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Design and Fabrication of Voltaline Bike (Dual Mode Power Drive)

M.Arumugam
Assistant Professor, Department of Mechanical Engineering, Shivani Engineering College, Tiruchirappalli, India.

R.Ajithkumar
UG Scholar, Department of Mechanical Engineering, Shivani Engineering College, Tiruchirappalli, India.

M.Ignatius sudhan
UG Scholar, Department of Mechanical Engineering, Shivani Engineering College, Tiruchirappalli, India.

A.Mohamed azarudeen
UG Scholar, Department of Mechanical Engineering, Shivani Engineering College, Tiruchirappalli, India.

Abstract – In automobile sector, the need for alternative fuel replacement of conventional fossils fuels, due to its depletion and amount of emission has given way for new technologies like Electric vehicle, Natural Gas Powered vehicle,. etc. Still lot of advancement has to place to in these technologies for commercialization. The gap between the current fossils fuels technology and zero emission vehicles can be bridged by hybrid technology. This technology maximize the advantage of the two fuels and minimize the disadvantages of the same. In this project our hybrid bike delivers the power both via an Internal Combustion Engine and Electric Motor .The Electrical powered is used to achieve either better Fuel Economy than a Conventional vehicle, better performance, and it cause less pollution. Driving mode selectivity improves this system more economical, stable and efficient. The hybrid system have long been existed and they are not a new technology. The hybrid system are strong enough to suggest that is much advanced than a conventional vehicle and it is highly beneficial to our environment.

Index Terms – Scooty , BLDC Motor, hall sensor, battery, cero 3.0,ansys 14.0.

1. INTRODUCTION

Around 93% of today's automobiles run on petroleum based product, which are estimated to be depleted by 2050. Moreover, current automobiles utilize only 25% of the energy released from petroleum and rest is wasted into the atmosphere. Despite recent efforts to improve fuel efficiency and reduce toxic emissions in cars, emissions have continued to increase steadily in the past two decades.An electric vehicle is pollution free and is efficient at low speed conditions mainly in high traffic areas. But battery charging is time consuming. Moreover, it cannot provide high power required by drives during high speed conditions or in slopes of hilly areas. Gasoline engine proves its efficiency at higher speeds in high ways and waste a lot of energy in urban areas. A hybrid vehicle solves these problems by combining the advantages of both the systems and uses both the power sources at their efficient conditions. The objective of this project aims at better utilization of fuel energy and reduces dependence on non-renewable resources using hybrid technology. The implementation involves development of voltaline bike (Dual mode power drive) that uses battery as well as gasoline power for propulsion of vehicle.

A Voltaline Bike is an automobile which relies not only on gasoline but also on electric power source. In Voltaline bike, the battery alone provides power for low-speed driving conditions. During long highways or hill climbing, the gasoline engine drives the vehicle solely. Voltaline bike comprise of an electric motor, battery as electric drive and an internal combustion engine with transmission connected as gasoline based drive. It is to achieve better fuel economy and reduce toxic emissions. It has great advantages over the previously used gasoline engine that is driven solely from gasoline. This hybrid combination makes the vehicle dynamic in nature and provides its owner a better fuel economy and lesser environmental impact over conventional automobiles.

This design consists of a dc power source battery. The battery is connected to the controller and that is connect to a HUB motor that works on DC. The hub motor is attached in both the front and back of the wheels in the two wheeler vehicle. As the motor rotates the attached wheel rotates too, thus, leading to vehicle motion. At low speeds this mode of propulsion is used. The next phase consists of an IC engine that moves the piston continuously.

2. LITERATURE REVIEW

Darshil G. Kothari, Jaydip C. Patel, Bhavik R. Panchal[1].The term "hybrid" usually implies that more than one energy source is used to power all or part of a vehicle's propulsion

Rechargeable battery is used with long life for charging. DC electric motor is also used in this project. The hybrid bicycle is a project that can promote both cleaner technology as well as a lesser dependence on oil. It will run on clean electric power with the ability to recharge the battery 3 separate ways: through the charger, by generating power through the pedals of the bicycle, and by solar-cell generative power.

