Design and Fabrication of Electric Skateboard for Off Road Application

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Abstract – 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. The implementation involves development of E-board that runs on battery as well as manual propulsion of vehicle.

Index Terms – BLDC Motor, Controller, Foot Steering, Hall Sensor, Creo 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.For preservation of gasoline for future and increasing the efficiency of vehicle an electric vehicle can be a major breakthrough. 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 basic design consists of a dc power source battery. The battery is connected to inverter that is fed to a BLDC motor that works on AC. The motor is attached to the front wheel of 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. This is connected to the transmission and thus, the vehicle moves.

EVs have been vehicles of numerous advantages. The problem of environmental pollution can be avoided to certain extent. This encourages the method of sustainable development that has been the topic of concern in the modern society. Moreover, EVs mode of operation are maximum efficient to the conditions, i.e., at low speed and high traffic areas where gasoline engine is least efficient with a lot of energy wasted, EV moves with power from battery. At up slopes where high power is required to skate the board hence electric power is used for vehicle motion to achieve the top easily. Thus the advantages of EV make it superior than any other vehicle of today.

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 electromagnetically 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. There are two types of motors commonly used in e-bikes, one is brushed motor and another is brushless. 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.

TYPES OF DRIVING SYSTEM

There are two types of driving condition is applied. They are as follows

- Manual driving system (from upstream to downstream)
- Electrical driving system (from downstream to upstream)

MANUAL DRIVING

By the Newton's third law of motion "*In Every Action there is equal and opposite reaction"*. The manual power is transmitted by applying the force by place one foot on the board and push-off another foot on the ground thus will gives a motion on the forward direction of the board. Give yourself another push when you slow down. Keep making little push-offs, and pivoting your feet to ride on the board until you slow down. Then pivot your riding foot straight, push off with your other foot, and pivot back.

ELECTRICAL DRIVING

In the electrical power transmission the power is transmitted to the driving wheel by the help of BLDC motor and the controller which drives on the 48 volt and 15 amps battery. Thus the battery gives the DC Current to the controller here the controlled gets feedback from the hall sensor inside the hub motor and gives the power to the motor depend upon by giving the signal from the accelerator. Thus the mechanical brake is applied on the brake drum by the brake shoe. And E-Brake will be applied on the motor by the effect of Hall sensor thus the signal will be given in the acceleration cable.

COMPONENTS OF ELECTRICAL DRIVE

- Hub motor
- Controller
- Battery
- Throttle sensor

2. LITERATURE SURVEY

Agus Purwadi[1] Two fundamental components in the electric car are the electric motor and its energy storage system. The motor used in this ITB-1electric car is brushless dc (BLDC) motor type. A controller will be used to convert the dc source into ac for BLDC motor power source.This electrical energy storage will affect performance of the electric car. Therefore we have to protect the battery from anything that can make the battery's life shorter. Voltage is one of the parameters that must be controlled by the battery management system, so that the battery can be protected effectively.

Zhidong Zhang[2] Base on PIC16F72, a design of brushless DC motor controller strategy applied to the electric bicycle control system was presented in the paper. Through analyzed some possible problems when electric bicycle running daily. 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.

Darshil G. Kothari [3] The Hybrid Bicycle System is a systems project which is used to power an electric hub motor running a bicycle. In this electric hybrid bicycle, the front wheel has a compact & light weight hub motor. It will be having regenerative charge system and solar panels, which enables substantially longer distance power assist cycling by regenerating power from pedaling energy (human energy) and solar energy and charging it in the battery.

Nicolò Daina[4]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. For time of day analysis of demand we identify activity-based modelling (ABM) as the most attractive because it provides a framework amenable for integrated cross-sector analyses, required for the emerging integration of the transport and electricity network. Amongst the most critical there is the lack of realism how charging behaviour is represented.

D.F. Flippo[5]Wheel design can be enhanced through experimentation, testing, and iteration. Unfortunately, the time and money needed to test full vehicles is costly. A cheaper, less conflated alternative could be to incorporate single wheel testing. The algorithm discussed in this paper uses single wheel testing to predict the full vehicle performance in a skid steer turn. With this prediction algorithm, skid steering can be easily enhanced by iterating on the design of a single wheel without the cost of vehicle testing. To validate this algorithm and explore skid steering enhancement several single wheel skid steering experiments were done and the results were compared to a full vehicle's turning performance.

