Design & Development of E-Bike - A Review

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Abstrac -- Modern world demands the high technology which can solve the current and future problems. Fossil fuel shortage is the main problem now-a-days. Considering current rate of usage of fossil fuels will let its life up to next five decades only. Undesirable climate change is the red indication for not to use more fossil fuel any more. Best alternative for the automobile fuels to provide the mobility & transportation to peoples is sustainable electrical bike. Future e-bike is the best technical application as a visionary solution for the better world and upcoming generation. E-bike comprises the features like high mobility efficiency, compact, electrically powered, comfortable riding experience, light weight vehicle. E-bike is the most versatile future vehicle considering its advantages.

Index Terms: E-bike , Eco-Friendly, Electric Bicycle, E-bike, BLDC Hub Motor, Solar Powered Vehicle, Green Energy

I. INTRODUCTION

Main reason to identify the need of finding and modifying E-Bike is to overcome the issue of the pollution because of vehicles in metro towns & urban zones is swelling uninterruptedly. Considering the all class of society it is not reasonable for all to purchase (scooters, mopeds or motorcycles). So, combining both issues, environmental progress supporting and economical affordable alternative would be the best solution. Typical parts of E-bike (Electric Bicycle) are Brushless DC Motor (Hub Motor), Throttle (Accelerator), Battery Storage (12 V), Chain Drive, Frame and other common bicycle parts (fig.1). There are two parts of electric bicycle as per their functions and working: Power on Demand and Pedal Assist. The motor is activated by a throttle with power-on-demand, customarily handlebar-mounted as well as on general scooters or motorcycles. By pedaling electric motor can be controlled with pedal-assist. The pedal-assist augments the efforts of the rider when they are pedaling. The e-bikes are known as pedelecs have a sensor to identify the pedaling force, the pedaling speed, or both. Disabling the motor is the brake sensing action.

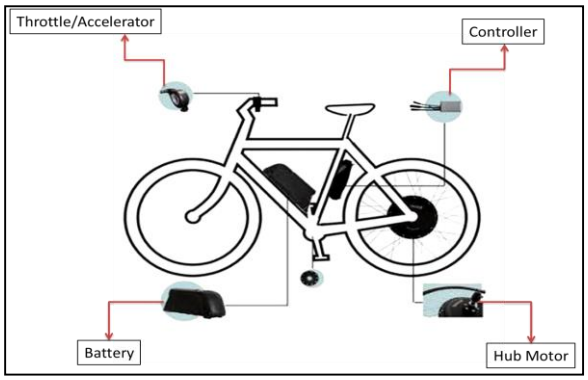

Figure 1 Key Components of E-Bike

II. OBJECTIVE

The main purpose of this research is to review the current situation and effectiveness of electric bicycle researched by various researchers. In order to approach this purpose, following objectives are specified:

i. To maximize the speed and efficiency.

ii. To optimize the cost.

III. LITERATURE REVIEW

A. The German Naturalistic Cycling Study – Comparing cycling speed of riders of different e-bikes and conventional bicycles [1]

Objective of this paper to was to explore the acceleration and speed of orthodox and electrically powered bicycles under truthful statuses. Authors distinguished between electric bicycles which deliver provision up to 45 km/h (as known as S-pedelecs) and 25 km/h (speed of pedelecs). Additionally, as speed limits of 30 km/h might influence especially on the

execution of speedier cyclists (e.g. Spedelec rider), the potential mean speed might be even advanced under various situations. Authors also found noteworthy variances in numerous measures between pedelecs and orthodox bicycles, although less noticeable. This might interpreted as a symptom that, when accelerating from standstill, the assistance provided from motor used by the pedelec riders to reach their preferred speed easier, not earlier. Authors also given the variance in the user population, it is not irrational to admit that at present, e-bikes do not cause any revolution in cycling mean speed at all. The growth of e-bikes in younger cyclists is still there. It has even been embraced that the e-bicycle is going from being a "recovery vehicle" to a stylish frill. By this authors gave the vision that this will change two wheeled activity and street security in the center and long stretch.