Arun Eldho Alias1, Geo Mathew2, Manu G3, Melvin Thomas4, Praveen V Paul5[2]. Hybrid vehicles are those which can run on two or more powering sources fuels. This technology maximizes the advantages of the two fuels and minimizes the disadvantages of the same. The best preferred hybrid pair is electric and fossil fuel. Driving mode selectivity improves this system more economical, stable and more efficient.

Zhidong Zhang [3]. a design of brushless DC motor controller strategy applied to the electric bicycle control system was presented in the paper. Function of over-current protection, under-voltage protection and helping were accomplished. Schematic diagrams of each function and drive circuit were given in the paper, the controller was debugged in rated voltage 36V and power rating 250W brushless DC motor, experiment turned out controller has better dynamic characteristics and ran steadily.

Said Mahmut Çinar, Fatih Onur Hocaoğlu [4]. In this paper joint performances of two hub motors that are designed for electrical motorcycles are investigated.

Nicolo Daina, Aruna Sivakumar., John W. Polak [5] This paper provides a systematic review of these diverse approaches using a twofold classification of electric vehicle use representation, based on the time scale and on substantive differences in the modelling techniques.

3. CONVVENTIONAL VEHICLE

An engine is a device that transforms one form of energy to another and if an engine converts thermal energy to mechanical works, it is called as heat engines. A heat engine converts the stored chemical energy of the fuels to thermal energy and finally this thermal energy is converted to mechanical work. A throttle valve controls the volume of the air that needs to be drawn. Air cooled system:

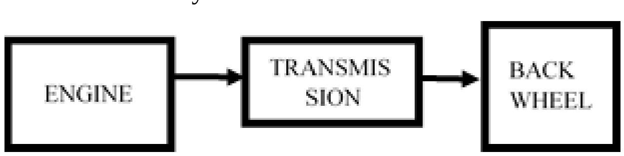

Fig 1.Transmission system in conventional mode

In this, a current of air is made to flow past the outside of the cylinder barrel, outside surface area of which has been considerably increased by providing cooling fins. The heat transfer rate is quiet low between metal and air, thus suitable for light weight engines. Cooling fins are cast integral with the cylinder and cylinder head to obtain maximum heat transfer.

4. ELECRICAL DRIVING MODE

The underlying principles for the working of a BLDC motor are the same as for a brushed DC motor; i.e., internal shaft position feedback. Most BLDC motors have three Hall sensors embedded in the stator on the non driving end of the motor. Whenever the rotor magnetic poles pass near the Hall sensors, they generate a high or low signal, which indicates that N or S pole is passing near the sensors. Based on the combination of these Hall Sensor signals, the exact sequence of commutation can be determined. In case of a brushed DC motor, feedback is implemented using a mechanical commutator and brushes. The most commonly used sensors are hall sensors and optical encoders.

Fig 2. Electrical mode driving

ELECTRICAL COMPONENTS

- Motor
- Battery
- Controller
- throttle position sensor

4.1 MOTOR

Motor is made up of skillful wrapping of coils on a stator, a rotor for the rotation, and magnets to influence the rotations. The magnets used their work Electro magnetically. That means electricity influences this iron to behave like a magnet, having both attraction and repulsion characteristics of a magnet into this, thereby helping it to generate the motion accompanying this. The principle in this is to switch the direction of the forces to keep the motor to move continuously, once it is started until the time it is stopped. There are two types of motors commonly used in e-bikes, one is brushed motor and another is brushless.

4.1.1TYPES OF DC MOTOR

Lists the comparisons of the different DC Motors available.