3. SKATEBOARD AND E-BOARD

3.1 SKATEBOARD

Skateboarding is an action sport which involves riding and performing tricks using a skateboard. Skateboarding can also be considered a recreational activity, an art form, a job, or a method of transportation. Skateboarding has been shaped and influenced by many skateboarders throughout the years. A 2009 report found that the skateboarding market is worth an estimated \$4.8 billion in annual revenue with 11.08 million active skateboarders in the world.

Modern decks vary in size, but most are 7 to 10.5 inches (18 to 27 cm) wide. Wider decks can be used for greater stability when transition or ramp skating. Standard skateboard decks are usually between 28 and 33 inches (71 and 84 cm) long. The underside of the deck can be printed with a design by the manufacturer, blank, or decorated by any other means.

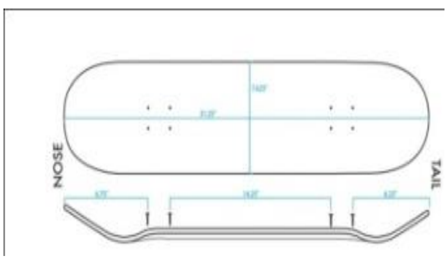

Fig1 Deck

Attached to the deck are two metal (usually aluminum alloy) trucks, which connect the wheels and bearings to the deck. The trucks are further composed of two parts. The top part of the truck is screwed to the deck and is called the *base plate*, and beneath it is the *hanger*. The axle runs through the hanger. Between the base plate and the hanger are *bushings*, also *rubbers* or *grommets* that provide the cushion mechanism for turning the skateboard. The *bushings* cushion the truck when it turns. The stiffer the bushings, the more resistant the skateboard is to turning. The softer the bushings, the easier it is to turn. Bushings come in varying shapes and urethane formulas as well as durometers, which may affect turning, rebound and durability. A bolt called a *kingpin* holds these parts together and fits inside the bushings. Thus by tightening or loosening the kingpin nut, the trucks can be adjusted loosely for better turning and tighter for more stability (useful when landing tricks). Standard kingpin nut size is 3/8" - 24tpi.

Fig 2 Truck

The wheels of a skateboard are usually made of polyurethane, and come in many different sizes and shapes to suit different types of skating. Larger diameters (55–85 mm) roll faster, and move more easily over cracks in pavement and are better for transition skateboarding. Smaller diameters (48–54 mm) keep the board closer to the ground, require less force to accelerate and produce a lower center of gravity which allows for a better response time, but also make for a slower top speed and are better for street skateboarding. Wheels also are available in a variety of hardness usually measured on the Shore durometer "A" scale. Again like car tires, wheels range from the very soft (about Shore A 75) to the very hard (about Shore A 101). As the Vertical ramp or "vert" skating requires larger wheels (usually 55–65 mm), as it involves higher speeds. Vert wheels are also usually slightly softer (A 98/ A 99), allowing them to maintain high speed on ramps without sliding. Slalom skating requires even larger wheels (60–75 mm) to sustain the highest speeds possible. Even larger wheels are used in long boarding and downhill skateboarding. Sizes range from 65 mm to 100 mm. These extreme sizes of wheels almost always have cores of hard plastic that can be made thinner and lighter than a solid polyurethane wheel. They are often used by skateboard videographers as well, as the large soft wheels allow for smooth and easy movement over any terrain.

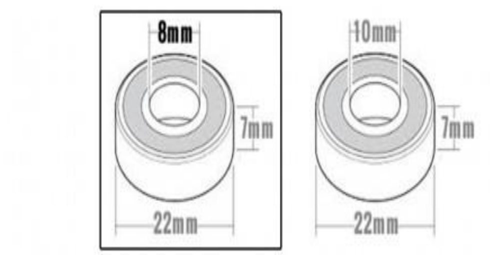

Fig 3 Wheel

TYPES OF SKATEBOARD

- The Long board
- The Cruiser
- Penny Board

3.2 ELECTRIC SKATEBOARD

An electric skateboard is typically a modified skateboard propelled by an electric motor, the power of which is usually controlled with an RF remote. As with a regular skateboard, it is steered by the rider shifting his or her weight. It was originally designed for local transport, but now offer a more serious "Off Road" model as a new thrill sport. The Off Road style boards are able to traverse grass, gravel, dirt and hard sand with ease and are often seen at low tide on the beach.

