

# HYPERLOOP TRANSPORTATION SYSTEM

Ajay Singh<sup>1</sup>, Akhil Mahajan<sup>2</sup>, Nikhil Mahajan<sup>3</sup>, Aditi Gaikwad<sup>4</sup>

<sup>1,2,3,4</sup>BE Students, Department of Electronics and Telecommunication Engineering, Shivajirao S. Jondhle College of Engineering, Asangaon, Maharashtra, India.

\*\*\*

**Abstract** –Hyperloop being fastest today Bullet train and maglev train it is easiest and cheapest method to reach desired place in matter of time. The system consist passenger capsule and a long pipe. The Capsule/Pod is suspended by vacuum in traveling pipe. To remove any amount of air present two motors are attached at start and end of the pipe so to aerodynamics of Hyperloop achieving it's high speed. Chances of accident are reduced as it is close system in which only one capsule can travel through given pipe. Capsule/Pod it is accelerated by electromagnetic loop created or guided pipe. Pod travels through passive magnetic levitation. Being an open design system further enhancement can be made by future generations Capsule can be controlled using application according users will. Hyperloop can change transportation as it takes less space, it is cost effective.

**Key Words:** Hyperloop, Vacuum Tube, Passive Magnetic Levitation, Propels, Capsules, Air Bearings.

## 1. INTRODUCTION

Hyperloop is a completely new mode of transportation which has proven to be fastest yet economical. Hyperloop was firstly proposed by Elon Musk and a team of engineers from Tesla Motors and Space Exploration Tech. Corporation in August 2013. Concept of hyperloop includes the travelling of people from one place to another in a capsule propelling at a very high speed. We can also call Hyperloop as solar powered transportation system and its a an alternative for high speed train (bullet train). So basically hyperloop is a magnetically levitated train which run inside a long tube or pipe. The tube is a low pressured tube with the capsule that transport at both low and high speed. It includes 28passengers pods and is driven by linear induction motor and compressor. For the purpose of proportion, magnetic accelerators are planted along the length of tubes, which helps in propelling the pods forward. The tube would create a low pressure environment which surrounds the with a cushion of air that allows a pod to travel safely at such a high speed like a puck glides over a air hockey table. The pressure built up in the front of the pod due to the tight quarters in the tube could be a problem. A system is provided to keep the air building up in this way. Musk's design recommended an air compressor on the front of the pod which will help in moving the air from the front to the tail keeping it overhead and preventing the pressure built up due to the

displacement of air. A one way trip in hyper loop is projected to take only about 35 minutes (Comparatively, the same distance would take about 6 hours if travelled by a car.) The passengers may enter or exit hyperloop at stations ocated at the ends of tube or branches along the tube length.

Electronic resource: <http://www.teslamotors.com>. [1]

Paper by Mark Sakowski, "The Next Contender in High Speed Transport Elon Musks Hyperloop", 2016 [6]

Musk, Elon (August 12, 2013). "Hyperloop Alpha"(PDF). SpaceX. Retrieved August 13, 2013.[9]

## 2. REVIEW OF LITERATURE

The design of hyperloop capsule with linear induction was discussed by Ahmed Hodaib, Samar F. Abdal Fattah (May 2016). The agenda of discussion was to propulsion system which is used to decelerate and accelerates the capsule. The motors run on three phase power like rotary synchronous motor, linear motors and supported with very high speed as they studied. The motors thrust speed was reduce by the end effects. Linear The normal rotary motors for any required force output where as linear induction motor are the less energy efficient as compare to normal rotary motors.Manufacturing of linear induction motor in these paper was also discussed.[1]

Mark Sakowski (2016) discussed the current maglev technology along with the theoretical evacuated tube technology and they concluded that the hyperloop is feasible and if properly designed, has the potential to be much more efficient in terms of energy usage of pods traversing down the tube.[2]

N. Kayela (2014) investigated the hyperloop in a 5th mode of transport. He discussed about the railway track for the hyperloop align with the stations. He also discussed the two version of capsule one passenger plus vehicle version and other passenger only version. [3]

Mohammed Imran (2014), He discussed about the two version of the hyperloop one is passenger only and other is passenger plus vehicle version. He focused his study element on the hyperloop technology (The passenger transport system). [4]

Jeffrey C. Chin, Justin S. Gray, Scott M. Jones, Jeffrey J. Berton, They discussed about the Open-Source Conceptual Sizing Models for the Hyperloop Passenger Pod in this paper. They concluded that the refined analysis illuminates several interdisciplinary couplings that alter two major aspects of the initial concept. First, the pod travel speed and the tube cross sectional area

are linked, forcing the tube size to be to be roughly twice the diameter of the original specification, in order for the pod to reach Mach 0.8. Second, the steady-state tube temperature is dominated by ambient thermal interactions unrelated to the heat generated by the pod compression system.[5]

