VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi – 590014

Seminar Report on

"Hyperloop Technology – Fifth mode of transportation"

Submitted in the partial fulfillment of the requirements for the award of the Degree of

Bachelor of Engineering in Computer Science and Engineering

Submitted by

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Under the support and guidance of

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(Accredited by NBA, New Delhi)

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Certificate

Certified that the Technical Seminar (18CSS84) entitled **"Hyperloop Technology – Fifth mode of transportation"** was presented by **Deepak Jaiswal (1VA18CS010)**, a bonafide student of Sai Vidya Institute of Technology, Bangalore, in partial fulfillment for the award of Bachelor of Engineering in Computer Science and Engineering of Visvesvaraya Technological University, Belagavi during the year 2021-2022. It is certified that all corrections/ suggestions indicated for Internal Assessment have been incorporated in the report. The seminar report has been approved as it satisfies the academic requirements in respect of seminar work prescribed for the said degree.

Prof. Ashwini S S	**Dr. Shantakumar B Patil**	**Dr. H S Ramesh Babu**
Assistant Professor Dept of CSE	Professor & Head Dept. of CSE	Principal

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ABSTRACT

The conventional modes of transportation of people consists of four unique types and that are rail, road, water, and air. These modes of transport tend to be either relatively slow, expensive or a combination of both. Hyperloop is a new mode of transport that seeks to change this pattern by being both fast and inexpensive for people and goods.

Hyperloop is a proposed mode of passenger and freight transportation that propels a capsule-like vehicle through a near-vacuum tube at more than airline speed. The pods would accelerate to cruising speed gradually using a linear electric motor and glide above their track using passive magnetic levitation or air bearings. Hyperloop consists of a low pressure tube with capsules that are transported at both low and high speeds throughout the length of the tube. The capsules are supported on a cushion of air, featuring pressurized air and aerodynamic lift. Passengers may enter and exit Hyperloop at stations located either at the ends of the tube, or branches along the tube length. It quickly becomes apparent just how dramatically the Hyperloop could change transportation, road congestion and minimize the carbon footprint globally. With the Hyperloop, extremely fast, inexpensive intercity travel would be widely accessible. If both people and goods can move more quickly and comparatively cheaply, rapid growth is a logical outcome.

The Hyperloop concept, pod speed competitions and current project developments have recently attracted much publicity. In this paper the transport technology of the vacuumed tube transport project Hyperloop is assessed through a system analysis of its principal aims, functional design, transport capacity and demand in comparison with existing commercial airlines, high-speed rail, and Maglev lines. First, the potential for high-speed long-distance travel demand for Hyperloop based on existing airline transport volumes between major airports in Germany on the one hand, and the proposed Hyperloop link from Los Angeles to San Francisco in California on the other, is assessed in general terms. Second, the technical feasibility of the proposed Hyperloop concept for vehicle design, capacity, operations, propulsion, guidance, energy supply, traffic control, safety, alignment, and construction is discussed in more detail. Third, possible environmental impacts and uncertain investment, operating and maintenance costs for implementation of a Hyperloop line are described. Finally, the risks for further Hyperloop project development and the need for more transparent research are emphasized.

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CHAPTER 1

INTRODUCTION

Hyperloop is a completely new mode of fastest transportation. Hyperloop is firstly proposed by Elon musk and a team of engineer from Tesla Motors and the Space Exploration Technologies Corporation in August 2013. The concept of hyperloop includes travelling people from one place to another place in a capsule which is propelling at a very high speed. We can also called hyperloop as a solar powered transportation system and it is an alternative of high speed train. Basically hyperloop is magnetically levitated train which runs inside a long tube or pipe.

It consists of low pressure tube with capsule that is transported at both low and high speeds. It is driven by linear induction motor and compressor. It includes 28 passenger pods. For propulsion, magnetic accelerators will be planted along the length of the tube, propelling the pods forward. The tubes would house a low pressure environment, surrounding the pod with a cushion of air that permits the pod to move safely at such high speeds, like a puck gliding over an air hockey table. Given the tight quarters in the tube, pressure buildup in front of the pod could be a problem. The tube needs a system to keep air from building up in this way. Musk's design recommends an air compressor on the front of the pod that will move air from the front to the tail, keeping it aloft and preventing pressure building up due to air displacement. A one way trip on the Hyperloop is projected to take about 35 minutes (for comparison, traveling the same distance by car takes roughly six hours.) Passengers may enter and exit Hyperloop at stations located either at the ends of the tube, or branches along the tube length.