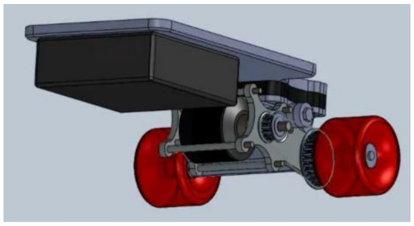

Fig 4 CONCEPT OF E-BOARD

BASIC DESIGN OF E-BOARD

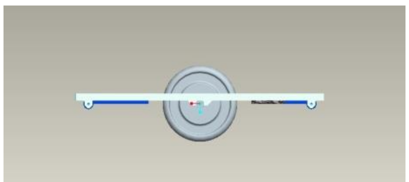

Fig 5 Side View

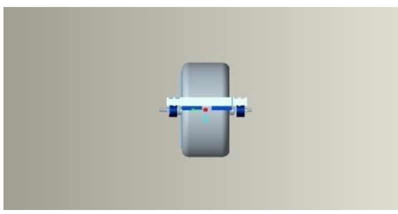

Fig 6 Front View

BLOCK DIAGRAM OF E-BOARD

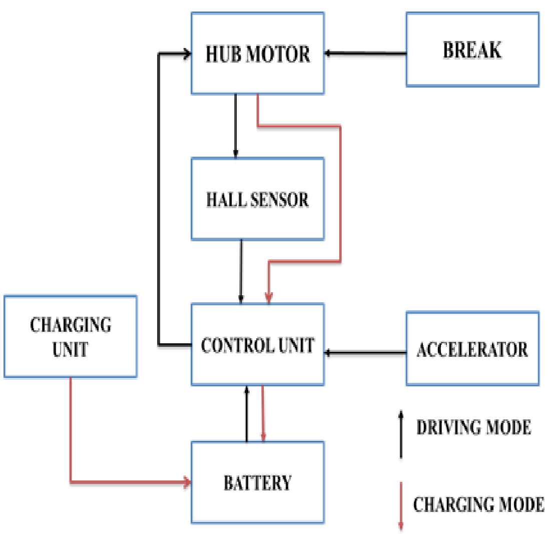

Fig 7 Block Diagram of E-Board

ADVANTAGES OF E-BOARD

- Go Uphill with Minimal Effort
- More Control over Your Speed
- You Don't Have to Push

TYPES OF DC MOTOR.

- Brushed Hub Motors
- Brushless Hub Motors

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 maintenance (brushes) Limited lifespan	Treadmill exercisers Automotive	Direct (PWM)

Table 1 Types of DC Motors

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.

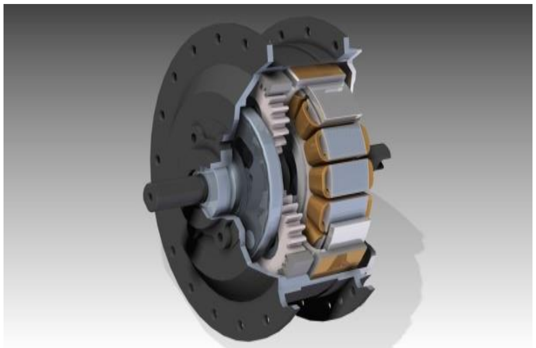

Fig 8 Render view of BLDC Motor

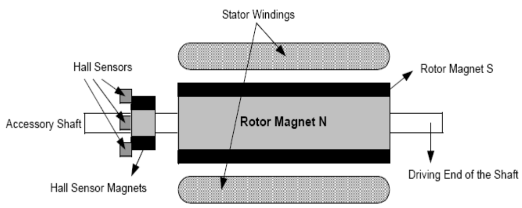

Fig 9 Working of BLDC Motor

In case of a brushed DC motor, feedback is implemented using a mechanical commutator and brushes. With an in BLDC motor, it is achieved using multiple feedback sensors. The most commonly used sensors are hall sensors and optical encoders.