Type	**Advantages**	**Dis-advantages**	**Typical application**	**Typical drive**
Stepper DC	Precision positioning Stepper DC High holding torque	Slow speed Requires a controller	Positioning in printers and floppy drives	Multiphase DC

Brushless DC electric motor	Long lifespan low maintenance High efficiency	High initial cost Requires a controller	Hard drives CD/DVD players Electric vehicles	Multiphase DC
Brushed DC electric motor	Low initial cost Simple speed control	High maintennce (brushes Limited lifespan	Treadmil exerciser Automotive	Direct (PWM)

Table 1 DC Motors

4.1.2 BRUSHED VS BRUSHLESS HUB MOTORS

Modern e-bikes all prefer to use "brushless" hub motors, just because they are more durable than its “brushed” counterpart, besides the maintenance cost in them is also very little. Limited in quantity making them expensive comparatively. But in the long run they seem to be lot reliable. Both by the cost and performance. They function little differently again as are described here below.

BRUSHED HUB MOTORS

In a brushed hub motor, small metal "brushes" which transfers electrical energy to the commuter, a rotating part of the motor. This replacement is not so expensive but to manage this work itself is not so easy.

BRUSHLESS HUB MOTORS

In a brushless motor, as there is no physical contact from any parts of the motor inside, therefore there is virtually no wear and tear possibilities, making the motor’s durability limitless. These motors have more sophisticated controllers, and it makes it possible for using three different windings, and power is supplied individual Windings according to the position they are in the movement. When the motor passes one winding, the controller passes the power to another winding, making the movement to continue without stopping. These types of motors are quite popular nowadays.

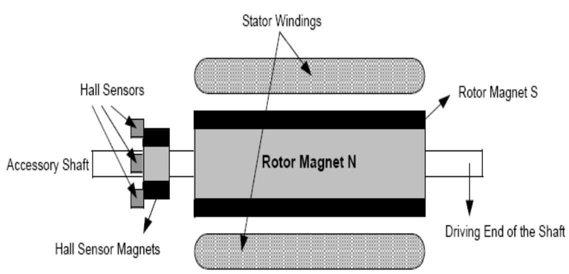

Fig 3 Construction of BLDC Motor

4.1.3 SPECIFICATIONS FOR BLDC MOTOR CONTROLLER

SL No	Particulars	Specifications
1	Rated Capacity	30KW
2	Input Voltage	36 - 48V DC
3	Rated Current (Max.)	15 Amp
4	Starting current	Not exceeding 2 times of nominal Current
5	Over current Limit	20% of nominal
6	Speed Range	300 RPM(±10%)
7	Overvoltage Limit	10% of nominal voltage.
8	Motor feedback	Hall effect sensors
9	Commutation	Trapezoidal
10	Mode of operation	Velocity mode(closed loop control)
11	Input signals	Run/Stop Emergency stop.
12	Display/Indications	LCD display for voltage, current, Frequency& speed.
13	Operating temp./Humidity	0 - 55ºC/ 95(+/-3%)
14	Approx Size	≤ 500 x 150 (D x W) in mm
15	Cooling for Inverter	Heat pipe to make controller Compact

Table 2 specifications for BLDC motor

4.1.4 ADVANTAGES OF BLDC MOTOR:

- ✓ High Speed Operation – A BLDC motor can operate at speeds above 10,000 rpm under loaded and unloaded conditions.
- ✓ Responsiveness & Quick Acceleration – Inner rotor Brushless DC motors have low rotor inertia, allowing them to accelerate, decelerate, and reverse direction quickly.
- ✓ It has no mechanical commutator and associated problems
- ✓ High efficiency due to the use of permanent magnet rotor

4.2 BATTERY

Batteries operate by converting chemical energy into electrical energy through electrochemical discharge reactions. Batteries are composed of one or more cells, each containing a positive electrode, negative electrode, separator, and electrolyte. Cells can be divided into two major classes: primary and secondary.

4.2.1TYPES OF BATTERY

Primary cells are not rechargeable and must be replaced once the reactants are depleted. Examples of primary cells include carbon-zinc (Leclanche or dry cell), alkaline-manganese, mercury zinc, silver-zinc, and lithium cells (e.g., lithium-manganese dioxide, lithium-sulfur dioxide, and lithium chloride).

Secondary cells are rechargeable and require a DC charging source to restore reactants to their fully charged state. Examples of secondary cells include lead-lead dioxide (lead-acid), nickel-cadmium, nickel-iron, nickel-hydrogen, nickel-metal hydride, silver-zinc, silver-cadmium, and lithium-ion.

