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Fabrication and Testing of Solar Smart Bicycle

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***Abstract*— The rapidly increasing prices of petroleum and diesel have made the role of alternative energy sources for vehicles more significant. Furthermore, the emission of poisonous gases from different types of vehicles has become highly detrimental to the health of the beings. For this reason, it is the right time to look for more economic friendly fuel sources. In this paper attempt has been made to design and prepare a self-charging electric bicycle consisting solar panel. Solar energy can be utilized which is available free of cost to charge the batteries. The BLDC (Brushless DC) motor to convert the electrical energy into rotations of wheel and to convert and store the same rotation energy into electrical energy we have employed dynamos. By this paper, the solar smart bicycle speed is 19 km/hr at plain road and at incline road the speed is litter decrease to 17 km/hr.**
***Keywords*— Solar Bicycle, Solar Charging, Dynamo Charging, Self-Charging.**

I. INTRODUCTION

In this paper, discussed about the solar smart bicycle & its status in the modern world. Here, we have focused its need in the modern world & the challenges that can be solved through a solar bike.

I.I INTRODUCTION TO SMART BICYCLE

An electric bicycle/e-bike/booster bike is a bicycle with an integrated electric motor which can be used for propulsion. E-bikes use rechargeable batteries & the lighter varieties can travel up to 25 to 32 km/h, while the more high-powered varieties can often do more than 45 km/h. Solar energy is used to charge the battery. Two or more Photovoltaic cells may be used to harness solar energy to generate voltage to charge the battery. Battery gives the required voltage to the hub motor mounted on the front wheel to run the bicycle. Solar bicycle is not sold generally in our everyday life but there manufacturing can be increased to prevent environmental pollution. These are primarily used as a practical project and are also sometimes sponsored by government agencies.

I.II CURRENT SCENARIO OF E-BIKE IN THE WORLD

In 2016, there are 210 million electric bikes worldwide used daily. It is estimated that there were roughly 120 million e-bikes in China in early 2010 & sales are expanding rapidly in India, the United States of America, Germany, the Netherlands & Switzerland.

The world's fifth-largest auto market is readying for a stupendous transformation: moving completely towards electric vehicles (EVs) by 2030.

It will set the standards and specifications for the vehicles and provide guidelines to incentivize their use.

Summary: - From this part of paper, the solar bikes are pollution free vehicles which can be used in day-to-day life by people to reduce the dependency on fossil fuels. They are efficient, have very less running & maintenance cost compared to other vehicles. They have potential for the future mode of transportation.

II. LITERATURE REVIEW

In this paper, during these researches e-bike literature survey is conducted by reviewing various research papers. In that number of research papers & patents are collected then analyzed by which we have get the information are:

In 2007, Annette Muetze at all[1], work on changing electric bicycle system as a platform to improve electric bicycle performance by using new drive systems i.e. key parameters that will result in improvement of the system performance. It also provides brief idea about power requirement, speed & load (Weight of rider & bicycle).

In 2012, Ian Vince Mcloughlin at all[9], were inventing the electric bicycle for the campus mobility in which they inculpated brushless DC motor which is mounted on either front or rear wheels for producing electricity. They also come with a modern technology that they provided navigation facilities for each system for the campus they invented for with android touchscreen. As bicycle required 200-250W continuous pedaling was required. So not accepted by most of the people.

In 2013, Swapnil Shringarpure at all[17], had experimented Automated Bicycle. development of electric bicycles which can be implemented as an alternative to the two wheelers consuming large amount of fuel & polluting the environment. To cope with the lightning speed of life these days quick transportation has been one of the key factors, in one way the fast transport provides us with the modern needs of life, but on the other side the it has resulted in increased consumption of fuels & played a crucial role in increasing pollution. research done in this paper is limited to making a prototype of electric bicycle the same can concept can be applied to a bigger cycle with taking many factors into consideration & keeping the basic logic same.

In 2013, Minas Roukas[13], work on Development of the control system for an electric vehicle as a platform to construct EDV as a demonstration Vehicle & for testing modern technologies. It also provides control allocation for control system by providing desired speed & reduce oscillation. They also performed various simulation test for required trajectory for movement of vehicle.

In 2014, Vivek V Kumar at all[21], have worked on design & implementation of electric assisted bicycle with self-recharging mechanism. They had used a PMDC motor, flywheel, housing, multi-crank free-wheel, sprockets, batteries & control system for the purpose. The motor utilizes an effective discharge of 12 V & 14 A from the battery. But it was noticed that with increase in the effective speed the current drops to 1.077 A.