SPECIFICATIONS FOR BLDC MOTOR

SL No.	Particulars	Specifications
1	Rated Capacity	30 KW
2	Input Voltage	36 - 48 V 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	Operating temp./Humidity	0 - 55ºC/ 95(+/-3%)
13	Vibration levels	1/3rd octave band levels not to exceed the straight line joining the coordinates 25Hz – 55AdB, 8Hz – 85AdB.
14	Approx Size	500 x 200 (Diameter x Width) in mm

Table 2 Specification of BLDC motor

FEATURES

- Longer service life due to a lack of electrical and friction losses.
- Virtually maintenance-free due to a lack of brushes and mechanical commutators.
- Reduced EMI and noise because of the elimination of ionizing spikes from brushes.
- More suitable for hazardous environments (dirt, oil, grease and other foreign matter) since they can be completely sealed.
- Hall sensor commutation .

THROTTLE POSITION SENSOR

PRINCIPLE OF TPS

A throttle position sensor (TPS) is a sensor used to monitor the position of the throttle in an internal combustion engine. It consists of a hall sensor. When the accelerator throttle angle changes magnetic field is created and it creates voltage across position sensor terminal. Thus for various angles, various voltages are obtained.

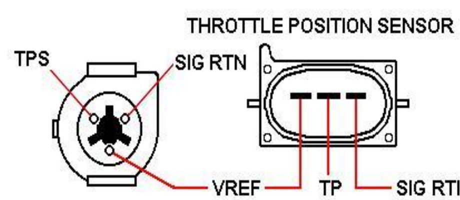

Fig 10 Throttle Position Sensor

E-board consists of a throttle position sensor, i.e., hall sensor. It gives voltage as output with respect to the angle displacement in the accelerator. The analog voltage generated is converted to digital through ADC and is given to microcontroller. If the speed corresponding to the angle deviation in accelerator is less than 30km/hr then the relay is switched on. The relay switching completes the circuit of the battery and hub motor; and vehicle is motioned by electric power. If the speed directed by accelerator is greater than 30km/hr, then the engine is started by closing the circuit of starting motor through a relay. The amount of opening is controlled by the PWM generated by the microcontroller as directed by the accelerator.

POSITION ANGLE		VOLTAGE
0	Under Travel	0.000
13	Closed throttle	0.901
20		1.440
30		1.900
40		2.370
50	Closed throttle	2.840
60		3.310
70		3.780
80		4.240
84	Full Throttle	4.538
90		
100	Over Travel	5.0
Were calculated for VREF = 5.0 volts.		

TABLE 3 Throttle position sensor

CONTROLLER

An electronic speed control or ESC is an electronic circuit with the purpose to vary an electric motor's speed, its direction and possibly also to act as a dynamic brake. ESCs providing an electronically generated three-phase electric power low voltage source of energy for the motor. Brushless ESC systems basically create a tri-phase AC power output of limited voltage from an onboard DC power input, to run brushless motors by sending a sequence of AC signals generated from the ESC's circuitry, employing a very low impedance for rotation.

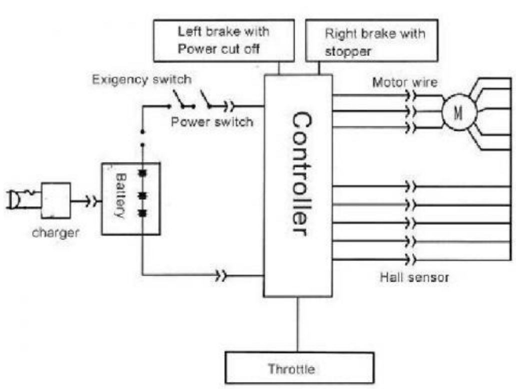

Fig 11 Electrical Circuit Diagram of Controller

Computer-programmable speed controls generally have user-specified options which allow setting low voltage cut-off limits, timing, acceleration, braking and direction of rotation. Reversing the motor's direction may also be accomplished by switching any two of the three leads from the ESC to the motor.

SPECIFICATION OF CONTROLLER

- Supply voltage 48 volt dc
- MOSFET based.
- High frequency PWM technique
- Throttle signal conversion
- Speed limit signal to pulse width modulation technique

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.

TYPES 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 thionylchloride).

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.

