VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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A Project Report
On

"DESIGN AND FABRICATION OF FOLDABLE ELECTRIC SCOOTER"

Submitted in partial fulfillment of the requirements as a part of the curriculum,

Bachelors of Engineering in Mechanical Engineering

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CERTIFICATE

Certified that the project work entitled "DESIGN & FOLDABLE ELECTRIC SCOOTER**"** is a bonafide work carried out by **Mr. Murugan, Mr. Monish, Mr. Sanjay Kumar, Mr. Sanjay Neelagar,** bonafide students of **CMR Institute of Technology** in partial fulfillment for of the requirements as a part of the curriculum,

Bachelors of Engineering in Mechanical Engineering, of **Visvesvaraya Technological University, Belagavi** during the year **2019-2020**. It is certified that all correction/suggestion indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of the project work prescribed for the bachelor of engineering degree.

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DECLARATION

We, students of Eighth Semester, B.E, Mechanical Engineering, CMR Institute of Technology, declare that the project work titled **"DESIGN AND FABRICATION OF FOLDABLE ELECTRIC SCOOTER"** has been carried out by us and submitted in partial fulfillment of the course requirements for the award of degree in **Bachelor of Engineering in Mechanical Engineering** of **Visvesvaraya Technological University, Belagavi,** during the academic year 2019-2020

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ABSTRACT

The population of world is increasing and the area is decreasing. We are in the stage of compact world, where all things are going to compact, the time is to think about the vehicle which can be folded easily and can be taken everywhere. The basic aim behind our project is to make a portable vehicle which would be easy to handle by both genders and it should emit 0% emission, also keeping in mind the parking problems, we have decided to make a portable suitcase vehicle which can be folded easily. So after the use, one can fold a suitcase and can scooterry it along with him or her as a luggage and keep it in home or wherever there is place for the size of suitcase. For power supply we have introduce DC motor, which will not consume fuel for running thus preventing emissions problems. The Dc motor will work on batteries which can be charged at home. Since batteries can be charged, the project is more economical to middle class peoples. We have applied our engineering knowledge as well as some references from Mazda's Foldable scooter for the development of this product. It is an environment friendly, small & cheap project which can be hold by any household member and used within certain limits on public roads. While designing, we have concentrated on power, economy, ease and comfort of riding and low maintenance cost.

Also we have concentrated on ergonomics factor to gives the user a comfortable ride.

DESIGN AND FABRICATION OF FOLDABLE ELECTRIC SCOOTER

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INTRODUCTION

As the population is increasing there is increase in demand of automobiles. Due to increase in automobiles, people will require space for driving and also for parking. As we know there is limited space available and due to increase in the number of scooters on roads they are causing traffic congestion and with that they require a place for parking. In addition to these pollution is also a priority nowadays. The pollution is reaching new limits day by day. So the idea of a foldable and portable vehicle comes into concept.

Tustries, college campuses etc. Portable scooter can be used to cover shorteFoldable scooter which can be folded to make it compact; hence it does not require the parking place. Due to its compactness it can be used in various shopping malls, in distance at many instances. It can be used for travelling purpose on the roads.

In order to overcome above mentioned disadvantages in the present invention, we can replace engine with motor and battery. But it will add more weight to vehicle. Portable vehicle can be assembled and dissembled whenever required as well as we can carry anywhere. If required we can assemble it in just less than ten minutes and drive it. In this portable vehicle we used two wheels, out of that the power is given to rear wheels via shaft and steering of the vehicle is done by front wheel. Power is produced in vehicle using a DC electric motor. If there is no use of vehicle then we can just simply folded using dc motors. This portable vehicle can scooterry weight up to 90kg and it has Maximum speed of 20 km/hr.

Objective

- Time required for assembly and disassembly should be as less as possible.
- The maintenance of suitcase vehicle should be low.
- The vehicle should be light weight so it can be lifted.
- Driver comfort is also important factor, so it must not be compromised.
- Folding ease: Folding should be easy, stress-free, and take no more than 10 minutes after user becomes familiar with the tri-scooter.
- Portability: It should be easily transportable for both women and men. It should be easy to handle and should be portable.
- Reliability: It should have a stable ride, confident feel, and similar performance to a conventional bike. Fit various sized people, should be easy to maintain and reliable.

LITERATURE SURVEY

Bjarni Freyr Gudmundson and Mr. Esben Larsen in their research paper have discussed about various techniques in which the foldable electric motorbike can be developed. They made a conceptual design and did detailed analysis on specification, material selection, design and structural analysis, component selection, test drive. Their basic idea behind manufacturing this type of design was to give the comfort and compact ability to the driver, so that driver can feel safe and comfortable to enjoy the every ride of kart. For making a vehicle the following subsystems such as chassis subsystem handling subsystem, wheel and tire subsystem, brake subsystem and power train subsystem should be designed and fabricated. They worked on the power train for the vehicle and also initiated work on developing powerful, light weight motorbike. They thought about the cost and efficiency of vehicle. To minimize the cost of the vehicle, they used electric arc welding as it is cheap and reliable option available

During this project, Mr. Sachin Achari with his team has discussed the feasibility, use and design procedure of the foldable tri scooter. They made effort in the experimental analysis as well as in design part of the project. Their main aim was to design a portable automobile which should be very easy to scooterry as well as easy to handle by both the sexes with equal ease. The aim was also that it should be environmental friendly and should be non-polluting. They used D.C motor as their main power source due to which there is no emission at all and also the problem of fuel consumption can be solved.Their design allows users to easily transport the triscooter using less space when it is “folded” into a compact size. They were the first to offer foldable triscooter in the market. While designing they concentrated on power, economy, ease and comfort of riding and low maintenance cost. Also they concentrated on ergonomics factor to give the user a comfortable ride. Their objectives included folding ease, Portability, Reliability and retailer network. They used mild steel as the frame material welded in suitcase shape

which serves as the base to hold all the accessories such as motor, weight of the load to be conveyed and the weight of the person driving the unit.

Mr. Akash Chaudhary Raghuvanshi with his team had made effort in developing foldable kart chassis.By this innovative idea, he conducted the structural analysis on the frame of their kart vehicle and developed a GO KART named as “ASHVA” which can be folded by its mid with the help of a joint that connected between its two chassis front chassis-rear chassis. They knew that Karts are used to just take the experience of racing scootersTaking this into consideration they manufactured an automobile that would be something really out of the box. As the speed of kart varies on the power of engine and how much fuel it takes. The chassis of kart was made up from the mild steel and the joint of kart had been made up of mild steel. This joint gave more power and stability to their vehicle. They used mechanical chain to transmit the power from the engine to the axle of kart. For a better karting experience, rack and pinion system was used by them. A fish body is a perfect aerodynamic natural structure, one can get inspired with hence the chassis of the kart was developed with an igniting idea of a fish body. Selection of material plays an important role on strength and safety of the product that was the reason they chose AS-202 stainless steel round tubes as a chassis material. Also they chose the material for shaft so that it can bear all the stresses. They discussed about the material selection procedure. They made an effort in describing the joints that can be used in foldable vehicle chassis.

Researchers at MIT with backing from General Motors Corp. are building a prototype of a lightweight electric vehicle that can be cheaply mass-produced, rented by commuters under a shared-use business model, & folded & arranged like grocery scooterts at subway stations or other central sites. It's called the City Scooter, and the key to the concept lies in the design of its wheels.

Other Researches

Karts are used just to take the experience of racing scooters. Mostly they are very entertaining vehicles in the markets. Karts are likely the basic concepts of scooter nothing else. As the speed of kart just varies on the power of engine and how much fuel it takes, the chassis of kart is made up from the mild steel and the joint of kart had been made up of mild steel. This joint gives more power and stability to the vehicle. Student competition based on the product they designed and fabricated is a good activity scooter out by university students. Here mechanical chain is used to transmit the power from the engine to the axel of kart.

Generally karts speed varies from 45 Km/Hr. – 65 Km/Hr. and this kart also had a speed of 52 Km/Hr. As joint gives the support to the both chassis front as well as it also helps to bears maximum force on it so that chassis have good strength and can bear maximum weight in comparing of other karts. For less turning radius we used simple rack and pinion. National Go-Kart championship is a platform where nation comes together with bringing new ideas of their minds in automobile field. This completion gives the basic knowledge of scooter and increases manufacturing skills of students. There is not much research about go-kart design. Most of the research is about the safety and injury. Risk compensation theories hypothesize that if individuals use safety belts, they will drive in a more risky manner than if they do not use safety belts due to an increased perception of safety.