Batteries are rated in terms of their nominal voltage and ampere-hour capacity. The voltage rating is based on the number of cells connected in series and the nominal voltage of each cell (2.0 V for lead acid and 1.2 V for nickel-cadmium). 12-volt lead-acid batteries, consisting of six cells in series, are also used in much general purpose. The ampere-hour (Ah) capacity available from a fully charged battery depends on its temperature, rate of discharge, and age. Normally, batteries are rated at room temperature (25°C), the C-rate (1-hour rate), and beginning of life.

Electrochemistry Cell	**Voltage**
Lead-Acid	2.0
Nickel-Cadmium	1.2
Nickel-metal hybride	1.2
Lithium-ion	3.4
Lithium-polymer	3.0
Zinc-air	1.2

Table 3 Average Cell Voltage during Discharge in various Rechargeable batteries

4.2.2SELECTION OF BATTERY

Battery	**Operating temperature range ºc**	**Overcharge Tolerance**	**Heat Capacity Wh/kg-k**	**Mass density kg/liter**	**Entropic heating on discharge W/A-cell**
Lead-Acid (Pb-acid)	-10 to 50	High	0.35	2.1	-0.06
Nickel-Cadmium (NiCd)	-20 to 50	Medium	0.35	1.7	0.12
Nickel-metal hybride	-10 to 50	Low	0.35	2.3	0.07
Lithium-ion	10 to 45	Very Low	0.38	1.35	0
Lithium-polymer	50 to 70	Very Low	0.40	1.3	0

Table 4 .Characteristic of battery

Battery	**Cycle life in full discharge cycles**	**Calendars life in years**	**Self discharge rate %/month at 25ºC**	**Relative cost $/KWh**
Lead-Acid(Pb-acid)	500-1000	5-8	3-5	200-500
Nickel-Cadmium	1000-2000	10-15	20-30	1500
Nickel-metal hybride	1000-2000	8-10	20-30	2500
Lithium-ion	500-1000	----	5-10	3000

Lithium-polymer	500-1000	----	1-2	>3000
Zinc-air	200-300	----	4-6	----

Table 5.Life and Cost Comparison of Various Batteries

Because of the least cost per deliver over the life, the lead acid batteries is best suited for the vehicle application where the low cost for the customers are necessary.

4.2.3 LEAD-ACID BATTERIES

Lead-acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. Large-format lead-acid designs are widely used for storage in backup power supplies in cell phone towers, high-availability settings like hospitals, and stand-alone power systems. **Gel-cells** and **absorbed glass-mat** batteries are common in these roles, collectively known as VRLA (valve-regulated lead-acid) batteries.

4.2.4 BATTERY SPECIFICATION

Nominal voltage (v)	12v
20 hour rate (0.25 a to 10.50v)	5ah
10 hour rate (0.475 a to 10.50v)	4.75ah
5 hour rate (0.85 a to 10.20v)	4.25ah
1c (5a to 9.60v)	2.833ah
3c (15a to 9.60v)	2.0ah
Weight	approx. 4.18lbs. (1.9kg)
Charging Methods at	$25^{0}C$ ($77^{0}F$)

Fig 4. Battery

4.3 CONTROL KIT

There are mainly two types of controllers which are designed to be effective on two types of motor, one is brushed, and another is brushless. According to the motor in use the controller function also varies. Brushless motors are popular nowadays because of high efficiency and durability, and it is also supported by the reduced cost factors, where as brushed motors because of less complex controller mechanism, is still in use fairly.

