (with in a range of 5 km) is a bicycle, motor cycle or electrical bicycle. Bicycles are the cheapest, healthiest and eco-friendly but poses problem in climbing slopes. Motor cycles are not affordable to poor people and with the rising fuel prices and pollutions; it does not seem a suitable option. Electric - Bicycle is eco- friendly and comfortable but costly[4] . It is infeasible as there is no enough provision for charging in rural India. Hence a bicycle which can be peddled as well as run on solar powered battery seems to be suitable option to solve the issues discussed above. [1]

Notations:

d = diameter of the cycle rim in metres. r = radius of cycle rim in metres.
ω = Angular velocity of cycle shaft.
N = Speed of cycle wheel in RPM
v = Linear velocity of the cycle in kmph
N_1=Normal reaction of the road on each tyre in Newtons.
μ=Coefficient of friction = 0.3
F=Frictional force between tyre and road in Newtons.
T=Torque developed on the shaft due to frictional force in Newton-metres.
P=Power required to ride the cycle in Watts.
t=time required to charge the battery by A- C Supply in hours

Bicycle data available:

Cycle Rim Diameter d = 66.04 cm = 0.66 m
Required Cycle Speed v = 20 kmph
Cycle Weight + Rider Weight w=100 kg

1.1 Design:

The design involves the calculation of power required to run a bicycle at a known speed (say 20 km/h) and to develop a solar powered system to produce the required power.

Since additional attachments are to be mounted on the

cycle, a light weight cycle with geared system and suspension was selected. A Hero DTB Cycle was purchased. [5]

Motor calculations

Since the total cycle weight is equal to **100 kg**, the Normal reaction acting on each tyre is equal to **(50 x 9.81) Newton** each.

Friction force acting on the tyre

$F = \mu N_1$
F = 0.3 x 490.5
F = 147.15 N

Specified Torque=21Nm.

Speed calculations:

$\omega = v \div r$, $\omega = (20 \times 1000) \div (0.33 \times 3600)$,$\omega = 16.83$ rad/sec
$\omega = (2 \pi N) \div 60$
$N = (60 \times \omega) \div (2\pi)$
$N = (60 \times 16.83) \div (2\pi)$
N = 161 rpm

Power calculations:

$P = (2 \pi N T) \div 60$
$P = (2 \pi \times 161 \times 21) \div 60$
P = 353.878 W

The solar power is used as a supplementary energy to

ride the bicycle. A motor with power of 350 W with peak wattage 388W is selected.

Battery specification:

Power = Voltage x
Current P = V.I

350 = 24 x I
I = 14.58Ah

Hence according to the above calculations, to drive a motor of **350 W**, **24 V** capacity; we select 2 batteries of **12V**, **12.5Ah**. We connect these batteries in series to achieve a voltage of **24V** as required by the motor.

Electrical charging:

Time required to fully charging the battery is calculated.

Power Supplied to Battery during AC Charging:

AC Adapter Specification: 12V, 3 A
P = V.I

P = 12 x 3
P = 36 W

Therefore the time required to charge the battery completely is:

t = 300 ÷ 36
t =8.5 hours

Hence, it is found that, the time required to charge the batteries completely is **8.5 hours**.

1.2 Solar Panel:

A solar panel of 40 W capacities were selected due to space constraint. To charge the battery completely, it needs 300/ 40 = **7.5 hours** are required. The solar panel is a photovoltaic converter which works in bright sunlight and in diffused sunlight .The DC voltage booster keeps the voltage optimum for the battery to get charged even while the voltage falls below threshold in diffused sunlight .

The blockage diode used in the charger prevents the reverse flow of current from the battery to solar panel .

1.3 Selection of Battery: Two lead acid Battery with 12 V and 12.5 amp-hour rating are used .The selection of battery depends on its voltage, ampere and wattage rating etc. The total power of fully charged battery in 8.5 hours is 300 Watt-hours.

1.4 Selection of Motor: A Brushless D C Hub Motor (BLDC) motor for 350 Watts power with electronic commutation system is selected. Brushless DC Motors (BLDC) have many preferred compared to mechanically commuted DC motors because BLDC motors have permanent magnet , electronically commuted, No winding on rotors, frictionless operation, less noise and more uniform torque.

1.5 Electrical accelerator :

An electrical signal accelerator works on the principle of Hall Affect generator, which produces speed controlling signals based on the rotation of the actuator.

2. Assembly of solar panel and power transmission system:

The fabrication process involves fixing the different components to the frame of the bicycle. The motor is fixed to the rear wheel shaft with proper alignment so that the weights are perfectly balanced. A battery casing in which 2 Pb batteries of 12 V, 12.5Ah are fixed to frame and wirings are drawn from battery to motor so as to transmit power from battery to motor. Also wiring for speed control is also incorporated. The solar panel is mounted on top of battery casing and cycle carrier. A DC voltage booster is placed below solar panel. Appropriate wiring is done to charge the battery through a jack for AC charging. This makes it possible to charge the battery either by solar power or by electrical charging. The speed controller mounted in the center of cycle cuts off the power supply to the motor and stops it[3]. The same brake stops the cycle with conventional friction brake. The braking system stops motor as well as cycle simultaneously.

3. Results and discussion:

The cycle was placed in sun light and was found that it requires 7.5 hours for fully charging the battery. But with electrical charging it needs 8.5 hours. The discharge time of battery theoretically is 1 hour. But it was observed that the discharge time of battery is 50 minutes and discharge takes place exponentially. The cycle was tested on plain flat road and a maximum speed of 15 Kmph (figure 5) could be obtained without pedalling.

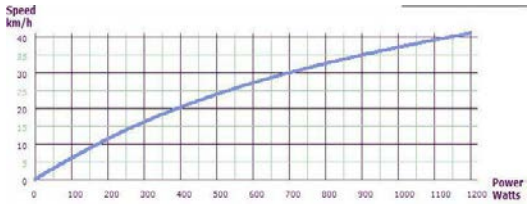

Figure 5: Speed Vs power on a flat horizontal road [2]

4 . Conclusion:

The solar powered bicycle has the following salient features. A cycle can run at an average speed of 15 kmph (without pedalling) with a maximum of 25 kmph with pedalling. The battery can be charged in dual mode, Solar or Electrical supply. The battery can be charged in rainy season or at nights also. The cost is less (Rs 20,000/-) compared to Luna (Rs 37000 /-) or E – Bike (Rs 30000 and above). Eco - friendly, No Pollution. The battery is being charged while riding in sun. Hence charging and usage takes place simultaneously. No running cost. It can be easily recommended as a local vehicle.

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