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DESIGN AND IMPLEMENTATION OF E-RICKSHAW

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ABSTRACT:

This topic presents model of the ELECTRIC RICKSHAW by using a brushless type DC motor and a suitable Lithium-Ion battery for the motor. Before that, we will know about what is Electric Rickshaw, how it's works and the benefits of EV RICKSHAW. Then we make an actual EV RICKSHAW model in SIMULINK with suitable block set. My main motto is to check how my RICKSHAW performs for any three standard driving cycles showing energy consumption, the temperature rises of motor and controller for vehicle cover around 100 km at constant speed driving 45 kmph. Made a comparison with Mahindra e-Rickshaw and my Simulink model.

Key words: *DC-DC Converter, Driving Cycle, Energy Management, Electrical Vehicle, Etc.*

1.INTRODUCTION:

Electric vehicles are now in revolutionary phase in India, but not so significantly in cars [1-2] Electric rickshaws (popularly known are-rickshaws or tuk-tuks) are popular in several cities of India human effort compared to pedal rickshaws. They are well accepted as an alternative to combustion engine-powered rickshaws and pedal rickshaw [3] The electric rickshaws are powered by brushless dc motors ranging from 850-1150 watts and mostly produced either in Chinaor India. An electric rickshaw offers a cheaper and eco-friendl transport facility to the low-income people [3].

Fig.1 E-Rickshaw

The electric rickshaws are powered by brushless dc motors ranging from 850-1150 watts and mostly produced either in China or India. An electric rickshaw offers a cheaper and eco-friendly transport facility to the low-income people [3]. Particularly battery electric vehicle such as electric rickshaw (e-rickshaw) has the benefits of high energy efficiency and zero-tailpipe emissions which are suitable for short distance commute within the city. India is home to about 1.5 million battery powered 3-wheeled e-rickshaw with 11,000 new e-rickshaws hitting the streets every month [4]. Also, the annual sales of e-rickshaw are expected to increase by 9% at the end of 2021[5]

The major reasons for the rise of e-rickshaw are:

1. They require lower investment than an Auto-Rickshaw and quite pleasing daily earnings than cycle rickshaws.
2. They have lower running cost as E-Rickshaw charging is easily available with conventional single phase socket at home and low operating cost model for rickshaw owners.
3. E-Rickshaw is one of the best options for passengers for quick, safe and cost effective last mile connectivity.
4. They provide mass scale employment and good source of income to the traditional rickshaw puller

These three-wheeled vehicles play the most important role as public, private and para-transit modes of transportation and they are suited to the Indian traffic environment. They play a fundamental role in the Indian auto industry. They are small and narrow, allowing maneuverability on congested roads. Despite the apparent advantages in the vehicle design, auto rickshaws present a huge pollution problem in major Indian cities. This is due to poor vehicle maintenance and the use of an inefficient engine with very little pollution control.

2. BLOCK DIAGRAM:

Electric Motor: BLDC type 650-1400W & 48V motor. It is controlled via an electronic controller. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency.

Electronic Motor Controller: Electrical E-rickshaw controller is one of the main component of the battery powered vehicle that governs its complete operation. The controller includes a manual or automatic switch turning the motor on/off, selecting forward or reverse motion, selecting and regulating speed.

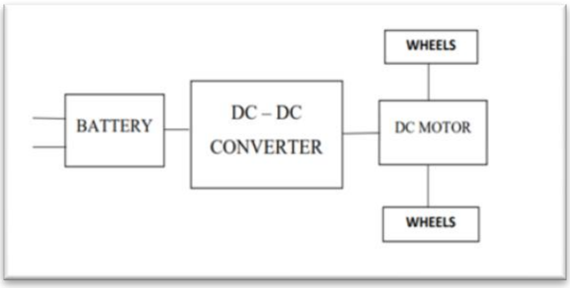

Fig.2 Block Diagram of E-Rickshaw

Battery: Set of four 12V deep cycle lead acid/Li-ion batteries.These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by starter motors.

Brakes: Drum brakes, actuated internally, expanding shoe type

Steering: Handle bar type steering.

Front Suspension: Helical Spring with dampener with hydraulic telescopic shock absorbers.

Rear Suspension: Leaf spring carriage spring with rear shocker.

