Hyperloop Prototype Using Electromagnetic Propulsion

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Abstract - **Hyperloop (HL) is presented as an efficient alternative of HSR (High Speed Rail) and APT (Air Passenger Transport) systems for long distance passenger transport. It could see passengers travelling at over 700 mph in a floating pod inside low pressure tubes, above or below the ground. Hyperloop can be seen as the evolution of MAGLEV, as it uses technology similar to it, but deploying more sophisticated techniques. This transportation system was firstly proposed by Elon Musk, in this report he explained this project of ultra-high speed transportation system. The main aim of the Hyperloop is to make Domestic Air Travel redundant. It is currently under development by two main ventures, Elon Musk's group of companies including Tesla & Spacex, and Richard Branson's Virgin Enterprises, with the latter being the only company to have tested a prototype with passengers on 8 November 2020**

keywords - **Hyperloop, Electromagnetic Levitation, HSR, Linear Motor, Sustainability.**

Introduction

There are two big differences between Hyperloop and traditional rail. Firstly, the pods carrying passengers travel through tubes or tunnels from which most of the air has been removed to reduce friction. This should allow the pods to travel at up to 750 miles per hour. Secondly, rather than using wheels like a train or car, the pods are designed to float on air skis, using the same basic idea as an air hockey table, or use magnetic levitation to reduce friction. The idea of using low-pressure or vacuum tubes as part of a transport system has a long heritage. The Crystal Palace pneumatic railway used air pressure to push a wagon uphill (and a vacuum to drag it back down) way back in Victorian south London in 1864. Similar systems using pneumatic tubes to send mail and packages between buildings have been in use since the late nineteenth century, and can still be seen in supermarkets and banks to move money around today. Hyperloop is projected to be cheaper and faster than conventional train or car travel, and cheaper and less polluting than air travel. It is also quicker and cheaper to build than traditional high-speed rail. Hyperloop could therefore be used to take the pressure off gridlocked roads, making travel between cities easier, and potentially unlocking major economic, benefits, including job creation as a result, with tickets for travelling 610 Km costing as low as $20 [1]. Our project has attempted at making a working prototype of the Virgin Hyperloop concept, on a smaller scale of dimensions.

Types of Hyperloop:

Tesla/Spacex Hyperloop Alpha

In his Hyperloop Alpha paper, Musk set out the case for a service running between Los Angeles and San Francisco, which would be cheaper and faster than a proposed high-speed rail link. He argued that his Hyperloop could be safer, faster, more affordable, weather-proof, self- powering and less disruptive to people living along the route. Hyperloop Alpha uses low pressure tubes, with a negative or near negative pressure to negate the piston effect, causing blockage by choking the air flow inside the tube, when the pod is travelling at high speeds. It uses a compressor fan mounted towards the front of the pod for propulsion, and uses air bearings mounted below the pod, on the track surface for levitation. [2].

Virgin Hyperloop

The Virgin Hyperloop is an evolution of the vaccum train concept. The original Hyperloop concept is proposed to use a linear electric motor to accelerate and decelerate an air-bearing levitated pod through a low-pressure tube. The vehicle would glide silently for miles at speeds up to 760 mph (1223.1 km/h) with very low turbulence. The system is proposed to be entirely autonomous, quiet, direct-to-destination and on-demand. Additionally, as Hyperloop is proposed to be built on columns or tunneled underground, this could eliminate the dangers of at-grade crossings and require smaller rights of way than high-speed rail or a highway.

Problem Statement (Conventional rail transport)

- Ever increasing expenses of Domestic of air travel.
- High travel times for conventional rail roads for domestic travel.
- Inefficient use and consumption of limited fossil fuels for conventional Rail and Air travel.

- Need of a sustainable mass transport system that will run on clean fuels, without contributing to pollution.