Fig 4 controller

CONTROLLERS USED IN BRUSHLESS MOTORS

There are various sensors used to check and control the speed movements. To do this quite efficiently, Hall sensor is used. The reason is also that e-bike requires strong initial torque to complement the low powered motor, this mechanism to control with safe the speed, the sensor has special functions to monitor the speed accurately. Various electronic controllers provide real time data input to the controller to react according to the situation

The controllers work with closed-loop speed control mechanism for precise speed control, by adjusting the speed and also over-voltage surge, over-current input, or other levels of protections. Controller uses PWM (pulse width modulation) to adjust the power input to motor

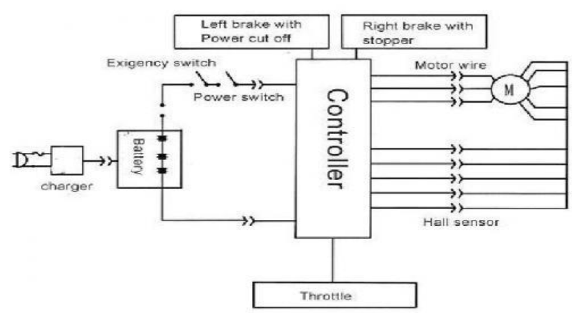

Fig 5 contoller circuit

4.5 THROTTLE POSITION SENSOR

A throttle position sensor is a sensor used to monitor the position of the throttle in an internal combustion engine. It consists of hall sensor .when the accelerator throttle angle 13 magnetic field is created and it creates voltage Across position sensor terminal. The battery connect to the control kit then the control kit connect to parallel connection in throttle and motor.so throttle adjust the angle the various speed obtain in the motor.

5. HYBRID VEHICLE

A hybrid vehicle uses two or more distinct types of power, such as internal combustion engine plus electric motor. e.g. in petrol-electric trains using petrol engines and electricity from overhead lines, and submarines that use petrol when surfaced and batteries when submerged. Other means to store energy include pressurized fluid in hydraulic hybrids.

The project discloses a hybrid system consisting of an Electric and Internal Combustion(IC) based power drives. The front wheel is being propelled by battery and the rear wheel is powered by propelled by battery and gasoline, i.e, it includes a single cylinder, air cooled internal combustion engine and a BLDC motor based electric power drive used for hybrid powering of the vehicle. The controller is designed to implement the switching between IC Engine and Electric motor depending on the power requirement and load conditions.

5.1CAD MODEL OF VOLTALINE BIKE:

Fig 6.Rendered View

Fig 7.Front Rendered View

Fig 8.Side Rendered View

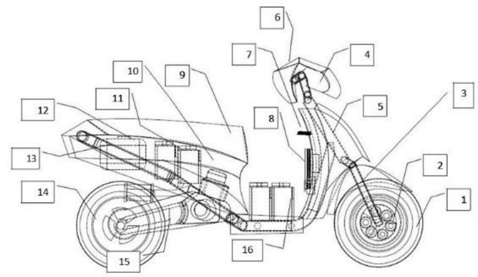

Fig 9.Wire frame model

1) Tyre 2)Hub Motor 3)Suspension 4)Headlamp

5) Body Cover 6) Display 7)Microcontroller 8)Controller 9) Seat 10) Engine 11) front battery set

12) Fuel Tank 13) 13)Chassis 14) Rear Tyre

15) Transmission 16) Rear Battery

5.2 BLOCK DIAGRAM

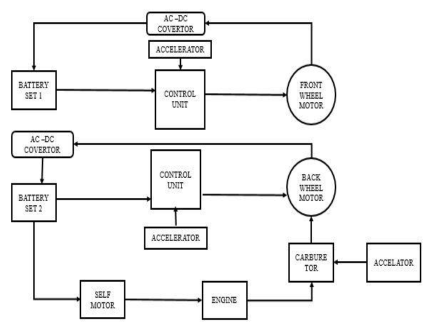

Fig 10. block diagram of Voltaline bike

5.3 WORKING PRICIPLE

In Voltaline bike the battery alone provide power for low speed driving condition, where the internal combustion engines are least efficient.

In the Voltaline bike system consist of battery set 1 and 2(a set consists of 4 battery each one 12 volts).it has one internal combustion engine with transmission system. and it has ,two e-bike wheel(hub motor) one in the front and another one in the rear side.so, this Voltaline bike offers three mode driving selectivity system.

CONVENTIONAL DRIVING SYSTEM:

In the conventional mode the engine that works on the basic principle and transmit the power through transmission system of the wheel to move the vehicle.