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 4 Average Cell Voltage during Discharge in various Rechargeable batteries

SELECTION 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	-10 to 50	High	0.35	2.1	-0.06
Nickel-Cadmium	-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 5 Battery Characteristics affecting Thermal Design

Battery	Specific Energy Wh/Kg	Energy Density Wh/liter	Specific Power W/kg	Power Density W/liter
Lead-Acid (Pb-acid)	30-40	70-75	200	400
Nickel-Cadmium (NiCd)	40-60	70-100	150-200	220-350
Nickel-metal hybride	50-65	140-200	150	450-500
Lithium-ion	90-120	200-250	200-220	400-500
Lithium-polymer	100-200	150-300	>200	>350
Zinc-air	140-180	200-220	150	200

Table 6 Specific Energy and Energy density of various Batteries

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 (NiCd)	**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 7 Life and Cost Comparison of Various Batteries

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

BATTERY SPECIFICATION

Nominal Voltage (V) 12 V

Nominal Capacity

20 hour rate (0.25A to 10.50V) 5 Ah

10 hour rate (0.475A to 10.50V) 4.75 Ah

5 hour rate (0.85A to 10.20V) 4.25 Ah

1C (5A to 9.60V) 2.833 Ah

3C (15A to 9.60V) 2.0 Ah

Weight Approx. 4.18 lbs.(1.9kg)

Internal Resistance (at 1 KHz) 19 mΩ Approx.

Maximum Discharge Current for 5 seconds 75 V

Charge -15ºC (5ºF) to 40ºC (104ºF)

Discharge -15ºC (5ºF) to 50ºC (122ºF)

Storage -15^{0}C (5^{0}F) to 40^{0}C (104^{0}F)

Charging Methods at 25^{0}C (77^{0}F)

Charging Voltage 14.4 to 15.0V Coefficient -5.0mv / ^{0}C / cell

Maximum Charging Current : 1.5 A

Fig 12 Battery

POWER TRANSMISSION SYSTEM

Power transmission is the movement of energy from its place of generation to a location where it is applied to perform useful work.

Power is defined formally as units of energy per unit time. In SI units:

$$\text{WATT} = \frac{\text{JOULE}}{\text{SECOND}} = \frac{\text{NEWTON X METER}}{\text{SECOND}}$$

4. PERFORMANCE ANALYSIS

CALCULATION FOR TOTAL POWER OF VEHICLE

TOTAL POWER OF VEHICLE

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

POWER LOSS DUE TO DRAG FORCE (P_{DRG})

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

Let the C_d = Drag coefficient = 1, A =frontal area of the skater and board A (Upright Skater) = 0.6 m^2 and A(Crouched Skater) = 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 SKATER	UPRIGHT SKATER
	18.7993	40.2842

Table 8 Power Loss Due To Drag Force Vs type of skater position

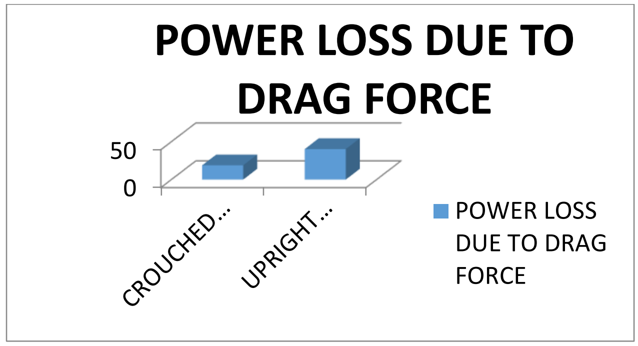

Fig 13 Power Loss Due To Drag Force

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, g = acceleration due to gravity = 9.81 m/s, Velocity (v) = 6.95 m/s, and mass (m) = 50 kg.

P_{RC} = 9.81*50*0.0014*6.95

P_{RC} = 4.772565

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

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) = 50 kg.

P_{RC} = 9.81*50*0.004*6.95

P_{RC} = 13.6359 (instant stony surface)

