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Solar-Powered Retrofit Electric Three-Wheeler for Multipurpose goods carrier with manual pedaling

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***Abstract*— Indian villages, towns and cities have high air and noise pollution caused by transport vehicles, especially petrol/diesel-powered three-wheelers. Conventional Internal Combustion Engine (ICE) driven 3 and 4 wheelers are against environment friendly and those are having very less efficiency when compared to EVs (Electric Vehicles). This paper details the overall construction and development of a Solar-powered Electric Three-Wheeler for multipurpose cargo applications with optional manual pedalling. Existing and developed solar-assisted electric auto rickshaw three-wheeler is investigated, as well as future conceptual designs for electric three-wheeler and the modern design study, real time development of the subsequent vehicle. This proposed solar powered retrofitted electric three-wheeler for multipurpose good carrier with manual pedalling is intended to match and exceed the existing vehicle's performance and efficiency. We commence the subsequent all-purpose design of the EV three wheeler in this paper as version 1k where the conventional vehicle as version 10k. The technological improvement endeavour for version 1k is to diminish the total electric power needed for propulsion with combine of sprockets for torque increments, optimized traction batteries which is charged either by PV modules or grid as optional, forward-reverse drive train preferences are covered, real time model is built for carrying 500 kg of pay load and several configurations are analysed for further improvements. This paper revealed how a manual pedal cycle rickshaw is retrofitted in to PMDC motor powered cargo cycle rickshaw with physical pedalling as optional. It is shown that these rickshaws can endow with a safe, environment-friendly, energy-efficient and cost-effective transport system in villages, towns and cities of India for multipurpose cargo EVs. Additionally commercialization, technology, social and policy issues are discussed for large-scale introduction of these rickshaws. This paper is developed as a project an initiative from Rural Energy Centre of Gandhigram Rural Institute – Deemed University.**

***Index Terms* – India, ICE, EVs, PV modules, Battery, PMDC motor, Three-wheeler, pollution, rickshaw, traction, drive train, sprockets, torque, retrofit, cargo, payload, Gandhigram.**

I. INTRODUCTION

In India, there are presently close to 15 million petrol and diesel-powered three-wheelers and their population is growing at a rate of about 15% per annum. Besides being a major hazard to people's health, these machines are burning huge amounts of petrol and diesel for which the country has to pay extremely on foreign exchange. Electric powered tricycles which are imported from china are recently banned by Delhi Government and costs of these imported vehicles on Indian roads are three times higher than the vehicle indigenously developed at Rural Energy Centre, Gandhigram Rural Institute, Deemed University, India. An improved and fully solar powered electric cycle rickshaw can provide a non-polluting and silent cargo transport system for urban and rural areas of India. It can also provide large-scale employment to millions of urban and in particular rural poor.

In this project a manual pedal cycle rickshaw is procured and it is retrofitted in to Permanent Magnet DC [PMDC] electric motor powered cargo cycle rickshaw with solar-charge-batteries. Optional electric charger is provided in case of cloudy days to charge the batteries. It is revealed that these rickshaws can provide with a secure, environment-friendly, energy-efficient and cost-effective transport system in rural India.

Issues of greenhouse gasses and amplified traffic in the roads, the most admirable way to renovate the three-wheeler is to widen a added proficient devise that will be motorized by a 100 percent non-polluting energy resource, which can be achieved with an electric motor drive train. A renewable source would make it an enhanced answer compared to the existing alternative fuel-powered rickshaws. An individual technique to carry out this is to use an energy scheme that can take benefit of abundant sources of renewable energy namely, an electric system powered by Photovoltaic's modules. The power afforded by solar, wind, hydro, or other renewable sources in addition to energy-storage systems such as batteries. Various renewable sources (i.e., PV modules) may be positioned on the vehicle roof top itself, or the batteries could separately be charged by the renewable sources via an off-site recharging station, or an amalgamation of these two options could be considered.

Three-wheelers are huge runners for electrification due to their stumpy speeds and comparatively small distance

they wrap in a day. In this paper, a novel solar-powered electric three-wheeler is presented. This innovative three-wheeler design attributes are defined and the original vehicle outline is designed and developed in here. This three-wheeler electric vehicle is close to the desired performance range about 25 km per charge. Range can be extended up to 150 km per charge if number of batteries is kept more underneath of this EV. In connection with this retrofit concept, solar PV modules on the vehicle roof top for charging the batteries and stationary charge-docking station infrastructure as well.

