Design and Fabrication of High Efficient and Low Cost Electro Magnetic Drive Car

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Abstract— In the present energy scenario the fossil fuel sources are fast depleting and their combustion products are causing global environmental problems. So it is inevitable to shift towards the use of other alternative energy sources such as renewable energy, green energy and bio fuels which leads to reduction in population. Magnetic energy is an alternative technology which uses magnetic flux density to run the engine and thus eliminates the use of fossil fuels. Since the exhaust temperature is slightly less than the atmosphere temperature it is used to reduce global warming, since there is no emission of carbon dioxide and hydrocarbon contents there is any chance of global warming. Due to elimination of pollution, this new technology is easy to adapt. Another benefit is that no external energy such as electrical and electronics energy is required to run the engine. This paper focuses on design and development of single engine which can be run by magnetic force of repulsion. The magnetic engine vehicle will contribute to reducing air pollution and tend zero pollution level promoting great environment.

Key words: Maglev, Electromagnets, Magnetic field, Hall Effect, Cranking mechanism

I. INTRODUCTION

The most widely known application of electromagnetic propulsion is of magnetic levitation trains. Magnetic levitation transport, or maglev, is a form of transportation that suspends, guide and propels vehicles (especially trains) via electromagnetic force. Magnetic levitation, maglev, or magnetic suspension is a method by which an object is suspended above another object with no support other than magnetic fields. The electromagnetic force is used to counteract the effects of the gravitational force.

Due to the lack of physical contact between the track and the vehicle, there is no rolling friction, leaving only air resistance (although maglev trains also experience electromagnetic drag. this is relatively small at high speeds). Maglevs can handle high volumes of passengers per hour (comparable to airports or eight-lane highways) and do it without introducing air pollution along the right of way. Of course, the electricity has to be generated somewhere, so the overall environmental impact of a maglev system is dependent on the nature of the gird power source. The main limitation of magnetic levitation transport system is the need for guide ways, which limits it application to rail system. The main focus of the research work is to eliminate this dependence on guide ways. A clear comparison shown in the next section shows comparison of fuel and electrical vehicle to advanced electromagnetic vehicles to justify by literature survey about various advantages of electromagnetic vehicles when compared to conventional vehicles.

II. LITERATURE SURVEY

Maglev is a completely new mode of transport that will join the ship, the wheel, and the airplane as a mainstay in moving people and goods throughout the world. Maglev has unique advantages over these earlier modes of transport and will radically transform society and the world economy in the 21st Century. Compared to ships and wheeled vehicles autos, trucks, and trains it moves passengers and freight at much higher speed and lower cost, using less energy. Compared to airplanes, which travel at similar speeds, Maglev moves passengers and freight at much lower cost, and in much greater volume. Maglev will allow millions of human beings to travel into space, and can move vast amounts of water over long distances to eliminate droughts.

In 1882, Nikola Tesla identified the concept of the rotating magnetic field. In 1885, Galileo Ferraris independently researched the concept. In 1888, Tesla gained U.S. Patent for his work. Also in 1888, Ferraris published his research in a paper to the Royal Academy of Sciences in Turin.

D. G. Dorrell studied on Combined Thermal and Electromagnetic Analysis of Permanent Magnet and Induction Machines to Aid Calculation [1],

In the year 2009 Richard D. Thornton worked upon Efficient and Affordable Maglev Opportunities in the United States [2]. Later in the year 2011 Ferran Silva and Marc Aragón worked on the high power electronics to drive the electrical engines of the new electric and hybrid vehicles produces high level low frequency EMI[3]. Monica reviewed on magnetic levitation-a technology to propel vehicles with magnets in the year 2013[4]. In 2014, Rakshith. M researched on electromagnetic active suspension system that provides both additional stability by performing active roll and pitch control during cornering and braking, as well as eliminating road irregularities, hence increasing both vehicle and passenger safety and drive comfort [5].

