CONVERSION OF OLD PETROL VEHICLES INTO MID DRIVE ELECTRIC VEHICLES

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ABSTRACT:
The global warming and Air pollution have become prominent issues over three decades. Worldwide research is oriented to obtain efficiency in utilizing Electrical Vehicles in order to replace conventional Internal Combustion Engine vehicles. This work includes modification of four stroke tvs scooty pep plus into Electric scooter. In this Assembly and the Dis-assembly of scooty pep plus Electric vehicle and modification of electric scooter is discussed in detailed way. Selecting parts that are to be replaced and retrofitted is covered in this work. It also includes basis for selection criteria of components, Weight of Electric vehicle, Calculation of overall load on vehicle, total Rolling resistance acting on wheels, torque, speed required in detailed way and based on requirements Motor power, speed and battery pack for required mileage which are the basic design Characteristics are selected. Components to be fabricated such as Swing Arm Sprocket, etc, are explained. Experimental results from converting a petrol scooter into electric vehicle are calculated and total cost of modification is presented.

Keywords-
Automobiles, Affordable, E-vehicles scrap, Metal waste management, Reusability, Sustainability.

INTRODUCTION

Electric vehicles

Electric Vehicles are automobiles in which power required to run is obtained fully or partially from electricity, which is stored in batteries. Electric vehicles, also known as green vehicles, are four-wheel vehicles that run solely on electric energy, eliminating the need for internal combustion engines and hydrocarbon fuels. Instead, electric energy powers the mechanical operations of these vehicles. As a result of the absence of IC engines, electric cars do not emit harmful pollutants, making them environmentally friendly and capable of improving environmental conditions.

Reasons for converting old Internal Combustion Engine Vehicles to Electric Vehicles

Pollution-Free: Imagine a world without petrol stations, all those carbon emissions, Global-warming effects, air pollution will replenish itself into a cleaner environment with time. It might sound unrealistic, however electric vehicles have the power to make this possible. Instead of fuel, electric cars need electricity to run. With the Rise in popularity of electric vehicles, car charging stations across the cities will be established. Hence, allowing the drivers to charge their vehicles at public spaces with the help of charge points. Moreover, Charging can be done by all-weather home charging unit. It can be installed in garage and charge the car by plugging in the charging cable. Typically, it takes 5-10 hours to charge fully, but rapid chargers can speed up this process. [1]

Cost Management: In spite of the fact that the price of an electric vehicle could be higher than diesel cars and petrol cars, the cost of running an electric vehicle can be incredibly low. Besides, they comprise three main components – on-board charger, inverter, and motor. Hence, there is minor wear and tear as EVs don't have conventional engines. As alternatives, they carry electric motor's fuel with rechargeable batteries. Lastly, electric vehicle batteries have a life of eight years or up to 100,000 miles. Those doesn't degrade manufacturers warrant level, eliminating additional costs [1].

Environmental Effects: The pollution caused by internal combustion engine (ICE) vehicles extends beyond their exhaust emissions. The entire process of extracting oil, refining it into fuel, and transporting it to gas stations contributes significantly to air pollution, known as well-to-wheel or upstream emissions. Despite reductions in CO2 emissions by modern ICE manufacturers, the manufacturing process itself still has a negative environmental impact. Consequently, many people prioritize environmental concerns when considering the purchase of an electric vehicle (EV). As countries progressively shift towards renewable energy sources, the electricity used to power EVs becomes cleaner and greener, potentially reducing carbon intensity by up to 90% compared to petrol models [1].

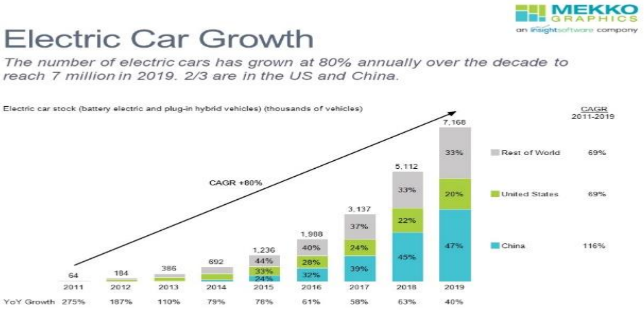


Figure No.1: Increasing trend in ev's adoption

Air pollution in India caused due to carbon emissions: India, in particular, faces severe air pollution due to carbon emissions. According to the Ambient Air Pollution (AAP) report for 2014, Delhi had the highest levels of PM 2.5 pollution in the world, followed by Beijing. This measurement is based on PM 2.5 outdoor air pollution monitoring conducted across nearly 1,600 cities in 91 countries. High concentrations of PM 2.5 pollutants pose a serious health risk, leading to respiratory diseases and even lung cancer.