CHAPTER 2

HISTORICAL REVIEW

Fig-2.1.1: Historical Work

Hyperloop concept was invented and designed in 1812 by the British Mechanical Engineer George Wenger and later on polished by various people like George Medhurs in 1827 and Alferd ely beach in 1869.

Concepts for high-speed trains in vacuum or evacuated tubes can be traced back as far as 1909, when rocket pioneer Robert H. Goddard proposed high-speed passenger-carrying pods traveling through evacuated tubes.

Bachelet introduced the core idea behind magnetically levitating trains as early as 1910. Over the years these ideas have been further renamed, for instance by the Rand Corporation in 1972 with their

"Very High Speed Transport System".

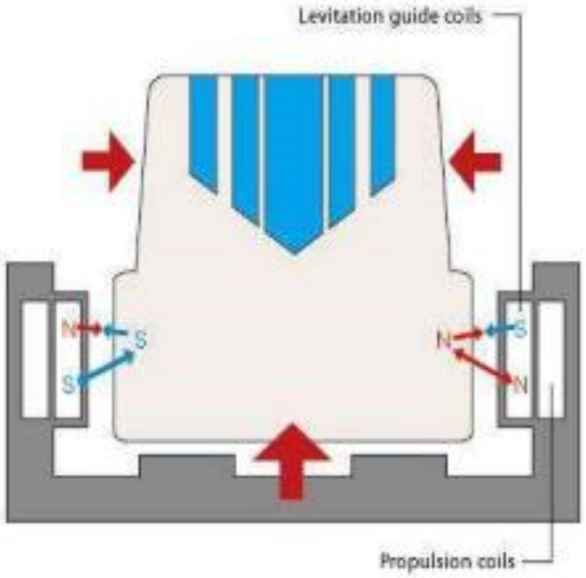
The concept of Hyperloop is now developed and redesigned by the billionaire Elon Musk in 2012.

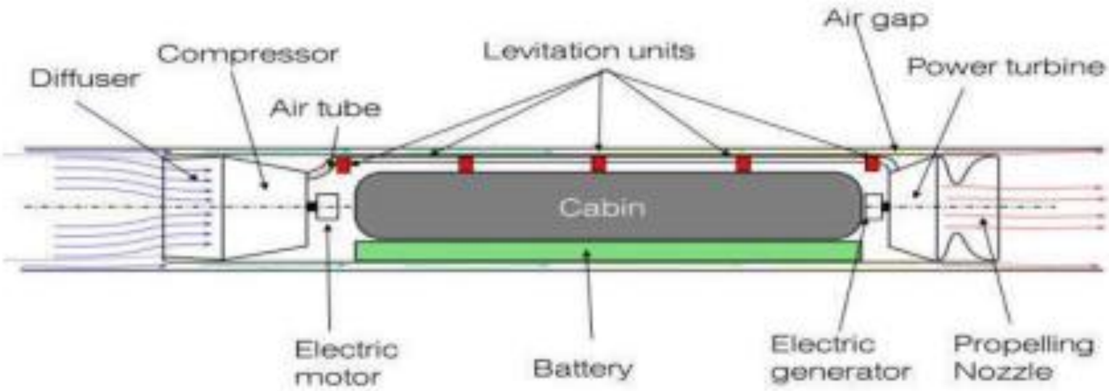
Hyperloop is in some countries a registered trademark of the Space Exploration Technologies Corporation (SpaceX) for the high speed transportation of passengers and goods in partially evacuated tubes. Earlier, in all types of transportation mode, we have encountered many accidents, cost issues, comfort issues, affordability, conservation issues and environmental issues. Hyperloop confront all the above point issues to provide better way to future with help of modern science and engineering solutions.

CHAPTER 3

WORKING PRINCIPLE OF HYPERLOOP

Hyperloop is based on a principle of magnetic levitation. The principle of magnetic levitation is that a vehicle can be suspended and propelled on a guidance track made with magnets. The vehicle on top of the track may be propelled with the help of a linear induction motor.