QUALITIES REQUIRED FOR A DESIGNER

LOGICAL THINKING:

A designer must possess highly developed intellectual powers.

GOOD MEMORY:

Good memory is essential for a designer in order to have fast amounts or facts and figures at his finger tips.

CONSCIENTIOUSNESS:

The ability to work thoroughly and conscientiously, so that no mistakes are made.

INTEGRITY:

A designer should not feel disappointed if corrections and suggestions for improvements are pointed in his work; at the same time he should not criticize the work of others, instead he should offer better solutions if possible.

Harmonious and balanced temperament, ability to work with people stimulation skill and skill in experimentation and measurement are the pre-requisites of a good designer.

ENVIRONMENT CONSCIOUSNESS:

A designer must be above of his responsibility to the environment.

REPORTING DESIGN:

Technical reports giving detailed calculations and reasons for design decisions must be written and maintained properly.

METHODOLOGY

FLOW DIAGRAM

I. Literature study Make review on other model and focusing on how to make it simple and relevance to the project title.

II. Conceptual design sketching several type of design based on concept that being choose. State the dimension for all part.

III. Materials Selection selected the true material based on model design and criteria. Light, easy to joining and easy to manufacture. Assemble all the part to the design.

IV. Fabrication model refinement. Fabricate according to the main frame and design. Refinement at several part of joining and sharp edge.

V. Performance testing.

VI. Documentation preparing a report for the project.

The proper selection of material for the different part of a machine is the main objective in the fabrication of machine. For a design engineer it is must that he be

familiar with the effect, which the manufacturing process and heat treatment have on the properties of materials. The Choice of material for engineering purposes depends upon the following factors:

- Availability of the materials.
- Suitability of materials for the working condition in service.
- The cost of materials.
- Physical and chemical properties of material.

Mechanical properties of material

The mechanical properties of the metals are those, which are associated with the ability of the material to resist mechanical forces and load.

- **Strength** : It is the ability of a material to resist the externally applied forces
- **Stress**: Without breaking or yielding. The internal resistance offered by a part to an externally applied force is called stress.
- **Stiffness**: It is the ability of material to resist deformation under stresses. The modules of elasticity of the measure of stiffness.

COMPONENTS AND DISCRIPTION

The major components of the wall painting crane are,

- BATTERY
- BLDC MOTOR
- BALL BEARINGS
- CHAIN AND SPROCKET
- FRAME WORK
- TOGGLE SWITCH

1. BATTERY:

In isolated systems away from the grid, batteries are used for storage of excess solar energy converted into electrical energy. The only exceptions are isolated sunshine load such as irrigation pumps or drinking water supplies for storage. In fact for small units with output less than one kilowatt. It is necessary that the overall system be optimized with respect to available energy and local demand pattern.

To be economically attractive the storage of solar electricity requires a battery with a particular combination of properties:

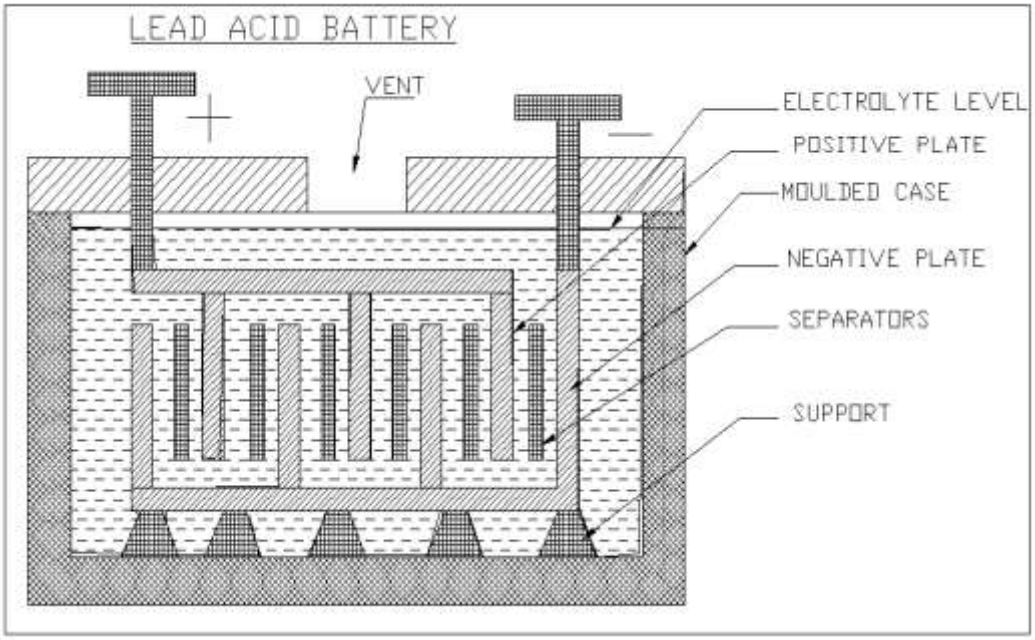
(1) Low cost
(2) Long life
(3) High reliability
(4) High overall efficiency
(5) Low discharge
(6) Minimum maintenance

(A) Ampere hour efficiency

(B) Watt hour efficiency

LEAD-ACID WET CELL:

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example, the load current to the starter motor is typically 200 to 400A. The charge and discharge cycle can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. However, heat with excessive charge and discharge currents shortends the useful life to about 3 to 5 years for an automobile battery.



CONSTRUCTION:

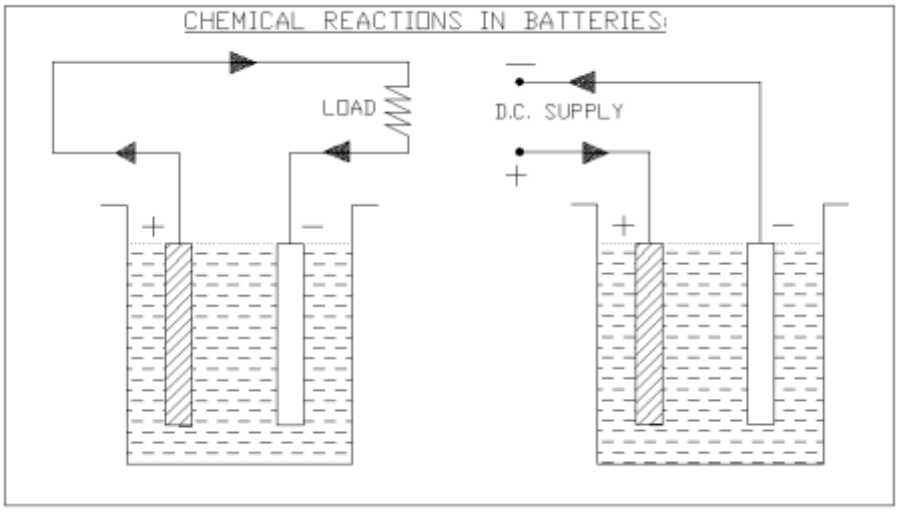
Inside a lead-acid battery, the positive and negative electrodes consist of a group of plates welded to a connecting strap. The plates are immersed in the electrolyte, consisting of 8 parts of water to 3 parts of concentrated sulfuric acid.

Each plate is a grid or framework, made of a lead-antimony alloy. In manufacture of the cell, a forming charge produces the positive and negative electrodes. The electrolyte is put in at the time of installation, and then the battery is charged to from the plates. With maintenance-free batteries, little or no water need be added in normal service. Some types are sealed, except for a pressure vent, without provision for adding water.

CHEMICAL ACTION:

Sulfuric acid is a combination of hydrogen and sulfate ions. When the cell discharges, lead peroxide from the positive electrode combines with hydrogen ions to form water and with sulfate ions to form lead sulfate. Combining lead on the negative plate with sulfate ions also produces he sulfate. Therefore, the net result of discharge is to produce more water, which dilutes the electrolyte, and to form lead sulfate on the plates.

On charge, the external D.C. source reverses the current in the battery. The reversed direction of ions flows in the electrolyte result in a reversal of the chemical reactions. Now the lead sulfates on the positive plate reactive with the water and sulfate ions to produce lead peroxide and sulfuric acid. This action re-forms the positive plates and makes the electrolyte stronger by adding sulfuric acid.



At the same time, charging enables the lead sulfate on the negative plate to react with hydrogen ions; this also forms sulfuric acid while reforming lead on the negative plate to react with hydrogen ions; this also forms currents can restore the cell to full output, with lead peroxide on the positive plates, spongy lead on the negative plate, and the required concentration of sulfuric acid in the electrolyte.