According to a recent report by GMI Research, the electric vehicle market in India is expected to grow at a robust CAGR of 25.5% from 2019 to 2026. In 2018, the market generated revenues of USD 1,202 million and is projected to reach USD 9,306 million by 2026. Currently, the electric vehicle market in India is in its early stages but shows promising growth prospects. The increasing levels of air pollution and global warming are key factors driving the growth of the electric vehicle market in India.

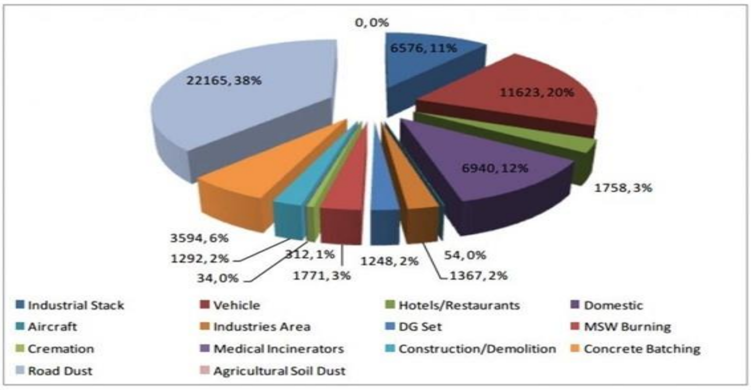


Figure No.2: Air Pollution Sources in Delhi

Requirements for Converting Existing ICE vehicles to Electric vehicles

Locating Scrap vehicles

Areas, where scrap automobiles are generally stored, are located such as Metal Scrap recycling Plants, Police go-downs, mechanic shops, automobile disposal warehouses, etc. Contact with the respective personnel is established and a1 supply is established for the continuous circulation of scrap vehicles to the designated reusing plant from these locations. Parallelly individuals are encouraged to dispose of their vehicles directly at the Modification plant or respective service centres, once the plant is fully established. This step will be the most crucial in establishing the conversion plant as in India scrap vehicles are very large in number but are vastly distributed. Considering big cities premises scrap vehicles will be majorly located at

- Recycling plants
- Government ceased vehicle go downs
- Waste collection centres
- Mechanic shops
- Houses, apartments

A major challenge in India is creating awareness among people about the disposal of their old vehicles, as most of them leave it within their house premises in the dilemma of repairing and using it, which as time progresses will only affect the condition of the vehicle. Another challenge in Indian automobile scrap management is improper disposal and improper segregation of materials, segregation of metals, plastics, glass, and rubber rarely occurs at the site of dump yards unless there is a useful component. Even though there are some recycling plants situated they do not work up to the capacity and also waiting period for the scrap will be high sometimes they will be left out for months or years, which makes metals rust [2]. To counter all these challenges, the low cost of E-vehicle should encourage people to dispose of their old vehicles at the modification plant, compensation more than the scrap value of the vehicle needs to be promised to people. Dealing with the government for scrap vehicles. Maintaining ties with the mechanics to provide a good value per scrap vehicle. Advertisement about the availability of such scrap reusing and converting plat is also given much importance.

Dis-Assembly and Inspection

Once a continuous scrap paradigm is established next step of dismantling these Scrap vehicles is carried and their respective petrol/diesel components (such as IC Engine, Silencer, gearbox, radiator, etc) are removed and the major and important part to be reused is chassis which needs to be in good condition, Chassis and other parts are inspected for its re-usability,

- If the chassis/frame and other non-functional parts are free from significant rusting it can be sandblasted and treated with anti-rusting paintings and reused.
- If the condition of the Engine, gearbox, radiator, silencer, etc is the medium used then they can be sent further to Re-work and these reworked components can be further used.
- If the non-functional and functional parts are heavily used and the rust formation has reached deep then they are crushed and recycled within the plants which can be later used for the fabrication of other parts required. Chassis, Panels, Wheels, and other mechanical components are inspected for their rust formation and most of these have a very long life, as panels are mostly made of plastic, and chassis, rims, hubs, etc if not deeply corroded will have a longer life.

Sandblasting and Painting room

After a thorough inspection of chassis/frames, wheel rims handles and other metal parts if the rust formation is minimal i.e., limited to the surface, it can be scrubbed and sandblasted which removes dust from existing painting as well as rust and treated with rust removal liquids such as Alkaline-Hydrocarbons if needed. Plastic, glass, and rubber parts are inspected if not broken then can be scrubbed and repainted. Broken plastic parts can be plastic welded. Minimal space is enough for these operations but the room needs to be closed to not let dust accumulate on the freshly coated paint. Sandblasting needs to be done in a separate room.

