Abstract - Industries today faces the problem of transportation of goods and raw materials from storage house to the manufacturing unit and within the manufacturing unit. Environment pollution is also the most significant issue today in industries. Many of the industries are not able to meet the expectations of the customers in terms of pricing, many factors affects the industries and one of the important factor is transporatation cost. As a solution to this problem, authors have developed a new electric vehicle viz. Easy Industrial Transport is developed. It saves time, power and ultimately money. Also it is environmental friendly.

Keywords- Industrial Transport, Electric Vehicle, Vehicle

1. INTRODUCTION

As per the Wikipedia census, the no. of automobiles on our planet doubled in last 10 years and in the next 50 years, the global population will increase from 6 billion to 10 billion and the number of vehicles will increase from 700 million to 2.5 billion. If all this vehicles run on internal combustion engines then the level of carbon dioxide would increase considerably, increasing global warming. So environmental issue provide a compelling impetus to develop clean, efficient and sustainable vehicles for transportation. Concerning the environment, electric vehicles can provide emission free transportation. Even taking into account the emission from the power plants to produce electricity, the use of electric vehicles can significantly reduce the global air pollution. From the energy aspect, electric vehicle can offer a secure, comprehensive and balanced energy option that is efficient and environment friendly. Hydrogen powered vehicles and solar powered vehicles are also the low/zero emission vehicles. Hydrogen powered vehicles are not fusible considering the safety measures as hydrogen is highly explosive. Solar powered vehicles are nothing but electric vehicles with zero emission. It eliminates also the indirect pollution caused at the time of production of electricity but producing electricity out of solar energy. So, electric vehicle is the only possible aspect in today's automobile industry to produce low/zero emission vehicles.[1-3]

Easy Industrial Transport is an electric vehicle but also something more than that, having some extra features which adds to its value and makes the work easier. It is a multipurpose vehicle which can be used as a transport vehicle while carrying goods from the storage house to the manufacturing unit and then can be transformed into a trolley to carry goods inside the manufacturing unit. So, it saves the time of transferring the goods from the transport vehicle to the trolley and hence increases the
efficiency of the workers. It also helps in reducing the overall pollution caused by an industry by replacing internal combustion engine vehicle with an electric vehicle.

2. CONCEPT OF ELECTRIC VEHICLE

The primary components of an electric vehicle system are the motor, controller, power source and transmission. Electrochemical batteries have been the traditional source of energy in electric vehicles. Lead-acid batteries have been the primary choice, because of their well-developed technology and lower cost. Alternate battery technologies are currently available which include nickel cadmium batteries which are more expensive than lead acid batteries. The batteries need a charger to restore the stored energy level once its available energy is near depletion due to usage.

An EV has the following two features:
1. The energy source is portable and chemical or electromechanical in nature.
2. Tractive effort it supplied only by an electric motor.

Figure 1 shows an EV system driven by a portable energy source. The electro-mechanical energy conversion linkage system between the vehicle energy source and the wheels is the drivetrain of the vehicle. The drivetrain has electrical as well as mechanical components. Mostly Electric vehicles use AC induction motors or PM synchronous motor.

![Figure 1: Circuit Diagram of Electric Vehicle](image)

2.1 ADVANTAGES OF ELECTRIC VEHICLE

- **Energy efficient**: Electric vehicles convert about 59% to 62% of the electrical energy from the grid to power at the wheels whereas conventional gasoline vehicles convert only about 17% to 21% of the energy stored in gasoline to power at the wheels.
- **Environmental friendly**: Electric vehicles emit no tailpipe pollutants, although the power plant producing the electricity may emit them. However electricity from nuclear power plant, hydroelectric power plant, solar power plant or wind power plant causes no air pollution.
- **Performance benefits**: Electric motors have quiet and smooth operation. It provides stronger acceleration and requires less maintenance than Internal Combustion Engines.
- **Reduction in energy dependence**: Electricity is a domestic energy source.
2.2 DRAWBACKS OF ELECTRIC VEHICLE

- **Driving range**: Most Electric vehicles can only travel about 100 to 200 miles before recharging whereas gasoline vehicles can travel over 300 miles before refueling.
- **Recharge time**: Fully recharging the battery pack can take about 4 to 8 hours, even a quick charge to 80% capacity can take 30 minutes whereas refueling can be done in maximum 5 to 10 minutes.
- **Battery cost**: The cost of batteries is high and may need to be replaced one or more times whereas in internal combustion engines the cost of fuel tank is comparatively low and need not to be changed frequently. \(^\text{[9,10]}\)