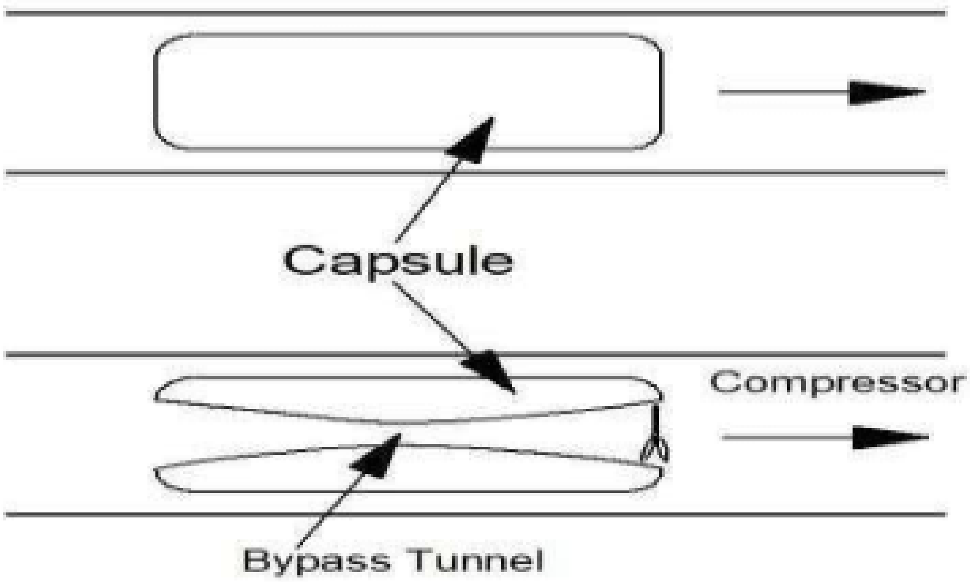
Working of hyperloop system is based on magnetic levitation principle. As we know that the passenger pad travel through low pressure tube which is pylon-supported tube.

In hyperloop system an air compressor fan is fitted on front side of pod which sucks the air. It transfer high pressure air front side to the rear side of capsule (pod) and it propel the pod. It creates the air cushion around the pod, so that the pod is suspended in air within the tube.

On the basis of magnetic levitation principle the pod will be propelled by the linear induction motor. By the linear induction motor the capsule send from one place to another place to a subsonic velocity that is slower than the speed of sound.

The pod will be self-powered. There is solar panel fitted on top of the tube. By this solar panel there is enough energy is stored in battery packs to operate at night and in cloudy weather for some periods. The energy is also is stored in the form of compressed air.

The air between the capsule acts as a cushions to prevent two capsules from colliding within the tube.



In above figure it shown that the air through the compressor is send to a bypass nozzle at the rear end of the capsule. If capsule cover too much area of the tube then, the air is not flow around the capsule and ultimately the entire column of air in the tube is being pushed ahead of the capsule and because of this there is friction between the air and tube walls is increases tremendously. Therefore to avoid this problem the compressor is fitted at the front of the capsule through which the air is flow which will not flow around the capsule and send it to bypass nozzle.

CHAPTER 4

CONSTRUCTION FEATURES OF HYPERLOOP

4.1.1. TUBE

The tube is made of steel. There are two tubes which are welded together side by side configuration to allow the capsules travel in both directions. The tube will be supported by pillars. There is a solar arrays are provided on a top of the tubes for the purpose of power to the system