B. Urban Electric Bike [2]

In this paper, authors considered importance of easy vehicle mobility and compactness. In which they revealed that folding is the strategic feature of the e-bike which would not have been probable devoid of the folding arms. For the ease of sliding of the arms a bolt is provided. In order to provide rigidity to the bike a guide has been provided on the main frame. See fig.

Figure 2 Foldable Frame

Figure 3 Guide with Slots

About other components, both the plates are welded on front arm of the bike and a constraint is established on the back arm to confine the angle between the two arms to 50°. Furthermore, in paper the specifications and functionalities regarding components of e-bike were discussed. At initially, fundamental driving component about Hub Motor that Regular electric motors utilize a mechanical gadget called a commutator and two contacts named carbon brushes to switch the electric current periodically and affirm the pivot continues handing over the comparative bearing. Hub motors are characteristically brushless motors (See fig. 4) which replaces the commutator and brushes with planetary gears and an electronic circuit. The Hall Effect Sensors help to locate the position of the permanent magnets and which coils to activate to keep the motor spinning.

Figure 4 Hub Motor

Figure 5 Twist Throttle

Then about the accelerator or say throttle, author discussed below working. Working of a Twist throttle is based on the principle of potentiometer which is also called variable resistor. It is used to fluctuate the voltage passing through the throttle. In order to pass more through the throttle, the more twist should be provided as a result less is the resistance. Therefore twist throttle offers the signal to the BLDC hub motor controller to increase or decrease the current passed to the motor.

C. Campus Mobility For The Future: The Electric Bicycle [3]

This paper presents the various outcomes and results of the study containing visions into the scheme. Electric bikes, of much sort have been surveyed by and by in a semi-open contract conspire on the Nanyang Technological University campus in Singapore. According to this campus, it is a famous and helpful administration, with a few models of electric bike being exceptionally very much utilized. Riders contemplate the premier of the electric bikes to be both agreeable and engaging while at the same time utilizing it, and extremely suitable for campus travel. Understudies and general society alike view the plan unhesitatingly, and creators have seen a lessening in the quantity of miles driven via auto inside the grounds for the dominant part of clients who are additionally drivers.

In this paper, authors have sensibly inspected the utilization of bikes on campus, displaying and investigating review results that endeavor to clarify blocks to bigger acknowledgment of the bike. Authors likewise bolster the general public by giving arrangement that if this information is coordinates with a portion of the qualities of the campus encompassing, it is conceivable to suggest specialized, arranging and

reasonable arrangements that together should help the more prominent acknowledgment of bike transport. This is the concentration of the rest of the paper.

D. Design And Fabrication Of Dual Chargeable Bicycle[4]

In this paper, authors discussed about the crucial components and its experiments of e- bike, alternator and batteries. First, alternator which is an electromechanical device that transforms mechanical energy to electrical energy in the form of alternating current. The brushes of a DC generator carries a small fraction of the current, which carry the generator's whole output. A set of rectifiers (diode bridge) is essential to alter AC to DC. To provide direct current with low ripple, authors used a three-phase winding and the pole pieces of the rotor are shaped (claw-pole) to produce a waveform similar to a square wave as an alternative of a sinusoid. Author used alternator of Yamaha bike which workings are done at high RPM since authors' electric bicycle is restricted to low RPM so they changed the windings of alternator and upsurge e the drive ratio. Hence, it can function at low RPM.

Another important part is discussed is regarding batteries Electric bicycles industrialized in Switzerland in the late 1980s for the Tour de Sol solar vehicle race accompanied sunlight based charging stations yet these were later settled on rooftops and associated in order to nourish into the electric mains. The bikes were then charged from the mains, as is normal at this point. Battery frameworks being used incorporate lead-corrosive, NiCd, NiMH and Li-ion batteries. Range is a key thought with electric bicycles, and is influenced by elements, for example, engine productivity, battery limit, effectiveness of the driving gadgets, optimal design, slopes and weight of the bicycle and rider. The scope of an electric bicycle is typically expressed as somewhere close to 7 km (tough on electric power only) to 70 km (minimum assistance) and is profoundly subject to regardless of whether the bicycle is tried on level streets or slopes. The vitality expenses of working electric bikes are little, however there can be noteworthy battery substitution costs. In lots of available preferences authors selected 2 lead acid batteries of 12 volt 5 amp because of its easy availability and low cost and connected in series to get an output of 24 volt. Overall experimented results of this paper are: Speed of 10-15 km/hr is achieved when battery is fully charged. When coming down the hill the charging can be achieved in 1hr. Driven mechanism wheel wear rapidly due to friction.