3. CONCEPT OF EASY INDUSTRIAL TRANSPORT

The concept of this design is that it will be driven in lateral direction by the main three wheels like rickshaw powered by electric motor from storagehouse to the industry. Then the frontal part containing the batteries, motor, controller and steering can be detached from the rear part to convert the vehicle into trolley. Then the remaining two main wheels can be switched to four castor wheels with the help of screw jack which gives the longitudinal motion to the vehicle like a trolley. In the industry the vehicle is moved as trolley. The operation of screw jack can be kept manual or electrically powered. A single frontal steering assembly can be attached to different trolleys and hence it reduces the cost of buying different motors for different trolleys. Figure 2 shows the Creo design of Easy Industrial Transport. Hub motor with a capacity of 1000 W is used in this vehicle to provide power to the vehicle.

![Figure 2: Easy Industrial Transport Concept](image)

4. WORKING OF EASY INDUSTRIAL TRANSPORT

A Hub motor of 1000 W capacity is connected to the frontal wheels, which in turn is connected to the controller circuit and batteries. As shown in figure 1, speed variation of hub motor is done with the help of lever which sends electronic signal to the controller circuit increasing or decreasing the speed of the vehicle. This controller circuit is provided with an exhaust fan to drain out heat from the circuit reducing the problem of burning of the circuit.

Thus the vehicle will get power from the hub motor and will run like a rickshaw and can be steered with the help of steering handle.

Now after reaching the manufacturing unit the frontal assembly will be detached and the castor wheels will be brought down converting the vehicle into a trolley.
4.1 Attachment & detachment of trolley

Hooks are provided on the trolley and mating part of the hook with locking mechanism is provided on the frontal assembly. So they could be attached and detached easily. The mechanism of detaching the trolley is shown in figure 3. The similar is the process for attaching the trolley.

![Figure 3: Detachment of Trolley](image)

4.2 Mechanism for lowering the castor wheels of the trolley

The conceptual drawing of chain mechanism used for lowering the castor wheels and converting the vehicle into a trolley is shown in figure 4.

![Figure 4: Chain Mechanism](image)

In total three sprockets one (10 teeth sprocket and two 20 teeth sprocket) are used to uplift and lower the castor wheels. The 10 teeth sprocket has to be rotated to uplift and down lift the castor wheels. It can be rotated manually or electrically with the help of a small motor. The 20 teeth sprockets are mounted on the screw jacks. As all the three sprockets are connected through a chain, on rotating the 10 teeth sprocket all the three sprockets will rotate, rotating the screw jack and lowering or uplifting the castor wheels according to the direction of rotation. As the number on teeth on jacks are double than the rotating sprocket, the effort required to rotate the jack would be half. The Creo design of chain mechanism is shown in figure 5.
Problems faced in chain mechanism

Problems faced while implementing the chain mechanism are as follows:-

1. The chain is designed to work with two sprockets and by implementing three sprockets, the no. of teeth coming in contact with the chain decreases resulting in improper functioning of the chain.
2. The chain is also designed to work with one side lagging and the other side transmitting power whereas here at each and every point the chain has to transmit the power which resulted in its improper functioning.
3. Industrial purpose chain has to be used to transmit high power which has higher self-weight and hence creates the problem of offsetting.

Solution found to use the chain mechanism

The solution of all the above mentioned problems was found by trial and error method. The solution found after many trials was to provide a guide way to the chain. So a special L section guide way was welded below the chain. It eliminated the problem of offsetting due to self-weight as it was compensated by the support given by the guide way. Also the problem of improper rotation is solved as the guide way allows the chain to move on desired path only. The photo of guide way is shown in figure 6.
5. LOAD CARRYING CAPACITY OF EASY INDUSTRIAL TRANSPORT

A hub motor manufactured by Electrotherm India Pvt. Ltd. was readily available having low cost. The specifications of the same are as below.

Maximum torque = 92 Nm
Motor diameter = 24.5 cm

Now, equation to calculate motor radius is

Motor radius = Motor diameter / 2
Motor radius = 24.5 / 2
Motor radius = 12.25 cm
Motor radius = 0.1225 m

Now,

Torque = Force * Radius
92 Nm = Force * 0.1225 m
Force = 750 N

So, Maximum force generated by the hub motor is 750 N.

Now, Co-efficient of friction is usually considered as 0.6 for plain roads

Also,

Force = Co-efficient of friction * Load
750 N = 0.6 * Load
Load = 1250 Kg

1250 Kg is the total load carrying capacity of the hub motor and not the load carrying capacity of Easy Industrial Transport

Load (Hub motor) = Load (Easy Industrial Transport) + Kurb weight (Easy Industrial Transport)
Therefore,

1250 Kg = Load (EIT) + 100 Kg
Load (EIT) = 1150 Kg

So, Maximum load carrying capacity of Easy Industrial Transport is 1150 Kg.