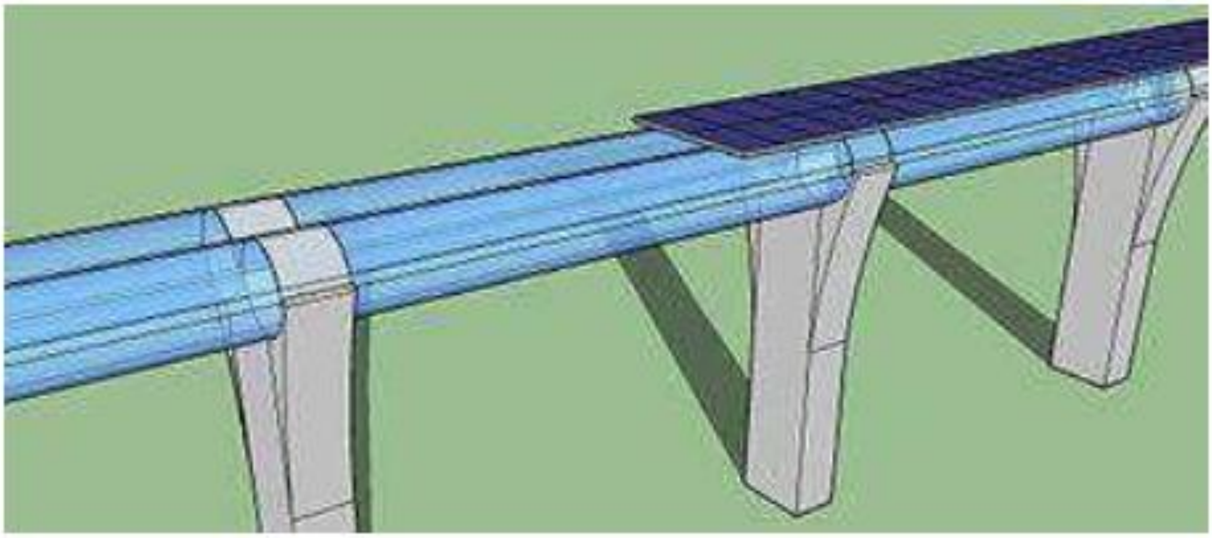


Fig-4.1.1: Construction of Tube

These tubes were theoretically meant to have vacuum inside them which should remove any resistance offered by air in direction where train is travelling, but still practically vacuum cannot be achieved for such a long track. Thus, capsule consist of very low pressure air which offers very negligible resistance. But low pressure air doesn't solve the problem wholly. While capsule is travelling the air ahead of it get compressed and increase pressure offering resistance to capsule giving rise to Kantrowitz limit , which can eventually stop the train but this problem was solved by adding compressor fan on bow(front) of train. The pressure in the tube is 100pa (equivalent to flying above 150,000 feet altitude). Pylons are placed every 30 m to support the tube.

A specifically designed cleaning and boring machine will make it possible to surface finish the inside of the tube and welded joints for a better gliding surface. In addition, safety emergency exits and pressurization ports will be added in locations along the length of tube.

A tube wall thickness between 20 to 23 mm is necessary to provide sufficient strength for the load cases considered in this study. These cases included, but were not limited to, pressure differential, bending and buckling between pillars, loading due to the capsule weight and acceleration, as well as seismic considerations.

In order to keep cost to a minimum, a uniform thickness steel tube reinforced with stringers was selected as the material of choice for the inner diameter tube. Tube sections would be pre-fabricated and installed between pillar supports spaced 100 ft (30 m) on average, varying slightly depending on location. This relatively short span allows keeping tube material cost and deflection to a minimum.

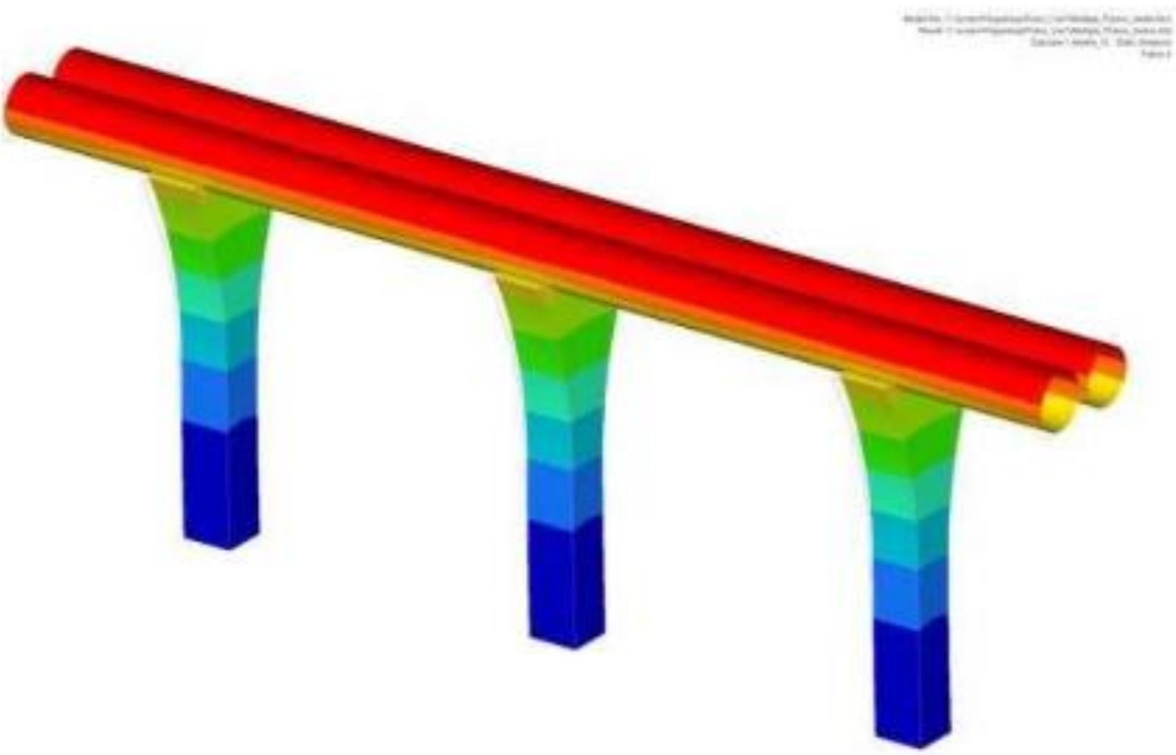


Fig-4.1.1: Simulation of tube and pillars

The cost of the tube is expected to be less than $650 million USD, including pre-fabricated tube sections with stringer reinforcements and emergency exits.