E. An Improved & Efficient Electric Bicycle System With The Power Of Real-time Information Sharing[5]

Firstly they are using the sun based board as a hotspot for E-bicycle. In that they utilized the 20 KW sunlight based board and it is associated with the 12 v battery. So the sun powered board is utilized to charge the battery. Here basic concept they applied that the solar energy is converted into electric energy by using photovoltaic effect. They connected the solar panel is in the series and it created the additional voltage, which is used to charge battery The block diagram of their design requirements is shown in fig.

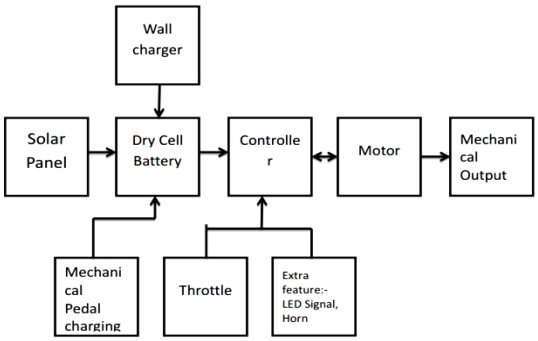

Figure 6 Block Diagram of E-bike design requirement

The second source of energy is that they are convert the mechanical energy into electrical energy by using dynamo. Dynamo is a electric device which generate the power with the help of commulator .In this paper they mentioned the procedure of how mechanical energy is converted into electrical energy and it will utilized for run the electrical bike. They connect the dynamo in the front wheel of E-bike. As the wheel of bike is run along the wheel commulator also rotate and it will generate the power. So the mechanical energy gets converted into electrical energy and it will store in dynamo whenever it will be required, it will supply the energy to E-bike.

F. Design Of Electric Bike With Higher Efficiency[6]

From this paper it can be found that they are focused on the improvement of efficiency of E-bike. Generally the speed of E-bike is in the range of 40-45 km/hr at maximum. So there they increase the speed of E-bike and design the aerodynamic shape in such a way that the efficiency of E-bike is improved.

For the increasing the speed they are done the comparison of power transmission system. In that they found four power transmission system. Based on Application the out of four any one of them power transmission system is used in E-bike. Generally the chain drive is used for transmitting the power. Along with that there are three different types of motor is also used like Gear hub motors, Crank drive motors and direct drive motors. So after completing experimental study it can be found that due to the specifications like light weight, inexpensive, compact, offering non-slip the chain drive is more efficient as compared to belts or gears.

In this paper they also show the design procedure of aerodynamic shape of E-bike. The importance of aerodynamic shape for the improvement of efficiency of E-bike is unavoidable. They mentioned the distribution of percentage of aerodynamics of E-bike enlisted below:

Aerodynamic in total (It means the combination of rider aerodynamic as well as bike aerodynamic) - 65 %

Wheels - 7 to 8 % of total aerodynamic

Fork - 6 to 9 % of total aerodynamic

Frame - 4 to 9 % of total aerodynamic

Other – 2 to 4 % of total aerodynamic

Drag coefficient is also essential characteristic in aerodynamic. So they described the different aerodynamic shape with their Drag coefficient as shown in Figure-7.