ROLLING RESISTANCE OR FRICTION	FLATE SURFACE	INSTANT STONEY
	4.772565	13.6359

Table 9 Rolling resistance Vs Surface

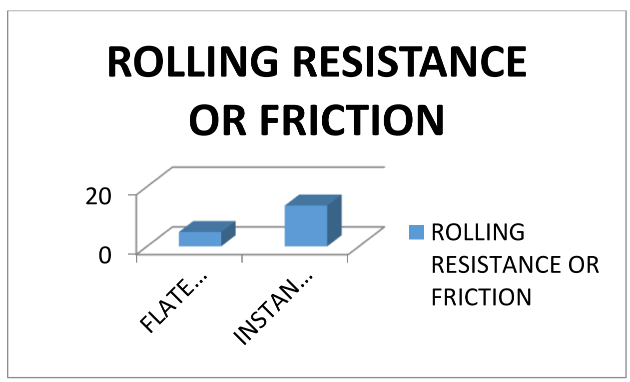

Fig14 Rolling resistance Vs Surface

POWER LOSS AT SLOPE OR HILL

$$\textbf{P(slope)} = \frac{g*m*v*\alpha}{100}$$

Let, g = acceleration due to gravity = 9.81 m/s, Velocity (v) = 6.95 m/s, and mass (m) = 50 kg, α = angle of slope or hill in radians.

Table 6.3 power loss Vs Angle of slope

If the $\alpha = 0^{O}$ then the P(slope) = 0

If the $\alpha = 10^{O}$ then the P(slope)

$$P(slope) = \frac{9.81*50*6.95*0.1745}{100} = 15.46$$

POWER LOSS DUE TO SLOPE OR HILL	ANGLE in Degree	0	5	10	15	20
	P(slope)	0	2.9748	5.9486	8.92466	11.89957

Table 10 power loss on slope Vs angle of slope

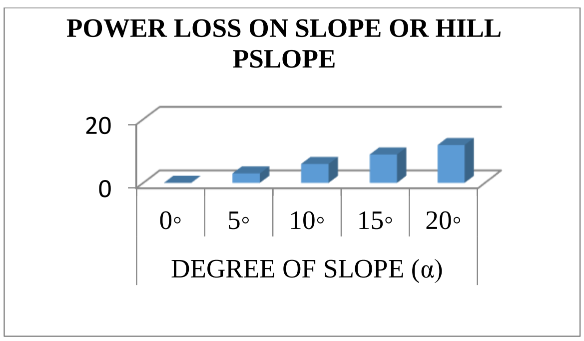

Fig15 power loss Vs Angle of slope

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

Drag power		Power loss on Rolling Resistance		Power loss on slope		Total power
upright skater	40.284	flat surface	4.7725	0	0	45.05
				5	2.974	48.03
				10	5.948	51.00
				15	8.924	53.98
				20	11.90	56.89
		stony surface	13.635	0	0	53.91
				5	2.974	56.89
				10	5.948	59.86
				15	8.924	62.84
				20	11.90	65.72
crouched skater	18.799	flat surface	4.7725	0	0	23.57
				5	2.974	26.54
				10	5.948	29.52
				15	8.924	32.49
				20	11.90	35.47
		stony surface	13.635	0	0	32.43
				5	2.974	35.40
				10	5.948	38.38
				15	8.92466	41.3586
				20	11.90	44.33