The chemical equation for the lead-acid cell is

$$Pb + pbO_2 + 2H_2SO_4 \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} 2pbSO_4 + 2H_2O$$

On discharge, the pb and pbo_2 combine with the SO_4 ions at the left side of the equation to form lead sulfate ($pbSO_4$) and water (H_2O) at the right side of the equation.

One battery consists of 6 cell, each have an output voltage of 2.1V, which are connected in series to get an voltage of 12V and the same 12V battery is connected in series, to get an 24 V battery. They are placed in the water proof iron casing box.

SCOOTERING FOR LEAD-ACID BATTERIES:

Always use extreme caution when handling batteries and electrolyte. Wear gloves, goggles and old clothes. "Battery acid" will burn skin and eyes and destroy cotton and wool clothing.

The quickest way of ruin lead-acid batteries is to discharge them deeply and leave them stand "dead" for an extended period of time. . If they remain in the lead Sulfate State for a few days, some part of the plate dose not returns to lead oxide when the battery is recharged. If the battery remains discharge longer, a greater amount of the positive plate will remain lead sulfate. The parts of the plates that become "sulfate" no longer store energy. Batteries that are deeply discharged, and then charged partially on a regular basis can fail in less then one year

CURRENT RATINGS:

Lead-acid batteries are generally rated in terms of how much discharge currents they can supply for a specified period of time; the output voltage must be maintained above a minimum level, which is 1.5 to 1.8V per cell. A common rating is ampere-hours (A.h.) based on a specific discharge time, which is often 8h. Typical values for automobile batteries are 100 to 300 A.h.

Note that the ampere-hour unit specifies coulombs of charge. For instance, 200 A.h. corresponds to 200A*3600s (1h=3600s). The equals 720,000 A.S, or coulombs. One ampere-second is equal to one coulomb. Then the charge equals

720,000 or 7.2*10^5ºC. To put this much charge back into the battery would require 20 hours with a charging current of 10A.

CHARGING THE LEAD-ACID BATERY:

The requirements are illustrated in figure. An external D.C. voltage source is necessary to produce current in one direction. Also, the charging voltage must be more than the battery e.m.f. Approximately 2.5 per cell are enough to over the cell e.m.f. so that the charging voltage can produce current opposite to the direction of discharge current.

Note that the reversal of current is obtained just by connecting the battery VB and charging source VG with + to + and –to-, as shown in figure. The charging current is reversed because the battery effectively becomes a load resistance for VG when it higher than VB. In this example, the net voltage available to produce charging currents is 15-12=3V.

Float charging refers to a method in which the charger and the battery are always connected to each other for supplying current to the load. In figure the charger provides current for the load and the current necessary to keep the battery fully charged. The battery here is an auxiliary source for D.C. power.

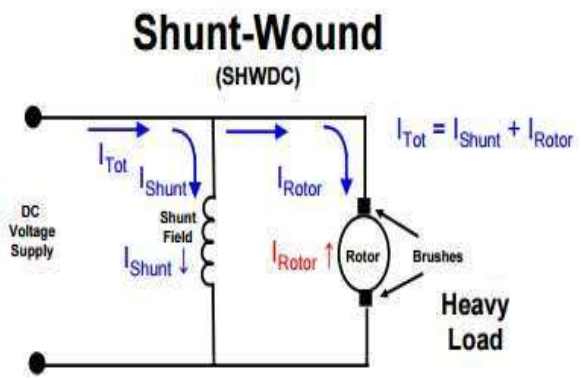
The battery charger is an AC generator or alternator with rectifier diodes, driver by a belt from the engine. When you start the scooter, the battery supplies the cranking power. Once the engine is running, the alternator charges he battery. It is not necessary for the scooter to be moving. A voltage regulator is used in this system to maintain the output at approximately 13 to 15 V.

BLDC MOTOR

An electric motor is an instrument which converts electrical energy into mechanical energy. In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy.

Motor consists of Rotor, Stator, Windings, Air Gap, and Commutator which works together to convert electrical energy into mechanical energy which may be linear or rotary depending upon motor. There are four types of brushed DC motors. The first type is the Permanent Magnet Brush DC Motor. Second, the shunt-wound brushed DC motor. Third is the series-wound DC motor and fourth is the compound-wound brushed DC motor which is a combination of both the shunt and series wound brushed DC motors.

Shunt-wound brushed DC motors have the field coil in parallel (shunt) with the rotor. The current in the field coil and in the rotor are independent of one another, thus, the total current of the motor is equal to the sum of the shunt current (or stator current) and the rotor current. So, during normal operation, as



Shunt-wound brushed DC motors have the performance characteristics of decreasing torque at high speeds and a high but more consistent torque at low speeds. The current in the field coil and in the rotor are independent of one another, thus, the total current of the motor is equal to the sum of the shunt current (or stator current) and the rotor current. As a result, these motors have excellent speed control characteristics. Shunt-wound brushed DC motors are typically used in applications that require 5 or more HP such as industrial and automotive applications. As compared to permanent magnet brushed DC motors, shunt wound brushed DC motors have no loss of magnetism and are more robust. Some drawbacks are that shunt wound brushed DC motors are more expensive than permanent magnet brushed DC motors and have the potential of motor runaway if the shunt current decreases to zero. This is a very dangerous condition that can lead the motor to literally break apart.

Principal of operation of DC Motor:

- When a current carrying conductor is placed in a magnetic field. It experiences a force.
- In case of DC motor, the magnetic field is developed by the field current i.e.

the current flowing in field winding.

- The armature winding is connected to an external dc source; hence it plays the role of the current carrying conductor placed in the magnetic field.
- Due to force exerted on it when placed in the magnetic field, it starts rotating and the armature starts rotating.
- The direction of rotation depends on the direction of the magnetic field produced by the field winding as well as the direction of magnetic field produced by the armature.

Effect of increase in load:

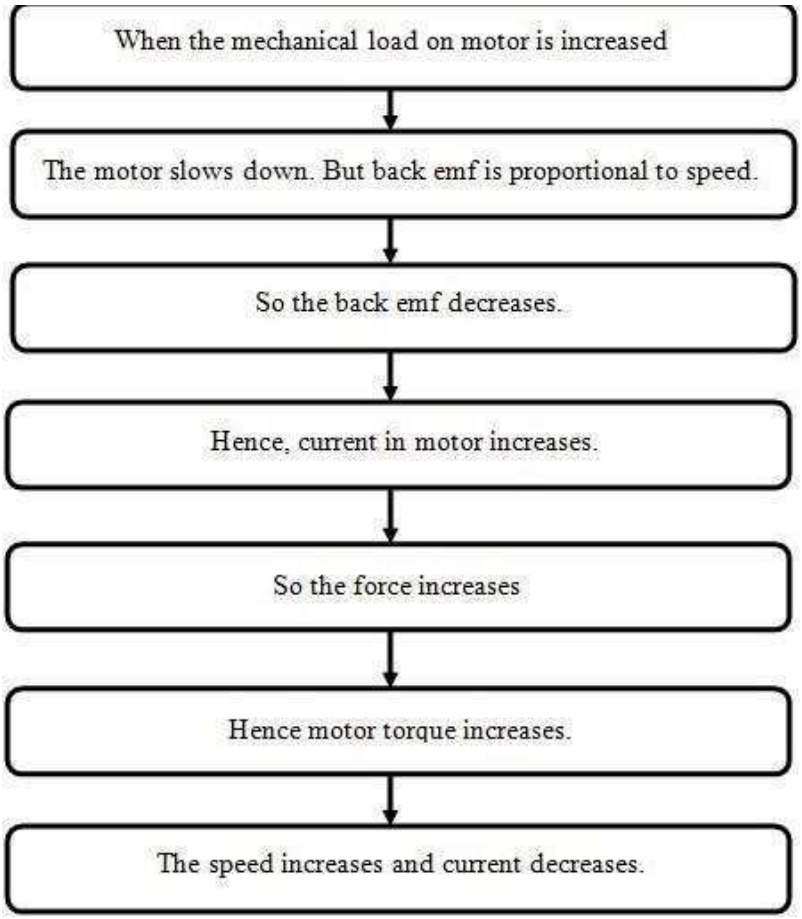


Fig-5: Effects of load on motor.