Fabrication unit:

Although most of the parts can be reused from automobiles few attachments, casings, etc need to be fabricated to fully modify these vehicles to Electric some of these parts are Swing Arm (Modified/Completely new), Battery casing, Sprockets, and other necessary parts will be further discussed in this paper in experimental analysis chapter. For this, a unit is allocated with welding, cutting, milling, drilling, and other required machinery.

Electrical and Electronics

After calculating the necessary Power, Torque, and Battery capacity based on the requirements Suitable EV components such as Motors, batteries, Controllers, wirings, and other necessary components are bought from suppliers. After testing for their working and locating these parts to the vehicle necessary mountings need to be attached.

Assembly and Testing station

Electrical and Electronic parts are assembled to their respective positions with their Chassis/Frames and a wiring connection is established. After complete assembly of the vehicle, it is tested for its Load capacity, Speed, Range per Charge, Over voltage, Under Voltage, charging, etc. For this assembly and disassembly, extra space with a lift kit is arranged to carry out various operations on the vehicles. These vehicles will have new registration which will enable them to be official on the roads.

Automobile Scrap Reusing & Circular Economy

The disposable economy was soon recognized as having significant economic and environmental consequences, leading to the introduction of the circular economy as an alternative. The circular economy is founded on the principles of "reduce, recycle, reuse" as a response to the extract-produce-dispose model. These principles find application in various contexts, including the recycling of materials like plastics, steel, and aluminum. In the case of scrap vehicle conversion to electric vehicles, it is proposed to adopt these concepts, ensuring adherence to the principles of the circular economy throughout the conversion process.

- Reducing the usage of new materials for manufacturing vehicles
- Reusing old scrap vehicles
- Reusing plastics, steel, aluminium, rubber, etc.

Recycling automobile scrap is a difficult, time-consuming, and uneconomical method so instead of recycling reusing these scrap vehicles after removing unusable parts which are generally engine, silencer, gearbox, fuel tank, etc as they are prone to rust and failure of these components is the main reason for scrapping the vehicle.

The machinery required for converting scrap automobiles to electric vehicles are known by researching EV manufacturing companies and by practically modifying a vehicle which will make machine requirements more precise. A practical approach will help in designing machine layouts, labour requirements, technician requirements, etc which help in setting up a plant. Practically going through step-by-step processes involved also helps to understand the flow of work [3].

Modification of TVS Scooty into Electric Vehicle

Introduction

Before carrying out the conversion process for EV scrap, it is crucial to consider the concept of vehicle performance requirements. Vehicle performance requirements refer to the specific demands of vehicle users, which determine the desired performance of the converted EV. This concept allows for customization and ensures that the investment in EV conversion delivers optimal value. There are three key factors to consider when addressing EV performance requirements: distance, speed, and cost. These factors play a significant role in planning the EV conversion process. Depending on the specific requirements, the conversion can be tailored to prioritize either distance or speed. Additionally, the cost function becomes a crucial aspect that influences the optimal values of distance and speed. To begin with, it is essential to identify the vehicle type that will undergo the conversion and gain a comprehensive understanding of each EV component. It should be noted that heavier vehicles typically require more power compared to lightweight ones [1]. Therefore, two major components, namely the battery and the electric motors, must be carefully considered before initiating the conversion process. These components play a critical role in determining the performance and capabilities of the converted EV.

Battery

Typically, electric vehicle batteries are either lithium-ion or lead-acid batteries. These batteries are specifically engineered to possess a high capacity in terms of ampere-hour or kilowatt-hour. It is important to note that electric vehicle batteries differ from starting, lighting, and ignition (SLI) batteries in that they are designed to provide sustained power over extended periods and are classified as deep-cycle batteries. Electric vehicle batteries are characterized by several factors, including their relatively high power-to-weight ratio, specific energy, and energy density. The desirability of smaller and lighter batteries stems from their ability to reduce the overall weight of the vehicle, thereby enhancing its performance. However, compared to liquid fuels, most current battery technologies exhibit significantly lower specific energy. This discrepancy often affects the maximum all-electric range of vehicles. Nevertheless, this challenge can be overcome by establishing an adequate network of charging stations to ensure convenient access to charging infrastructure [9].

Electric Motor

The working of an electric motor is based on the fact that a current-carrying conductor produces a magnetic field around it. An electric motor is a machine that converts electrical energy into mechanical energy. and it opposes/aligns with the flow of the existing magnetic field due to it there is an attraction or repulsion between the two magnetic fields which is then converted to a rotational form of mechanical output.