**COMPARISON OF HYPERLOOP TRANSPORTATION SYSTEM WITH OTHER TRANSPORTATION SYSTEM**




	RAIL TRANSPORTATION SYSTEM	TRACTION	TRAFFIC	MAX SPEED	COST (Billion Rs/km)
HIGH SPEED RAIL		Electric power: wheel-rail friction	Passenger	280-300 Km ph	1.2-2.6
MAGLEV TRAIN		Magnetic levitation and guidance technology using linear synchronous motors	Passenger	400-500 Km ph	7.2
HYPERLOOP		Levitated pods through a low pressure tube over an air cushion	Passenger and Freight	1200 Km ph	2.4-5.6

Figure 2.1 COMPARISON OF HYPERLOOP TRANSPORTATION SYSTEM WITH OTHER TRANSPORTATION SYSTEM

**3. Basic Principle**

An underground or above ground pillar-supported tube will establish a controlled environment. A low pressure system is created through which passenger capsule will travel with very little air pressure to oppose its motion. This near vacuum atmosphere which is basically pressure around 5 to 6 Pounds per square inch absolute will be maintained by providing vacuum pumps at regular intervals. An air compressor fan driven by electric motor on the front of the capsule will transfer high air pressure from its front to the rear and sides of the vessel. This will result in the reduction of friction in front of the pod, helping it to propel and create an air cushion around it, so that the pod levitates in the air within the tube. Therefore air bearings that work on same basic principle of air hockey table will replace wheels as wheels would not work at the required high speeds (1200 kmph). The capsule will be battery-powered and will be propelled by an external linear electric motor which plays important role in propulsion of capsule producing motion in straight line than rotational motion. This linear induction motor would propel the pod to near sonic velocity which is slower than the speed of sound but still fast enough for

movement of capsule and provide a re-boost about every 120kms. The propulsion system is required for as little as 1 percent of the tube length which goes to prove that propulsion system is not particularly costly. Erection of the tube on pillars above ground enables to have the benefits of saving money, provision of protection from earthquakes, rainfall and snowfall and allowing solar panels to be placed on top. The energy obtained from these solar panels more than satisfy the operational need of the Hyperloop. This energy would also be stored in battery packs for operation during cloudy and rainy condition and during nights.

**4. CONSTRUCTION**

The practically implemented prototype of Hyperloop comprises of the following fundamental parts:

**1. Tube and Evacuation System:**

The capsules carrying passengers or goods travel in tubes. One of the reasons for the high speeds of Hyperloop is its low air drag. This is possible by removing the air inside the tube and conditioning it to a near vacuum state. This can be accomplished by

installing vacuum pumps/pressure pumps at regular intervals throughout the length of the tube. Accelerators such as a linear induction motor propel the capsules, which then cruise through the vacuum for the remainder of the trip using no additional power. The energy used for propulsion can be regenerated as the capsules slow down. Using evacuated tubes make the Hyperloop 50 times more efficient per kWh than electric cars or trains. Solar arrays will be installed over the top of the tubes in order to provide power to the system. Given the length of the tube, the power generated through solar is much more than what is consumed by the propulsion system and the evacuating pumps. The tubes are laid like freeways and the capsules are automatically routed from origin to destination for making the system efficient. The tubes can be built for 1/10th the cost of High Speed Rail track, or 1/4th the cost of a freeway.

## 2. CAPSULE

Two versions of the Hyperloop capsules are being considered: a passenger only version and a passenger plus vehicle version.

### 2.1 Hyperloop Passenger Capsule

Assuming an average departure time of 2 minutes between capsules, a minimum of 28 passengers per capsule are required to meet 840 passengers per hour. It is possible to further increase the Hyperloop capacity by reducing the time between departures. The current baseline requires up to 40 capsules in activity during rush hour, 6 of which are at the terminals for loading and unloading of the passengers in approximately 5 minutes.

### 2.2 Hyperloop Passenger Plus Vehicle Capsule

The passenger plus vehicle version of the Hyperloop will depart as often as the passenger only version, but will accommodate 3 vehicles in addition to the passengers. All subsystems discussed in the following sections are featured on both capsules. For travel at high speeds, the greatest power requirement is normally to overcome air resistance. Aerodynamic drag increases with the square of speed, and thus the power requirement increases with the cube of speed. For example, to travel twice as fast a vehicle must overcome four times the aerodynamic resistance, and input eight times the power. Just as aircraft climb to high altitudes to travel through less dense air, Hyperloop encloses the capsules in a reduced pressure tube. The pressure of air in Hyperloop is about 1/6 the pressure of the atmosphere on Mars.