Electric Motor, Controller & Throttle

Electric Motor:

We have chosen electric motor instead of IC engine in our project. But due to space constraints, we opted for electric motor. Motor which we used is reduction electric DC motor which provides required torque. Also reason behind choosing this motor is we did not want emission issues with our vehicle. Only disadvantage with this motor is increase in size of battery and decrement in RPM. Also this reduction motor comes with controller and throttle control for handle. Specification for the electric motor is provided below:

Table-2: Motor Specifications

Parameters	Specifications
Type	DC Motor
Voltage	24
RPM	4000
Rated Wattage	250w
Rated Current	14.7A
Torque	22 Nm
Reduction Ratio	5.78:1

Table-2: Motor Specifications

Controller:

Controller is a device that serves to govern the performance of an electric motor. This may have automatic or manual means of starting and stopping the motor, selecting forward and reverse rotation, selecting and regulating or limiting the torque and protecting against overloads and faults. The given controller is of manual starting or stopping Direct on Line (DOL) type which is controlled by using throttle. This is pre-loaded with software to work for the given electric motor.

Fig: Controller for 250W Electric Motor

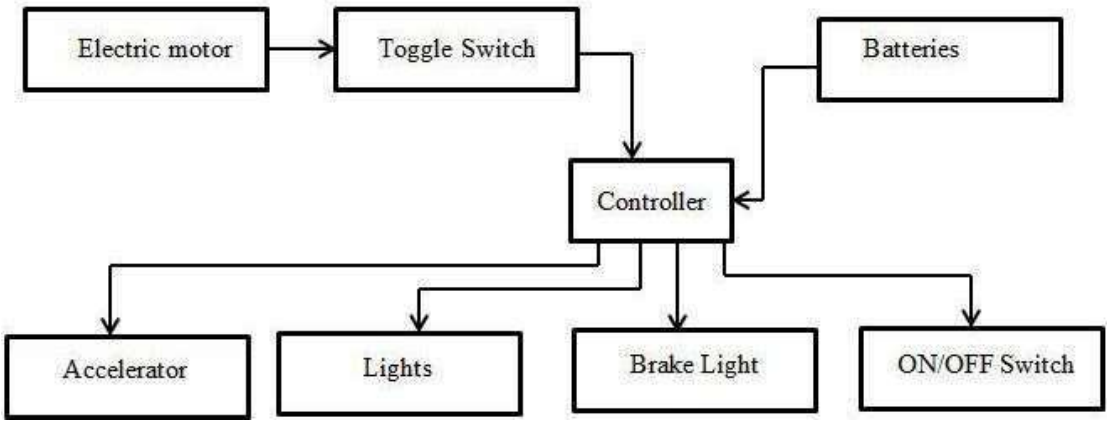


Fig-: Block Diagram of controller connections

Throttle:

Electronic Throttle control (ETC) is an automobile technology which electronically connects the accelerator pedal to the throttle, replacing mechanical linkages. ETC consists of accelerator pedal module, ETB and ECM. There are throttle positions sensor embedded in ETB which helps in determining the required throttle. The given ETB works on potentiometer.

Fig-: Electronic Throttle Body

Wheel

We have used three wheels for the vehicle. Out of these three wheels, one wheel at front steering handle and other two wheels used with shafts at rear of the vehicle for propulsion purpose. These wheels are made up of hard rubber which will help in transferring weight to the roads. Due to their smaller size and high weight handling capacity they are best for use. Specifications for the used wheel are as follows:

Table-: Wheel Specifications

Component	Parameters	Specifications
Front wheels		
	Quantity	1
	Size	8”
Rear Wheels		
	Quantity	2
	Size	8”

Fig-: Wheel

Chassis

We have used perimeter type chassis frame which provides more space and area for mountings. It is also the internal part of vehicle. It also helps in distributing space equally over the vehicle. We have manufactured the chassis in two different

parts which can be assembled by an intermediate member. We have compared many different materials such as AISI 4130, AISI 1020, AISI 1006 and ASTM A500 GRB. Comparisons of these materials are provided below.

Material Comparisons

Parameter	**AISI 4130**	**AISI 1020**	**AISI 1006**	**ASTM A500**
UTS (MPa)	1075	380	295	300
YTS (MPa)	986	205	165	210
Density (g/cc)	7.85	7.87	7.87	7.85
Poisson‟s ratio	0.29	0.29	0.29	0.26
Elasticity Modulus (GPa)	205	200	205	205
Cost	₹ 550/ mtr	₹ 400/ mtr	₹ 250/mtr	₹ 350/ mtr

Out of these materials ASTM A500 Gr B has used. The reason behind using this grade above all others was that it provides much strength and cost efficiency. The AISI 4130 is much good in strength but is costly and moreover we do not require this much strength for vehicle. Frame has made up of square pipe with following dimensions:

Parameter	**Specifications**
Dimension	1" & 3/4th " Pipe with 1.6 mm thickness
Material	ASTM A500 Gr B
Yield tensile strength	210 MPa
Ultimate tensile strength	300 MPa
Bulk Modulus	140 GPa
Shear modulus	80 GPa
Poisson"s Ratio	0.26
Density	7.85 g/cc

Table-: Chassis Material Specifications

Steering

The primary purpose of the steering system is to allow the driver to guide the vehicle. As the vehicle is not too heavy so we used a simple steering mechanism. Following things were mounted on steering handle.

- Handle Driven Single Wheels
- Brakes on handle
- Throttle on handle

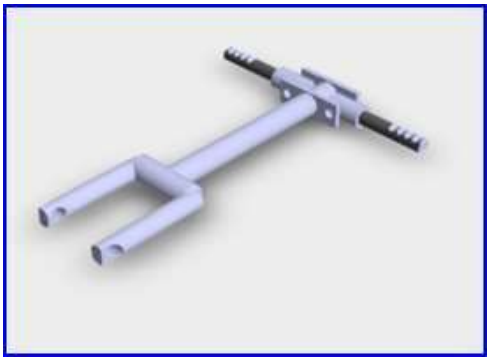


Fig-: Steering handle

Shaft

A solid shaft of circular cross section has used. As maximum bending force and torque was coming on shaft so the solid shaft has opted. Brakes and rear sprocket has mounted on the shaft.

Table-: Shaft Material Specification

Parameter	Specification
Material	Stainless steel 302 (annealed)
SUT	620 MPa
Elastic modulus	193 GPa
Poisson Ratio	0.25

MILD STEEL ROD

General purpose steel bars for machining, suitable for lightly Stressed components including studs, bolts, gears and shafts. Often specified where weld ability is a requirement. Can be Case-hardened to improve wear resistance. Available in bright rounds, squares and flats, and hot rolled rounds. Can be supplied in sawn blanks, and bespoke size blocks

MILD STEEL

- Mild steel is a scooterbon steel typically with a maximum of 0.25% Scooterbon and 0.4%-0.7% manganese, 0.1%-0.5% Silicon and some + traces of other elements such as phosphorous, it may also contain lead (free cutting mild steel) or sulphur (again free cutting steel called resulphurised mild steel)
- The stuff is used everywhere, looking out of my office window I can see diesel pump injector parts, loudspeaker pole pieces, Automated packing machinery parts and I haven't even got my glasses on.

NUT AND BOLT

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten two or more parts together. The two partners are kept together by a combination of their threads' friction (with slight elastic deformation), a slight stretching of the bolt, and compression of the parts to be held together. In applications where vibration or rotation may work a nut loose, various locking mechanisms may be employed: lock washers, jam nuts, specialist adhesive thread-locking fluid such as Loctite, safety pins (split pins) or lock wire in conjunction with castellated nuts, nylon inserts (Nyloc nut), or slightly oval-shaped threads. The most common shape is hexagonal, for similar reasons as the bolt head - 6 sides give a good granularity of angles for a tool to approach from (good in tight spots), but more (and smaller) corners would be vulnerable to being rounded off. It takes only 1/6th of a rotation to obtain the next side of the hexagon and grip is optimal. However polygons with more than 6 sides do not give the requisite grip and polygons with fewer than 6 sides take more time to be given a complete rotation. Other specialized shapes exist for certain needs, such as wingnuts for finger adjustment and captive nuts (e.g. cage nuts) for inaccessible areas.

BALL BEARING

The bearings are pressed smoothly to fit into the shafts because if hammered the bearing may develop cracks. Bearing is made upon steel material and bearing cap is mild steel.