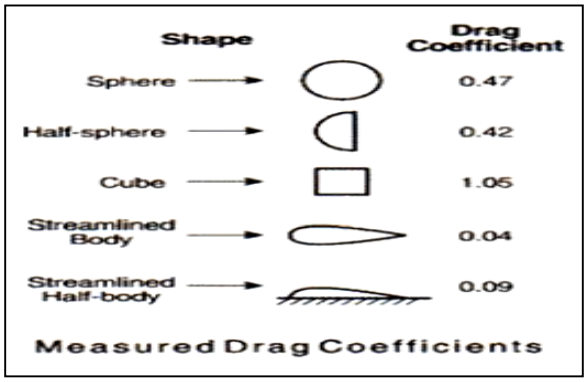

Figure 7 Various Drag Coefficients

G. Design And Development Of Solar Assisted Bicycle[7]

In this paper, study on alteration of present bicycle in form of solar assisted which is energized by solar energy is carried out. For both city and nation streets that are made of bond, black-top, or mud, this bike is fitting, It is reasonable, unobtrusive in development and can be widely utilized for short separation voyaging especially by school youngsters, understudies, office goers, villagers, postmen and so forth. It is especially reasonable for youthful, matured, disable individuals and provides food the need of financially poor class of society. The best critical component of this bike is that it doesn't expend important petroleum products along these lines sparing crore of outside trades. It can be worked all during year that time for nothing out of pocket.

The supreme noteworthy highlight of this bike is that it doesn't ingest valuable petroleum derivatives along these lines sparing crores of outside economic forms. It can be said to be environmental-friendly and less contaminated, as it doesn't have any emanations. Furthermore it is silent and can be energized with the AC connector if there should be an occurrence of crisis and overcast climate. In this paper, the working expense per kilometer is depicted as negligible around Rs.0.70/km. It can be fueled by manual accelerating if there should be an occurrence of any tricky circumstance with the close planetary system. It has littler sum parts, can be effectively mounted or gotten off, consequently requires less support.

H. Design, Fabrication And Performance Analysis Of Solar Power Bicycle[8]

In this paper, authors carried the selections of different components of E-bike.

Determination of Battery: Two Li-ion Battery storing with 12 V and 12 amp-hour rating are kept in use. The variety of battery relies upon its voltage, ampere and wattage rating and so forth. The whole energy of totally charged battery in two hours is 288 Watt-hours.

Choice of Motor: A Brushless D C Motor (BLDC) for 300 Watts control with electronic compensation framework is painstakingly picked. Brushless DC Motors (BLDC) have many favored contrasted with mechanically moved DC motors in light of the fact that BLDC engines have permanent(long enduring) magnet , electronically drove, No twisting on rotors, frictionless operation, not so much commotion but rather more undeviating(uniform) torque..

I. Design, Development And Performance Evaluation Of Solar Power Assisted Tricycle[9]

In this paper, the solar powered tricycle as an auxiliary for

auto rickshaw is carried out by authors. Authors mentioned key relevant features of the solar power assisted tricycle in this paper.

a. For higher power, motor of higher capacity can be used.
b. It works with a reasonable speed with less fatigue to the rider.
c. Source of power and shade utility by mounting solar panel..
d. The tricycle is steadier contrasted with a two wheel bike.
e. The parking place for solar powered vehicle does not involve a shed.
f. The battery can be charged even while riding the tricycle. This guarantees unremitting vitality contribution to the tricycle with no extra cost.

J. A Dynamic Model For The Performance And Environmental Analysis Of An Innovative E-Bike[10]

The authors have directed an ecological investigation of the considered vehicle, especially contrasting the e-bicycle and a thermal moped, as far as ecological effect. This paper spoke to the natural examination of an electrically supported bike under genuine driving circumstances of mimicked speed-time profiles.

In think about, trial results of roller test seat estimations completed on a warm moped utilized so as to assemble the apropos emissive information amid genuine driving circumstances. The ecological appraisal was performed considering an examination with the emissive execution of this moped by utilizing kinematic parameters that assign the reenacted driving elements; an unmistakable advantage of e-bicycle likened to thermal mopeds was appeared and figured as far as emanations spared of CO, HC and NOX, which was a general report finding of this paper.

K. The Copenhagen Wheel: An Innovative Electric Bicycle System That Harnesses The Power Of Real-Time Information And Crowd Sourcing[11]

In this paper authors deliberate innovative bicycle wheel concept which is used for comfortable ride of e-bike. The name of that wheel is known as Copenhagen wheel. The Copenhagen wheel is a bike wheel that can be effortlessly retrofitted into any normal bicycle. It look for red center point not just contains engine , batteries and inward apparatus framework yet in addition incorporates ecological and area sensors which are controlled by the batteries in the haggle information for cycling related versatile application.