III. OBJECTIVES OF THE RESEARCH

- To design and fabricate the coils to the requisite capacity to generate electro-magnetic force.
- To design and fabricate the piston being fixed on the piston rod which is moving within the coils, properly held and spaced as required.
- To design and fabricate the four wheel base with drive mechanism, cranking mechanism, the cranking mechanism being propelled by electro-magnetic force.
- To design and make the controls to operate the switching mechanism to changeover the coil connection during cranking.

– To design and make the control circuit to give supply for energizing the coils, which controls the speed of the vehicle.

IV. WORKING PRINCIPLE

A. Electro Magnets:

The basic idea behind an electromagnet is extremely simple, by running electric current through a wire; you can create a magnetic field. By using this simple principle, you can create all sorts of things, including motors, solenoids, read/write heads for hard disks and tape drives, speakers, and so on.

B. A Regular Magnet:

All magnets have two ends, usually marked "north" and "south," and that magnets attract things made of steel or iron. And you probably know the fundamental law of all magnets: Opposites attract and likes repel. So, if you have two bar magnets with their ends marked "north" and "south," the north end of one magnet will attract the south end of the other.

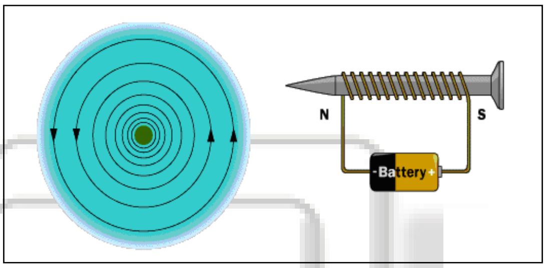

Fig.1 Principle of Electromagnets

C. An Electromagnet:

An electromagnet starts with a battery (or some other source of power) and a wire. What a battery produces is electrons. In a battery of normal D cell, there are two ends, one marked plus (+) and the other marked minus (-). Electrons collect at the negative end of the battery, and, If a wire is attached between the positive and negative terminals of a D cell, three things will happen: Electrons will flow from the negative side of the battery to the positive side as fast as they can. The battery will drain fairly. For that reason, it is generally not a good idea to connect the two terminals of a battery to one another directly. The load might be a motor, a light bulb, a radio or whatever. A small magnetic field is generated in the wire. It is this small magnetic field that is the basis of an electromagnet. The figure 1 above shows the shape of the magnetic field around the wire. The green circle in the figure is the cross-section of the wire itself. A circular magnetic field develops around the wire, as shown by the circular lines. The field is perpendicular to the wire and that the field's direction depends on which direction the current is flowing in the wire. The compass needle aligns itself in the opposite direction when the battery is flipped.

V. METHODOLOGY

Two solenoid coils have been held one after the other and a shaft is being housed between them. The basic definition of a solenoid is a cylindrical coil of wire which creates a magnetic field within itself when an electric current passes through it to draw a core of iron or steel within the coil. The solenoid generally uses electrically conductive, non-magnetic and insulated wire of specific length that is coiled or wrapped around a tube or hollow cylinder. The core, in general terms, is a magnetic object, a portion of which moves in at least a portion of the tube's interior. The passing of an electrical current through the wire coiled around the tube generates a corresponding magnetic field or force around the tube/wire coil. This effect, commonly known as the Electro Motive Force (EMF), denotes that the polarity and strength of the electrical current passing through the wire coil will correspondingly determine the polarity and strength of the resulting magnetic field or force. In this manner, the manipulation of the various attributes of the electrical current (e.g., polarity, duration and strength, etc.) respectively controls the attributes of the resulting magnetic field and the movement of the magnetic object in relation to the magnetic field. In controlling the electrical current to the solenoid or inducer, the subsequently created magnetic field draws, holds or expels the magnetic or polar object in relation to the interior of the wire wrapped tube. When the first coil is energized it will pull the shaft which in turn makes half rotation of the crank wheel. In the second set of coil the coil is energized in opposite direction which in turn makes another half rotation of the crank wheel and hence completes one full rotation. The timing of energizing the coil is done by DPDT switch and control circuit, which is activated by accelerator sector which governs the speed of spindle: A solenoid based propulsion systems comprising of:

