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Design and Development of Electric Tri-Wheeler

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***Abstract* – Vehicles used for travelling longer distance is in paramount to the world. But least is used to travel at shorter distance. People either prefer to walk or cycle to reach their nearest destination in which it involves a much load of man power. In order to overcome this an electric tri-wheeler is introduced in which the vehicle is used for smaller distance travel to reach the nearest desired place with shorter time period and less man power. It is mainly focused on electrical working for the transportation which overcomes the fuel usage of vehicle which runs in demand in present days. The electrically driven motor from the battery makes the shaft of the rear wheels rotate and also a steering system is provided at the front wheel adopted from a conventional bi-cycle. The movement of the vehicle is controlled by a controller and a throttle twist in which a braking system is also used. Thus through these ways the transportation is made in easy and simpler ways for the better usage of vehicle in shorter distance.**

I. INTRODUCTION

Electric powered vehicles are becoming an increasingly popular and highly viable form of transport, particularly for short distances such as daily commutes to work or school. There are a number of factors driving this expansion; primarily the development of technology used in electric vehicles, making them an attractive option in many cases. Development of battery technologies, specifically Lithium chemistry batteries, has resulted in batteries being produced that have much higher energy density than previously. The discharge and recharge rates of Lithium chemistry batteries is far superior to other battery chemistries. There are many advantages of using electric motors over internal combustion engines; the running cost is very low, they can achieve near silent operation, and there are no emissions. However there are also limitations; to get the same range as an internal combustion engine driven vehicle, they need large and expensive battery packs.

Given these limitations, this Masters project aims to focus on investigating the gains in performance that can be achieved using advanced motor control techniques, and to apply these to a small electric powered vehicle to compare the performance to that of a typical motor controller.

A. LITERATURE REVIEW

1. Alex Rowe (2016) An electric powered skateboard was designed and built for testing and development of an innovative hub motor propulsion system and motor controller. The electric skateboard prototype is able to reach speeds of over 50km/h and achieve a range of over 35km on a single battery charge. The prototype weighs 8.6kg and can easily be carried by the user. This mode of transport has potential uses in recreational use, motor sports (racing), short commutes, and most notably, in 'the last mile' of public transport – getting to and from a train station, bus stop, etc. to the user's final destination.

Typical electric powered skateboards use external motors(s) requiring a power transmission assembly to drive the wheels. The hub motor design places the motor(s) inside the skateboard wheels and drives the wheels directly. This removes the need for power transmission assemblies therefore reductions in size, weight, cost, audible noise, and maintenance are realized. The hub motor built for this prototype has proven to be a highly feasible option over typical drive systems and further improvements to the design are discussed in this report.

Advances in the processor capability of low cost microcontrollers has allowed for advanced motor control techniques to be implemented on low cost consumer level motor controllers which, until recent times, have been using the basic 'Six-Step Control' technique to drive Permanent Magnet Synchronous Motors. The custom built motor controllers allow for firmware to be flashed to the microcontroller. Firmware was written for the basic motor control technique, Six-Step Control and for the advanced motor control technique, 'Field Oriented Control' (FOC). This allowed for the two control techniques to be tested and compared using identical hardware for each.

Six-Step Control drives a three-phase motor by controlling the inverter output to six discrete states. The states are stepped through sequentially. This results in a square wave AC waveform. Theory shows that this is not optimal as the magnetic flux produced in the stator is not always perpendicular to the magnet poles but rather aligned to the nearest 60°. FOC addresses this by controlling the magnetic flux to always be perpendicular

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to the magnet poles in order to maximize torque. The inverter is essentially controlled to
produce a continuously variable voltage vector output in terms of both magnitude and direction (vector control).
2. Vishwabarathy.P (2017) Environmental protection and energy conservations are the main concern of 21st century which has now accelerated the pace to plan and develop electric vehicle technology. The electric vehicles (EVs) offer a zero emission, new automobile industry establishment, and economic development, efficient and smart transportation system. This project having a foot controlled steering system to control the vehicle easily. It designed to suitable for any road conditions and to reduce the effort of a rider to drive skateboard easily. Currently the permanent magnet brushless direct current motors are the present choice of automobile industries and researchers because of its high power density, compact size, reliability, and noise free and minimum maintenance requirements. Initially thus the designing of the vehicle in CAD and CRE-O, and simulations models are done. Equipment and cost analysis are done. It deals with the fabrication of vehicle. This includes assembly of skateboard and electric hub motor drive and designing the controllers. Thus the final stage is to improve the design model of the e-board for off road conditions and suitable for the physically challenged persons. The objective of this project to improve the driving mode of skateboard on off road condition by centerized electric wheel on the board and to reduces the effort of skateboard even on uphill area and to design it with foot steering for to improve the steering sensitivity of the skateboard. Dependence on non-renewable resources using latest technology.