In 2014, Rahul Sindhwani at all[15], have theorized the basic requirement to increase the efficiency of the e-bike. They represented the improvement of 50% in efficiency of e- bike with hub motor incorporated in the rear wheel for producing the initial torque required to set the vehicle from rest to motion & main motor incorporated along with the chain drive for further power transmission.

In 2015, Ivan Evtimov at all[10], had constructed an experimental electric bicycle for evaluation of the energy efficiency. In this experiment, they studied 3 typical city routes of the city Ruse of Bulgaria. It was indicated that depending on the conditions of moving & the slopes of the streets, the regeneration of energy varies from 6 - 14 %. During their experiment, they covered 215 km with the average regeneration of 5.5%. The Less will be the braking & acceleration the more will be the regeneration. They also found that the use of these electrical bicycle by 1 person can reduce pollution up to 15 times compared to the conventional cars.

In 2016, Mohammad Reza Maghami at all[14], had experimented the amount of power loss due to soiling on solar panel. They found that dust reduces output power from PV between 2% to 50% in different areas. Based on daily, monthly, seasonal & annual basic. Thus, they proposed to clean the PV module from dust accumulation on daily basis to reduce the power loss.

In 2017, S. T. Wankhede at all[16], had experimented the Multi Charging Electric Bicycle. Electric bicycles with may be addressed by custom-designed drives that are most efficient over a given operating cycle. Also, we take PIC16F72 controller & this controller has function of over-current protection. Experiment turned out controller has better dynamic characteristics & run steadily.

In 2017, Kunjan Shinde[11], worked on electric bike as it is a modification of the existing cycle by using electric energy & solar energy if solar panels are provided, that would sum up to increase in energy production. With the increasing consumption of natural resources of petrol, diesel it is necessary to shift our way towards alternate resources like the electric bike & others because it is necessary to identify new way of transport. The operating cost per/km is very less & with the help of solar panel it can lessen up more.

OUTCOME FROM LITERATURE SURVEY

- BLDC motors are more efficient & powerful among the alternators & dynamos.
- Battery capacity directly affects the range of the e-bike.
- The sprocket & chain drive used in the e-bike system should be same or like the sprocket & chain drive of the bicycle to be used.
- Soiling on solar panel reduces its efficiency.
- BLDC motor can charge the batteries if the polarity is reversed. The efficiency of the system depends on the quality of the material used in the system.

COMPARISON OF VARIOUS SOLAR BICYCLE

Author	Motor	Solar Panel	Batteries	Output
Kartik S Mishra [5]	BLDC	Yes	Lead acid	40-45%
Ivan Evtimov[1]	BLDC	Yes	Lead acid	24-29% (HILLY)
Kartik S Mishra (Less charge) [5]	BLDC	Yes	Dry cell	30-35%
M. Reddi Sankar (0.45rs/km) [6]	BLDC	Yes	Dry cell	Avg. speed- 23km/hr
Mohmmad Reza Maghami[3]	NO	Yes	No	Cleaning increase
Akshay S. Dhabekar[7]	BLDC	No	Lead acid	Max. Safety
Per Roger Johansen [9]	BLDC	No	Dry cell	Max. Distance
Ajit B. Bachhe (Max. speed) [8]	BLDC	Yes	Lead acid	20-25%
Rahul Sindhwani[4]	NO	No	Dry cell	55-60%
Minas Roukas[2]	Brush	No	Lead acid	14-18%

Table 1: - Comparison of Various Solar Bicycle.

RESEARCH GAP

- Single dynamo is used in the bicycle for charging the batteries, but no one has used more than one dynamo in the system.
- For testing the researchers have used metaled roads and not the unmetalled roads.
- Researchers haven't combined Dynamo, BLDC motor and Solar panel together to make a fully-fledged regenerative self-charging bicycle.

III. FABRICATION AND DESIGNING OF SOLAR BIKE

In this part of research paper, we have discussed the components & materials & their specification required to convert any cycle into a solar bike.