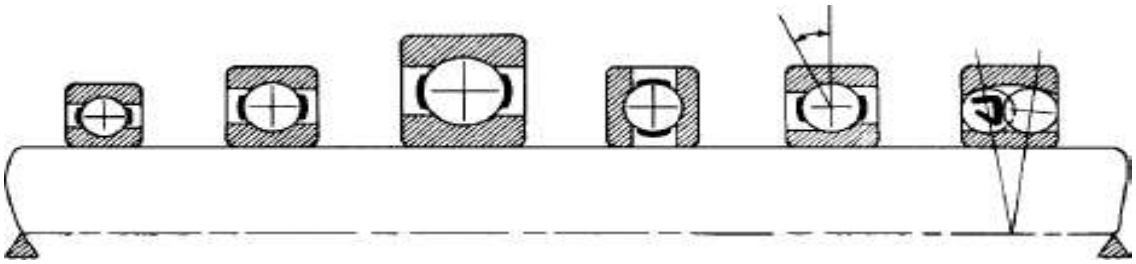
Ball and roller bearings are used widely in instruments and machines in order to minimize friction and power loss. While the concept of the ball bearing dates back at least to Leonardo da Vinci, their design and manufacture has become remarkably sophisticated. This technology was brought to its present state of perfection only after a long period of research and development.

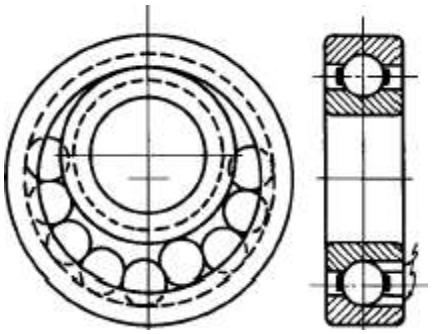
Construction and Types of Ball Bearings

A ball bearing usually consists of four parts:

- inner ring
- outer ring,
- balls
- Cage or separator

To increase the contact area and permit larger loads to be scooterried, the balls run in curvilinear grooves in the rings. The radius of the groove is slightly larger than the radius of the ball, and a very slight amount of radial play must be provided. The bearing is thus permitted to adjust itself to small amounts of angular misalignment between the assembled shaft and mounting. The separator keeps the balls evenly spaced and prevents them from touching each other on the sides where their relative velocities are the greatest. Ball bearings are made in a wide variety of types and sizes. Single-row radial bearings are made in four series, extra light, light, medium, and heavy, for each bore, as illustrated in Fig. 1-3(a), (b), and (c).





Some makers list deep groove bearings and bearings with two rows of balls. For bearing designations of Quality Bearings & Components (QBC), see special pages devoted to this purpose. The radial bearing is able to scooterry a considerable amount of axial thrust. However, when the load is directed entirely along the axis, the thrust type of bearing should be used. The angular contact bear- ing will take scootere of both radial and axial loads. The self-aligning ball bearing will take scootere of large amounts of angular misalignment. An increase in radial capacity may be secured by using rings with deep grooves, or by employing a double-row radial bearing. Radial bearings are divided into two general classes, depending on the method of assembly. These are the Conrad, or nonfilling-notch type, and the maximum, or filling-notch type. In the Conrad bearing, the balls are placed between the rings as shown in Fig. 1-4(a). Then they are evenly spaced and the separator is riveted in place. In the maximum-type bearing, the balls are a (a) (b) (c) (d) (e) (f) 100 Series Extra Light 200 Series Light 300 Series Medium Axial Thrust Bearing Angular Contact Bearing Self-aligning Bearing Fig. 1-3 Types of Ball Bearings Fig. 1-4 Methods of Assembly for Ball Bearings (a) Conrad or non-filling notch type (b) Maximum or filling notch type

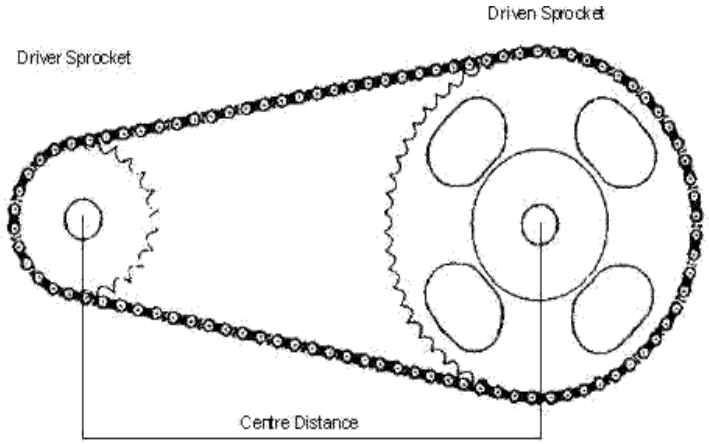
SPROCKET AND CHAIN DRIVE

Drive

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle using a chain. Since there is a reduction gear mounted in electric motor, that's why we do not need different gear ratios and because of this we are using direct chain drive. Motor sprocket has attached to motor and with its specification we have designed our shaft ratio. Since there was already reduction setup in motor we were trying to achieve 1:1 ratio from motor output to shaft. Pinion details are as follows.

Table-: Chain Drive Specifications

Parameters	Specifications
Type	Direct chain drive using clutch
Pinion	9 Teeth"s
Module	2.75 mm
Pitch	9.2364
Gear Ratio	1.4
Center distance	200mm



This is a cycle chain sprocket. The chain sprocket is coupled with another generator shaft. The chain converts rotational power to pulling power, or pulling power to rotational power, by engaging with the sprocket.

The sprocket looks like a gear but differs in three important ways:

1. Sprockets have many engaging teeth; gears usually have only one or two.
2. The teeth of a gear touch and slip against each other; there is basically no slippage in a sprocket.
3. The shape of the teeth is different in gears and sprockets.

Figure Types of Sprockets

Engagement with Sprockets:

Although chains are sometimes pushed and pulled at either end by cylinders, chains are usually driven by wrapping them on sprockets. In the following section, we explain the relation between sprockets and chains when power is transmitted by sprockets.

1. **Back tension**

First, let us explain the relationship between flat belts and pulleys. Figure

2.5 shows a rendition of a flat belt drive. The circle at the top is a pulley, and the belt hangs down from each side. When the pulley is fixed and the left side of the belt is loaded with tension (T0), the force needed to pull the belt down to the right side will be:

T1 = T0 3 eμu

For example, T0 = 100 N: the coefficient of friction between the belt and pulley, μ = 0.3; the wrap angle u = ¼ (180).

T1 = T0 3 2.566 = 256.6 N

In brief, when you use a flat belt in this situation, you can get 256.6 N of drive power only when there is 100 N of back tension.

For elements without teeth such as flat belts or ropes, the way to get more drive power is to increase the coefficient of friction or wrapping angle.

In the chain's case, sprocket teeth hold the chain roller. If the sprocket tooth configuration is square, as in Figure 2.6, the direction of the tooth's reactive force is opposite the chain's tension, and only one tooth will receive all the chain's tension. Therefore, the chain will work without back tension.

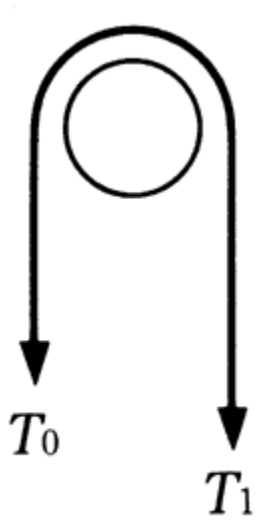


Figure Flat Belt Drive

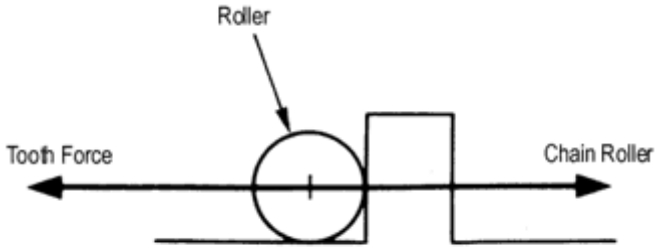


Figure Simplified Roller/Tooth Forces

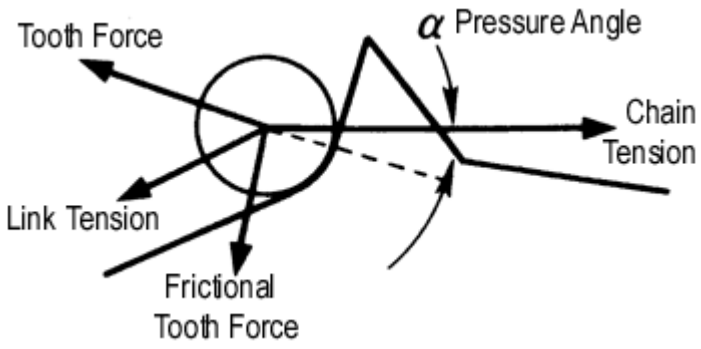


Figure The Balance of Forces Around the Roller

But actually, sprocket teeth need some inclination so that the teeth can engage and slip off of the roller. The balances of forces that exist around the roller are shown in Figure 2.7, and it is easy to calculate the required back tension.

