A Study on E-Highway - Future of Road Transportation

K.Chandra mouli, N.Pannirselvam, V. Anitha, D.V.V.Nagasai pardhu

Abstract*— *Highways are one of the significant parts of the modernized world. They play an important role for the development of country's economy. The transport sector heavily depends upon non-renewable sources. The transportation sector not only contributes for the nation's development but also for the green house gases emission that accounts for nearly 1/5th of the global total energy consumption. Constant release of harmful gases into the atmosphere by the vehicles must be restricted and replaced with a more sustainable transportation alternative. The workable alternative for this regular petroleum-based road transportation is the introduction and application of E-Highways with Electrical Vehicles. The Electric highway is a technique where large trucks or vehicles, hybrids with dynamic pantographs on their top, attached or coupled to the overhead power cables so as to get electricity from the power grid. As a result, E-Highways with the combination of EVs can eliminate the need of vehicle recharging. This technology is the efficient one in terms of both fuel-consumption and smart power supply.

Keywords: Dynamic pantographs, Electrical road systems, E-highways, Electrical vehicles, Green house gases, Power grid, Smart power supply, Vehicle recharging etc.

I. OBJECTIVE

The main objective of present work is to carry out a research if there is a probability to substitute the major part of the transportation area's enslavement on fossil fuels by presenting a new system as Electrical Road Systems-ERS.

II. INTRODUCTION

Every nation aims at a future which doesn't need non-renewable sources of energy. As there is a presumed growth of demand for transport, the quantity of emission of carbon dioxide is more than that of country's economy. In order to minimize the effect of the fossil fuel gases, a new, harmless and an efficient technique or system should be practiced. The E-Highway system is introduced with such a motto. ERS are principally, the electrified roads enable to the vehicles on the road to perform using power transfer. Generally, power source integrated into the road surface by externally driving energy to an electric engine.

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Dr. K.Chandra mouli, Professor & HOD-Department of Civil Engineering, NRI Institute of Technology, Visadala(V),Medikonduru(M), Guntur, Andhra Pradesh, INDIA. (E-mail:koduru_mouli@yahoo.com)

Dr. N.Pannirselvam, Associate Professor-Department of Civil Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai, INDIA. (E-mail: pannirselvam.n@ktr.srmuniv.ac.in)

V. Anitha, Asst. Professor, Department of Civil Engineering, NRI Institute of Technology, Visadala(V),Medikonduru(M), Guntur, Andhra Pradesh, INDIA, (E-mail: anitha12.civil@gmail.com)

D.V.V.Nagasai pardhu, M.Tech Scholar, Department of Civil Engineering, NRI Institute of Technology, Visadala(V),Medikonduru(M), Guntur, Andhra Pradesh, INDIA.

III. III. HYBRID-DRIVE TECHNIQUE AND EFFICIENT POWER SUPPLY

The modern e-Highway integrates the railway technology as resource efficient to attain the feasibility of road transport economically by utilizing the existing infrastructure and reduces energy use. These modern highway reformed hybrid trucks are provided with electricity from overhead connection lines through a dynamic pantograph, which can couple and uncouple the overhead cables to speeds of up to 90 kmph (Fig. 1).

In ERS, a two-pole system is practiced so that not only power in-feed but also power out-feed can be managed whereas in trains overhead transmission technology is used to manage the return circuit. 80 to 85% achieved in the direct transmission of electric energy to the wheels. This system enables to regain the braking energy and backup it onboard or feed to the other trucks following the system or excess into the public grid.

Figure 1. Illustrates a truck driving on an electrified road using overhead lines. (Source: Scania)

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When implemented on routes with sufficient volumes of traffic, healthy returns. The e-Highway system is therefore reliable and open-standard contact-line technology which does not interfere with the surface of the road. When comparing all options, an overhead contact line system contains a critical backbone of the most cost-effective solution for carbon-neutral long haul freight.

IV. PANTOGRAPHS

'Pantograph' is a word derived from Greek language, which means 'every write'. It is a structure with mechanical linkage therefore it works by forming a parallelogram. Technically, pantograph is a conducting arm extending above the rolling stock, collecting traction current from Over-headed line system. Modern Pantograph principle is derived from a linked support structures called "Scissors mechanism". The system is used to make contact with wire or cable overhead. Depending on the locomotive speed, pantographs come in all shapes and sizes. A pantograph's basic parts are a lower arm(s) pivoting against the roof of a carriage / loco and attached to the upper arm attached to the head or pan of a collector. The head is the pantographer's only part to touch the pick - up wire. The current is gathered on the head through metalized carbon strips.

They are significantly classified into three types such as a. Bow collector, b. Trolley pole and c. Pantograph

V. CATEGORIZATION OF PANTOGRAPHS

a. Based on the speed of the vehicle

1. Under 125 mph (200 km / h) operate low - speed pantographs. To carry out the operations, these systems use springs and air pressure. The up springs are in the stretched position when folded down to the carriage / loco roof. Then the pantograph raises in a cylinder called the operating cylinder by letting air, this moves a piston forward and pulls the control rod and moves a slotted connection to control the process. Then the springs take over and lift the head to contact the wire (through leverage). The reason the air cylinder has is to compress the spring down. Air is exhausted from the cylinder to lower the pantograph and the down spring acts on the device to lower the head to the carriage / loco roof.