1) At least one multiple wire coils set solenoid.
2) Magnetic object, at least a portion of which reciprocally moves within the multiple wire coil set solenoid, and an energizing control system connected to multiple wire coil sets of the solenoid that controls the dwell angle for each wire coil.
3) Solenoid based propulsion system, wherein the multiple wire coil set solenoid has an open ended tube through which the magnetic object will be unilaterally and completely propelled out of tube when all the wire coil sets are de-energized.
4) Solenoid based propulsion system, wherein the one multiple wire coil set solenoid contains a centring magnet.
5) At least one tube with an exterior and an interior.
6) Multiple wire coil sets wrapped around the exterior of the tube.
7) Magnetic object which reciprocally moves within at least a portion of the interior of the tube.
8) An energy control system connected to wire coil sets at selected times.

A. Methodology for operating a solenoid based propulsion system:

Placing a magnetic object inside an open ended tube that has at least one multiple wire coil solenoid wrapped around it exterior. Center the magnetic object within the midpoint of the reciprocal movement. Move the magnetic object reciprocally.

1) Rotating magnetic fields:

The rotating magnetic field is a key principle in the operation of alternating-current motors. A permanent magnet in such a field will rotate so as to maintain its alignment with the external field. This effect was conceptualized by Nikola Tesla, and later utilized in his, and others, early AC (alternating-current) electric motors. A rotating magnetic field can be constructed using two orthogonal coils with 90 degrees phase difference in their AC currents. However, in practice such a system would be supplied through a three-wire arrangement with unequal currents. This inequality would cause serious problems in standardization of the conductor size and so, in order to overcome it, three-phase systems are used where the three currents are equal in magnitude and have 120 degrees phase difference. Three similar coils having mutual geometrical angles of 120 degrees will create the rotating magnetic field in this case. The ability of the three-phase system to create a rotating field, utilized in electric motors, is one of the main reasons why three-phase systems dominate the world's electrical power supply systems.

2) Coil energizing circuit explanation

The circuit is made on the basis of supply of constant voltage to the IC-UM606 at the input pin number 7. Pin number 2 and 3 are connected to the variable resistance through a capacitor by which inverted output is given at pin number 6 which is triggered by transistor BC 547, again transistor BC 547 (twice because we are using heavy relay). The relay is connected to the coil by the triggering of the transistor. The coils are connected and disconnected by the DPDT switch and the relay will switch on/off the coils which give the output as the rotations and speed control. Initially the motor is put on by the button which drives the propulsion or cranking while rotating the rear wheels simultaneously moving the piston rod to effect the cranking and when the coil energizing button is put on the supply to the coils is effected and the relay puts off the motor supply to stop the motor since the coil energized is driving the propulsion.

3) Hall Effect

Because the Lorentz force is charge-sign-dependent (see above), it results in charge separation when a conductor with current is placed in a transverse magnetic field, with a buildup of opposite charges on two opposite sides of conductor in the direction normal to the magnetic field, and the potential difference between these sides can be measured. The Hall Effect is often used to measure the magnitude of a magnetic field as well as to find the sign of the dominant charge carriers in semiconductors (negative electrons or positive holes).

VI. ELECTRONIC PARTS

A. Resistors:

According to ohms law "Electrical resistance of a conductor is the effective opposition offered by the conductor to the now of charges through it and is defined as the rate of potential between the ends of the conductor to the current flowing through the conductor. The SI unit of resistance is the Ohm (Ω)

B. Color Code of Resister:

Resistors are available in various shapes and sizes. Among them carbon composition resistors are most commonly used? Carbon composition resistors are physically very small and hence it is difficult to print the resistance value on the component. Instead it is indicted by a color code in the form of circular color bands round the resistor. The tolerance i.e., the percentage deviation from the rated value is also indicated in figure 2.