III.I RAW MATERIAL & ITS SPECIFICATIONS

In table various raw material for discuss: -

Sr. no.	Description	Specifications	Amount (₹)
1	Bicycle.	Hero Crest Bicycle	1000/-
2	E-bike kit: - BLDC Motor, brakes, accelerator, Speed controller, sprocket, charger & lights.	BLDC Motor: - 24 DCV, 2700 RPM, 250W Sprocket: - Mild steel	10,000/-
3	Batteries.	2*12V DCV	2,500/-
4	Dynamo.	3*6W	1,200/-
5	Chain.	-	100/-
6	Nut & bolt & washers.	Mild Steel	150/-
7	Locks & joints.	-	100/-
8	Solar panel & Solar charge controller.	24 DCV,20W	2500/-
9	Color spray bottle.	Grey, Blue	80/-
10	Power charging socket.	3Phase AC main	40/-
11	Fuse & socket.	20A	100/-
12	Grease.	-	60/-
13	Motor fitting.	-	200/-
14	Fabrication & electrical job.	-	700/-
15	Fiber sheet.	-	700/-
Total cost		₹19,430/- (Rounded off)	

Table 2: - Various Raw Material & Its Specifications.

III.II Design and calculation

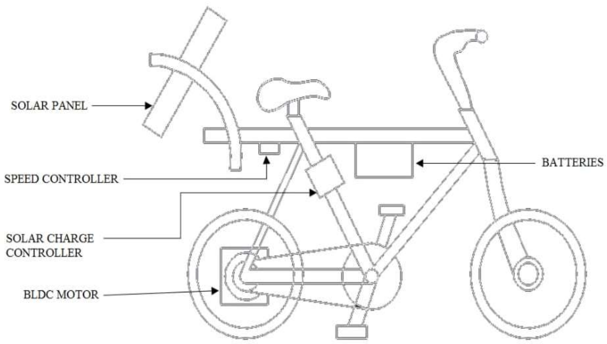

Figure 1: Assembly Diagram.

Figure 2: Solar Smart Bicycle.

CALCULATION

In this part, we have calculated all the theoretical data related to the solar bicycle, using all the data & formulas available to us before & after the testing.

Problem statement

Diameter Of wheel (D)= 60cm
Average Speed(v)= 19 kmph
Weight of Bicycle= 25 kg
Weight of Rider= 70 kg

Power calculations

1) Normal reaction (N) on each tire = W/2 = 95/2 = 47.5kg = 47.5*9.81 = 465.98 N
2) Friction Force (F) acting on each tire:
For Static Friction, u = 0.03
F= u*N= 0.03*465.98= 13.98 N
For Dynamic friction u=0.004
F= u*N= 0.004*465.98= 1.86 N

Torque requirement (t)

For static Friction, T = F*R = 13.98*0.30 = 4.194 ~ 4Nm
For Dynamic Friction, T = F*R = 1.86*0.30 = 0.558 Nm
Speed calculations
w= V / R= 19000 / (0.30*3600) = 17.59 rad/sec

Power requirement (p)

A) On plain ground,
1) For Dynamic Friction, P= T* w= = 9.82 watt
2) For Static Friction, P= T* w= = 73.78 watt
Overall power requirement= 73.78*2= 147.5 watt
B) On Inclined Surface, a=2'
1) Total force required to move vehicle F = u * mg * cos(a) + mg sin(a)
F= 60.46 N
Therefor power required= F * V = 251.91 W extra power required = 251.91 – 147.5 = 104.41 W
2) Considering dynamic friction
F= 0.004 * 95 * 9.81 * cos (2) + 95 * 9.81 * sin (2) = 36.25 N
Power (P) = F * V= 150.81 W

Battery selection

Since motor selected is of 24V hence battery voltage rating should also be 24. Therefore, we select two batteries of 12V and 7 Ah in series combination of we get 24 V and 7 Ah.

Charging time

Time required to charge the battery by adapter 12 V 12Ah
P= 12* 12= 144 W T= (24*12) / 144
= 2 hrs.
By using solar panel T= (24*7) /20
= 8.4 hrs.

Panel selection

we use one panels of 20 W each having dimension 520mm* 350 mm* 22 mm

Motor selection

Hub motor of 250 W 24V is selected

Expected results using pedal arrangement

Using pedal arrangement for charging battery: Voltage rating for motor = 12-24 V
Rated speed = 1400 – 2700 rpm Current rating = 14 Amps
Power rating = 16 – 33 HP
Dry Cell battery = 12 V battery
Bike wheel to pulley turn ratio is 26'' diameter to 2'' diameter = 1:13
19 – 22 km/hr hours of speed is required to charge a battery of 24 volts.