II. PROBLEM DEFINITION

The movement of the individual person within a larger premises is difficult and energy consuming just because to move from one block or station to another. Though we can use the mode of conventional transportation it cannot be provided in concern for a single person utilization as it includes more of economical and environmental factors. Hence there were alternatives introduced like bi-cycle, skateboard etc., But these need a certain type of training which means it cannot be accessed by all members in an organisations.

Design Objectives

It was desired to create a prototype DC motor drive for an electric tri-wheeler application. Therefore, a high-performance electric tri-wheeler was selected as the basis for the Light Electric Vehicles prototype for this Masters project. Some key performance objectives were identified for the electric tri-wheeler, as listed below:

- Reach a top speed of 20km/h.
- Achieve a range of 15km at a speed of 10km/h on an overall level route.
- Achieving these objectives would result in a high performance and highly practical LEV for not only

recreational use, but also for what some authors call to “the last mile” of travel in public transport. This refers to the gap in where public transport ends and the commuter’s final destination, for example, from a train station to a person’s workplace.

MATERIALS

Mild steel

Mild steel, also known as plain-carbon steel and low-carbon steel, is now the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. It is iron containing a small percentage of carbon, strong and tough but not readily tempered. Mild steel contains approximately 0.05–0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing.
Rubber Rubber exhibits unique physical and chemical properties. Rubber's stress–strain behaviour exhibits the Mullins effect and the Payne effect and is often modelled as elastic. Due to the presence of weakened allylic C-H bonds in each repeat unit, natural rubber is susceptible to vulcanisation as well as being sensitive to cracking. The only two main available solvents for the material, rubber are turpentine and naphtha (petroleum). Because rubber does not dissolve easily, the material is finely divided by shredding prior to its immersion, Rubber begins to melt at approximately 180 °C (356 °F). Plywood Plywood is a material manufactured from thin layers or "plies" of wood veneer that are glued together with adjacent layers having their wood grain rotated up to 90 degrees to one another. It is an engineered wood from the family of manufactured boards which includes medium-density fibreboard (MDF) and particle board (chipboard). All plywood bind resin and wood fibre sheets combine to form a composite material. This alternation of the grain is called cross-graining and has several important benefits: it reduces the tendency of wood to split when nailed in at the edges; it reduces expansion and shrinkage, providing improved dimensional stability, etc. There is usually an odd number

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of plies, so that the sheet is balanced—this reduces warping.

III.COMPONENTS

Batteries

A battery is made up of a number of cells connected together in series to achieve the desired voltage. The battery nominal voltage is the single cell nominal voltage multiplied by the number of cells connected in series. A battery is typically given a capacity rating which is measured in amp hours (Ah) and quantifies the amount of time that the fully charged battery can sustain a load for until it is fully discharged. When comparing the amount of energy a battery can supply in a single charge, the battery voltage must also be taken into account. Therefore when comparing batteries of different chemistries, the metric watt hours (Wh) is used:

Energy Capacity [Wh] = Current Capacity [Ah] x Voltage [V]

Lithium-ion chemistry batteries are superior over other battery chemistries by measures of specific power and specific energy capacity. There are numerous varieties of Lithium-ion batteries available, each with advantages and disadvantages over others in the Lithium-ion family. The most common Lithium-ion battery is Lithium Cobalt Oxide (LiCoO2) which is used in mobile phones, laptops, etc. due to having the high specific energy and favorable safety characteristics. Lithium Nickel Manganese Cobalt Oxide (LiNiMnCo2), also known as NMC is often used in electric vehicles due to its high specific power rating and high specific energy.

Motor

The electric motor is the machine which converts electrical energy to a mechanical torque. Electrical current flowing through the motor windings creates an electromagnetic field which interacts with the 'rotor' magnetic field to produce a force on the rotor, causing it to rotate.

There are many different types of electric motors available, each having its own advantages and disadvantages and suitability to a particular application. The different types of motors and applications are vast and therefore this report will not provide an exhaustive discussion on this topic. Motors can be classified by the type of electrical current they require as an input to make the motor rotate continuously – either AC or DC.

A DC motor is one that will rotate continuously when a DC voltage is applied to the motor terminals. A commutator mechanism is used to switch path of the direct current between the discrete windings inside the motor in order to achieve continuous rotation of the rotor. DC motors are still widely used due to the ability to run directly from a battery, and for their simplicity to drive at a variable speed through a DC motor controller, as the controller does not commutate the motor as with an AC motor controller.

4.4.5. Motor Control Theory

Motor control theory refers to the various methods of controlling a motor's speed and/or torque. With many different types of motors available, each with specific control requirements and typically many different methods of control available for each motor type, the field of motor control theory is vast. This thesis will not attempt to summaries the entire field of motor control theory, rather the scope of this thesis will be limited to motor control methods used for the PMSM. PMSMs are widely used in electric vehicle applications ranging from full size passenger cars to smalll electric vehicles such as electric bikes and skateboards.