ELECTRICAL DRIVING SYSTEM:

- ✓ Front wheel electrical drive system

- ✓ Rear wheel driving system

1) Front Wheel Electrical Drive System

In this electrical driving mode the vehicle is running in the front hub motor.

The battery set 1 is provide power to drive the vehicle. At the same time the rear hub motor generate the power and stored in the battery set 2.

2) Rear Wheel Electrical Drive System

In this electrical driving mode the vehicle is running in the rear hub motor.

The battery set 2 is provide power to drive the vehicle. At the same time the front hub motor generate the power and stored in the battery set1 .

Thus the charging and discharging are repeated in cyclic based on driving mode selection.

In the conventional system both front and rear hub motors are act as a power generator and it is stored in battery set 1 and 2 respectively.

6. EXPERIMENT RESULT

6.1ANALYSIS

During combustion of gasoline, high temperature gases are generated which increase the temperature of the cylinder head. A long, conductive radiating fins are casted with the cylinder head to remove the heat from the interior to the environment. High temperature affects the performance of the engine, combustion of the lubricating oil is a serious problem which needs to be taken care of. the temperature distribution of the cylinder head when the vehicle is running at higher speeds and heat transfer is mainly through convection.

The simulation is colour coded which depicts that red colour shows higher temperature and blue colour shows the region of lower temperature. the heat flux distribution in a cylinder head. Fig (a) shows the stress analysis of the the chassis.

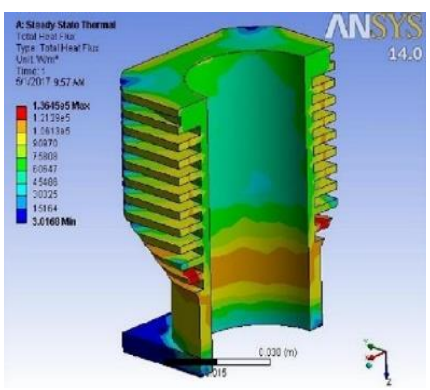

Fig 11.temperature analysis for engine

The bluish portions experience less stress and the reddish portions have more stress. The chassis portion with red in colour is to be made with proper care The square wave produced is fed to the BLDC motor for maximum efficiency.

Fig the variation of torque, speed, output voltage and armature current with time of the electric drive.

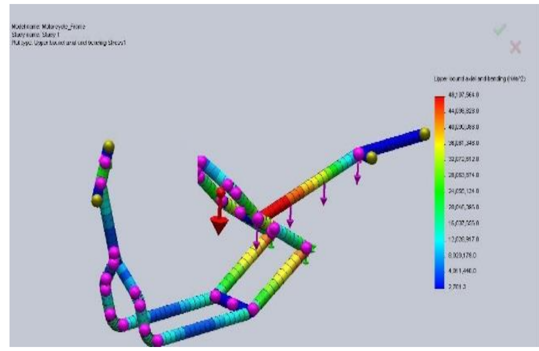

Fig 12Stress analysis of chassis

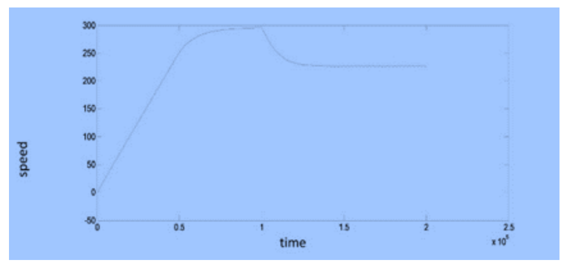

Fig 13 Speed of BLDC motor at no load

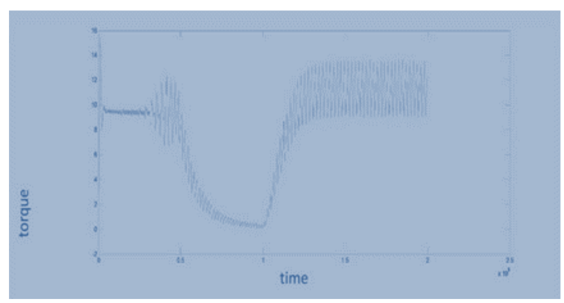

Fig14 Output torque of BLDC motor at no load

7. CALCULATIONS

DETERMINATION OF TORQUE OF TWO WHEELER:

N=550rpm

Power of Vehicle= 2.68 KW,

$P=\frac{2\pi NT}{60}$

$T=\frac{2684*60}{2*\pi*550}$

T=46.609NM @ 550 Rpm

Hence the minimum torque of the vehicle is 46.609Nm. @ 550 rpm.