Graphs

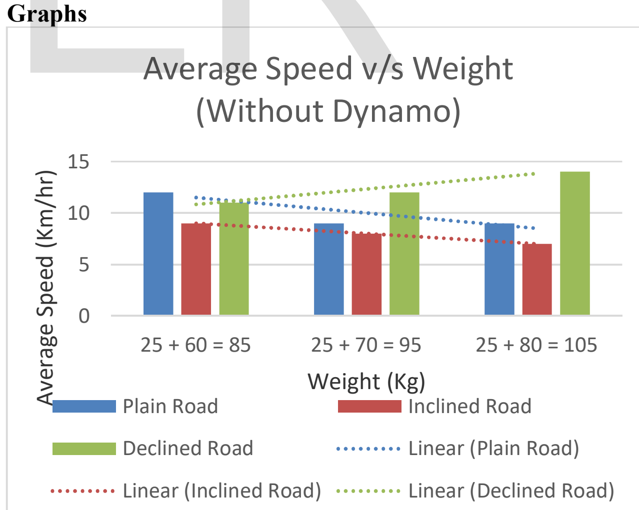

Figure 3: - Average Speed v/s Weight (Without Dynamo).

From the testing, we found that:

- On plain road the average speed decreases with increase in load. The load of 85 kg had the highest average speed of 12 km/hr.
- On inclined road the average speed decreases with increase in load. The load of 85 kg had the highest average speed of 9 km/hr.
- On declined road the average speed increases with increase in load. The load of 105 kg had the highest average speed of 14 km/hr.

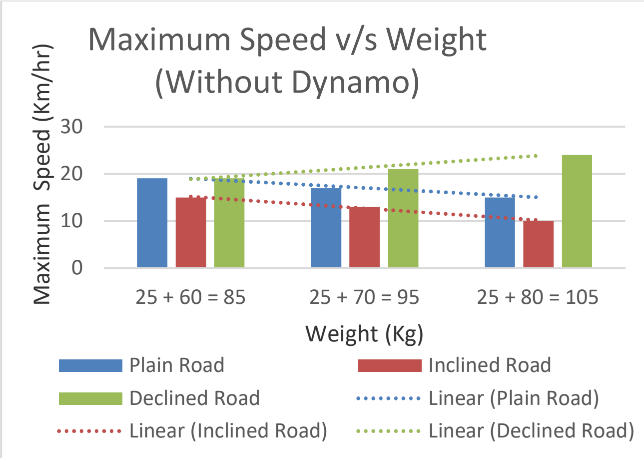

Figure 4: - Maximum Speed v/s Weight (Without Dynamo)

From the testing, we found that:

- On plain road the maximum speed decreases with increase in load. The load of 85 kg had the highest maximum speed of 19 km/hr.
- On inclined road the maximum speed decreases with increase in load. The load of 85 kg had the highest maximum speed of 15 km/hr.
- On declined road the maximum speed increases with increase in load. The load of 105 kg had the highest maximum speed of 24 km/hr.

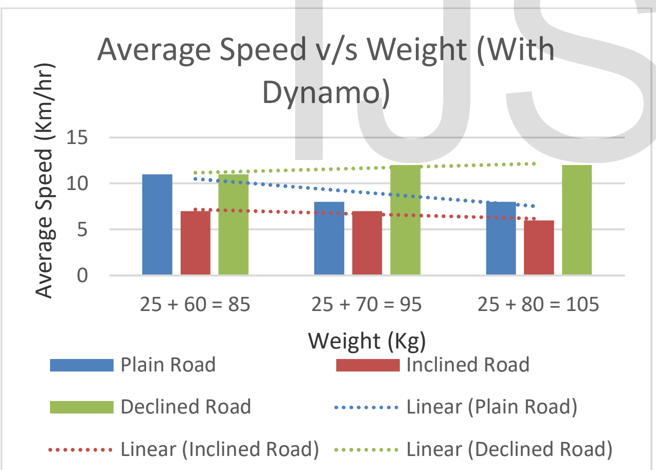

Figure 5: - Average Speed v/s Weight (With Dynamo).

From the testing, we found that:

- On plain road the average speed decreases with increase in load. The load of 85 kg had the highest average speed of 11 km/hr.
- On inclined road the average speed decreases with increase in load. The load of 85 kg & 95 kg had the highest average speed of 7 km/hr.
- On declined road the average speed increases with increase in load. The load of 95 kg & 105 kg had the highest average speed of 12 km/hr.