Differential: Chinese manufactured differential is used in E-Rickshaws which is connected to the electric motor and rear wheels.

Speedometer/Indicator: Speedometer generally used have analog dials. The one the left side indicates vehicle speed and one on the right side indicate battery charge level. It is connected to the controller unit.

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Dc to Dc Converter: Practical electronic converters use switching techniques. Switched mode DC-to-DC converters convert one DC voltage level to another, which may be higher or lower, by storing the input energy temporarily and then releasing that energy to the output at a different voltage. It is designed to fulfill dc power requirement of e-rickshaw vehicle. It can be operated from 40v dc to 60v dc. Light weight, which allows to move from one place to another place. Input reverse connection protection.

Miscellaneous Spare parts: Centre locking, Alloy wheel, Rear light, Front glass, Front Indicator, Head light, Ignition switch, Charger, Converter, left-right switch, Type, Wirings, Throttle set etc.

3. WORKING PRINCIPAL OF ELECTRIC RICKSHAW

Working of E-Rickshaw is based on DC motor, battery & suspension system different from conventional auto rickshaws. It uses a Brush Less DC motor ranging from 650-1400 Watts with a differential mechanism at rear wheels. The electrical system used in Indian cities is 48V. Some variants made in fiber are also in use due to their strength and durability, resulting in low maintenance. It consists of the controller unit. The battery used is mostly Lead acid/Li-ion battery with a life of 6-12 months. Deep discharge/cycle batteries designed for EVs are mostly used. The working of e-Rickshaw is based on DC motor, battery & suspension system different from conventional auto rickshaws. It uses a Brush Less DC motor ranging from 650- 1400 Watts with a differential mechanism at rear wheels. The electrical system used in Indian cities is 48V. Some variants made in fiber are also in use due to their strength and durability, resulting in low maintenance. It consists of the controller unit. The battery used is mostly Lead acid/Li-ion battery with a life of 6-12 months.

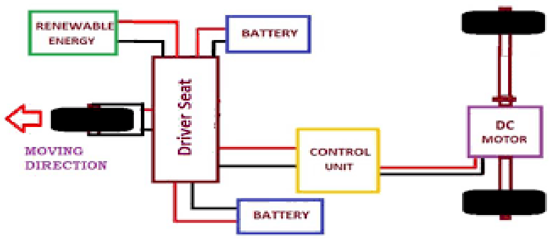

Fig3.Working Diagram

4. E-RICKSHAW SYSTEM ARCHITECTURE

The sizing of every component like energy source, electric motor, power electronic converters etc., of an E-rickshaw depends on the vehicle parameters and driving patterns. The total tractive force required by the vehicle for propulsion was calculated using Equation 1. System parameters like mass of the vehicle, frontal area etc., is available from Table 1. Vehicle velocity and acceleration is obtained from drive cycle data. Required load power is calculated as the product of total tractive force and velocity. The energy flow in a conventional electric-rickshaw is as shown in Figure 4. The vehicle dynamics of an auto-rickshaw is modeled in Matlab-Simulink environment.

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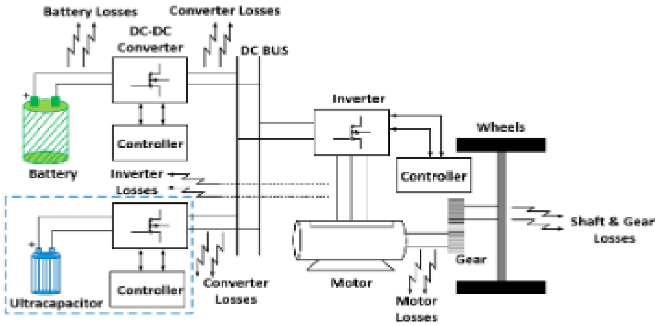

Figure 4: Energy flow diagram of an E-rickshaw with losses

The E-rickshaw is designed for the Indian City Drive Cycle (IDC)as shown in Figure 1 measured for a total time of 500 secs. The vehicle, being operated in the cities is desired to be run at a speed **not more than 40**kmph due to the frequent starts and stops in traffic. The peak velocity **is observed to be nearer at 38**kmph.