7.1.2 CALCULATION FOR TOTAL POWER OF ELECTRIC VEHICLE.

TOTAL POWER:

$P_{TOTAL} = P_{DRG} + P_{RC} + P_{SLOPE}$

POWER LOSS DUE TO DRAG FORCE.

$$P_{DRAG} = \frac{Cd * A * \rho * v^3}{2}$$

C_d = Drag coefficient = 1

A =area of the vehicle and rider.

A (Upright rider) = 0.6 m^2 and A(Crouched rider) = 0.4 m^2, ρ =Density of Air = 0.4 kg/m^3

v = velocity = 6.95 m/s.

$$P_{DRAG} = \frac{1*0.6*0.4*6.95^3}{2}$$

P_{DRAG} = 40.2842 (upright skater). $P_{DRAG} = \frac{1*0.4*0.4*6.95^3}{2}$

P_{DRAG} = 18.7993 (crouched skater)

POWER LOSS DUE TO DRAG FORCE	CROUCHED RIDER	UPRIGHT RIDER
	18.7993	40.2842

Table 6 power loss due to drag force

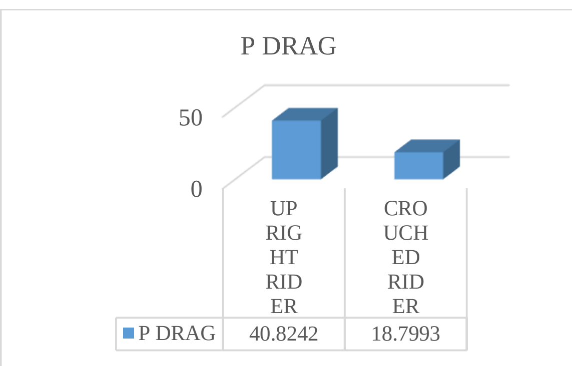

Fig 15 power loss due to drag

ROLLING RESISTANCE (P_{RC})

$P_{RC} = g * m * R_C * v$

Let R_C = 0.0014 for the flat surface and R_C = 0.004 for the instant stony surface, elocity (v) = 6.95 m/s, and mass (m) = 130 kg.

P_{RC}=9.81*130*0.0014*6.95

P_{RC} = 12.4086 (flat surface)

$P_{RC} = g * m * R_C * v$

Let R_C = 0.004 for the instant stony surface,

g = acceleration due to gravity = 9.81 m/s,

Velocity (v) = 6.95 m/s, and mass (m) = 130 kg.

P_{RC} = 9.81*130*0.004*6.95

P_{RC} =35.4533(instant stony surface)

ROLLING RESISTANCE OR FRICTION	FLATE SURFACE	INSTANT STONEY
	12.4086	35.4533

Table 7 power loss due to rolling resistance

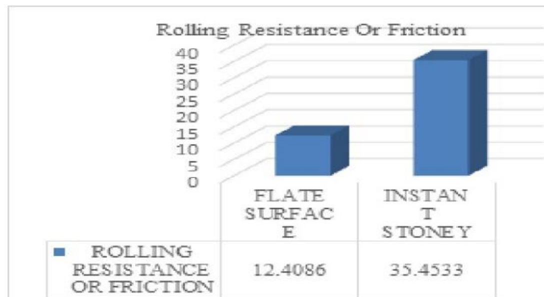

Fig 16 power loss due to resistnce

POWER LOSS AT SLOPE OR HILL

$$P_{slope} = \frac{g*m*v*\alpha}{100}$$

Let g = acceleration due to gravity = 9.81 m/s,

Velocity (v) = 6.95 m/s,
and mass (m) = 130 kg, α = angle of slope or hill in radians.
If the $\alpha = 0^O$ then the $P_{slope} = 0$
the $\alpha = 5^O$
$P_{slope} = \frac{9.81*130*6.95*0.0872}{100}$
P_{slope} =7.7288
If the $\alpha = 10^O$ then the P_{slope} = 23.1953
If the $\alpha = 15^O$ then the P_{slope} = 23.1953
If the $\alpha = 20^O$ then the P_{slope} = 30.9330