2. A separate system is used for high - speed pantographs for locomotives with a higher speed exceeding about 125 mph (200 km / h). These are elevated by pressure - air via a spring - free regulator. This set keeps the overhead wire a constant force. When the overhead wire's height falls, air is bled from the system and air is added when the train leaves the tunnel and the overhead wire's height rises.

b. Based on the mechanism of pantograph arms

1. Single armed pantograph - Lighter and uncomplicated design.
2. Double armed pantograph - Heavier design.
3. Wing (T) shaped pantographs - Very uneconomical to construct and maintain.

VI. PARTS OF PANTOGRAPHS

A pantograph generally contains the following structural features:

1. Pan head - A carbon strip that acts as a conductive and dry lubricant is the contact surface between rolling stock and over headed line wires.
2. Upper arm.
3. Lower arm.
4. Damper assembly - provides better control for pan lifting up/down than simply making use of compressed air.
5. Air cylinder - acts like a piston-cylinder. Compressed air pushes the piston, hence extending the piston rod to raise pantograph; vice versa for pan drop.
6. Raising/Counterbalance spring - provides pantograph articulation against vibrations and harmonics.
7. Base frame - base of the pantograph assembly.
8. Foot insulator - insulating assistance that safeguards the pantograph assembly on the top of the rolling stock.
9. Air feed insulator - an insulator, solid state device that permits gas into the cylinder.

VII.FUNCTIONING AND WORKING OF E-HIGHWAY AND RESULTS

a. Supply of power and its distribution: Substations provide the power supply constantly throughout the e-Highway. In order to distribute the power to the hybrid trucks, a specifically designed two-pole contact line system provides a safe and secured supply of energy although the speeds exceed up to 90kmph (Fig.2).

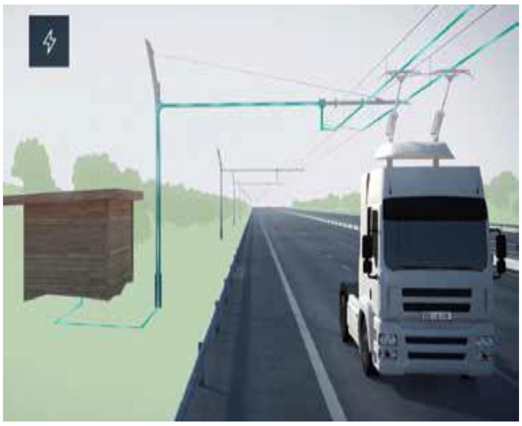

Fig.2 Power distribution
(Source: www.siemens.com/mobility/eHighway)

b. Dynamic pantograph: The major advancement of this modern highway system is the active pantograph. At various speeds, it can couple and uncouple the vehicle with the contact lines. Pantograph is to transfer the energy directly from overhead contact line to the electric motor of the truck that is carried on the e-Highway. A sensor technology that is designed exclusively permits the dynamic pantograph to alter its place under the contact line so as to counteract the lateral movements of the truck in the lane. This technique reduces the wear across the pantograph and ensures the durability (Fig.3).

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Fig.3 Dynamic pantograph
(Source : www.siemens.com/mobility/eHighway)

c. Hybrid drive system: Within the facilities of electrification, the E- Highway truck's hybrid drive system makes it highly electrical operation. It even assures the feasibility to shift between hybrid and electric modes while overtaking, to traverse the non-electrified constituents of the highway, to accomplish the initial and final mile of each drive. This modern highway system is consistent and corresponding to other substitute fuel-based technologies and allowing the access to choose a different kinds of hybrid configurations like parallel or serial concepts and integrations with on-board energy storage. At the time of braking, the electric machines function as generators, which permits otherwise unutilized braking energy to be provided into the onboard energy storage or back into the grid to be utilized as required by other trucks on the e-Highway (Fig.4).

Fig.4 Hybrid drive system
(Source : www.siemens.com/mobility/eHighway)

VIII. PRE-REQUISITES AND ASSUMPTIONS

1. This technique is applicable for heavy trucks/vehicles exclusively.
2. The height of the overhead cables should be approximately 5.5-6.0m.
3. The approximate consumption of the power by the truck/vehicle is 1.1-1.5 kWh (unit)/km.
4. All trucks should maintain a maximum speed of 90kmph.
5. For an effective feasibility, it is less suitable for least trafficked roads.
6. For every 3km, the traction substations should be available.

IX. MERITS OF E-HIGHWAY SYSTEM

1. It is a highly energy efficient system.
2. It minimizes the operating costs.
3. An instant and prompt integration into existing infrastructure is possible.
4. It is a safe, reliable and open technology.

X. CONCLUSION

It is hereby to conclude that the E- Highway system not only enhances the benefit of reducing the harmful CO_2 emissions into the atmosphere but also improves the nation's economy by its reliable system. The electrification of roads/highways will enable evident decrement in CO_2 emissions and ensures a sustainable supply of energy. The significant advantage in this system is that Electricity can be produced in several ways i.e. through conventional power plants and also from renewable sources.

This modern electrifying highway is twice as efficient as internal combustion engines. Besides this, this is a noiseless system which turns out as an eco-friendly technique in transportation sector. The power consumption is less i.e. running cost is less when compared to that of conventional petroleum based transportation.

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