Keeping,

Factor of safety = 1.5

Actual load = Max load / Factor of safety
Actual load = 1150 / 1.5
Actual load = 766.67 Kg
Actual load = 750 Kg (Approx)

Hence, the load carrying capacity of Easy Industrial Transport can be considered as 750 Kg.

6. OPERATING COST OF EASY INDUSTRIAL TRANSPORT

As Easy Industrial Transport is an electric vehicle, its operating cost can be calculated on the biases of the electricity tariff and how much it consumes. The electricity tariff rates are different in every state. It changes according to its application i.e. domestic, commercial or industrial. The electricity tariff rates keep changing every year.
Table I
Industrial electricity tariff slabs in Gujarat for the year 2015

<table>
<thead>
<tr>
<th>City</th>
<th>Category</th>
<th>Load</th>
<th>Tariff (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-RGP</td>
<td>0-10 kW</td>
<td>4.25/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-40 kW</td>
<td>4.55/kWh</td>
</tr>
<tr>
<td></td>
<td>Rest</td>
<td>0-40 kW</td>
<td>4.60/kWh</td>
</tr>
<tr>
<td></td>
<td>LTMD</td>
<td>41-60 kW</td>
<td>4.60/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 60 kW</td>
<td>4.60/kWh</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>Non-RGP</td>
<td>0-5 kW</td>
<td>4.40/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-15 kW</td>
<td>4.40/kWh</td>
</tr>
<tr>
<td></td>
<td>LTMD</td>
<td>0-50 kW</td>
<td>4.45/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>51-80 kW</td>
<td>4.60/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 80 kW</td>
<td>4.60/kWh</td>
</tr>
<tr>
<td>Surat</td>
<td>Non-RGP</td>
<td>0-10 kW</td>
<td>4.25/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-15 kW</td>
<td>4.45/kWh</td>
</tr>
<tr>
<td></td>
<td>LTMD</td>
<td>0-20 kW</td>
<td>4.75/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21-60 kW</td>
<td>4.75/kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 60 kW</td>
<td>4.75/kWh</td>
</tr>
</tbody>
</table>

Non-RGP → This tariff is applicable to the services for the premises those are not covered in any other tariff categories and having aggregate load up to and including 40 kW.
LTMD → This tariff is applicable to the services for the premises those are not covered in any other tariff categories and having aggregate load above 40 kW and up to 100 kW.\(^{[12,13]}\)

Calculating the average tariff of electricity gives Rs 4.53 / kWh

As per the technical specification of 1000 W hub motor of Electrotherm India Pvt. Ltd., It consumes 4.7 kWh / 100 Km\(^{[12]}\)

So, 100 Km will cost,
\[4.7 \times 4.53 = 21.29 \text{ Rs}\]

Hence, cost of operation per Km would be,
\[21.29 / 100 = 0.21 \text{ Rs} = 21 \text{ Paisa}\]
21 Paisa per km is much cheaper as compared to one which runs of internal combustion engine.

7. SAFETY ASPECTS

It is a purely electric vehicle and so distinctly safer then vehicle with internal combustion engines as they don’t carry any gasoline. But it adds an entirely new factor to the safety equation. It uses large array of Lithium-ion (Li-ion) batteries, which have a tendency to catch fire and occasionally explode. But the rate of catching fire of internal combustion engine vehicle is more as compared to electric vehicle and hence they are safer.\(^{[14,15]}\)

Some of the hazards due to which an electric vehicle catches fire and its safety precautions are given below:

1. The hotter the batteries are the more likely they are to explode, so batteries are kept such that they are cooled by flowing environmental air.
2. Wet electric system will short circuit and burst into flames, so complete circuit has been kept packed in order to prevent it from rain.
8. CONCLUSION

Easy Industrial Transport is a multipurpose electric industrial vehicle which fulfills many industrial needs of transportation of raw materials and finished goods, saving time, energy and money. The multipurpose vehicle can serve load carrying objective of small and medium scale industries as well as ancillary industries of very large scale production companies. Also being an electric vehicle it is eco-friendly and hence helps in reducing the air pollution. It saves the cost of transportation to a considerable amount as its operation cost is too low.

REFERENCES

11. Technical Specification of 1000 W hub motor provided by Electrotherm India Pvt. Ltd.

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