This manuscript will primarily provide a concise narration on existing solar assisted electric auto rickshaw as version 11k and its drawbacks. India's policies for EVs are also discussed so that these types of EVs can be used on Indian's road without breaking the traffic laws. This paper will preliminary furnish a concise narration of existing solar assisted EV rickshaw version-11k and transportation industry with a spotlight on these auto rickshaw, as well as efforts by the government to diminish greenhouse gasses effects and encourage less-polluting technologies (see Sections II and III). In Section IV, the study on these type of EV rickshaw meet via the speed switching techniques without solid state devices like MOSFET's and IGBTs will be covered. Stationary charging- recharging infrastructure research in Section V is discussed. Section VI defines Solar-powered Electric Three-Wheeler for multipurpose cargo applications with optional manual pedalling version-1k, describing its technical targets and design description, and presents the drive-train options for version-1k. The selected configuration and real time calculations of the subsequent version-*next* are also roofed. Design sheets for PV powered retrofit electric rickshaw model are emphasized in part VII. Section VIII presents conclusions and prospect work on this solar-powered three-wheeler and its components.

II. TRADITIONAL SOLAR-ASSISTED AUTO RICKSHAW

Fig.1a shows the existing manual pedaled three-wheeler rickshaw, which is to be retrofitted in to solar-powered three-wheel rickshaw. Conservative solar-assisted auto rickshaws shown in Fig.1b are may be suited to the Indian roads if CMVR Act 1989 permits. They are very small and slender, allowing maneuverability on congested roads. The drive train shown in Fig. 2 usually includes an air-cooled two-stroke or four-stroke petrol/diesel engine and a transmission four-speed gearbox), although many newer vehicles are powered by diesel, LPG, or CNG. They have a top speed of 40 to 50 km/h and generally carry one to four passengers and their freight articulate about 300 kg of pay load.

Despite the vehicle design is so convenient in maintenance and applications, these solar incorporated IC Engine driven auto rickshaws present a huge pollution problem. This is owing to deprived vehicle continuance and the use of an ineffective engine with very little toxic smoke waste control.

Distinctive engine molds have capacities ranging from 145 to 175 cm^3 and maximum engine power ranging around 9 hp. Capacity of fuel tank is around 9 liters. The electrical systems contain a straight 12-V lead-acid battery for lighting and engine manage and ignition. Weight of the vehicle diverges from 250 to 500 kg for larger models. In addition to this solar powered system and electric parameters of this existing rickshaw like DC motor 15hp, battery 400ah, PV modules 250W, range of 120 km per charge with solar and 80 km per charge without solar with maximum speed 40km/h.

Tables I–IV give many of the existing auto rickshaw factors and performance standards.

III. SPEED CONTROL TECHNIQUES

Since the proposed vehicle is less than 20kmph, incorporating solid state speed control devices are absolutely increase additional cost and more maintenance. More over these solid state devices like MOSFETs and IGBTs are unable to withstand overload if it encounters very often. Hence we suggest to introduce voltage based speed control method using swap interlocking switches. These type of switches is very easy to handle by the riders, it comes for long life and easily available even in the village markets since we design and develop for rural applications.

IV. STATIONARY CHARGING DOCKING STATIONS

Plan for hybrid-stationary Re-charging stations are also to be designed and included in this research so that the proposed-electric-rickshaws can be charged while the vehicle is in the state of waiting. In the rickshaw stand a new docking station is constructed and root top of this station can be incorporated with solar PV modules. In addition to that wind mills can be mounted either vertical or horizontal, so that the batteries available in the stations are charged. These charged batteries can be swapped further in case if the rider runs out of batteries.

v. VERSION 1K: DRIVE-TRAIN OPTIONS, SELECTED CONFIGURATION

A general purpose three-wheeler manually driven vehicle is procured and all its parameters are studied. This vehicle is exemplified by its iron body supported by three 72cm bi-cycle wheels (one in front and two at the rear), with a seat for the driver in the front and a tub like structure to carry any goods for multipurpose. It is fully open design but can be converted in to closed type to carry passengers around four in numbers. In our revamp of the three-wheeler, we do not wish to transform any part of the abovementioned characteristics, which we consider to be aspects of the "signature" or identity of the rickshaw. We want the new rickshaw to be compatible with the old, that is, to be used by drivers and passengers like the old rickshaw is used.