## 3. SUSPENSION

A very low drag and stability is offered by air bearing suspension at a very feasible rate. A stiff air bearing suspension is perfect for reliability and safety. When a gap between ski and tube wall

is high then it shows a non-linear reaction and which results in restoration of a large pressure.

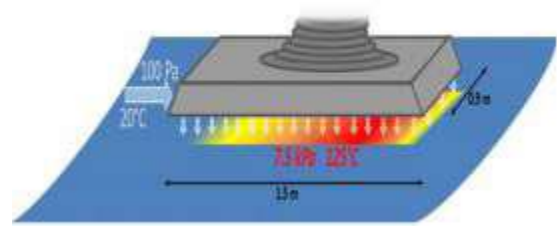


Figure.-2.2.1: shows a Schematic of air bearing skis that support the capsule

## 4. Propulsion System:

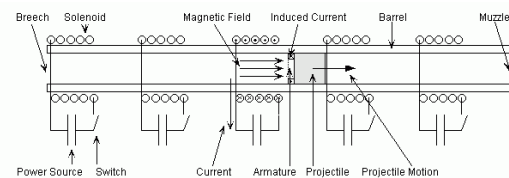


Fig. 4.1 Coil Gun Schematic

A high velocity accelerator is needed for the capsule to launch from its station. One of the methods by which this can be implemented is through a coil gun. A coil gun is an accelerator consisting of a coil used as an electromagnet analogous to how a linear motor accelerates a ferromagnetic projectile to high velocity. By using a 18 gauge enameled copper wire wound over a Poly vinyl chloride (PVC) pipe, the coil gun was supplied an impulse voltage of 300 volts through charged capacitors. For maximum acceleration, current through the coil gun needs to be high. To achieve this, capacitors were connected in parallel as the charges held by them when discharged in parallel fashion output a high current at the voltage of a single capacitor. The projectile was inserted inside the coil gun which accelerates at high velocities pushing the hyper loop pod. This force given by the projectile is enough to launch the pod thus satisfying the function of coil gun as a propulsion device.



Fig. 6 Prototype Coil Gun



Fig. 7 Capacitor Bank

Fig.. 4.2 Gun Coil

However implementing a coil gun on a large scale is not practical as well as feasible. The coil gun



generates massive amounts of magnetism. For safe operation, a majority of the costs would be required to provide magnetic shields. A safer and more feasible option would be to opt for a Linear Induction Motor.[4] The stators will be laid along sections of the tube – long enough to accelerate and decelerate the capsule between 480 and 1,220 km/h and to accelerate at 1g. They would be installed near stations and at booster points along the line. Only about 1% of the tube’s length would need to be fitted with stators. The three-phase stators, laid out symmetrically on either side of the rotor, will have one slot per pole per phase. A variable number of turns per slot will allow the inverter to operate at a nearly constant phase voltage, thus simplifying the design of the power electronics. Accelerators at each terminal will employ two inverters – one to accelerate outgoing capsules and the other to capture energy from incoming capsules as they slow down, allowing for regenerative braking. The inverters will power only those sections of the track occupied by the capsule, hence improving the power factor.

### 5. WORKING

Hyperloop is system which consist of a capsule which is passed through a tunnel or pipe at a very high speed. It removes all the disadvantages occurred in the maglev train. The system consist of copper coils which are coiled around the pipe at a given distance from each other. The pipe is non magnetized, but capsule can be magnetized. The coil therefore produce electromagnetic current/charge which pulls the capsule in forward direction. Until it reaches next coil the first coil is turned OFF and second coil is turned ON, in this way it reaches till last coil. The supply is given by either over head wires or a battery is connected which is in turn connected to solar panel for reserved supply. We use two fans one at bottom end of pipe and one at starting top of pipe. Due to this an air in pipe is removed along with are pollutant thrown by capsule. There by providing vacuum and more free to the capsule to move in forward direction. To control time of copper coil we use a microcontroller. Relay controller are used to as to handle heavy current flow. To control the capsule as we want, an application designed which connects via Bluetooth so as to give instruction. The speed and direction etc. is show on LCD display.