For example, assume a coefficient of friction μ = 0, and you can calculate the back tension (Tk) that is needed at sprocket tooth number k with this formula:

$$Tk = T0\ 3 \sin ø\ k\text{-}1 \sin(ø + 2b)$$ Where:

Tk= back tension at tooth k

T0 = chain tension

ø = sprocket minimum pressure angle 17 64/N(š)

N = number of teeth

2b = sprocket tooth angle (360/N)

k = the number of engaged teeth (angle of wrap 3 N/360); round down to the nearest whole number to be safe

By this formula, if the chain is wrapped halfway around the sprocket, the back tension at sprocket tooth number six is only 0.96 N. This is 1 percent of the amount of a flat belt. Using chains and sprockets, the required back tension is much lower than a flat belt. Now let's compare chains and sprockets with a toothed-belt back tension. Although in toothed belts the allowable tension can differ with the number of pulley teeth and the revolutions per minute (rpm), the general recommendation is to use 1/3.5 of the allowable tension as the back tension (F). This is shown in below Figure 2.8. Therefore, our 257 N force will require 257/3.5 = 73 N of back tension.

Both toothed belts and chains engage by means of teeth, but chain's back tension is only 1/75 that of toothed belts.

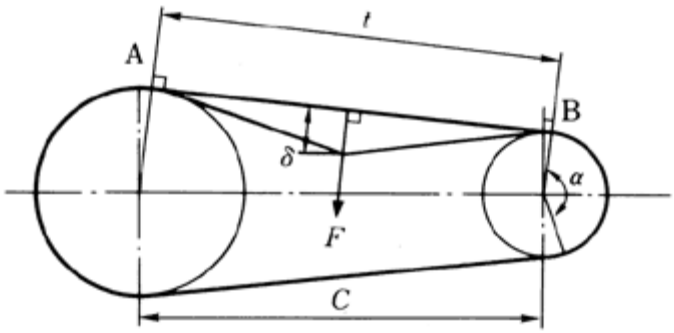


Figure 2.8 Back Tension on a Toothed Belt

Chain wear and jumping sprocket teeth

The key factor causing chain to jump sprocket teeth is chain wear elongation (see Basics Section 2.2.4). Because of wear elongation, the chain creeps up on the sprocket teeth until it starts jumping sprocket teeth and can no longer engage with the sprocket.

Figure 2.9 shows sprocket tooth shape and positions of engagement. Figure 2.10 shows the engagement of a sprocket with an elongated chain.

In Figure 2.9 there are three sections on the sprocket tooth face:

a: Bottom curve of tooth, where the roller falls into place;

b: Working curve, where the roller and the sprocket are working together;

c: Where the tooth can guide the roller but can't transmit tension. If the roller,

which should transmit tension, only engages with C, it causes jumped sprocket teeth.

The chain's wear elongation limit varies according to the number of sprocket teeth and their shape, as shown in Figure 2.11. Upon calculation, we see that sprockets with large numbers of teeth are very limited in stretch percentage. Smaller sprockets are limited by other harmful effects, such as high vibration and decreasing strength; therefore, in the case of less than 60 teeth, the stretch limit ratio is limited to 1.5 percent (in transmission chain).

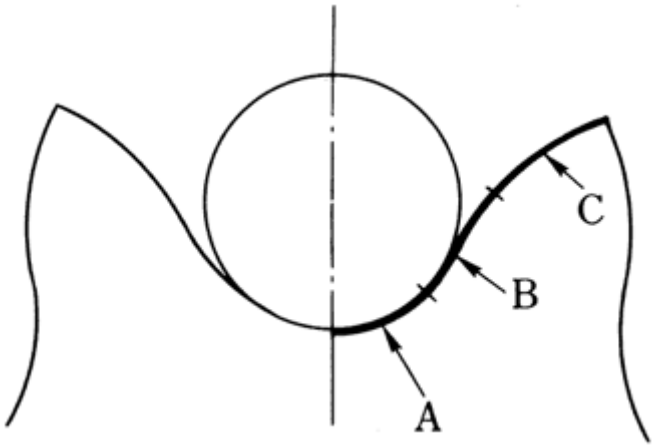


Figure 2.9 Sprocket Tooth Shape and Positions of Engagement

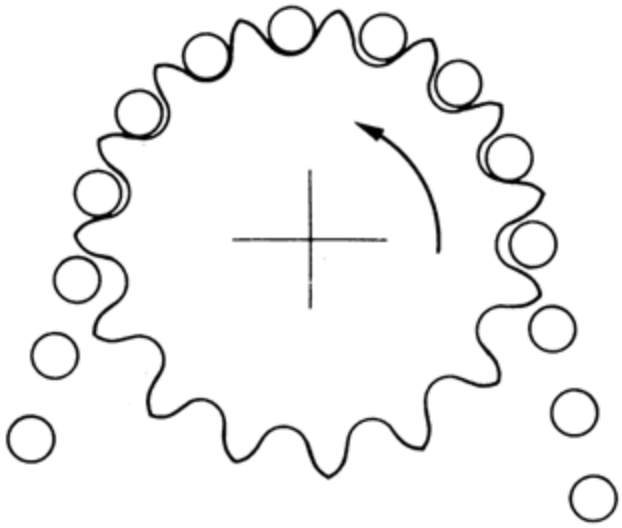


Figure 2.10 The Engagement Between a Sprocket and an Elongated Chain

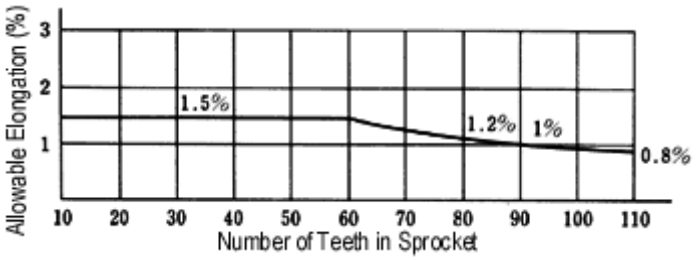


Figure 2.11 Elongation Versus the Number of Sprocket Teeth

In conveyor chains, in which the number of working teeth in sprockets is less than transmission chains, the stretch ratio is limited to 2 percent. Large pitch conveyor chains use a straight line in place of curve B in the sprocket tooth face.

A chain is a reliable machine component, which transmits power by means of tensile forces, and is used primarily for power transmission and conveyance systems. The function and uses of chain are similar to a belt. There are many kinds of chain. It is convenient to sort types of chain by either material of composition or method of construction.

We can sort chains into five types:

- Cast iron chain.
- Cast steel chain.
- Forged chain.
- Steel chain.
- Plastic chain.

Demand for the first three chain types is now decreasing; they are only used in some special situations. For example, cast iron chain is part of water-treatment equipment; forged chain is used in overhead conveyors for automobile factories.

NOTE: Roller chain is a chain that has an inner plate, outer plate, pin, bushing, and roller.

In the following section of this book, we will sort chains according to

their uses, which can be broadly divided into six types:

1. Power transmission chain.
2. Small pitch conveyor chain.
3. Precision conveyor chain.
4. Top chain.
5. Free flow chain.
6. Large pitch conveyor chain.

The first one is used for power transmission; the other five are used for conveyance. In the Applications section of this book, we will describe the uses and features of each chain type by following the above classification.

In the following section, we will explain the composition of power transmission chain, small pitch chain, and large pitch conveyor chain. Because there are special features in the composition of precision conveyor chain, top chain, and free flow chain, checks the appropriate pages in the Applications section about these features.

Basic Structure of Power Transmission Chain

A typical configuration for RS60-type chain is shown in Figure 1.1.

