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ANALYSIS OF ELECTRIC TRACTION FOR SOLAR POWERED HYBRID AUTO RICKSHAW

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Abstract:

In the modern state of technological development, the future of vehicles appears to be with the hybridization of various energy sources. Auto rickshaws are three-wheeled vehicles which are commonly used as taxis for people and goods in many Asian countries in large number. Thus by hybridization of auto rickshaw tends to reduce carbon emission and also hybrid vehicle normally use the electric motor that will provide high torque at low speed which suits for an auto rickshaw. For the design of a new solar/battery powered electric auto rickshaw, the most critical components of the motor and motor controller of the drive train have to be studied to balance the design modifications in order to achieve an optimally sized and controlled system. This paper focuses precisely on the electric propulsion motor used in the hybrid vehicle. The efficiency analysis of the traction motor is used for the calculation of the overall efficiency of the drive trains of the system. This hybrid vehicle will be having solar energy as the additional sources in addition to the conventional IC ENGINES. Thus by using the solar panel, controller, and DC motor setup, the light energy will be converted into electrical energy which is fed to the DC motor to obtain mechanical motion. This mechanical motion will be transferred to wheels through chain drive in the transmission shaft which leads to cheap and effective transmission.

Keywords: hybridization, electric motor, motor controller, electric propulsion, and drive train, internal combustion engine (ICE).

Introduction:

With the increasing demand for environmentally friendly and higher fuel economy vehicles, many automotive companies are focusing on electric vehicles, hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell vehicles. Vehicle electrification can lead to significant improvements in vehicle performance, energy conservation, and polluting emissions. Research and development in vehicle electrification are widely pursued many vehicles, such as construction vehicles, rail vehicles, farm vehicles and others. A great deal of these developments is on the electrification of vehicle traction systems, such as electric traction, hybrid electric traction, and fuel cell powered traction. So that it can provide 1) high efficiency and low emissions, 2) compact and simple structure, and 3) good reliability and low cost.

Auto rickshaw is one of the major vehicles extensively used in India and in some other Asian countries as a taxi, but the design of the vehicle has not been upgraded much since it was first introduced. Auto rickshaws are mostly used in urban areas in large number. This stance a worsening pollution problem to India as the country sees a rapid growing in urban pollution due to vehicle population. This tends to increase in road traffic and making electric vehicles especially electric auto rickshaw will be a viable solution for it. The drawback of these hybrid vehicles is the range. In the design of the new solar/battery electric auto rickshaw, the drawback will be overcome by the change in the propulsion system.

Compare to other electric vehicle we tried to improve the efficiency of the hybrid electric auto rickshaw by using the series-parallel hybrid system. Like an internal combustion engine, the electric motor and motor controller each have their own efficient and relatively inefficient regions of operation. In hybrid electric vehicles, the multiple propulsion systems can be controlled in a way to complement each other, forcing highly efficient operation of each component. However, in electric vehicles, the electric propulsion system is the sole provider and so cannot be optimized to always run at an optimum efficiency. Instead, it must meet the demand of the vehicle at all times. The battery used in the vehicle is charged by solar energy, this stored energy in the battery should be consumed by the traction motor through the controller effectively. Since the speed and torque of the propulsion motor vary with respect to the demand of the vehicle, the overall efficiency may go down. Though, it has been proposed that optimizing motor and controller operation to resemble a particular driving pattern would improve the vehicle efficiency. And a higher speed motor can be used if a more complex type gear mechanism is designed.

In this paper, we will be discussing the selection of the traction motor for the hybrid electric auto rickshaw and the design of the propulsion system for the hybrid vehicle to improve its efficiency with some simulation module.

Vehicle Specification

Engine

TYPE: Single cylinder, two stoke

Displacement: 145.45cc

Maximum Power, Pmax: 4.8kW @ 5000rpm

Maximum Torque, Tmax: 12.17Nm @ 3500rpm

Transmission

Type: 4 forward, 1 reverse

Gear Ratio, G: [5, 2.93, 1.84, 1.12]

Primary Ratio, Gp: 1.13

Final drive ratio, God: 4.125

Electric System

System Voltage: 48V

Dimensions

Overall width, W: 1300mm

Overall length, L: 2625mm

Overall height, H: 1710mm

Wheelbase: 2000mm

Rear track: 1150mm

Ground Clearance: 180mm

Tyres

Front and Rear, Rw: 4.00-8, 4PR

Assumptions

Drag coefficient, Cd: 0.45

Rolling resistance, Cr: 0.01

Frontal area, Af: 2.09m^2

Block Diagram

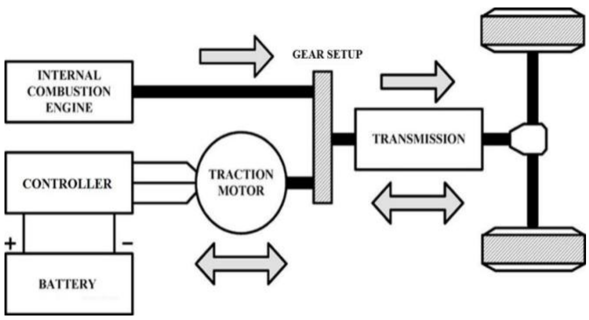

Fig.1.General Block diagram of the system.