Table 11 Total power loss due to various factor

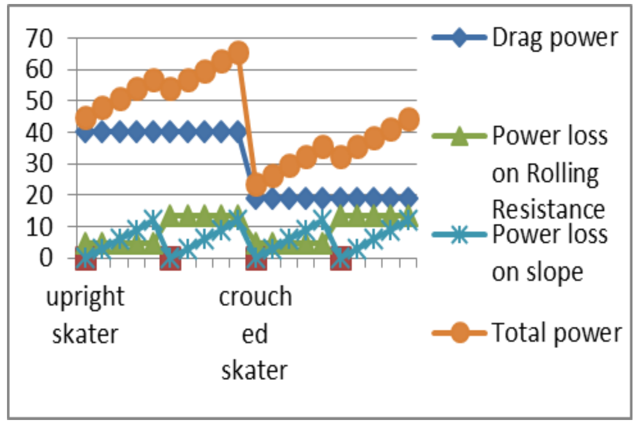

Fig16 Total power loss due to various factor

CALCULATION FOR ACKERMAN ANGLE

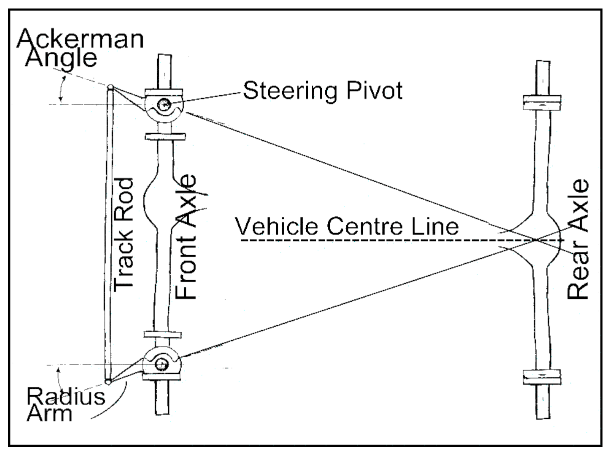

Fig 17 Ackerman Angle

To find the arm angle α

$\tan^{-1}\{(\text{length of the track rod}/2)/\text{length}\} = \alpha$

where, length of the track rod = 350 mm , and length = 500 mm.

$\alpha = \tan^{-1}\{(350/2)/500\}$

$\alpha = \tan^{-1}(0.35)$

$\alpha = 19.29^{o}$

Therefore ackerman arm angle $\alpha = 19.29^{o}$

CALCULATION FOR STEERING ANGLE

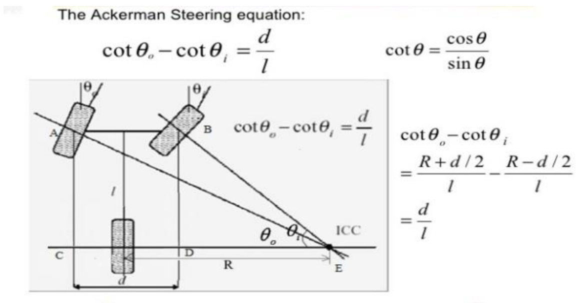

Fig 18 Calculation of Ackerman Steering

Let us consider the radius of turn R= 1000 mm

Where, L = 500mm,d = width of the vehicle = 300mm, and Ɵi and Ɵo be the inner and outer angle of the wheel respectively.

From the triangle ACE

Cot Θ_i = [(R + (d / 2)) / L]
Cot Θ_i = [(1000 + (300 / 2)) / 500]
$\Theta_i = 23.4^O$
Therefore from the equation
Cot Θ_o – cot Θ_i = d / L
Cot Θ_o – cot 23.4 = 300/500
cot Θ_o – 2.3108 = 0.6
cot Θ_o = 0.6 + 2.3108
$\Theta_o = \cot^{-1}(2.9108)$
$\Theta_o = 18.9^O$

Hence the inner and outer angle of the front wheel for the turning radius of 1000mm is 23.4^O and 18.9^O respectively.

5. STRUCTURAL ANALYSIS OF FRAME

Here the structural analysis has been made on using ANSYS software by appling the load of 1KN (Approx 100kg) on the frame and the deformation of the frame and stress analysis result has been determined.

