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Study of braking system in hyper loop

#1AMIT

1amitbidlan05@gmail.com

#1Mechanical Engineering Department,

Maharaja Agrasen Institute of Technology
Rohini, Sector-22, New Delhi-11004, INDIA

ABSTRACT

The aim of this paper is to investigate magnetic levitation technology with pneumatic levitation in order to deal with highest performance of HYPERLOOP and its breaking system. The pneumatic levitation mainly helps in levitating object whereas the magnetic levitation provides direction as well as braking system to HYPERLOOP train. The system should be able to levitate an object from below, clear of an array of electromagnets and pneumatic system.

Keywords— HYPERLOOP, HTSC, MAGLEV, PID, EDS

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I. INTRODUCTION

An expansion in population and lives has increased vital need for economically suitable transport system to ensure the conventional fuel burning automobile systems can be minimized. The pollution free transport system demand has increased exponentially. The transport system should be convenient, time saving, eco-friendly, lower maintenance, compact, less weight and best suitable for industrial transportation. HYPERLOOP train comes out to be the best recommendation which can withstands to our requirements. The HYPERLOOP system is a hybrid of pneumatic system and maglev system. The conventional train uses the principle of friction to drive wheels by motor. The HYPERLOOP and maglev doesn't make such contact and reducing the friction which was the major cause for energy losses. The electromagnets in the train levitate the body up to certain fixed level and maintain it throughout the guide way. On 1934 the German Hermann kamper patented it. Since, then new designs and models were proposed and finally in 2003 in Shanghai, maglev was in public services. The magnetic levitating force is directly proportional to the flux generated. Also, the magnetic levitating mechanism provides the counteracting force for lifting up the train.

The number of vehicles per cities increasing exponentially and becoming major issues in case of pollution and inconvenience.

Air pollution in India is becoming major issue. According to WHO, 1.5 million people is estimated to kill because of pollution. Polluting gases from vehicles contributes 18% of total pollution. The total number of vehicles registered in Delhi is 9.63 million which intimates the vital need for eco-friendly transport system.

Advantages of maglev over conventional friction force driven trains are:-

1) Due to the reduction of track and wheels, the maintenance cost decreases.
2) Low guide way cost.
3) HYPERLOOP system will never get derailed.
4) Since, there are no wheels; there will be no chance of slipping and sliding accidents.
5) The turning radius us about 30meters.
6) HYPERLOOP is less dependent on weather.

Even if there is no proper magnetic shielding, the magnetic field reaches to 0.09T at the floor level and slightly less to seat level around 0.04T which is not considered harmful for humans.

The vibrations and noise in HYPERLOOP is about 60-65DB which is much lesser than conventional trains.

II. WORKING PRINCIPLE

The conventional train had the surfaces in contact which ultimately lead to friction and heat. Thus, greater loss of energy. The vibrations and noises are also high.

The bulk HTSC levitation can be utilized as frictionless bearings of high speed rotation of inertia in which the electric energy can be stored in form of kinetic energy.

HYPERLOOP system is considered as the combination of pneumatic system and maglev system. The pneumatic system is basically a vacuum tube which was used in early 80's or 70's to transfer documents from one place to other. The change in pressure was mainly cause for the movement.

From that concept, HYPERLOOP creates a pressure difference inside vacuum tube. The HYPERLOOP power system consists of two compressed air tanks, one auxiliary tank and rechargeable batteries.

The pressure difference is thus created by high speed moving fans. The HYPERLOOP system is expected to touch a speed of 850 miles/hour. The distance between san Francisco and Los Angeles can be covered within 30 minutes which is making a greater distance between flight time taken.

The most important aspects of this system is to provide the best comfort to passengers. But in order to stop a vehicle which is at its high speed comes out to be a difficult task and no frictional force is available to support braking.

III. SUSPENSION AS BRAKING IN HYPER LOOP

Mainly, three basic types of levitation technologies are present. Levitation technology is used to lift up objects without any support. The HYPERLOOP system should be able to levitate an object structure or device assisting in levitating object.

1. Electromagnetic suspension:
The electromagnetic suspension works within an air gap of +10 or -10mm. This type of suspension system is highly unstable for fast moving trains because, as the speed increases, maintaining control over guide ways tough. The levitation works on the attraction force between two magnets. High temperature magnets are the best suitable for electromagnetic levitation because, of low cost and provides high magnetic field.