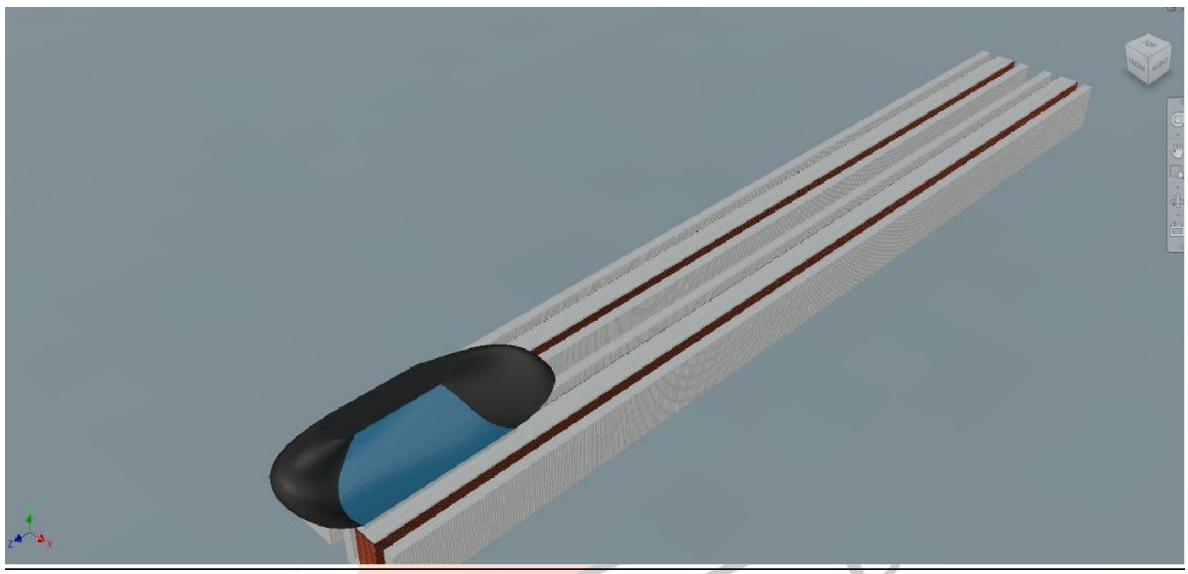
Objectives

The objectives of this paper are:

- To summarize the work done in developing our prototype system
- To highlight the benefits and the need of the Hyperloop system
- To present a cleaner, much more efficient alternative to the existing rail transport systems.
- To make domestic air travel redundant, using our proposed system.

Proposed System

Our prototype uses the hybrid concept between Hyperloop Alpha and Virgin Hyperloop, by using the low pressure tubing system found in both the concepts, and using linear motor for propulsion from the Virgin Concept, but for convenience at our scale, we have used the concept of electromagnetic levitation similar to the MagLev concept instead of Halbach array, for ease of fabrication. We have used two sets of electromagnets for the entire length of the track as the primary, aluminum plate as a secondary which also acts as a pod.
A 3D model of our proposed system.



Basic Components

Levitation Track	Linear Motor	Vaccum Tunnel
Copper Wire, 17 Gauge	Copper wire, 27 gauge	30.48cm ID, HTPB Pipe, Length 76.42cm
E-Shape Transformer Core Lamination, 7.6cm * 5cm	E-Shape Transformer Core Lamination, 4.4cm * 2.6cm	Acrylic plate for sealing the ends of the tube.
L-Shape fiber guide ways	Mounting brackets/Plate	Vaccum pump
Threaded bolts	Aluminum plate, 63.5cm * 3cm	Pneumatic Solenoid Valves
Electrical Connection terminal	3-Phase Auto Transformer	Pneumatic hose, fittings
Single Phase Auto Transformer	Star connection terminal box	Arduino, relay etc. As a controller for valves and pump
Aluminum plate, 16.24cm * 25.4cm	Frequency controller for speed control (Mitsubishi FRD740 080EC)	

Our designed linear motor prototype

Operating Modes:

Levitation: We have used the basic principle of electromagnetism for levitation of the pod. We control the lift of pod by modulating the current flowing through the coil.

Propulsion: In our proposed system, we use the concept of linear motor for the propulsion of the pod. For the speed modulation of the pod, we use a frequency controller module.

Construction:

Levitation Track:

We have used E-shape transformer core lamination 7.6cm * 5cm, to build a track of length 63.6cm approximately. Next, we installed two copper coils, 17 gauge with 132 turns for each coil, in the track for levitation, in series connection. We have used a supply of 450V, 12A to produce a required magnetic field in the track. This resulted in levitation of Aluminum plate/pod.

Linear Motor:

For Linear motor we have used E-shape transformer core lamination 4.4cm * 2.6cm, and stacked all of them in series, to create a 9-pole linear stator. We have also used copper wire of gauge 27, to create 6 coils for linear motor, of 120 turns. To control the speed of linear motor, we use VFD (Variable Frequency Driver), Mitsubishi FRD740 080EC.

Vaccum Tunnel:

For the vaccum tunnel, we have used a 30.48cm internal diameter, HTPB Pipe, Length 76.42cm. For the low pressure generation, we are using a generic single piston vaccum pump connected with a solenoid valve, and required pneumatic hoses and fittings.

Our Prototype track, including the linear motor.

Benefits:

- Higher ratio of distance travel to time required.
- Effective utilization of energy sources.
- Promises low cost of travel as compare to air travel.
- Potential for high-skill as well low-skill job creation in design & construction.
- Potential to effectively make domestic air travel redundant.
- Complete elimination of pollution caused by the system itself due to the use of electricity, when compared to conventional diesel rail or IC engine personal mobility.
- Low maintenance cost due to virtually no contact between moving parts.

Limitations

- High electrical energy consumption for continued operation in comparison to conventional Electric locomotives.
- High initial investment for construction, design and development.
- Highly skilled engineers required for the project.
- The technology is still in a budding, initial stage worldwide, and will take some time from concept to creation.

Conclusion

This paper, highlights the construction, benefits and limitations of our Hyperloop prototype system. During our time working & researching on this project, we have concluded that the concept of Hyperloop can prove to be a boon and a radical step forward for developing countries like India, where an efficient, sustainable and fast means of mass public transport is required. Since the proposed solution, runs on clean, electrical energy, its direct carbon footprint is virtually zero, and thus limiting the contribution of the countries using it to the larger global warming crisis. Since, there are virtually no moving parts in contact with each other, very little energy is lost in transmission losses only, taking hyperloop's overall efficiency to unprecedented levels in land transport. The proposed hyperloop concept has the potential to make the domestic, inter country air travel completely redundant.

References

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