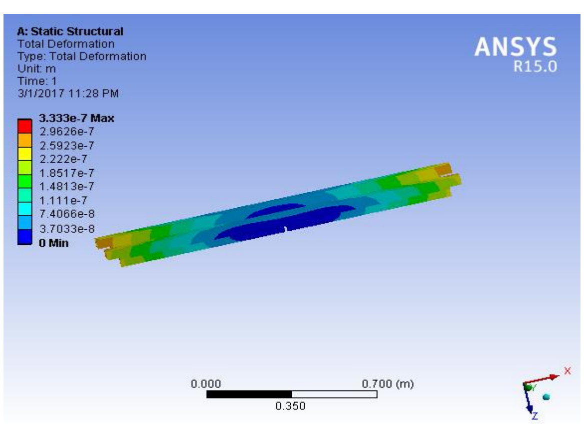

Fig19 Deformation of Frame

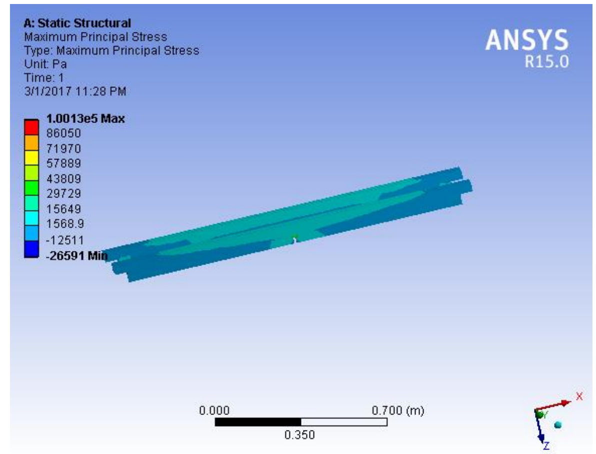

Fig20 Internal Stress of the Frame

By Applying the load 1KN = 1000N which is 100Kg equally on the frame deformation of the frame max at the two ends and minimum in the middle portion of the frame. Thus the load is applied on this frame using ansys software then the result is as shown in this figure. Thus the maximum deformation in both ends which is 3.33x 10^{-7}m and minimum in center is zero deflection and thus the internal stress of the frame minimum in end 0.265 x 10^5 Pa and high on its center upto 1.001 x10^5 Pa as shown in this figure.

6. CONCLUSION

EV is a vehicle that uses two sources of manual and battery. For low power application manual drive is used whereas for high power application where power requirement is very high electric power is used. Electric drive is most efficient at high speed drive. Thus EV's both mode of operation occurs at their maximum efficiency. Thus it is most efficient in urban areas mainly in high traffic electric skateboard is used with more efficient. This paper has reviewed the techniques that have been used to model the board design, method of use a board on centerized wheel on skateboard. This vehicle will make substitute for light electric vehicle for single riders which is gives a better utilization of fuel. It can be suitable for the transportation on the industrial supervisation, like etc, The charging behavior is improved by use of the lithium battery and high speed charging will occur.

REFERENCES

[1] Agus Purwadi, Jimmy Dozeno, Nana Heryana, "Testing Performance of 10 kW BLDC Motor and LiFePO4 Battery on ITB-1 Electric Car Prototype," Procedia Technology., pp. 1074 – 1082, Nov.2013.
[2] Zhidong Zhang, "Design of Controller in Electric Bicycle," Modern Applied Science, Vol. 5, No. 5, October 2011.
[3] Darshil G. Kothari, Jaydip C. Patel, Bhavik R. Panchal, " Hybrid Bicycle," IJEDR, ISSN: 2321-9939, Volume 2, Issue 1,2014.
[4] Nicolo Daina, Aruna Sivakumar., John W. Polak," Modelling electric vehicles use: a survey on the methods," Renewable and Sustainable Energy Reviews., Vol. 68, pp. 447–460, 2017.M. J. Riezenman,

[5] "Electric vehicles," IEEE Spectrum, pp. 18–101, Nov.1992.
[6] D.F. Flippo, "Turning efficiency prediction for skid steering via single wheel testing," Journal of Terramechanics 52, pp. 23–29, 2014.
[7] H. Shimizu, J. Harada, C. Bland, K. Kawakami, and C. Lam, "Advanced concepts in electric vehicle design," IEEE Trans. Ind. Electron., vol. 44, pp. 14–18, Oct. 1997.
[8] C. D. S. Tuck, Ed., Modern Battery Technology. Harwood, p. 411, 1991. M. Terashima, T. Ashikaga, T. Mizuno, and K. Natori, "Novel motors and controllers for high-performance electric vehicle with four in-wheel motors," IEEE Trans. Ind. Electron., vol. 44, pp. 28–38, Feb. 1997.
[9] Satoshi Ito, Shouta Takeuchi, Minoru Sasaki, " Motion measurement of a two wheeled skateboard and its dynamical simulation" Applied Mathematical Modelling., vol.36, pp. 2178–2191, Feb. 2012.
[10] Robinson AP, Blythe PT, Bell MC, Hübner Y, Hill GA. Analysis of electric vehicle driver recharging demand profiles and subsequent impacts on the carbon content of electric vehicle trips. Energy Policy 2013;61:337–48.
[11] Bruce, N. Butcher, C. Fell, Lessons and insights from experience of electric vehicles in the community. In: Electric Vehicle Symposium 26. Los Angeles, CA; 2012.
[12] Urban GL, Hauser JR, Quails WJ, Weinberg BD, Bohlmann JD, Chicos RA. Information acceleration: validation and lessons from the field. J Mark Res 1997;34:143–53.
[13] Richardson DB. Electric vehicles and the electric grid: a review of modeling approaches, impacts, and renewable energy integration. Renew Sustain Energy Rev 2013;19:247–54.