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4.2. Motor Controller

The purpose of the controller is to control the speed and/or torque output from the motor, based on inputs from the user and other various sensors. It does this by modulating the voltage to the motor, using Pulse Width Modulation (PWM). Most motor controllers used in electric vehicles have some form of current sensing to allow for current limiting or current regulation.

Pulse Width Modulation (PWM) is a technique used to modulate an output by switching an input on and off at some fixed frequency. The ratio of the time that the switch is in the on state to the time that the switch is in the off state is known at the duty cycle. In the case of a motor controller, the input is the battery voltage which passes through a semiconductor switch to the motor. The average voltage applied to the motor is equal to the battery voltage multiplied by the duty cycle. Motor controllers use an H-bridge scheme for the switches which allows for current to pass through a motor winding in either direction.

Throttle

A 'throttle' input from the user is used to vary the voltage to the motor according to how much throttle input the user is giving. This input is usually used to vary the power to the motor by performing one of the following:

 Throttle input is used to directly adjust the PWM duty cycle.

 Throttle input is used to set a speed reference set-point. The motor controller software uses a control algorithm (for example, a PID controller) to adjust the PWM duty cycle in order to attempt to achieve an actual motor speed that is the same as the speed reference set-point.

Steering

The steering system adopted from a conventional bi-cycle is made to fix to the platform of the vehicle using welding technique. A bicycle handlebar is the steering control for bicycles; it is the equivalent of a steering wheel for vehicles and vessels. Besides steering, handlebars also often support a portion of the rider's weight, depending on their riding position, and provide a convenient mounting place for brake levers, shift levers, cycle computers, bells, etc. Handlebars are attached to a bike's stem which in turn attaches to the fork. The design goals of handlebars vary depending on the intended use of the bicycle. Common to all bicycles:

- Providing the necessary leverage to steer the bicycle.
- Proper positioning of the rider's hands according to the purpose and style of the bicycle.
- Providing a mounting platform for brake and gear levers as well as various accessories.
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IV. DESIGN AD MODELLING

Modelling software is used to show case the product in batter ways for understanding before the fabrication part is done.

Front view

Side view

Isometric view

V. FABRICATION OF TRI-WHEELER

Fabrication & working

The fabricating of the Electric tri wheeler starts with the frame making in which the platform is made of mild steel material in a rectangular shape with a dimension of 60x45cm.The mild steel used if a hollow rectangular plot which is made to cut as per the desired dimensions and the platform is fixed using welding technic. Once the platform is made the steering system is fixed to the platform. The steering system is adopted from the conventional bi-cycle. The major reason for adopting from a conventional bi-cycle is that it can be easy to control while on turning and also it has a zero turning radius. Next to the frame, the rear wheels are attached to the platform .A shaft of 1inch diameter with length of 60cm is used to attach the wheels and fix to the platform. The rear wheels used here is both of different ones. One wheel is of bush type and other wheel is fitted with bearing. The reason for using this type of technic is that it is very much useful while on turning and thereby avoids skidding. Thus it acts as a mini differential. Further on the electrical equipment's are fixed at correct positions for making the vehicle move. The battery used here is of lithium-ion battery for the purpose of rechargeable. The battery is fully laminated and it weighs of 1kg with compact in size. The battery is placed at the front bottom portion of the vehicle and the connections are given as per required. This DC motor is most preferred for the Light Electric Vehicles (LEV) in order to make the movement of the vehicle in perfect manner. Through this power driven motor, the rear wheels are made to rotate by transmitting the power to the rear shaft. The transmission

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is made through the chain and sprocket method in which a sprocket is fixed to the middle of the rear shaft and a chain is connected to the motor and the sprocket. A controller and a throttle twist is used in this Light Electric Vehicle (LEV) in order to make the movement simpler and easier. Braking system is also provided at the front wheel in order to stop the movement of the vehicle. The braking system used here is a manual system braking. An ON/OFF switch is placed at the mid of the handle bar position in which it is used in turning on/off of the vehicle.

VI. RESULT AND DISCUSSION

The maximum speed that the vehicle could move is at 20kmph and the average speed is at 10-15kmph.The vehicle can continuously run at the battery capacity of 90 minutes. Further on the battery should be recharged for further movements. The Final product images are as below.

Front view

Side view

VII. CONCLUSION

The Light Electric Vehicles (LEV) which are underrated in present times will the most wanted vehicles in next one or two decades. One among them is an Electric tri wheeler which will serve the people for there better usage of vehicle to move to their nearest desired place with shoter time. Thus EV's both mode of operation occurs at their maximum efficiency. It is most efficient in urban areas mainly in vast areas Electric Tri-wheeler is used with more efficient. It can be suitable for the transportation on the industrial supervision. The charging behaviour is improved by use of the lithium battery and high speed charging will occur. Equipped with modern electrical components and techniques, the electric tri wheeler will provide a safe and smooth movement of the vehicle with a long lasting life since it has many more of advantages and over comes many crisis and problems faced at current times and it will be a better alternative to the people in the society with minimum resources and maximum utility.

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