Distance

The concept of distance for EV conversion focuses on the daily distance traveled. Electric vehicles are particularly well-suited for city commuting purposes, such as traveling between residences and offices. According to a survey conducted by General Motors in the early 1990s, the findings were as follows:
- The majority of people do not cover long distances while driving.
- Over 40% of total travel is below 8 km.
- Only 8% of individuals travel beyond 40 km.
- Almost 85% of drivers travel less than 120 km daily.

Calculations

1) Motor Torque: Pre-requisite data for calculation of Torque requires following below parameters:
2) Rolling Resistance: Rolling resistance is the force that acts against the motion of a vehicle, arising from the interaction between the wheels and the surface it moves on. It is influenced by the coefficient of rolling friction, which varies based on the tire material and the surface roughness.
To calculate rolling resistance:

Rolling resistance = gross weight x rolling friction co-efficient

3) Grade resistance: The grade resistance acting on the vehicle is the form of gravitational force. It is the force that tends to pull the vehicle back when it is climbing an inclined surface.

Grade Resistance = Gross Weight x sin θ

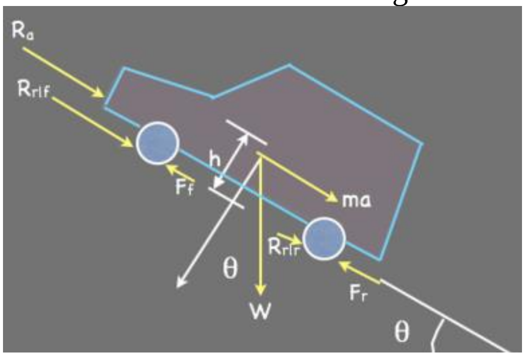


Figure No.3: Grade Resistance

4) Calculating the acceleration force: The acceleration force is the force that enables the vehicle to achieve a predetermined speed from a stationary position within a specific time frame. The motor torque directly influences the acceleration force, with higher torque resulting in reduced time for the vehicle to reach the desired speed. Additionally, the mass of the vehicle plays a role in determining the acceleration force. The calculation for acceleration force is as follows:

F = Mass x Acceleration

This tractive force can be assumed as acting at wheels of the car so torque required on the wheels is this TTF x Radius of wheel.

5) Real World Losses Check: Generally total torque of motor is reduced when it is transferred onto the wheels because of frictional losses.

Total tractive force =

Rolling Resistance + Grade force + Acceleration force

The maximum tractive torque (MTT) a wheel can transmit =

Frictional force (L x u) x Radius of wheel/tire

Torque on Wheels > (TTF x Radius (Resistive Torque))

Now Total Torque the wheel can transmit without slipping

Torque on wheels=

Torque generated by Motor x Coefficient of friction

For each drive wheel, the Maximum Tractive Torque signifies the maximum torque that can be applied before slipping occurs. It is important to ensure that the total wheel torque, as calculated earlier, remains below the combined sum of the Maximum Tractive Torques for all drive wheels. Exceeding this limit would result in slipping.

Max Tractive torque of all wheels > Torque on wheels from Motor

Only then vehicle will move

6) Calculation of Motor Power: After calculating Torque required to get the vehicle into motion based on the speed required for the vehicle (EX: 100km/hour) now can calculate Power required for our motor through

Motor Power = Torque required x No. of Revs of Shaft

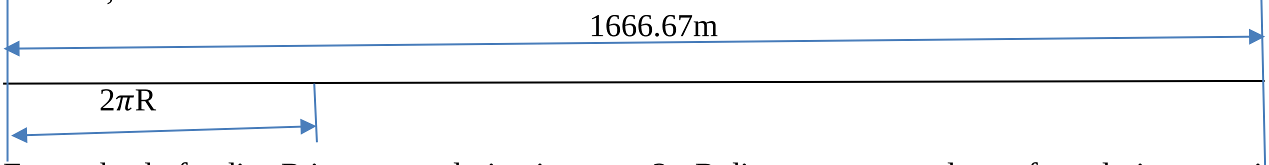
$P = T \times N\ (2\pi/60)$ in N-m/sec

7) Speed of vehicle required: Let's say standard design requires 100km/hour as max speed so the motor revolutions should be able to achieve it i.e., Select standard wheel/tire size of radius R and speed required V km/hour

Now, 100km/hour needs to be converted into no. of revolutions of wheel

100km/hour = 1666.67m/minute

Assume, 1666.67m



For a wheel of radius R in one revolution it covers $2\pi R$ distance now total no. of revolutions required will be

Total distance (in meters) = $2\pi R$ x No. of revolutions

Dividing with time,

Distance travelled/minute = $2\pi R$ x No. of revolutions per minute

Let's take standard tyre size of 155/65 R 12 (12inch) and required max speed is 100km/hour so can get no. of revolutions required (i.e., N value).