Similar to that of the above block diagram shown in fig the hybrid vehicle is designed. Since we are using the electric motor, it as to be controlled using a controller. Both the IC engine and electric motor are coupled using gear setup with a gear ratio of 1:1 which is attached to the transmission. The battery used to run the electric motor is charged using solar panel over the vehicle.As in normal stages, the hybrid vehicle will be operated using the IC engine when the battery is charged we can switch it over to an electric motor. Similarly, when the battery is discharged the vehicle will be operated using IC engine. Thereby the hybrid vehicle can be operated in both IC engine and electric motor effectively.

Thus the electric motor used in the hybrid vehicle has to be selected in such a way that it must pull the load of the vehicle more effectively and efficiently.

Selection Of Motor

Due to the hybridisation of the auto rickshaw, the IC engine, and the electric motor has to be coupled in a proper way for an effective mechanical transmission. Since the traction motor has to run the auto-rickshaw when the IC engine is OFF, The traction motor should have the capability to pull the vehicle. Also, the load of the vehicle may vary according to the number of passenger or goods in the vehicle. Auto rickshaws are more often used in the urban areas it requires high torque at low speed, and the speed should be limited in cities according to the traffic rules. Thus for this hybrid vehicle, many choices of a motor can be used in it. Though it requires a high torque DC motor will be more suitable for it. Some factors to be considered for selecting the motor for this hybrid vehicle is the load connected to the motor, approximate input and output power of a motor, necessary torque and load current required for a motor.

Calculation for the selecting DC motor

Weight of the auto rickshaw, W = Wa +We = 650 Kg

Power of the auto rickshaw, P = 4.8 kW

Revolution of the crankshaft, N = 5000rpm

Engine torque, Te = (P*60)/ (2*pi*N) = (4800*60)/ (2*3.14*5000) = 9.17 Nm

Wheel torque, Tw= Efficiency*Gear Ratio*Engine torque = 0.75*3*4.125*9.17 = 85.10 Nm

Transmission shaft torque, Ts = (Wheel torque/Differential gear ratio) = 85.10/4.125 = 20.63 Nm

Thus after calculating the necessary torque required for the motor to drive the vehicle, a suitable motor is chosen for the propulsion system which should have torque more than the theoretical value for the safety measure.

Specification Of motor

According to the above factors and calculation, series motor, PMDC motor, and BLDC motor can be used as the traction motor. For good performance BLDC motor has been chosen as the traction motor for this hybrid vehicle. BLDC motor was chosen due to its good torque, less maintenance, less weight and compact in size.

Motor

Power Rating: 1.2 kW

Voltage Rating: 48 V

Current Rating: 25 A

Torque: 23 Nm

Speed: 3500 rpm

Maximum Load: 1250kg

Simulation Module

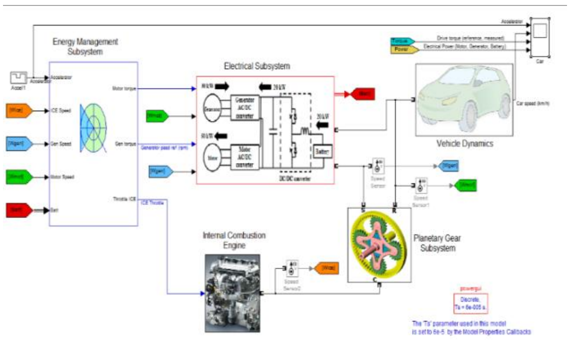

Fig.2. Simulation module of the hybrid vehicle.

By using the assumed parametric values, we have simulated the hybrid vehicle combination in MAT lab. The simulation module of the system is shown in fig. Thus by running the simulation module we got some output with are shown in fig.3 and fig.4. Where fig.3 and fig.4 show the variation of the motor speed and motor torque with respect to time respectively.

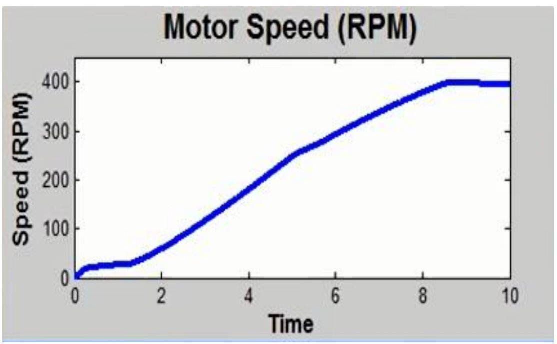

Fig.3. Graphical output of Motor speed vs Time.