Table V shows the practical specifications of a model proposed for the next-generation general purpose cargo carrier. These are technically calculated and it is a concrete outcomes. These types of three-wheelers are designed and selected based on the production and manufacturing phases. Make a note of that the ceiling power of the electric motor is almost 1/10 times power of the usual rickshaw's engine for two grounds: 1) The motor which is considering in here has a superior top speed around 1500 RPM, so to attain the similar torque requirements to move the vehicle with its own mass, we ought to employ a upper power mechanism; 2) as declared formerly, the new cargo vehicle is intended to contest and go beyond the existing version 11k's vehicle's presentation, for instance, with a superior consignment ability.

In attendance a small number of choices for slot in solar PV modules on the vehicles roof-top, as conferred and investigated beneath: 1) solar power for driving force loads; 2) solar power for supplementary loads; and 3) solar power for additional loads if any like communication equipments. The solar energy per quadrangle meter per day received on the average in most parts of India is about 4–7 kWh. The rear tub of the three-wheeler has about 3.4 m^2 of space available on the crown only to situate solar sheets. Bearing in mind only being able to capture about 5–10% of that energy due to inefficiencies of the panel, converters, dust, and less-than-ideal tracking conditions, the actual energy recoverable per day may be less than 1–2.5 kWh when using the entire surface. Required amount of energy for the main loads are 3.5kwh, the auxiliary load is predictable at 500 Wh per day, depending on the use of the rickshaw and the climate conditions. Consequently, solar panels jacket the roof would deliver additional energy to meet this necessity.

A. *Drive Train Options*

The fig 3: shows the overall drive train manual cum solar powered three-wheeler for cargo applications. The advantage of these vehicle is one can carry any load which is less than half a ton of weight in small speed around 10-20 kmph. The major disadvantage is it does take long time for recharging the battery stack for a next range of ride.

A manual driven load carrying three-wheeler rickshaw (shown in Fig. 1a) was procured to retrofit to a solar-powered electric rickshaw model with drive train shown in Figs. 4 & 5 shows the position of the motors, batteries, and controllers under test while table VI shows the lists of various results gathered after real time road test.

This solar powered cum manual driven load carrying three-wheeler rickshaw shown in Fig 6: is optimized from version 11k in to version 1k due to incorporations of pulleys and sprockets. Also 500w permanent motor DC [PMDC] motor is used as a drive train to drive the entire vehicle with or without loads.

By decreasing the speed of motor using pulleys in between motor and rear wheel sprockets, the total power in this model version 1k is reduced when compared with version 11k. In version 11k the speed of the vehicle is around 60kmph whereas in version 1k the speed is not more than 25kmph, so that torque is increased to carry 500 kg of pay loads. This part in this project is very significant to accomplish this mission.

VI. Conclusion and Upcoming Exertion

This solar powered cargo vehicle plays an elementary part in the Indian automobile engineering. It has been investigated that function and the role of substitute technologies in this commerce, including renewable energy technologies. Study illustrates that there is ample support and a immense principle for technologies incorporating renewable energies. Real time experiments have been performed on the sustaining transportation for an electric rickshaw and on the rickshaw itself.

Experiments and testing emphasis that an all-electric three-wheeler with solar powered can accomplish a sufficient range of maneuver throughout a solitary charge. The devise well thought-out as real lessons here can go about 120 km per charge. If apt power control and solar energy input are there, it is promising to attain the common daily range of the vehicle. In connection with this, hard work should partly be paying attention on increasing the effectiveness of the electrical scheme and all motorized mechanism. Outlook investigational confirmation should focus on the solar panels mounted on the roof top. Prospect examination will also involve a comprehensive study of solar technologies, including sizing and systems. For instance, a study of the advantages of adding up a limited sun-tracking structure and MPPT method, and the tradeoffs associated with such trappings will be discovered. On account of optimizing the standard vehicles design and efficiency, auxiliary exploration of the motor and regulator effectiveness is indispensable.

(VERSION-11k)

Fig. 1a. Manual powered three-wheeler rickshaw

Fig. 1b. Retrofit solar-assisted electric rickshaw prototype

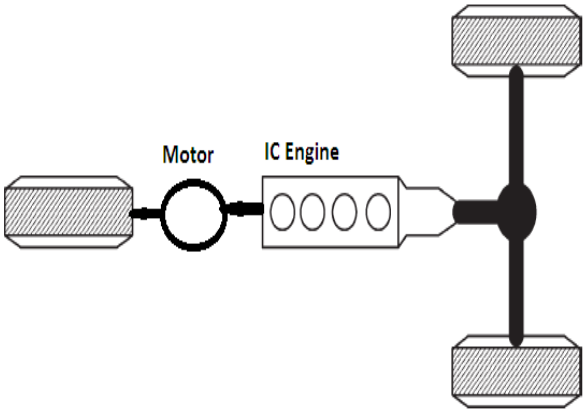

Fig. 2. Drive train of a conventional solar powered auto rickshaw three-wheeler.