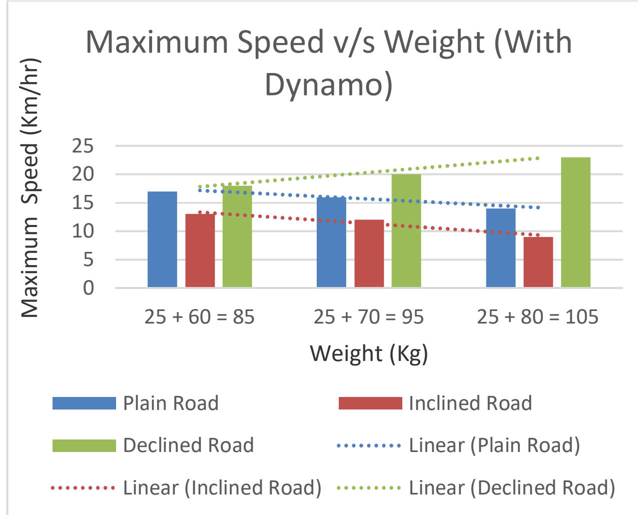

Figure 6: - Maximum Speed v/s Weight (With Dynamo).

From the testing, we found that:

- On plain road the maximum speed decreases with increase in load. The load of 85 kg had the highest maximum speed of 17 km/hr.
- On inclined road the maximum speed decreases with increase in load. The load of 85 kg had the highest maximum speed of 13 km/hr.
- On declined road the maximum speed increases with increase in load. The load of 105 kg had the highest maximum speed of 23 km/hr.

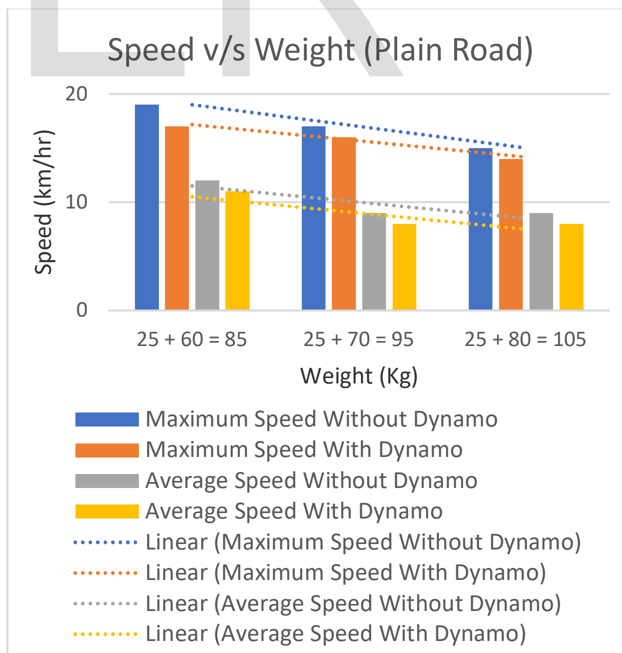

Figure 7: - Speed v/s Weight (Plain Road).

From the testing, we found that:

- Maximum speed without dynamo decreases with increase in load. The load of 85 kg had the highest maximum speed of 19 km/hr without dynamo.

- Maximum speed with dynamo decreases with increase in load. The load of 85 kg had the highest maximum speed of 17 km/hr with dynamo.
- Average speed without dynamo decreases with increase in load. The load of 85 kg had the highest average speed of 12 km/hr without dynamo.
- Average speed with dynamo decreases with increase in load. The load of 85 kg had the highest average speed of 11 km/hr with dynamo.

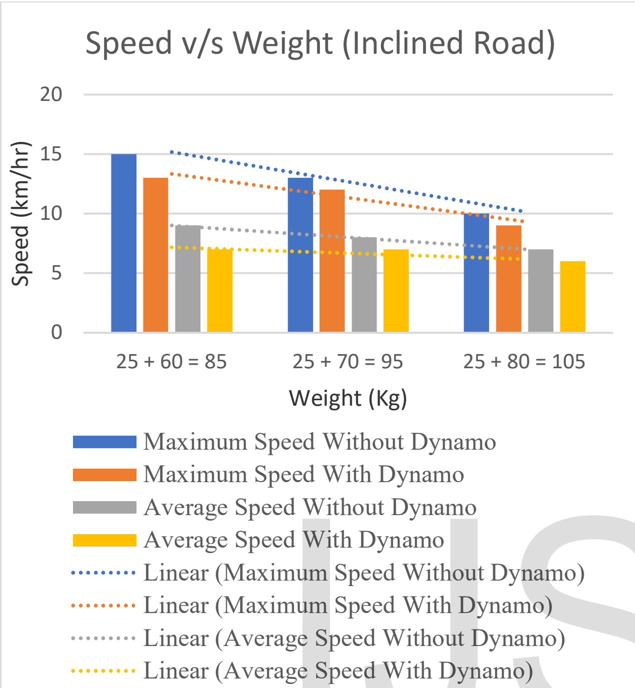

Figure 8: - Speed v/s Weight (Inclined Road).