4.1.2. CAPSULE

Just like train have bogeys and engine hyperloop have capsules, there are two type of capsules

1. Hyperloop passenger capsule

2. Hyperloop passenger with capsule

For increasing speed and efficiency of capsules certain geometrical changes are brought in capsule design by minimizing frontal surface area which makes it more comfortable for passengers.

The vehicle is streamlined to reduce drag. Interior design was highly concentrated for comfort of passengers. The seats are design as to nullify high speed acceleration discomfort produced during he travel. Entertainment of passengers are kept in mind and modern accessories are equipped to suffice also passengers will be provided with access to landscape scenery.

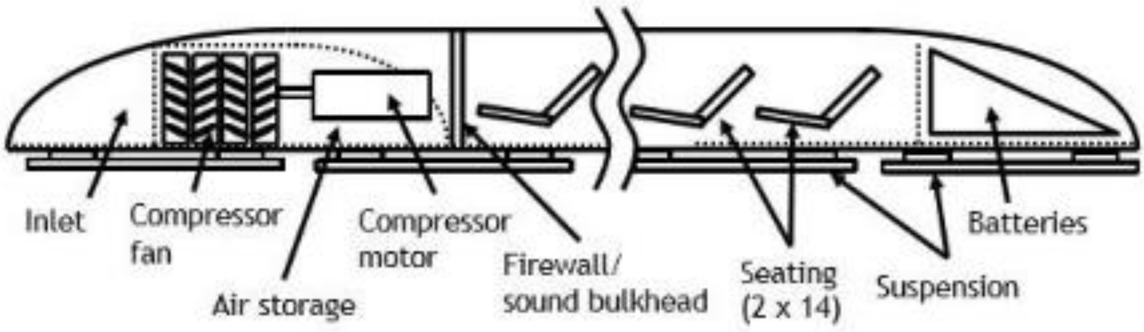


Fig-4.1.2: Hyperloop Capsule

The maximum width is 1.35 m and maximum height is 1.10 m. With rounded corners, this is equivalent to a 1.4 m2 frontal area, not including any propulsion or suspension components

The aerodynamic power requirements at 700 mph (1,130 kph) is around only 100k with a drag force of only 320 N, or about the same force as the weight of one oversized checked bag at the airport. The doors on each side will open in a gullwing (or possibly sliding) manner to allow easy access during loading and unloading. The luggage compartment will be at the front or rear of the capsule.

The overall cost of the structure including manufacturing is targeted to be no more than $245,000.