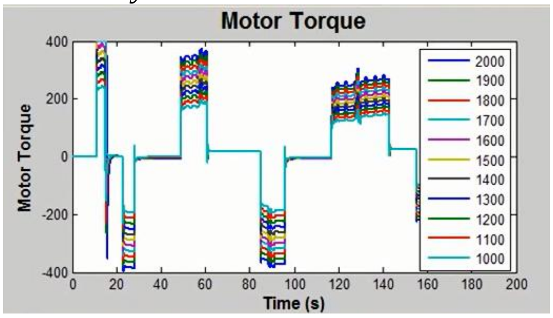

Fig.4. Graphical output of Motor torque vs Time.

Using the simulation module the speed, voltage and current response of the motor is obtained by varying the parameters of the electrical subsystem module. The figure shown below are the response of the simulation module for a single drive cycle.

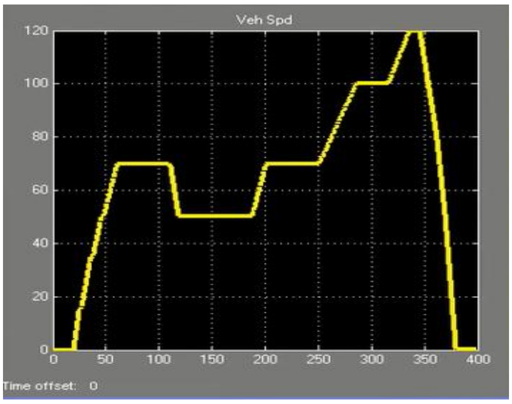

Fig.5. Drive cycle of the hybrid vehicle.

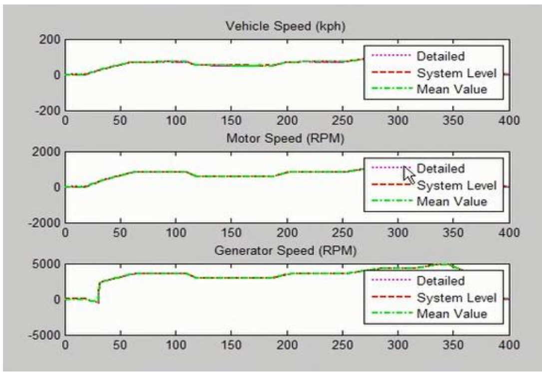

Fig. 5(a). Speed response of the system with respect to drive cycle.

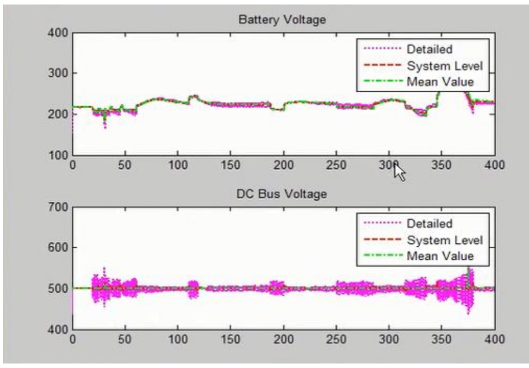

Fig. 5(b). Voltage response of the system with respect to drive cycle.

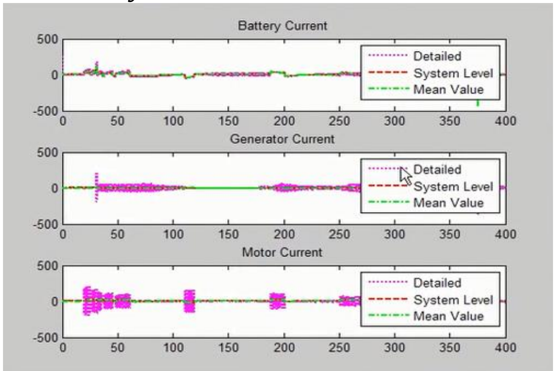

Fig. 5(c). The current response of the system with respect to drive cycle.

Result

Thus by the theoretical calculation and with the help of the simulation module, the suitable electric propulsion motor for the hybrid vehicle is chosen and implemented in the hardware module. For our hybrid vehicle, we used 1.2kW electric motor for the propulsion system .The performance of the hybrid electric auto rickshaw was good. In future, the specification can be modified to the efficiency of the hybrid electric vehicle

Conclusion

Thus by using the theoretical calculation and the simulation result we assisted for the BLDC motor for our project for compact and effectiveness. And by varying the value of rating and speed of the motor with some other parameters, we found that the electric propulsion efficiency can be increased. The lower speed with higher power rating can give good mileage for the hybrid vehicle. Since we used low rating motor in our project, the mileage of our vehicle is less. This disadvantage can be solved by using higher rating motor as said before. Similarly, with appropriate control and transmission, we could use higher speed motor by limiting its operation for more efficiency.

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