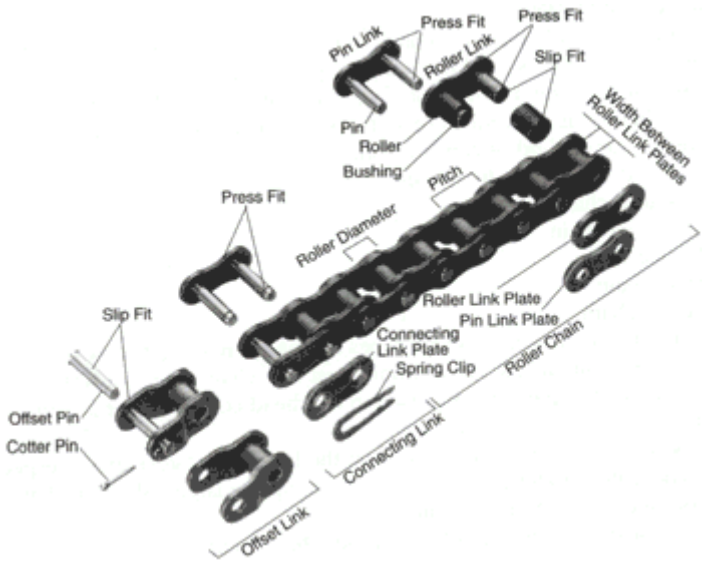


Figure 1.1 The Basic Components of Transmission Chain

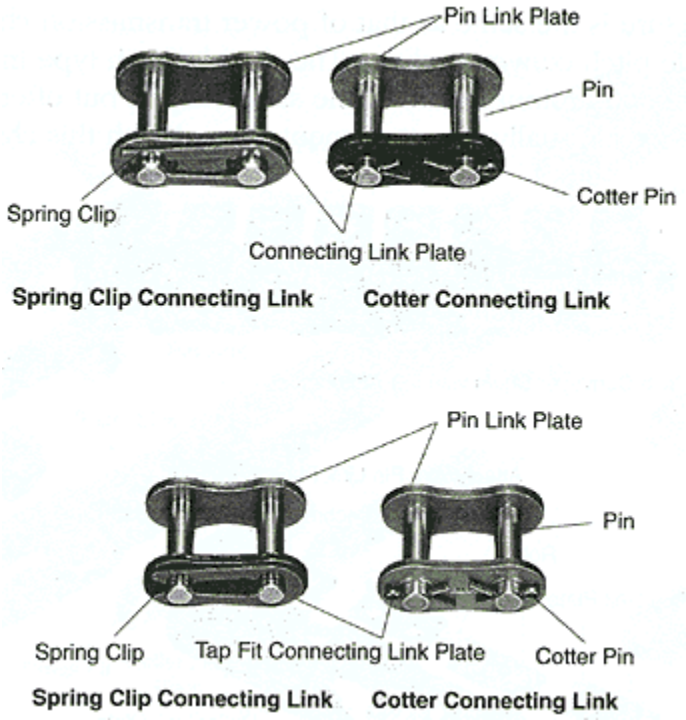
Connecting Link

This is the ordinary type of connecting link. The pin and link plate are slip fit in the connecting link for ease of assembly. This type of connecting link is 20 percent lower in fatigue strength than the chain itself. There are also some special connecting links which have the same strength as the chain itself. (See Figure 1.2)

Tap Fit Connecting Link

In this link, the pin and the tap fit connecting link plate are press fit. It has fatigue strength almost equal to that of the chain itself. (See Figure 1.2)

Figure 1.2 Standard Connecting Link (top) and Tap Fit Connecting Link (bottom)



Offset Link

An offset link is used when an odd number of chain links is required. It is 35 percent lower in fatigue strength than the chain itself. The pin and two plates are slip fit. There is also a two-pitch offset link available that has fatigue strength as great as the chain itself

DESIGN CALCULATION

Total Forces or Loads on the Bike:-

The Calculations are done by taking 100 kg mass (m) including both bike and rider. Acceleration forces on the bike (AF) = m*a
Where, m = Mass of Rider and bike = 100 kg a
= acceleration = dV/dT
V (initial) = 0 m/s
V (Final) = 20 m/s
T = Accelerating time or time to attain maximum speed = 45 s
a = dV/dT = (20-0)/ (45-0) = 0.1234 m/s2
AF = m*a = 100*0.1234 = 12.345 N
Radius of the tyre (R) = 6 inches = 6*0.0254 = 0.1524 m
Torque required to move wheel (T) = AF*Radius of the tyre
= 12.345* 0.1524 = 1.88 N-m
w = angular velocity of tyres = V/R
Power Required (P) = T*w = 1.88*(20/0.1524) = 246.72 W
Hence, due to availability of BLDC hub motors in market, 250 W power output motor is being used.

For Batteries

From the internet search and study, it was established that for every 20 Watt-hours (Wh) of battery power the electric bike runs upto 1.6 kms or 1 mile.
Standard Minimum voltage required for batteries for an electric bike = 24 V
And the range of the bike per charge = 12-15 kms
Ampere Hours = 10 Ah (can vary from 8 Ah to 20 Ah but we are using optimum capacity battery for bike)
Watt-hours = Voltage*Ampere hour = 24*10 = 240 Wh
Hence, a battery pack of 24 V and 10 Ah capacity is being used.

SHAFT

Maximum torque $T = 28.11Nm = 28110Nmm$

Maximum bending moment $M = 35 \times 9.81 \times 6.5 \times 2.54 = 56687.085\ Nmm$

Considering FOS= 4

Acc. Max. Shear stress theory:

$$\tau_{max} = \frac{1}{2} \times \sqrt{{\sigma_b}^2 + 4\tau^2} = \frac{1}{2} \times \sqrt{620^2 + 4 \times (0.5 \times 620)^2} = 438.406\ MPa$$

$$TE = \sqrt{M^2 + T^2} = \sqrt{56687.085^2 + 28110^2} = 63273.989\ Nmm$$

$$D = \sqrt[3]{\frac{16TE \times FOS}{\pi \times \tau_{max}}} = \sqrt[3]{\frac{16 \times 63273.989 \times 4}{\pi \times 438.406}} = 14.233mm$$

Acc. Normal stress theory:

$$Me = \frac{1}{2} \times \left(M + \sqrt{M^2 + T^2}\right) = \frac{1}{2} \times \left(56687.085 + \sqrt{56687.085^2 + 28110^2}\right) = 59980.54\ Nmm$$

$$D = \sqrt[3]{\frac{32\ Me \times FOS}{\pi \times \sigma_b}} = \sqrt[3]{\frac{32 \times 59980.54 \times 4}{\pi \times 620}} = 15.79mm = 16mm$$

Therefore, considered shaft of 16mm or greater than it for design.

TRANSMISSION

Velocity:

$$v = \frac{2\pi Nr}{G} \times \frac{60}{1000} = \frac{2\pi \times 4000 \times 0.0762}{1.4 \times 5.78} \times \frac{60}{1000} = 14.2\ Kmph$$

Tractive resistance = AR+GR+RR … (I)

AR= Aerodynamic resistance

$$AR = \frac{1 \times Cd \times \rho \times A \times v^2}{2} = \frac{1 \times 1.15 \times 0.4558 \times 1.225 \times 3.88^2}{2} = 4.83\ N$$

GR= Grade Resistance

Which is given as, $GR = W \times sin\theta$ =90 × 9.81 × sin(5) =76.94 N … (2)

RR= Rolling resistance

Which is given by, $RR = fr \times W$ = 0.01 × 9.81 × 90 = 8.83 N … (3)

Putting Values from eq^n 1, 2, 3 in eq^{n}I, we get,

TR=4.83+76.94+8.83=90.6 N

Traction:

$$TF = \frac{Te \times G \times \eta_t}{r} = \frac{0.8 \times 5.78 \times 1.4 \times 0.9}{0.0762} = 129.37N$$

Torque:

$$Td = Te \times G = 0.8 \times 5.78 \times 1.4 = 6.4736\ Nm$$

Acceleration:

a= tractive effort / mass = 129.37/70= 1.85 m/s^2

CHAIN AND SPROCKER

No. of teeth on sprocket $T_2 = T_1 \times 1.4 = 9 \times 1.4 = 13$

Diameter $D_2 = T_2 \times module = 13 \times 2.75 = 35.75mm$

Chain Length:

$$l = \frac{T_1 + T_2}{2} + \frac{2C}{P} + \frac{(T_2 - T_1)^2 P}{4\pi^2 C} = \frac{13 + 9}{2} + \frac{2 \times 200}{9.2364} + \frac{(13 - 9)^2 \times 9.2364}{4\pi^2 \times 200} = 54.49link = 55link$$

$$= 55 \times 9.2364 = 508mm$$

BRAKES

For effective braking of vehicle the braking torque of wheels should be greater than Engine Torque at wheels. The designing of brake system is based on this factor.