POWER LOSS DUE TO SLOPE OR HILL	ANGLE in Degree	0	5	10	15	20
	P(slope)	0	7.72	15.46	23.19	30.93

Table 8 power loss due to slope

Fig 17 power loss due to slope

TOTAL POWER

$$P_{TOTAL} = P_{DRG} + P_{RC} + P_{SLOPE}$$

Drag power		Power loss on Rolling Resistance		Power loss on slope		Total power
upright rider	40.284	flat surface	12.4086	0	0	52.69
				5	7.728	60.4
				10	15.4665	68.15
				15	23.19	75.8
				20	30.93	83.6
		stony surface	35.4533	0	0	75.73
				5	7.7288	83.46
				10	15.4665	91.19
				15	23.1953	98.93
				20	30.9330	106.66
crouched rider	18.799	flat surface	12.4086	0	0	31.2
				5	7.7288	38.92
				10	15.4665	46.67
				15	23.1953	54.39
				20	30.93	62.1
		stony surface	35.4533	0	0	54.2
				5	7.728	61.9
				10	15.4665	69.71
				15	23.1953	77.44
				20	30.9330	85.18

Table 9 total power loss

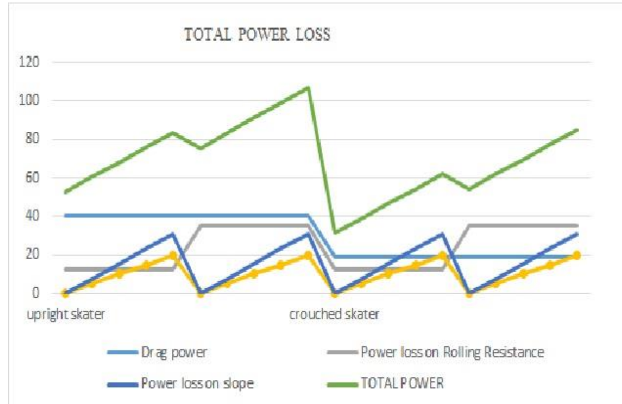

Fig 18. Total power loss

8. CONCLUSION

Voltaline is a vehicle that uses two sources of power from ICE and battery. For low power application battery drive is used whereas for high power application where power requirement is very high gasoline engine is used. Gasoline drive is most efficient at high speed drive. Thus Voltaline's both mode of operation occurs at their maximum efficiency. But in gasoline engine low speed operation is not efficient. Its high speed mode is only efficient. Therefore, it gives twice the mileage given by a normal vehicle. As this hybrid vehicle emits 50% less emission than normal vehicle it plays an important role for reducing pollution to certain extent without compromising with efficiency. Thus it is most efficient in urban areas mainly in high traffic where gasoline engines are least efficient as the energy from gasoline is being wasted away and creates pollution. Then this concept are generate the power in repeated. The sychronization between the electrical motor and internal combustion engine propulsion leads to less petrol consumption can be seen with charging cycle of batteries. If one vehicle can save an average of about 30% of petrol, then average of about 40 -60 % of national fuel can be conserved in this type of vehicle. The algorithms can be developed in synchronizing the electric motor and internal combustion engine turning on and off periods releventaly depending upon the driving cycle, so fuel efficency of the vehicle can be much improved. The Repeated regeneration process will surely helps the consumer to drive the vehicle in electrically and it will bridges towards the zero emission Environment. The batteries used in this vehicle will get in to recycle after they lose the capacity to store the power.

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