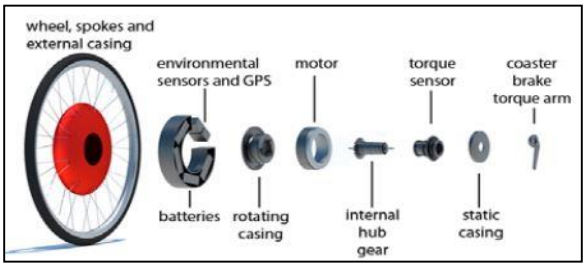

Figure 8 Copenhagen wheel assembly

L. Parametric Finite Element Analysis Of Steel Bicycle Frames: The Influence Of Tube Selection On Frame Stiffness[12]

Authors presented a parametric Finite Element model of road bicycle frames using beam elements with wavering tube profiles in this paper. In order to observe the impact of tube profiles on lateral stiffness and vertical compliance of the frames, wide range of current frame geometries had been subjected to several in plane and out of plane loading situations. This was postponement of preceding effort which considered the influence of overall frame geometries (tube lengths and angles) on the stiffness characteristics of frames. For a subset range of frame sizes (with seat tube lengths varying from 490-630mm), parameters were utilized to characterize measurements for roundabout tube profile shapes, shifting divider thicknesses related with butted tubes. In this paper just steel tubing was considered so as to segregate and accentuation inside and out on the effect of the tube profile geometries on the firmness attributes of the edges for a solitary material. Authors confines their work by setting future work to confirm this model by methods for a frame stiffness jig and to characterize the impact of material choice on the stiffness and attributes industrially open tubesets and their distributed solidness and quality esteems for steel, aluminum and titanium outlines frames.

M. Parametric Finite Element Analysis Of Bicycle Frame Geometries[13]

This paper has outlined by respective authors which includes a Finite Element model by means of beam elements to signify a customary road bicycle frame. The model simulation carries two standard loading constraints to undergo the vertical compliance and a lateral stiffness characteristic of 82 existing bicycle frames from the bicycle geometry project and compares these characteristics to an improved solution in these circumstances. Maybe obviously littler edges

(490mm seat tube) act the most thoughtfully as far as both vertical consistence and horizontal solidness, while the shorter best tube length (525mm) and bigger head tube edge (74.5°) brings about an along the side stiffer edge which relates with discoveries from literature outcomes. The upgraded esteems demonstrate an extensive improvement over the best of the current casings, with a 13% expansion in vertical dislodging and 15% decline in horizontal relocation when identified with the best of the dissected edges. Here general stacking conditions for frame structure and other auxiliary parts (rear dropouts, sections, handlebar, situate tube) are appeared in Figure-9 and 10.

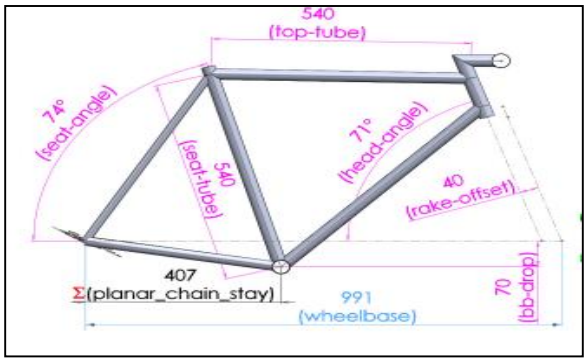

Figure 9 Beam element model with key frame geometries

The model has been progressed to take into consideration extra improvement to involve more in depth tube geometry, facilitate investigation of more edge geometries, elective materials, and examination of other basic attributes.