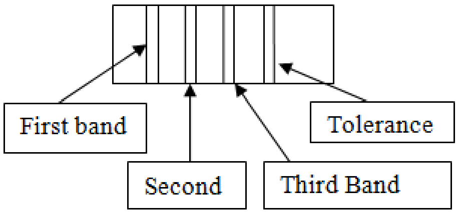

Fig. 2 Color bands of Resistors

In the color band system, generally a resistor has 4 bands on it. The band at the end of the resistor indicates the first digit; the next band indicates the second digit, while the 3^{rd} band indicates the number of Zero's. The fourth band indicates the tolerance.

C. Transformer:

A transformer is a static electrical device, which transfer electrical power from one electrical circuit to the other which is magnetically coupled together with or without change of voltage and without any change in power and frequency. The basic use of transformer is to increase or decrease A.C. voltage. If it is used to increase the voltage, it is called a step-up transformer, if it is used to decrease the voltage; it is called a step down transfer. If the voltage is not changed, it is called one to one transformer.

As the transformer is a static apparatus, there are no moving parts. Hence, there are no mechanical losses in a transformer. Hence, there are no mechanical losses in a transformer. Hence 'η' is of order 95% to 98%. There are no slots, no teeth, and no air gaps. Hence the maintenance of transformer is very easy. It works on the principle of mutual induction between two magnetically coupled coils.

D. Integrated Circuits:

An integrated circuit (abbreviated as IC) is a small Silicon semiconductor crystal, called a Chip, containing electrical components such as transistors, diodes, resistors and capacitors. The various components are interconnected inside the chip to form an electric circuit. The chip is mounted on a metal or plastic package, and connections are welded to external pins to form the IC. The Dual in Line Package is the most widely used type because of the low price and easy installation on circuit boards. The envelope of the IC package is made of plastic or ceramic. Most packages have standard sizes and the number of pins ranges from 8 to 64. Each IC has a numeric designation printed on the surface of the package for identification. The size of IC packages is very small. For example, four AND gates are enclosed inside a 14 pin dual in line package with dimensions of 20 x 8 x 3 mm^3. Besides a substantial reduction in size, ICs offer other advantages and benefits compared to electronic circuits with discrete components. The cost of ICs is very low, which makes them economical to use. Their reduced power consumption makes the digital system more economical to operate. They have high reliability against failure. So the digital system needs less repairs.

E. Diode:

It is a combination of P-type and n-type semiconductors or a P-n junction is called a crystal diode or a semiconductor diode. Symbolically it has shown above figure.

In p type semiconductor Holes are the majority charge carriers and electrons minority carriers. In n type semiconductor electrons are the majority charge carriers and holes are the applied voltage opposes the junction p.d and for values of the applied voltage greater than the junction p.d. the charge carries easily cross the junction from either side. The motion of the majority carries constitutes a current in the external circuit. This current rises sharply with the applied voltage. Thus a forward based p-n junction offers a small resistance.

F. Relay:

A relay is a simple electromechanical switch made up of an electromagnet and a set of contacts. Relays are found hidden in all sorts of devices. In fact, some of the first computers ever built used relays to implement Boolean gates.

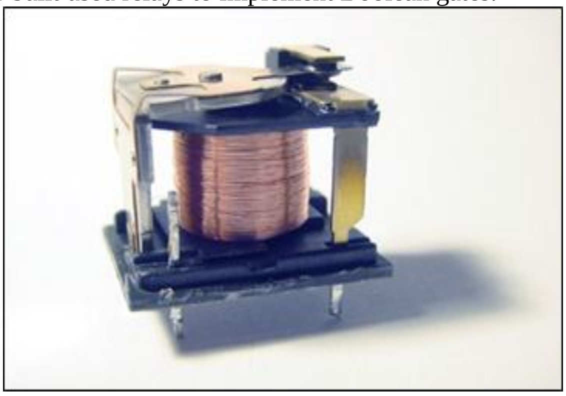

Fig. 3 Relay

Relay Construction Relays are amazingly simple devices. There are four parts in every relay:

1) Electromagnet
2) Armature that can be attracted by the electromagnet
3) Spring
4) Two separate and completely independent circuits.