8) Results: So now in $P = T \times N\ (2\pi/60)$ Torque required which is greater than total tractive effort along with frictional losses and No. of revolutions required on wheel to get desired output speed, based on these two values, power required for the Motor is calculated with a factor for real world problems and losses.

9) Battery Capacity: Battery capacity is the number of electrons that a battery can store inside it and at what rate it can deliver electrons i.e., nothing but Voltage, Current and size of the battery these three along with BMS determine the battery capacity which is the driving function for Mileage of EV.

Based on power required max Current and max Voltage of battery are found and along with this in accordance with Mileage required per charge which may be modified/altered based on requirements by adding batteries.

$$\text{Power, } P = T \times N\ (2\pi/60) = \text{Voltage} \times \text{Current} = V \times I$$

kWh-Kilo Watt Hour is explained as kilo watts of energy delivered for certain number of hours this contains voltage in its equation whereas in practical applications voltage always varies while charging and discharging, So for precise estimation battery capacity is measured in Ampere Hour (Ahr) this implies that Number of amperes of electrons delivered for umber of hours.

Example: 100Ampere Hour =100Ahr = 50A x 2H = 25A x 4H

Above equation can be explained as 50A current can be supplied for 2Hours or 25Amps of current can be drawn for 4Hours. Based on voltage Current drawn is related. 100Ahr x 15V = 1.5kWh

10) Weight of EV: Weight of an electric car/vehicle is one of the most important areas for automobile designer and manufacturer to study and research particularly in EV because it will determine many factors such as Mileage, Power, Acceleration and other abilities of EV. Most important among them is range of EV to differentiate good and bad EV its power to weight ratio is one of the important parameters.

Taking a scrap vehicle to convert

A scrap two-wheeler TVS Scooty pep+ is taken to modify to Electric Vehicle to test it for the cost analysis, machinery required for establishing the plant, etc also to study and note the experimental result.

Figure No.4: scrapped TVS Scooty

Dismantling the scooter

All the unnecessary components such as the engine, fuel tank, silencer, radiator, etc are removed and only the basic Chassis, handle, Wheels, Seat, and a few other components are left assembled.

Order of dis-assembly:

- Outer body panels of the vehicle are removed first
- Seat and boot space box is removed
- Outer chrome body bumpers are taken out
- Fuel tank, Back tyre guard, and other top rear attachments are removed
- Carburettor is dismantled from the engine and the intake filter
- Suspension is removed
- Engine, Radiator, and other mountings are removed
- Finally back tyre and rim are removed from the centre hub mountings

- Brake cables, wirings for the headlight, battery, and other electrical connections are removed

Problems faced during dis-assembly: Most of the outer panels were removed with ease but when coming to the engine and radiator there were few bolts that were struck and their threading was damaged as well as because of dust formation it took much effort to unscrew it. Most of the silencer and gearbox were rusted out, the silencer was in no position to send it for rework. Back wheel Engine Shaft was completely locked out after applying alkaline hydrocarbon spray and with much effort, the shaft got dismantled. Most of the inner parts were greased which had to be cleaned with thinner solutions.

Fabrication of necessary equipment

The swing Arm is the extra attachment attached to the chassis using which the back wheel is attached to the bike, generally, in ICE scooters in India, the back wheel is attached to the engine, the engine itself acts as swing arm mounting but the engine is an unnecessary component for EV and is removed so, an alternate swing arm has to be made along with-it Chain drive/belt drive system. Chain drive has advantages over belt drive belt and pulley for required gear ratio are difficult to find whereas sprockets of different sizes and the different numbers of teeth are easily available by which required gear ratio can be easily achieved so it is preferred.

The following parts need to be fabricated:

- Swing Arm
- Battery casing in place of the fuel tank
- Back Wheel sprocket mounting
- Sprocket for required Torque and Speed
- Chain tension Adjuster

Points to note for making Swing Arm:

- Ergonomics of the vehicle should not be changed.
- Back wheel should be located in the middle of the shaft.
- Suspension location needs to be alterable. The height of the vehicle needs to be alterable by adjusting the suspension position on the swing arm.
- Dimensions of the swing arm should be such that the length of the vehicle needs to be unaltered.
- By checking the compatibility and positioning the basic model fitting required for the motor and controller is added.

Swing Arm

Motor dimensions are accurately noted down and a 2D drawing is drawn roughly on paper first with two or more views to cover all the characteristics, based on the motor dimensions Swing Arm width is calculated to make sure the sprocket of the motor is attached to the wheel sprocket and both the sprockets align parallel to each other to prevent the chain from fall and wear of sprocket teeth as well as to enable smooth power transfer. The length of the Swing Arm is designed in such a way that it will not alter the ergonomics of the original vehicle which also involves positioning the suspension. The suspension is positioned at the end.