From the testing, we found that:

- Maximum speed without dynamo decreases with increase in load. The load of 105 kg had the highest maximum speed of 24 km/hr without dynamo.
- Maximum speed with dynamo decreases with increase in load. The load of 105 kg had the highest maximum speed of 23 km/hr with dynamo.
- Average speed without dynamo decreases with increase in load. The load of 105 kg had the highest average speed of 14 km/hr without dynamo.
- Average speed with dynamo decreases with increase in load. The load of 105 kg had the highest average speed of 12 km/hr with dynamo.

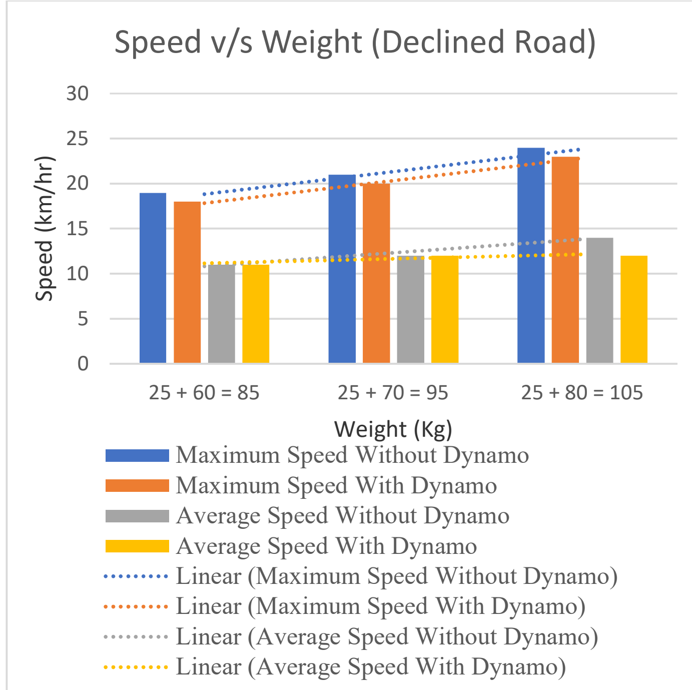

Figure 9: - Speed v/s Weight (Declined Road).

From the testing, we found that:

- Maximum speed without dynamo increases with increase in load. The load of 105 kg had the highest maximum speed of 27 km/hr without dynamo.
- Maximum speed with dynamo increases with increase in load. The load of 90 kg had the highest maximum speed of 22 km/hr with dynamo.
- Average speed without dynamo increases with increase in load. The load of 90 kg had the highest average speed of 28 km/hr without dynamo.
- Average speed with dynamo increases with increase in load. The load of 90 kg had the highest average speed of 21 km/hr with dynamo.

V. CONCLUSION

- Battery capacity directly affects the range of the e-bike.
- The sprocket & chain drive used in the e-bike system should be same or like the sprocket & chain drive of the cycle to be used.
- Soiling on solar panel reduces its efficiency.
- BLDC motors can charge the batteries if the polarity is reversed. The efficiency of the system depends on the quality of the material used in the system.
- In no dynamo usage condition, on plain Road the cycle's average speed almost remained constant up to 15 km/hr-16 km/hr for all the tested weights, while on declined road the average speed increased with the weight because of the factor gravitational force.
- In no dynamo usage condition, on plain Road the cycle's maximum speed decreased from 20 km/hr to 18 km/hr (10%) by increasing the weights, while on declined road the maximum speed increased slightly from 26 km/hr to 28 km/hr (7.6%) and which was greater than to that on plain road by (30%).
- In dynamo usage condition there was a slight loss in maximum speed by (15%) on plain road compared to no dynamo usage condition because the energy lost by the friction between dynamo and wheel contact, while on the inclined road it remained almost same as in the case of no dynamo used.

- On the plain and inclined road, the maximum speed decreased with the increase in weight while for declined road the maximum speed increased with increase in weight.
- The actual time required to charge the battery by adapter 12 V 12Ah was 2hrs 15 mins which was more than the theoretical time by 12.5 % because of external factors like loose pin connection, air resistance, wire resistance factor etc.
- The actual time required to charge the battery by solar panel was 9.2 hrs which was more than theoretical time by 9.5% because of factors like inclination angle, soil factor, solar tracking etc.

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