G. Toggle switch:

Fig. 4: Toggle switch

In the simplest case, a switch has two pieces of metal called contacts that touch to make a circuit, and separate to break the circuit. The contact material is chosen for its resistance to corrosion, because most metals form insulating oxides that would prevent the switch from working. Contact materials are also chosen on the basis of electrical conductivity, hardness (resistance to abrasive wear), and mechanical strength, low cost and low toxicity. A pair of contacts is said to be 'closed' when there is no space between them, allowing electricity to flow from one to the other. When the contacts are separated by an insulating air gap, an air space, they are said to be 'open', and no electricity can flow at typical voltages.

Switches can be and are classified as "one-way", "two-way", "three-way" and "four-way" switches. The terms pole and throw are also used to describe switch contact variations. A pole is a set of contacts, the switch's electrical terminals that are connected to and belong to a single circuit, usually a load.

H. Power Supply:

Depending on use, special batteries are available for specific applications e.g. application in spacecraft or to be used in extremely cold areas or in extremely hot areas, etc. In some cases power factor may important not the volume or weight, whereas, in others both volume and weight may have to be kept as low as possible. Amongst various batteries the lowest cost and most versatile is lead/acid battery. The entire circuit operates using 12 Volts DC.

The advanced Lead-Acid Battery Consortium (ALABC) of USA has developed a procedure, wherein the battery is charged via a series of current pulses. Average current of consecutive sets of pulses is reduced on decreasing current amplitude and duty cycle simultaneously. Triggering of change in these two parameters is initiated by either resistance free voltage or by amount of charge return. The voltage component (V=IR0 is subtracted from the pulsed voltage during ON time to give resistance free, pulsed voltage. Constant voltage charging stage is initiated at a low average pulsed current (~0.5A). This keeps overcharge to a minimum. Thus water loss is minimized.

VII. DESIGN CALCULATIONS

A. Design of Coils

Due to electromagnetic force of solenoid, shear stress is induced in the piston and shaft. The design should be safe with respect to shear stress induced on shaft and piston.

Current consumed by solenoid, I = 3.58A

Voltage required V = 12V.

Magnetic field produced by solenoid,

$$B=\frac{\mu NI}{L} \text{ Tesla} \quad (1)$$

Where μ = Permeability ($\mu_r \times \mu_o$)

μ_r = Relative permeability. (875)

μ_o = Absolute permeability ($4\mu \times 10^{-7}$)

N = Number of turns, 270

L = Length of solenoid wire, 1.5 m

From Equation 1

$$B=\frac{875\times4\pi\times10^{-7}\times270\times3.58}{1.5} \quad (1.1)$$

B=0.708 Tesla

Force induced on the piston,

$$Fs=\frac{B^2A}{2\mu_o} \text{ Newton} \quad (2)$$

Where A= area of core of solenoid $=A=\pi r^2$

$$=\frac{\pi\times0.027^2}{4}$$

$= 0.00057\ m^2$

$$Fs=\frac{0.708^2\times0.00057}{2\times4\mu\times10^{-7}}=113.85\text{ N.} \quad (2.1)$$

Power required

$$p = current \times voltage \quad (3)$$

= 3.58 x 12

=42.96W.

B. Design of Chain

Pitch of chain = p =8.25mm
Width of chain = w =3.175mm
No of teeth on sprocket = z = 18

$$\text{Pitch diameter } D = \frac{p}{\sin(\frac{180}{z})} = \frac{8.25}{\sin\frac{180}{18}} \quad (4)$$

= 47.50mm

$$\text{Velocity:} \quad v = \frac{pzn}{60000} = \frac{8.25\times18\times100}{60000} \quad (4.1)$$

=0.24 m/s.