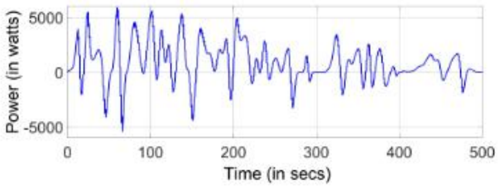

Figure 5: Load Power Requirement for Indian Drive Cycle (IDC)

The load power requirement for Indian City Drive Cycle (IDC) is shown in Figure 5. The peak power requirement was found to be approximately 5.0 kW. Considering the losses at each stages of transmission of power (source, converter and inverter), the required power to be provided by the E-rickshaw energy source was calculated. Assuming a constant source voltage of 48V (most of the E-rickshaws in India are operated with 48V Lead acid battery), the source current is calculated and as shown in figure

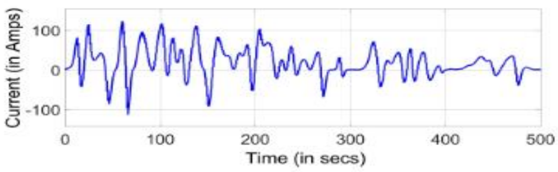

Figure 6: Source current for IDC

The proposed E-rickshaw is expected to have a driving range of75 kms and the total distance travelled a day is expected to be 150kms, there by calling for twice charging a day. The normal charging period is 2.5-3 hours. Figure 6 shows the average speed at which E-rickshaw commutes inside a city. The vehicle covers a total distance of 2.548 kms at the end of 500 secs Figure 6 atan average speed of 18.3 kmph.

5.SIMULATION RESULTS

The vehicle has been tested in Matlab-Simulink environment for different conditions of battery . The results are discussed in detail below.

Case-I: Both Battery and UC fully charged (Batt-SOC=100%&UC-SOC=100%)

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Both battery and ultra-capacitor is assumed to be fully charged at start (i.e., Initial SOC = 100%).Depending on the power requirement, battery SOC and ultra-capacitor SOC, the load power is shared between battery and ultra-capacitor as shown in Figure 7.

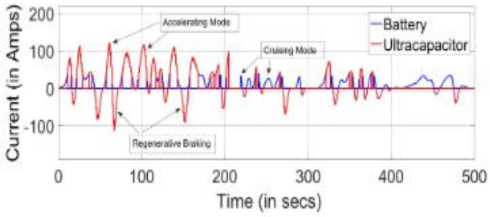

Figure 7: Case-I: Power split between Battery and UC

Case-II: Battery fully charged but UC less charged (Batt-SOC=100%&UC-SOC=25%)

Battery is assumed to be fully charged at start (i.e., Initial SOC = 100%) and ultra-capacitor is assumed to be 75% discharged. Depending on the power requirement, battery SOC and ultra-capacitor SOC, the load power is shared between battery and ultra-capacitor as shown in figure for a standard Indian drive cycle (IDC).

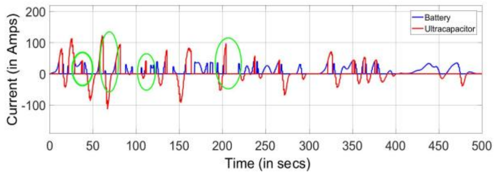

Figure 8: Case-II Power split between Battery and UC

Case-III: UC fully charged but Battery less charged (Batt-SOC=25% & UC-SOC=100%)

Battery is assumed to be initially charged at 25% (i.e., Initial SOC = 25%) and ultra-capacitor is assumed to be fully charged. Figure 8 Depending on the power requirement, battery SOC and ultra-capacitor SOC, the load power is shared between battery and ultra-capacitor as shown in Figure9

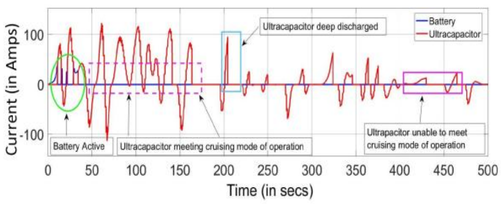

Figure 9: Case-III: Power split between Battery and UC

6.E-RICKSHAW DYNAMICS

The structure of a conventional auto-rickshaw is shown in Figure 10. The specifications of the auto-rickshaw are shown in Table 1 whose parameters are taken as reference to design the E-rickshaw power-train. Load power requirement is calculated based on the drive cycle and vehicle dynamics. Energy source sizing is carried out based on this power requirement