Generally lever ratio lies between 4 to 6. We assumed it as

4. The force applied on the piston= 90 N

Net force on lever end

= lever ratio force on the Pedal

= 4* 90= 360 N

Force produced by caliper piston = Force produced at lever end = 360 N

Force on rotor =Force produced by

caliper piston =360 N Total frictional

force

= Forced on rotor x coefficient of friction between

pads & disc No. of caliper F =360 *0.4 x 1 =144 N

Deceleration = Force/mass = 144/90 = 1.6 m/s^2

Stopping Distance

= $(velocity^2)$ / (2 deceleration) = $(3.88)^2$ / (2 1.6) =4.726 m

Stopping time

= Velocity / deceleration = 4.726 / 1.6 = 2.95 s

Total stopping time

= Stopping time + Driver Reaction

= 2.95+ 1.5= 4.45 s

Effective Radius of rotor

$= 2(R^3-r^3)/ (3(R^2-r^2))$

$= 2(80^3-67^3)/ (3(80^2-67^2)) = 73.3$ mm

Braking Torque

= Braking force Effective Radius

= 144 0.0733 = 10.55 Nm

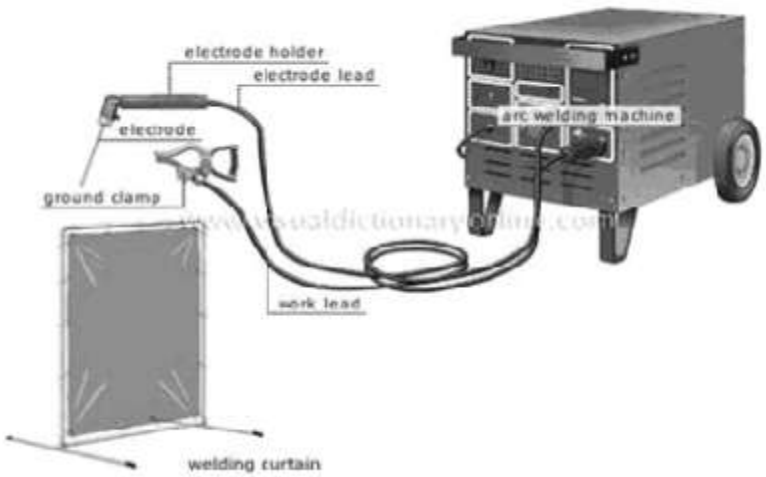
Torque at wheel = 9.58 Nm Torque at Wheel < Braking Torque Therefore, Design is Safe.

METAL FINISHING

Arc welding

Arc welding is a process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. It is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, or slag. Arc welding processes may be manual, semi-automatic, or fully automated

ARC WELD EQUIPMENTS



Welding is the joining of metals through coalescence by the use of either heat or pressure or both. Coalescence is a term that means the joining of two materials to become as one piece. The basic arc welder components consist of the machine that generates the power, the electrode holder or wire feed gun, a means of shielding the weld as it forms, and protective equipment for the user. The process begins in all types when the wire or rod makes contact with the piece to be welded. This completes an electric circuit and creates an arc through which the transfer of the metal from the wire or rod to the piece is facilitated. Spatter occurs during transfer; some of the molten drops of metal become airborne and cover the piece and surrounding area with small globules that solidify on cooling. Spatter may be minimized depending on the skill of the operator and the welding method being used.

CORROSION PREVENTION

The following methods are used for corrosion prevention of the various components of the Multipurpose sowing machine.

RUST CLEANING

Oxidation creates a scale formation on the surface of the material. Scale formation gives rough structure of surface of iron oxide. This iron oxide

formation penetrates into the surface and makes the metal weak and reduces the life of the components. Different grades of emery sheets are used to remove the rust formed on the surface of the steel and cleaned properly.

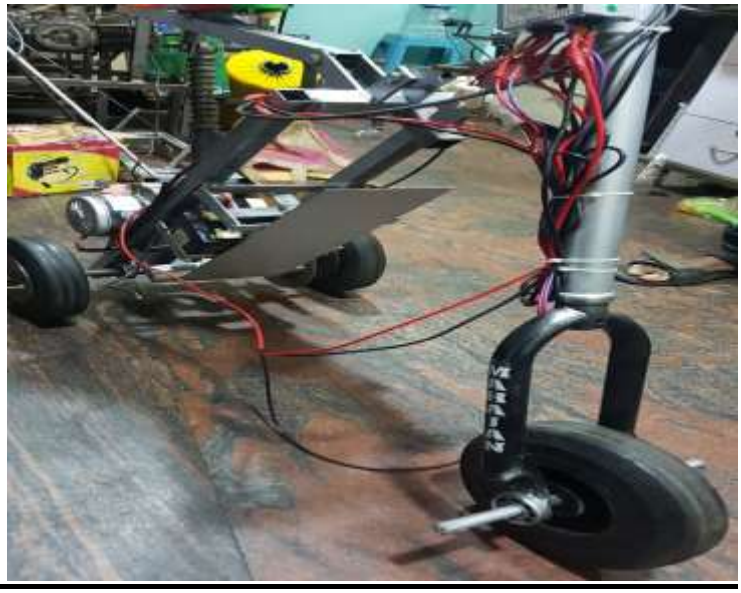
RED OXIDE COATING

This Red Oxide Paint Coating is to prevent the action of corrosion and protect the Surface of the components from atmospheric corrosion. Red Oxide Paint and Thinner liquid are mixed in proper proportion and coated on the surface of the components. The purpose of thinner is to reduce the viscosity of the paint and free flow of the paint over the surface of the components.

FINISH COATING

Milky white color paint is applied over the surface of the machine after the application of the above coatings in a smooth manner using a paint sprayer. This final finish coating of the milky white color of the paint gives good pleasing appearance and effective corrosion prevention.

PROJECT WORK



ADVANTAGES:

- This vehicle has an advantage due to its folding characteristics.
- This type of vehicle fits in a category of Portable vehicle which means handling of vehicle from one place to another is easier without any hesitation.
- This vehicle is compact in size so it can be used where other vehicles have restriction due to their huge sizes i.e. in big shopping mall and industries.
- This vehicle can be folded and unfolded in led time
- The vehicle can use engine instead of an electric motor, hence its operating cost required will be less than any other ordinary vehicle.
- Due to the use of engine, speed and load scooterrying capacity can be increased for vehicle.
- Weight of vehicle has reduced as no. of batteries required is less and smaller in size.
- This vehicle can be operated by a single person to fold and unfold.
- Battery used is rechargeable using AC adaptor

FUTURE SCOPE

- This vehicle can be modified to provide more space by increasing suitcase size and motor capacity.
- Engine can be used to provide more power and torque if needed.
- Weight can be optimized by using more strength and light weight material.
- Thickness of chassis material can be reduced if high strength material is in use.
- If the vehicle is equipped with safety equipment's, then it can be used on public roads within certain limits.
- It can be made into four wheel drive if size of suitcase is increasing.
- We can use electric motor hub if there is only one wheel to transmit power to vehicle.
- A differential can be used to reduce turning radius
- Can add solar power to increase battery backup
- Lithium ion battery can be used to increase life, durability and reduce in weight.

COST ESTIMATION

MATERIALS COST:

SL. NO.	NAME OF THE PARTS	MATERIAL	QUANTITY	AMOUNT (RS)
1	Battery	Lead-Acid	2	3000
2	D.C. Motor (12 V)	Aluminium	1	2500
3	Chain and sprocket	Mild Steel	1	250
4	controller unit		1	1000
5	Ms shaft	M.S	1	1500
6	Frame Stand	M.S	1	1750
7	Connecting Wire	Cu	-	200
8	Ball bearings	SS	4	400
9	spring	MS	1	100
10	Seat		1	100
11	wheels	rubber	2	500

TOTAL = 11300/-

MATERIAL

1) **TOTAL COST =11300/-**
2) **LABOUR COST =2000/-**
3) **OVERHEAD CHARGES**

MANUFACTURING COST = 11300+2000

= 13300/-

OVERHEAD CHARGES = 20% OF 13300

= 2660/-

TOTAL COST OF PROJECT = 13300+2660

=16010/-

CONCLUSION

Our project "**Design and Fabrication of foldable vehicle**"" is the perfect application of theory and practical we have studied so far in engineering. The aim of this project was to design and build a coaxial, light weight vehicle which will consume less space for parking and can be scooterried along. This aim has achieved and a foldable suitcase vehicle with electric motor has manufactured and successfully tested.

A comprehensive literature review has conducted, covering technical information relevant to the project. A formulated design approach was used to create the most efficient and robust configuration for fabrication of the foldable vehicle. The structural design was considered concurrently with component selection, aesthetics, and ergonomics to minimize mechanical, electrical and rider integration problems.

It can be used in college campuses and industrial areas to minimize the walking distance. As it is electric motor powered, it is easy to operate. The vehicle is compact, lightweight, has simple design and hence easily portable. Cost of manufacturing is moderate. Other vehicles can be manufactured having greater capacity as well as larger area for heavy duty works. Thus, our project "Design and fabrication of foldable vehicle" is a successful attempt to overcome traffic congestion and parking problems.

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