Power required
N = force x velocity
= 786 x 0.24
= 0.188 KW.

$$N = \frac{F_\theta v}{1000\times K_l\times K_S} \quad (5)$$

$$0.188 = \frac{f_\theta \times 0.24}{1000\times 1.3\times 1.2}$$

$\boldsymbol{f_\theta}$= 1225 N.
Ks=service factor= 1.2 From Data Hand Book
K l=load factor= 1.2 – 1.5 from DHB
Allowable pull Fu = 8.533 KN from DHB
η_0 = Working factor of safety = 11.2
Fa =Allowable pull

$$= \frac{Fu}{\eta_0} = \frac{8.533\times1000}{11.7} \quad (6)$$

=729.35 N

$$\text{Number of strands } i = \frac{F_\theta}{F_a} = \frac{1225}{729} = 1.69 = 2$$

Checking for actual factor of safety
Actual factor of safety

$$\eta_a = \left(\frac{F_u}{F_\theta+F_{cs}+F_s}\right)\times i \quad (7)$$

$$F_\theta = \frac{1000\,N}{v} = \frac{1000\times0.188}{0{,}24} = 783.33N$$

$$F_{cs} = \frac{w\times v^2}{g} = \frac{127.5\times0.24^2}{9.81} = 0.74N$$

$$F_\theta = required\ pull \qquad F_s = K_{sg}wc$$

C= Centre distance = 450mm
K_{sg}= Coefficient of Slag From DBH
There for Fs = 6x127.5x0.45 = 344.25 N

$$\eta_a = \left(\frac{F_u}{F_\theta+F_{cs}+F_s}\right)\times i \quad (8)$$

$$= \left(\frac{8533}{783.33+0.74+344.25}\right)\times 2 = 15.12.$$

$\eta_a > \eta_0$ 15.12 >11.2 there for the selection of chain is safe

C. Design of Axle

1) Diameter of shaft =20 mm.
2) Length of shaft =420 mm.

M_t=10× 1000 × 9.81
= 98100 N - mm
For C-40 steel, from DHB
σy= 328.3 N/mm^2
$\tau y = \sigma y/2$=164.15 N/m^2.
Taking factor of safety=3,
We have,
τed =164.15/3 =54.71 N/m^2.

$$D = \left(\frac{16\times K_t\times M_t}{\pi\times\tau_{ed}}\right)^{\frac{1}{3}} \quad (9)$$

$$= \left(\frac{16\times1\times98100}{\pi\times54.71}\right)^{\frac{1}{3}} = 20mm$$

Where Kt= endurance factor =1.

VIII. MANUFACTURING OF THE PARTS

A. Magnet coil set:

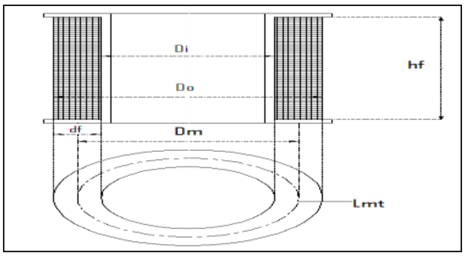

Fig. 5 Coil Front and Top view cylinder core

Di = Inside Diameter of the coil,
Do = Outside Diameter of the coil,
D_m= Mean Diameter of the coil,
df = Radial depth of coil,
hf = Axial length of coil,
Lmt= Length of mean turn.
Mean dia. $Dm = (Do + Di) / 2$
Depth of winding $df = (Do - Di) / 2$
Coil number of turns=270
Diameter of the wire =1.4 mm

B. Moving Shaft:

It is made out of C30 steel of diameter of 12mm and length of 600mm being turned on the lathe machine for the size of 10mm and one end is inserted within the bush of the clamp which is connected to crank by pin and locked by the M6 screw. The other end is passing through the coils and shaft guides.