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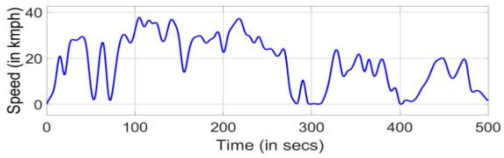

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Fig10. Indian City Drive Cycle (IDC)

E-rickshaw Dynamics table

Sl.no	Vehicle Model Parameter	Values
1	Payload [kg]	300
2	Gross Weight (m) [kg]	700
3	Width (w) [mm]	1324
4	Height (h) [mm]	1510
5	Frontal Area (A) [m2]	1.22
6	Rolling Resistance Coefficient (urr)	0.0152
7	Drag Coefficient (Cd)	0.33
8	Transmission efficiency	0.95
9	Gear ratio (Gratio)	10
10	Gravity acceleration, (g) [m/s2]	9.81
11	Air-density(d)[kg/m3]	1.25
12	Accessories power [watt]	20
13	Solar Panel [watt]	300

7.TOTAL TRACTIVE FORCE

The forces acting on a vehicle needs to be understood for an effective modeling of vehicle dynamics. The forces acting on an auto-rickshaw while hill climbing is shown in Figure 10. The tractive force generated by the electric motor of the vehicle has to experience and overcome these forces namely (a) Rolling resistance force (b) Aerodynamic drag (c) Grade resistance force and (d) Acceleration force.

The major forces acting on an E-rickshaw and their expressions are shown in Table 1. Here, M is the mass of the vehicle in kg, g is the gravitational constant, i.e., 9.81 m/s 2, Cr is the coefficient of rolling resistance, ρ is the air density in kg/m 3, A is the frontal area of vehicle in m 2 , Cd is the drag coefficient, v is the velocity of the vehicle in m/s, θ is the clockwise angle made by the slope of the road with the horizontal plain and a is the acceleration of the vehicle in m/s 2 .

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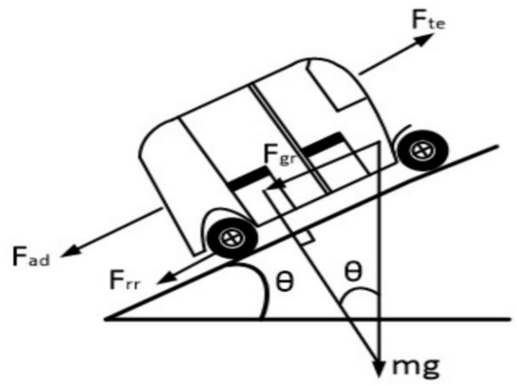

Fig11.Forces acting on an auto-rickshaw moving along a slop

The total tractive force is the force required to propel the vehicle forward by overcoming all the above mentioned forces acting on the vehicle. Neglecting all other forces acting directly or indirectly on the vehicle, the total tractive force can be obtained from the Equation 1 Fte = Frr + Fad + Fgr + Faf[3].

Force	Definition	Expression
Rolling Resistance force, Frr	The force experienced by the vehicle due to friction between the tyres and the running surface.	Cr .M.g
Aerodynamic drag, Fad	The force experienced by the vehicle due to friction with the surrounding air	1 2 .ρ.A.Cd.V 2
Grade Resistance force, Fgr	The force required to drive the vehicle upward on a slope.	M.g.Sinθ
Acceleration force, Faf	The force which is needed to accelerate the vehicle for different running velocities.	M.a

8. DISCUSSION AND CONCLUSION

This paper has attempted for the hybridization of energy sources for an E-rickshaw system architecture in Indian scenario. The performance improvement was justified using simulation and implementation in real-time results in this paper. Successful implementation of a fuzzy logic based energy management algorithm has enhanced the performance of E-rickshaw. The vehicle dynamics was calculated real-time based on an Indian city drive cycle calculated using a GPS based Performance Box tool of VBOX motorsport. The vehicle was tested for three different driving modes of operation and three different batteries and ultra-capacitor state of charge conditions. It was found that the algorithm was working perfectly with less computation time and complexity. Implementation of a hybrid energy source for an E-rickshaw can extend its driving range. Also successful absorption of the generated regenerative power can further enhance the vehicle performance

9. ACKNOWLEDGMENT

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