2. Electrodynamics suspension:
Electrodynamics suspension works on the principle of repulsive forces between two electromagnets. The electrodynamics suspension is stable and there is no need to maintain the air gap because, it actuates that air gap automatically. That's why electrodynamics suspension is highly recommendable for high speed trains. The electrodynamics system can be of two types further permanent magnet and superconducting magnet. The power supply in permanent magnet is not needed. So, the permanent type system can be used in smaller distance trains. The world record of superconducting magnet type is 581 km/hour in japan, 2003.

3. Hybrid electromagnetic suspension (HEMS):
The reduction of power consumption in hybrid system is done by using partially electromagnets with permanent magnets. Hybrid electromagnetic suspension needs a greater difference of amplitude of current in comparison to electromagnetic suspension because, the permeability of air is relatively equal to that of permanent magnet.

Electrodynamics suspension comes out to be the best choice which should be installed on platform where the **hyper loop** needs to stop.

An additional array of electromagnets should be fitted on the head of **hyper loop** which making interlocking for suspension.

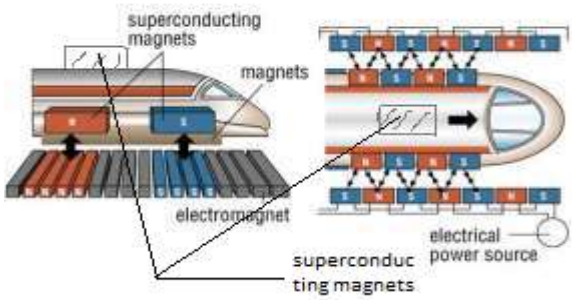
BRAKING WITHOUT ARRAY OF HEAD ELECTROMAGNETS:

Since, there is no surface contact; there will be no chance for friction. If the brakes are applied in hyper loop at 830km/hr. speed there is a chance of generation of reactive force on rear end of train leading to misalignment. Also, because of the less space in tunnel, the time requirement to overcome the situation will be increased.

BRAKING WITH ARRAY OF HEAD ELECTROMAGNETS:

The head array electromagnets provide reactive force downwards which cancels the reactive force.

Also, the head array electromagnet helps the hyper loop train to be in proper place. It provides suspension on application of sudden brakes.



IV. EQUATIONS

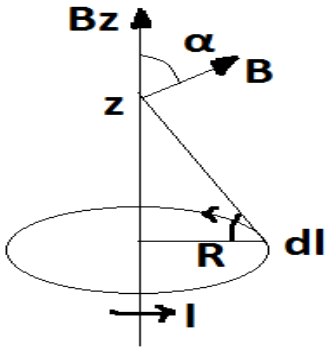


Fig: 2: Axial magnetic field by BIO-SAVRAT LAW.

The process can be analysed by using Right hand Rule which states that pointing of index finger towards velocity V with magnetic field carry towards the observer. The magnetic repulsive force on top of array of superconductors will be in direction of gravitational force helping in making contact of hyper loop train with guide way.

Using BIOT-SAVRAT LAW

Bz can be calculated as:

$$Bz = \frac{\mu}{4\pi}\frac{2\pi R}{z^2 + R^2}\cos\propto$$

$$Bz = \frac{\mu I R}{2(z^2 + R^2)}\frac{R}{\sqrt{Z^2 + R^2}}$$

$$Bz = \frac{\mu I R^2}{2 \times \sqrt[3/2]{(z^2 + R^2)}}$$

MAGNETIC FORCE:

Considering the head array magnets and hyper loop train as straight conductors parallel to each other. The magnetic force experienced by them is:

$$\overrightarrow{dF} = I\,\overrightarrow{dl} \times \vec{B}$$

$$\frac{F}{l} = -\frac{\mu I_1 \times I_2}{2\pi R}$$

This force will counter balance the reactive force experienced at rear end of hyper loop train.

USE OF HALL EFFECT SENSOR:

Placing a HALL EFFECT SENSOR on the central axis of electromagnet will enhance the generation of alternation of poles. It will analyse, if the orientation of an electromagnet is wrong then, alternation of poles will not be there and unwanted loop will get generated.

USE OF PID CONTROLLER:

A PID controller detects error in the system. **P** stands for proportional, **I** stand for integral and D stands for derivative.

P determines the error in current.

I develop the sum of errors in current.

D calculates the rate at which errors are changing.

IV. CONCLUSION

High speed hyper loop train may have lots of vibrations during which is inconvenient for the passengers at a high speed. These vibrations can be minimized by providing addition array of electromagnets on the head of hyper loop train which fits inside the outer lining of tunnel making a inverted U shape lining. Thus to overcome catastrophic failures during braking, these additional array of electromagnets are must because, guide ways provides incredible high speed in hyper loop.

This incredible system is best suitable for mass transportation in a limited period of time. This system is revolutionary and cheap.

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