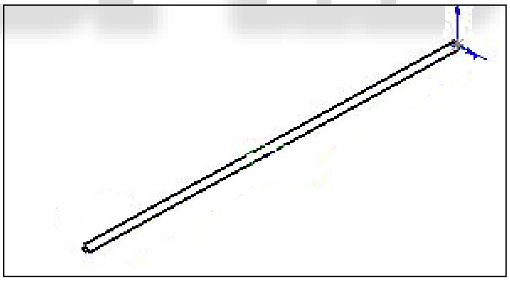

Fig. 6: Moving Shaft

Length of shaft=600 mm
Diameter of the shaft=8 mm.

C. Crank lever:

It is made out of brass casting being machined on milling machine and being bored on lathe machine maintaining the centre distance and hole diameter to suit the roller bearing and pin diameter. Length of crank lever=120mm

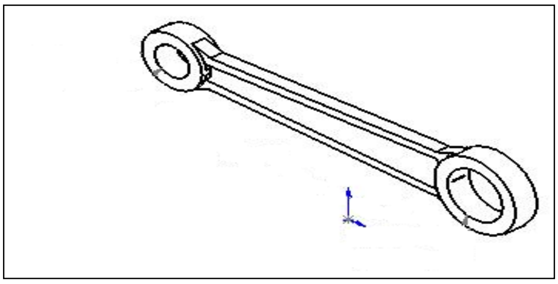

Fig. 7 Crank lever arrangement

D. Piston rod guide bush:

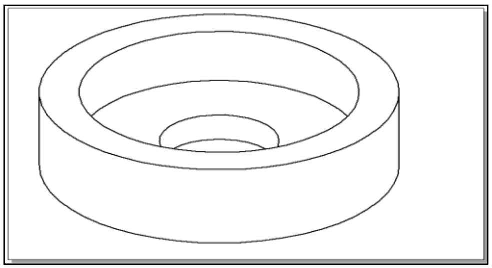

Fig. 8 Guide bush

It is made out of 25mm rod of the length of 25mm being turned on the lathe machine to make a diameter of 20mm and centre drilling is done for the diameter of 10mm to suit the piston rod, and faced from other side to make the final length as 20mm. such two number of bushes are made for this project.

E. Changeover switch actuator bush:

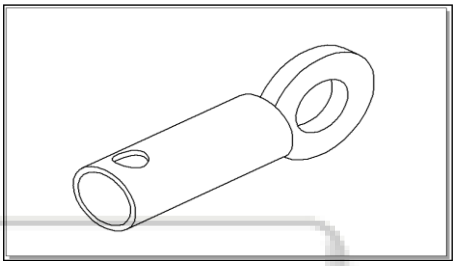

Fig. 9 Switch actuator bush

It is made out of 25mm rod of the length of 25mm being turned on the lathe machine to make a diameter of 20mm and centre drilling is done for the diameter of 10mm to suit the piston rod, and faced from other side to make the final length as 20mm. such two number of bushes are made for this project. This is then marked for the hole of 5mm diameter and tapped for M6 tapping at the distance of 8mm from one side on the circumference on both the bushes.

F. Piston:

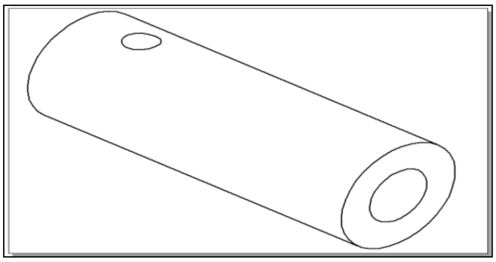

Fig. 10 Piston

This is made out of mild steel round bar being cut from the round bar of diameter 30mm for the length of 60mm-2nos and then turned on lathe machine to make the diameter as 28mm to suit the coil inner diameter and drilled at the centre for the hole diameter as 10mm for the entire length and faced from the other side to make the total length as 55mm and then marked for the hole of 5mm at 10mm distance on the circumference and tapped for M6 tapping to be able to fasten grub screw in it. Such two number of bushes are made for this project.