A 3D model of the motor, Swing Arm are then drawn in NX CAD software and assembled to check their mesh.

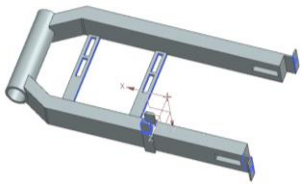


Figure No.5: Swing Arm 3D drawing using NX

After welding into a basic U-shape, the motor is checked for its position rigidity then after locating the motor its mountings are welded to Swing Arm, by placing the motor and back wheel in their respective position, holes on two sides of the Swing Arm for the wheel shaft mounting are made to make adjustable shaft position for horizontal movement. Suspension mountings are made during an assembly at the end. Based on the seating position. The location of the suspension is important as a slight change in it alters the ergonomics of the vehicle as well as the sensitivity of the shock absorption.

Figure No.6: Completely fabricated Swing Arm

The material used for making the Swing Arm is mild steel which resembles the characteristics of the petrol version so that the safety of the vehicle does not change. Thickness is 3mm same as that of the chassis which makes its stress distribution to be almost the same as the earlier version and also reduces weak spots in the final vehicle.

Fabrication of Sprocket mounting to Back-Wheel

The Scooty pep+ has a belt drive system and has bevel gear setup which is situated inside the engine mounting, this setup cannot be modified to connect with the motor. so, a new sprocket mounting needs to be fitted to the wheel to drive the back wheel using the motor's sprocket and chain.

Figure No.7: Back wheel sprocket mounting & sprocket

To this mounting sprocket is attached using a bolt and nut arrangement.

Selection of electric vehicle components

Based on the EV specifications speed, range, and load capacity components of the EV are chosen. Every component required for an electric vehicle is either fabricated or bought from the vendors. Selecting parts and sub-assemblies for the designed output specifications of the EV is the biggest task that can resulting either good/bad vehicles. The minimum required speed is 40 km per hour and mileage is 100km based on these parameters' calculations will be made for the selection of electric components. All the calculations and formulas involved in finding motor power, battery capacity, speed, torque, Rolling Friction, etc are studied from [6], [10], [11].

Choosing motor: 750watt motor will normally have 3000rpm but torque is 17kg-cm. But for 250+kg load capacity torque required on the tyre will be approximately 80+kg-cm. To achieve the required load capacity with the required number of rotations, need to adjust the gear ratio of the motor. Suitable gear ratio is 1:6 reduction to increase torque

Specifications of Motor

The motor used in the project is 750watt Brush Less DC with pure copper windings.

Rated Operating Voltage	:	48V
Rated Power	:	750W
Load Current	:	4.0A

No Load Speed	:	500 RPM
Rated Torque	:	102Kg-cm
Rated Speed	:	400 RPM
Rated Current	:	13.4A
Efficiency	:	80%
Gear Ratio	:	6:1
Dimensions	:	23.5cm x 17.4cm x dia13.5cm
Load capacity	:	250kg
Weight	:	3.7-4kg

Figure No.8: Brushless DC Motor

Motor Controller: Based on the specifications of motor the following motor controller is chosen. Voltage, Power, and Rated Current are based on these specifications of the motor.

Controller Specifications

Rated voltage	:	DC48V
Rated power	:	750Watt
Rated current	:	30A
Under-voltage protection	:	DC41.5V+-0.5V
Current limited	:	30A±0.5A
Efficiency	:	≥83%
Consumption	:	<1.5W

Figure No.9: Controller

Battery: The required range of the EV is 100+ km per charge, to get that for the following 750watt motor needs a 30Ah battery capacity with 48V rated voltage. Lithium Ion Battery is the only best solution for scooters because of the availability of space and no. of duty cycles of Li-Ion battery are more than any other Li phosphate or Lead Acid battery types.

Battery Specifications

Rated Voltage	:	48V
Capacity	:	30Ah
Water Resistance	:	Splash-proof
Charging Time	:	5-6 hours
Type	:	Lithium Ion
Warranty	:	2years
Casing	:	Metal casing and carriable
Weight	:	4kg

Figure No.10: Battery

Charger: Conditions of selecting the charger are it needs to be compatible with the battery, for that Voltage of the battery, max Capacity of the battery as well as continuous charging current and discharging current according to Indian standard available input current will be 230-240 VAC, the output current is based on the time of charging the battery.