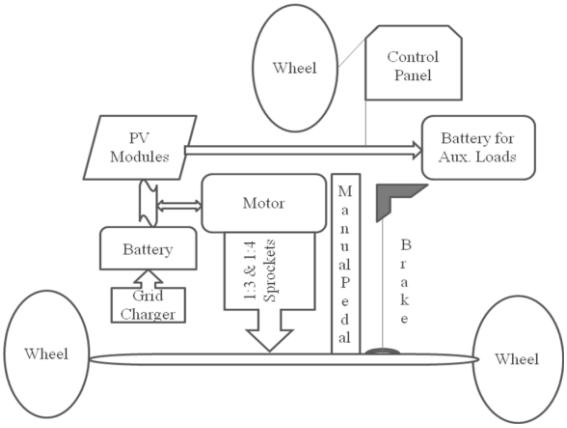

Fig. 3. Drive Train – Manual pedal retrofit three-wheeler with solar powered

Fig. 4. Drive Train – Manual pedal retrofit three-wheeler with grid powered

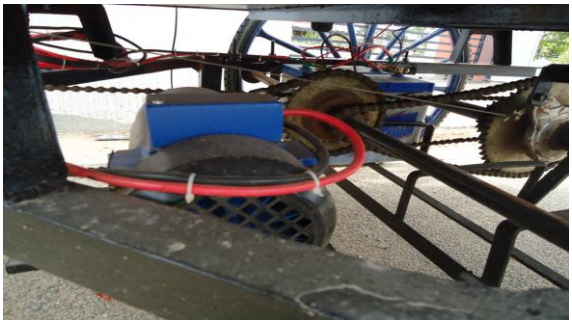

Fig. 5. Position of the motor with its sprockets & pulleys

Fig 6: optimized solar powered cum manual driven load carrying three-wheeler rickshaw

TABLE I
PHYSICAL DIMENSIONS OF Version 11k

Parameter	Value
Length	2675mm
Width	1300mm
Height	1700mm
Clearance	180mm
Frontal Area	2.09 m^2
Drag Coefficient	0.5
Centre of Vehicle mass	0.4m
Wheel Base	2000mm
Kerb Weight	280 kg
Daily distance ride	90 – 100km

TABLE II
PHYSICAL SPECIFICATIONS OF THE ENGINE BLOCK OF Version 11k

Parameter	Value
Type	4 stroke, Forced Air cooled
Weight	45kg
Displacement	175 cc
Max. Power	6kw @ 5000 RPM
Max. Torque	12.7 Nm @ 4000 RPM
Pay load	310kg (max), 100kg (avg)

TABLE III
LOAD CHARACTERISTICS OF THE Version 11k

Parameter	Value	
Top Speed	55kmph	
Grade ability	16% @ 10kmph for 300kg	
Acceleration	0 -20 kmph	4.4 sec
	0-30 kmph	6.6 sec
	0-40 kmph	10 sec
	0-55 kmph	20 sec

TABLE IV
ELECTRICAL CHARACTERISTICS OF THE Version 11k

Parameter	Value
Drive Motor	11000 w
Battery	400 ah
Solar PV Module	250 w
Range	120 km per charge
Speed	70 kmph

TABLE V
SPECIFICATIONS OF A REPLICA DESIGN FOR THE VERSION 1K

Components	Value
Drive Motor	500 w / 1500 RPM
Battery	150 ah
Solar PV Module	300wp
Range	100 km per charge
Speed	20-25 kmph
Gear Type	Sprockets
Gear Ratio	1:12

TABLE VI
RESULTS FOR VARIOUS MODES OF OPERATION

Mode	Efficiency of Gear, Rear Wheel	Efficiency of Motor	Vehicle Economy (Miles per kwh)	Range
Manual	90%	90%	10	120
Motor Without Solar	70%	73%	07	84
Motor With Solar	80%	80%	09	96
Pedal Only	90%	-	-	30

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