G. Crank shaft:

It is made out of C 30 steel of diameter 20mm and turned on the lathe machine for the length of 22 to house the crank wheels as per the drawing.
Diameter of the crank shaft: 15mm

H. Crank wheel:

It is made out of C30steel of diameter 65mm and of thickness 15mm being turned for the diameter of 60mm and thickness and milled to get the shape of the crank. It is then bored to suit the crank pin diameter of 10mm and offset bore of diameter 10mm is also done on the milling machine Such two number of wheels are processed. Diameter of the crank wheel is 60mm and Thickness of crank wheel is 10mm.

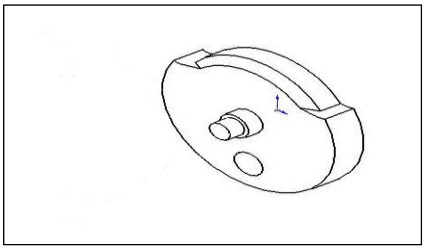

Fig.11 Crank wheel

I. Crank Pin:

It is made out of C30 steel of diameter 16mm of the length of 32mm being turned on the lathe machine to make a diameter of 12mm for the length of 32mm being slide fit clearance of crank lever and coupling.

J. Crank Housing Plate:

It is made out of mild steel rectangular flat being cut for the material of 75mm x 80mm of thickness 20mm-2nos and then machined to make the rectangular size of 65mm x 75mm x 15mm and made right angle on milling machine and then marked for the centre of 50mm from base to drill the hole of 10mm and then bored for the diameter of 16mm and counter bored for the diameter of 35mm to suit the ball bearing outer diameter of 35mm for the depth of 10mm for both the plates and then these housing plates are welded on the chassis frame with proper alignment.

K. Chassis Frame:

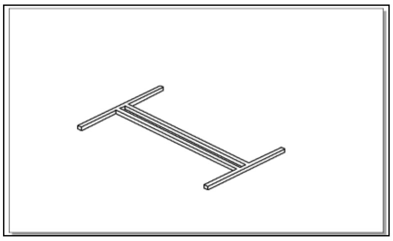

Fig. 12 Chassis frame

It is made out of angle 20mm x 20mm square pipe being cut for the lengths of 675mm (2nos), 460mm (1nos), 430mm (1nos) and then corner grinding is done to remove the burrs and then joined to make the frame as per the requirement according to the drawing to be able to hold the wheel holdings as per the requirement. On this frame crank housing plates are welded and then coil holding flats are also welded to hold the coils. On this frame the outside frame of the vehicle is welded and legs are bolted to this frame at four places.

L. Coil holder:

It is made out of mild steel flat 20mmx5mm being cut for the size of 45mm and bend to suit the radius of the coil outer surface. A round washer of size 8mmhole, 15mm outer diameter is welded on this to locate the end of the clamping bolt. Such 4numbers are made to clamp two number of coils.

M. Battery box:

It is made out of mild steel flat 20x3mm being cut and bend to make the form of the box to accommodate the two number of batteries within it as per the drawing.

N. Circuit holder:

It is a flat strip of mild steel of size 12x3x100mm being cut and drilled for the hole of size 4mm at two places and being welded on the frame, so that circuit is clamped on this.

O. Switch activating bushes:

These are totally two number made out of mild steel round bar of size 22mm being turned on the lathe machine to make the size of 20mm outer diameter and 10mm inner diameter and faced to make the length of 15mm and on the circumference, 5mm hole is drilled and M6 tapping is done for locking purpose.

IX. CONCLUSION

The size of the car gets reduced (Length of vehicle is 675 mm and Width of vehicle is 460 mm), but health concerns regarding the exposure to electromagnetic field must be taken in to consideration. There is no expense on the fuel at the same time the efficiency of the mechanism increases.

Fig. 13 Fabricated Model

The four wheel base with drive mechanism, cranking mechanism being propelled by electromagnetic force. Changeover of the controls during cranking is possible. The speed of the vehicle is controlled by energizing the coil using control circuits to the required level.

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