Charger Specifications

Voltage Input	:	180-280 VAC
Voltage output	:	54.2 VDC
Current Input	:	2.5A MAX
Current Output	:	6
Charging Time	:	5-6hours
Model	:	APCP400W
Type	:	13S Lithium ion

Figure No.11: Charger

Throttle: Its working is the same as that of the throttle in ICE scooters but the working of EV throttle is unique, based on a magnetic sensor 49e as the accelerator is rotated current supply to the motor from the battery is controlled by the controller. The parameter for choosing the throttle is Voltage (48 V supported) it needs to match the voltage of the battery, motor, etc.

Figure No.12: Throttle

Connections:5 pin cable from the controller is connected to 5 pin cable from the motor which has connections for the power supply, and hall sensor signals. A, B, and C phase cables from the motor are connected to controller cables. Red wire from the controller is extended to the key set and then to the power supply phase. Red and black cables from the motor and controller are connected to the battery. Red and green 2-pin wire is connected from the controller to the throttle giving power supply to the throttle as needed.

Assembling and Testing

Suspension mountings are welded and suspension is attached. Motor and wheel are connected by a chain. Controller, Battery, and Lockset are adjusted at their respective suitable positions and clamped to the chassis. After fitting all the components electrical connections are given and these wires and connections are safeguarded from water exposure and moisture contact

Figure No.13: Modified EV

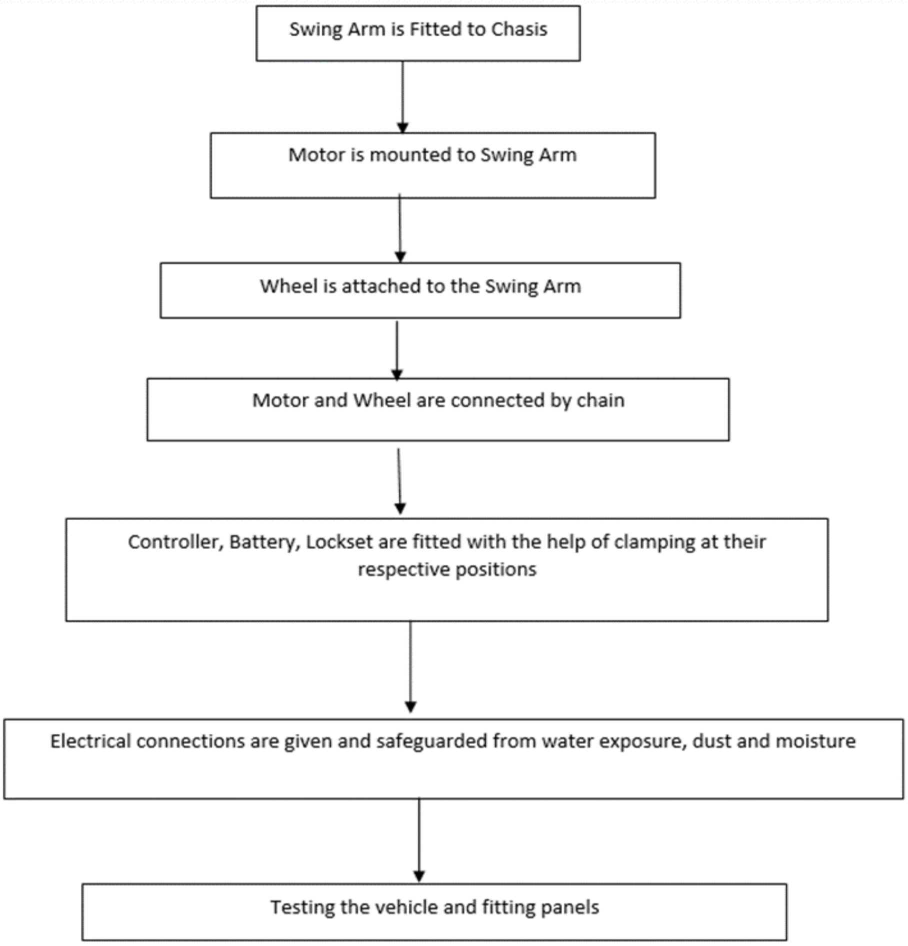


Figure No.14: Flowchart of Methodology

After testing the vehicle, again the whole vehicle is dismantled and painting work is done to protect it from rusting and also to give it a new look. Vehicle is assembled and tested.

Review

Figure No.15: New modified EV

Results and Discussions

The Electric vehicle is working smoothly just like its previous petrol version with smoother power transfer and with low noise output, so the ride feels more comfortable. Apart from the performance, the vehicle has new look, people will not feel it as a scrap reused vehicle. As the battery is placed in the place of the fuel tank boot space is not changed, unlike electrical vehicles in the market, it has a bigger boot space, usually, batteries of many scooter-type EVs are positioned inside the boot place which minimizes the empty space in it.