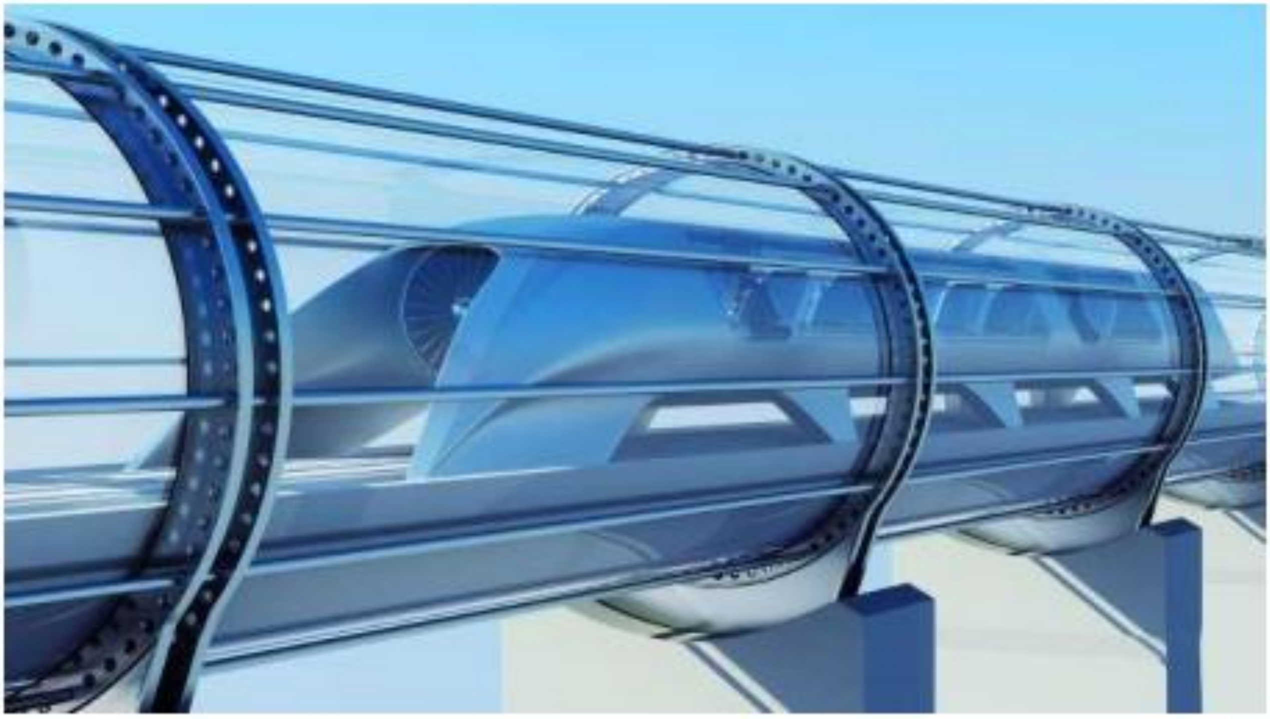


Fig-4.1.2: Capsule in Tube

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. In order to optimize

the capsule speed and performance, the frontal area has been minimized for size while maintaining passenger comfort.

The vehicle is streamlined to reduce drag and features a compressor at the leading face to ingest oncoming air for levitation and to a lesser extent propulsion. Aerodynamic simulations have demonstrated the validity of this 'compressor within a tube' concept.

4.1.3. COMPRESSOR FAN

Since need of vacuum was not sufficed in tube, capsule travelling in low pressure tube accumulates air on its front side, which is further compressed by motion of capsule, this compressed air will resist motion of capsule decreasing its velocity, forming a choke inside the tube and eventually stopping it.

Fig-4.1.3: Compressor fan

Thus, hyperloop demands new innovation to solve this problem known as Kantrowitz limit. Compressor fans were introduced to nullify effect of Kantrowitz limit.

Compressor fans are installed on front of capsules. These fans suck the accumulated compressed air from front of train and exhale it to air bearings. Thus, resistance is removed and no further choking because of Kantrowitz limit is caused.

One important feature of the capsule is the onboard compressor, which serves two purposes. This system allows the capsule to traverse the relatively narrow tube without choking flow that travels between the capsule and the tube walls (resulting in a build-up of air mass in front of the capsule and increasing the drag) by compressing air that is bypassed through the capsule. It also supplies air to air bearings that support the weight of the capsule throughout the journey.

4.1.4. AIR BEARINGS

Friction was another major hurdle of hyperloop, which had only one solution to remove any surface contact between capsule and tube i.e. capsule should be levitating i.e. it should float in air.

Air bearings are installed on surface of capsules, the air inhaled by front of capsule's compressor fan is exhaled by air bearing providing it hovering and levitation.

Air bearing also provide suspension to capsules so traveling is more smooth in hyperloop.

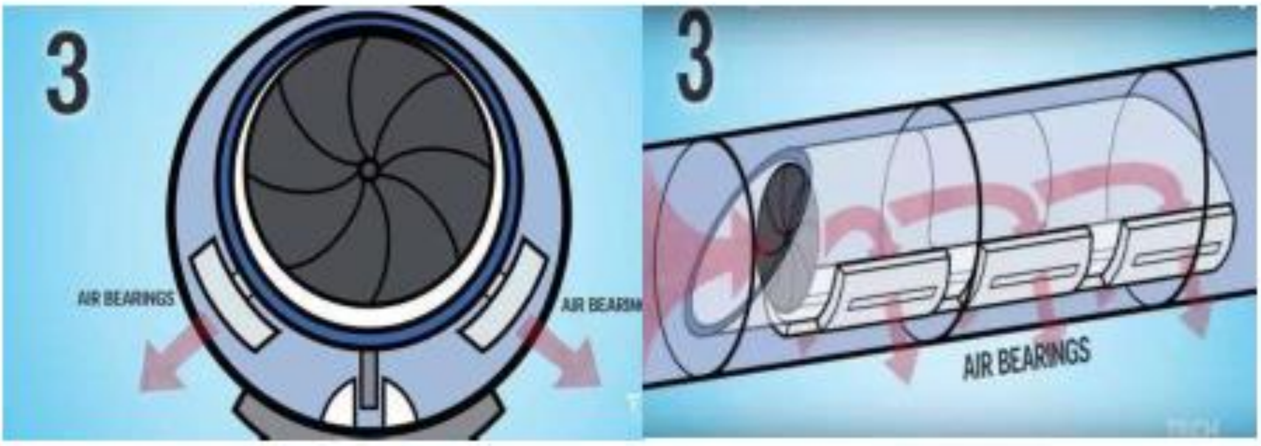


Fig-4.1.4: Air Bearings

As the design process began, the Drexel team realized in order to excel in the competition, they needed to overcome a few obstacles. Drawing on the work of Elon Musk's original vision, the team explored the intriguing possibilities of leveraging air bearings to facilitate levitation for the POD.