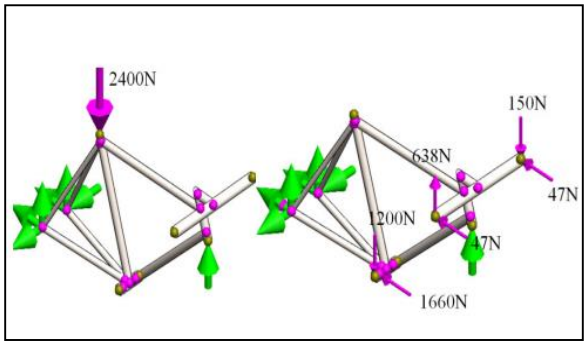

Figure 10 Beam element model with Headtube & Rear Dropout constraints for seat tube (Left), and BB / handlebar (Right)

N. Numerical Study On Materials And Design Optimization Of A Bicycle Frame[14]

In this paper the procedure of selecting a material for robust frame structure is approached by authors Author has taken- materials like composites (HT Graphite epoxy and S-Glass Epoxy) and Aluminium Alloy 6061-T6 for Circular and Elliptical cross section. From ANSYS 14.5 simulation results it is determined that composites (HT Graphite epoxy and S-Glass Epoxy) can be used as bicycle frame material due to its better results (stress, strain & displacement) when compared with Aluminium Alloy 6061-T6. Also, for the bicycle frame the Circular cross section is more preferable than Elliptical cross-section because of high strength withstanding ability. Then in the two composite materials (HT Graphite epoxy and S Glass Epoxy) Due to less cost and reasonably high strength S-Glass Epoxy can be preferred when compared to HT Graphite Epoxy Figure-11 and Figure-12 shows the stress, strain values and deformation values for circular cross section frames and elliptical cross section frames respectively.

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S. No.	Particular		Circular cross section		
	Result		Aluminium Alloy6061-T6	HT Graphite Epoxy	S-Glass Epoxy
1	VON -MISES STRESS(Pa)	Max	1.5896e7	1.6251e7	1.6332e7
2	VON MISES STRAIN(Pa)	Max	0.00023094	7.3595e-5	0.0001816 2
3	TOTAL DEFORMATI ON (mm)	Max	6.2309e-5	2.8539e-5	9.1385e-5

Figure 11 Analysis for Circular Cross Section Frame

S. No.	Particular		Elliptical Cross section		
	Result		Aluminium Alloy6061-T6	Graphite Epoxy	S-Glass Epoxy
1	VON -MISES STRESS(Pa)	Max	3.8132e7	3.8362e7	3.8443 e7
2	VON MISES STRAIN	Max	0.00020857	0.000660 72	0.0005 1439
3	TOTAL DEFORMAT ION (mm)	Max	0.00015066	4.7279e-5	0.0001 033

Figure 12 Analysis for Elliptical Cross Section Frame

O. Performance Evaluation Of Electric Bicycles[15]

In this paper authors discuss the configuration and overview of E-bike. In this they have classified the various possible components used to build an e-bike. As per shown In the figure 13, the fundamental design of an electric bicycle drive comprise of a controller that controls control stream the battery to the electric engine. It implies the power provided from electric engine is utilized to run e-bicycle. The power act parallel along the power delivered by rider via pedal on the bike. The specifications regarding E-bike is shown in figure 14.

Sr. No	Parameters	According to
1	Bicycle Kit Type	Custom built Add on
2	Motor Type	Brushed dc machine Brushless dc machine
3	Motor Assembly232	Gear Hub Friction
4	Assist Type	Full-assist Half-assist
5	Throttle Type	Thumb throttle Twist throttle Push button
6	Motor Placement	Front wheel Rear wheel
7	Battery Type	Lead acid NiMH Others

Figure 13 Classification of E-Bike Components

Speed	Average speed 19 km/h.	Max. Speed 32 km/h
Travel range(Full charge)	16–80 km	
Batteries Charging time	2–6 h	
Cycles of charge/discharge	Up to 400	
Power consumption (Each full charge)	100–500 Wh	
On-board power supply	12–36 V	
Torque (Hill climbing ability)	up to 6% slope	
Weight of Electric bicycle kit excluding original bicycle weight	4.6–22.8 kg	
Price range	Rs 25000 - Rs 35000	

Figure 14 Performance of E-Bike

IV. CONCLUSION

The objective of a comfortable, compact, high speed and efficient bicycle can be achieved by this various experiment results obtained by different authors by advancement in current E-bike model. This advancement includes the pre-discovered results from literatures like the selection of materials of frame tubes, aerodynamic design.

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