Rotatory speed of the wheel = 500-600 rpm at max speed low load

Average speed of the wheel = 500 rpm

Radius of the wheel = 30.48 / 2 cm

Circumference of the circle = Distance covered by the wheel in one rev

= $2\pi r$ m

= $2\pi \times 20 \times 10^{-2}$ m

1 min – 500 revolutions,

= $2\pi \times 20 \times 10^{-2} \times 500 \times$ m/min

= $2\pi \times 20 \times 10^{-2} \times 500 \times 10^{-3} \times$ km/min

= 0.628 km/min

If N_{min} (500rpm) is considered,

Speed = 47.8 km/hr

1) Range Calculation:

Power = 350Watt

Voltage = 24V

Maximum Speed = 23km/hr

Maximum Load = 100kg

Maximum Current,

P = V × I

I = P/V

I = 750/48

I = 15.63(at max speed or max load)

Consider,

Average person weight(W) = 70 kg

Average Speed = 40 km/hr

The current(I) required by the motor for 70 kg load and 40 km/hr speed is less than 15.63(maximum current). The amount of current utilized can be tested precisely by considering friction, losses, load, accurate speed with Amp-meter.

Considering average non-fluctuating current for above case to be approximated as,

I (Ideal) = 12~14(for various cases)

Range for I = 14A, Battery capacity of 30Ah

Battery = 30Ah / 14 A = 2.14-hour current

For 1 hour = 40km average speed at max load or Max speed at average load

For 2.14 hours = 100km

So, for 1 full charge EV can complete 100km

2) Weight Calculation:

Battery with casing = 6 kg

Motor + Throttle + Controller= 7 kg

Frame + Handle = 18 kg

Swing Arm = 5 kg

Seat = 1 kg

Suspensions = 1.2 kg

Wheels (2) = 2 kg

Break lever and wire + Horn + Headlight = 1 kg

Panels = 1 kg

Total Weight obtained = 43.2 kg

3) Charge Time:

Voltage Input:240 VACS

Voltage output:48 VDC

Current Input:2.4 A MAX

Current Output: 6A

Charging Time: 5hours

Type: Lithium ion

Charge time of 1hr is required to charge the battery for 5A

$$1 \text{ hr} \rightarrow 6A \qquad -(1)$$

Calculating the charge time required to charge the battery for full capacity i.e., 30A

$$P \text{ hrs} \rightarrow 30A \qquad -(2)$$

Equating (1) and (2) the charge time obtained is,

$$P = (30/5)\ (hr)$$

$$P = 6 \text{ hrs}$$

Therefore, a total charge time of 5 hrs is required to charge the battery for full capacity = 30A.

After fully charging the battery, the EV is tested for its range and speed under the most possible flat road conditions. From this the range and speed of the vehicle have been observed after multiple tests it is approximately noted to have a 40 km per hour speed and 100 km range for a full charge under seemingly ideal conditions The Electric components' specifications are practically tested and cross-checked and the results are noted. For charging the battery to 100%, the time taken is noted as 6 hours with household slow charging. Rpm of the motor under no load conditions has been noted along with its load-carrying capacity. The final test report outcome is shown below.

Table No.1: Test Results

S.No	***Components***	***Values***
1	Battery	48 V 30 Ah
2	Motor Power	750 Watts
3	Motor Speed	~500 rpm
3	Controller range	600-1000 Watts
4	Charger Voltage	54.2 V
5	Charging Time (0-100) (Slow Charging)	6 hours
6	Mileage per charge	100 km
7	Speed	40 km per hour
8	Gear reduction	1:6
9	Load Capacity	250

Discussions

For optimum range, a 750W motor is used which also consumes less power but the drawback of this motor is it has low initial torque with high RPM to compensate for this, a reduction planetary gear system is attached to the motor to give more initial torque by sacrificing speed.

Lithium-ion batteries are used as they have a high power-to-weight ratio and more life span compared to Li phosphate or Lead Acid batteries. But when converting auto rickshaws and other four-wheelers Lead-Acid batteries can be used as they are very affordable but their lifetime is lower than Li-ion batteries and also occupy more space.

The range of the vehicle can be increased by increasing the capacity of the existing battery or by adding another battery.

Conclusions

1. Old vehicle components are being reused which creates an overall sustainable environment and continuous scrap management paradigm.

2. By saving the cost of Chassis, Panels, handles, Wheels, etc, the resulting E-vehicle was very affordable. Which will encourage new vehicle seekers to lean more towards EVs because of their affordability.

3. Reusing Automobile scrap as well as encouraging people to convert their old vehicles to EVs will result in a more economical shift towards adopting electrical vehicles for people.

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