Musk's original concept for the Hyperloop consisted of a fleet of capsules traveling at high speeds between Los Angeles and San Francisco through a low-pressure tube. The capsules themselves would be supported on a cushion of air, created by internal pressurization and aerodynamic lift. The essential technology for the realization of that vision was the air bearing.

4.1.5. PROPULSION

Finally, hyperloop requires a propelling machine. And thus, linear induction motor is used in hyperloop, the same motor used in tesla cars which in hyperloop can produce velocity of 20000 meter per second. The moving motor element (rotor) will be located on the vehicle for weight savings and power requirements while the tube will incorporate the stationary motor element (stator) which powers the vehicle.

The overall propulsion system weight attached to the capsule is expected to be near 2,900 lb (1,300 kg) including the support and emergency braking system. The overall cost of the system is targeted to be no more than $125,000. This brings the total capsule weight near 33,000 lb (15,000 kg) including passenger and luggage weight. The overall propulsion system weight attached to the capsule is expected to be near 3,500 lb (1,600 kg) including the support and emergency braking system. The overall cost of the system is targeted to be no more than $150,000. this brings the total capsule weight near

57,000 lb (26,000) kg including passenger, luggage, and vehicle weight.

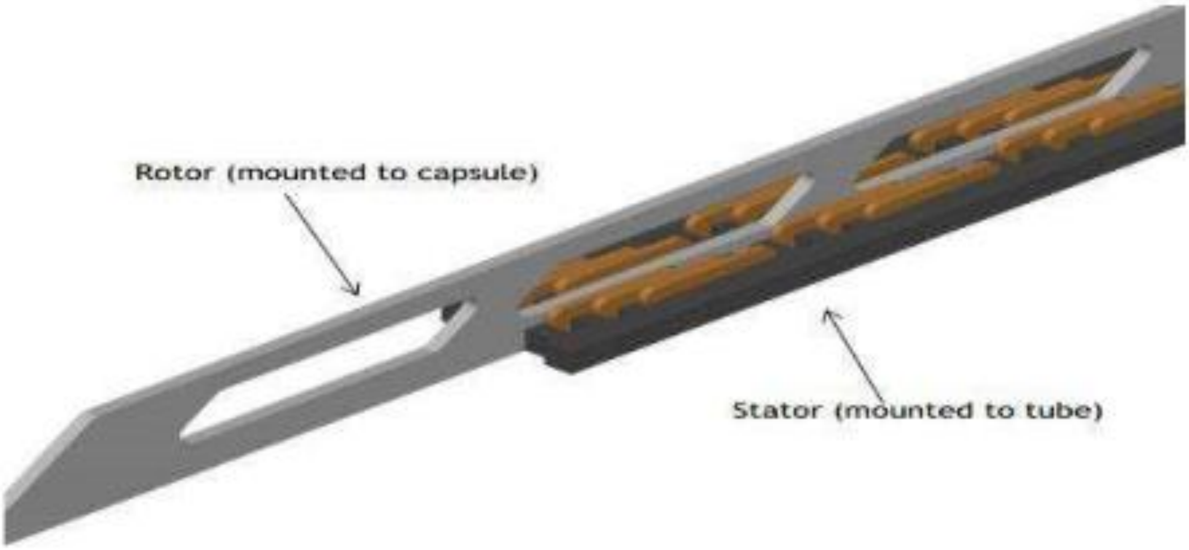


Fig4.1.5: Propulsion

To accelerate and decelerate the capsule the linear induction motor is used in hyperloop system. It provides some advantages over a permanent magnet motor. To accelerate the capsules there is linear accelerators are constructed on a length of the tube. Stators are placed on the capsules to transfer momentum to the capsules via the linear accelerators.