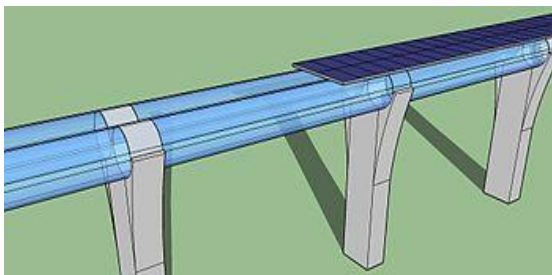
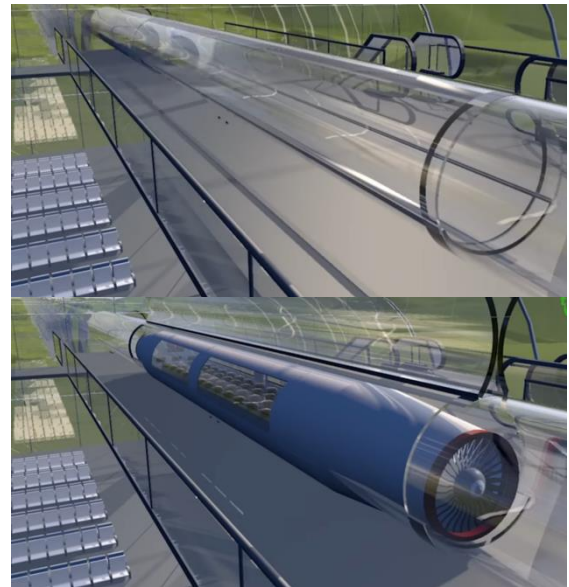


Figure. 5.1 Travelling Tube

### RESULT



Hyperloop is low energy design may help to reduce the impact of carbon carbon and other air pollutants, however the full energy demand of the proposed systems is yet to be determined until a real-world demonstration is established Hyperloop will likely pay an important role as both a solution to alleviate existing and growing travel demand on the current transport infrastructure and as the disruptor to the shape of travel demand on existing modes of transportation. Assuming the energy requirement are low. Hyperloop could also serve to reduce the carbon impact associated with transport. Hyperloop provides more passenger accessibility, low noise and vibration impacts resulting in safe travel. The hyperloop concept could progress in some locations and will likely change both the face of the transport industry. As well as sicio-political boundries nad structers as we know them.

### 6. CONCLUSION

A high speed transportation system known as Hyperloop has been developed in this document. The work has detailed two versions of the Hyperloop: a passenger only version and a passenger plus vehicle version. Hyperloop could transport people, vehicles, and freight between Delhi and Mumbai in 1 hour. Transporting 7.4 million people each way every year and amortizing the cost of \$6 billion over 20 years gives a ticket price of \$20 for a one-way trip for the passenger version of Hyperloop. The passenger only version of the Hyperloop is less Than 12% of the cost of the proposed passenger only flight system between Delhi to mumbai. An additional passenger plus transport version of the Hyperloop has been created that is only 25% higher in cost than the passenger only version. This version would be capable of transporting passengers, vehicles, freight, etc. The passenger plus vehicle version of the Hyperloop is less

than of the cost of the proposed passenger only air travel system between Delhi to Mumbai. Additional technological developments and further optimization could likely reduce this price. The intent of this document has been to create a new open source form of transportation that could revolutionize travel.

## 7. FUTURE WORK

The technology of Hyperloop is in its rudimentary stage. Even if the technology is successful, it can be worked upon for improvement in the future. A detailed design for the stations, including loading-unloading of passengers, improved safety features and propulsion of the capsule, has a large scope towards developing Hyperloop. One of the major challenges for Hyperloop is its adaptability to topography – sharp turns and change in altitudes. The current capsule design allows only 28 passengers to commute at a time. Research can be focused on improving the design such that the numbers of passengers is more.

## REFERENCES

- [1] Electronic resource <http://www.teslamotors.com>.
- [2] Moravec H. A Non-Synchronous Orbital Skyhook // The Journal of the Astronautical Sciences. — Vol. 25. — October-December, 1977.
- [3] Knapman J. Diverse Configurations of the Space Cable // 61st International Astronautical Congress. — Prague, Czech Republic, September 27 — October 1, 2010.
- [4] Ahmed Hodaib, Samar, et al, international journal of mechanical, aerospace, industrial, mechatronics and manufacturing engineering Vol:10 No:5, (May 2016)
- [5] Chin, Jeffrey C.; Gray, Justin S.; Jones, Scott M.; Breton, Jeffrey J. (January 2015). Open-Source Conceptual Sizing Models for the Hyperloop Passenger Pod (PDF). 56th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference. January 5–9, 2015. Kissimmee, Florida. doi:10.2514/6.2015-1587.
- [6] Paper by Mark Sakowski, "The Next Contender in High Speed Transport Elon Musks Hyperloop", 2016
- [7] N. Kayela, editor of scientific and technical department, "Hyperloop: A Fifth Mode of Transportation", 2014
- [8] Mohammed Imran, international journal of engineering research, 2016
- [9] Musk, Elon (August 12, 2013). "Hyperloop Alpha"(PDF). SpaceX. Retrieved August 13, 2013.
- [10] Compressor: <https://patricknewman.files.wordpress.com/2016/03/compressoriso.png>
- [11] Operating principle of hyperloop <http://web-japan.org/kidsweb/hitech/maglev/images/004.jpg>
- [12] Tube <https://upload.wikimedia.org/wikipedia/commons/thumb/8/86/Hyperloop.jpg/220px-Hyperloop.jpg>