CHAPTER 5

ANALYSIS

5.1 ADVANTAGES:

1. It saves the travelling time.
2. There is no problem of traffic.
3. It is powered by the solar panel.
4. It can travel in any kind of weather.
5. Cost of hyperloop is low.
6. Not disruptive to those along the route.
7. More convenient.
8. Resistance to earthquake.
9. Pollution Free
10. Light Weight
11. Weight ¼ for the Same Strength
12. Corrosion & Chemical Resistance
13. Excellent Elastic Properties
14. Extremely Strong
15. High Speed of 760mph

5.2 DISADVANTAGES:

1. Turning will be critical.
2. Less movable space for passenger.
3. High speed might cause dizziness in some passenger.
4. Punctured tunnel could cause shockwaves.
5. High Cost of Fabrication.
6. Complex repair procedure.
7. Compressive strength not dependable.

CHAPTER 6

PROGRESS

Presently the idea of hyperloop was proposed for route between San Francisco, California and Los Angeles in 35 minutes. This requirement tends to size other portions of the system. Given the performance specification of the Hyperloop, a route has been devised to satisfy this design requirement.

The Hyperloop route should be based on several considerations, including:

1. Maintaining the tube as closely as possible to existing rights of way.
2. Limiting the maximum capsule speed to 760 mph (1,220 kph) for aerodynamic consideration.
3. Limiting accelerations on the passengers to 0.5g.
4. Optimizing locations of the linear motor tube sections driving the capsules.
5. Local geographical constraints, including location of urban areas, mountain ranges, reservoirs, national parks, roads, railroads, airports, etc. The route must respect existing structures.

For aerodynamic efficiency, the speed of a capsule in the Hyperloop is typically:

- 300 mph (480 kph) where local geography necessitates a tube bend radii < 1.0 mile(1.6 km)
- 760 mph (1,220 kph) where local geography allows a tube bend > 3.0 miles(4.8 km) or where local geography permits a straight tube.

These bend radii have been calculated so that the passenger does not experience inertial accelerations that exceed 0.5g. This is deemed the maximum inertial acceleration that can be comfortably sustained by humans for short periods. To further reduce the inertial acceleration experienced by passengers, the capsule and/or tube will incorporate a mechanism that will allow a degree of 'banking'. The Hyperloop route was created by the authors using Google Earth.

Fig-5.2.1: map of present work path

Progress in India

Hyperloop Transportation Technologies are in process to sign a Letter of Intent with the Indian Government for a proposed route between Chennai and Bengaluru. If things go as planned, the distance of 345 km could be covered in 30 minutes. HTT also signed an agreement with Andhra Pradesh government to build India's first Hyperloop project connecting Amaravathi to Vijayawada in a 6-minute ride.

On 22 February 2018, Hyperloop One has entered into a MOU (Memorandum of Understanding) with the Government of Maharashtra to build a hyperloop transportation system between Mumbai and Pune that would cut the travel time from the current 180 minutes to just 20 minutes.

Indore-based Dinclix GroundWorks DGWHyperloop advocates a Hyperloop corridor between Mumbai and Delhi, via Indore, Kota, and Jaipur.

CONCLUSION

The Train of future is reviewed in this paper. Hyperloop has two versions namely passenger only and passenger plus vehicle hyperloop. This technology can reduce travel time between Los Angeles and San Francisco up till 35 minutes. The price of one way trip would be as less as $20. Hyperloop is much cheaper compared to railway between Los Angeles and San Francisco.

On other hand passenger plus vehicle version would just cost more 25%. This version would be capable of transporting passengers, vehicles, freight, etc. this version is 11% more cheaper than proposed by rail system between Los Angeles and San Francisco. Further more the hyperloop is at development stage in future the price will be much lower than present price. A high speed transportation system known as Hyperloop has been developed in this report.Hyperloop transportation system can be used over the conventional modes of transportation that are rail, road, water and air. At very high speed it provides better comfort and cost is also low. By reducing the pressure of the air in the tube which reduces simple air drag and enables the capsule to move faster than through a tube at atmospheric pressure. As it has number of advantages it will very help full for transport public as well as goods in a very short period of time (at a top speed of 1220 kmph) and also in lower cost. It is a new concept so there is some future work will be required for development of this project .Conventional means of transportation (road, water, air, and rail) tend to be some mix-off expensive, slow, and environmentally harmful. Road travel is particularly problematic, given carbon emissions and the fluctuating price of oil. As the environmental dangers of energy consumption continue to worsen, mass transit. Rail travel is relatively energy efficient and offers the most environmentally friendly option, but is too slow and expensive to be massively adopted. 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 11% of the cost of the proposed passenger only high speed rail system between Los Angeles and San Francisco. Additional technological developments and further optimization could likely reduce this price.

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