ON PERFORMANCE OF QUANTUM LOCKING FOR WHEEL-LESS TRANSPORTATION

Qasim Jan, Tahir Hasan, Javed Iqbal,
Department of Electrical Engineering, Sarhad University of Science and IT, Pesahawar.
Email: qasimjan1@yahoo.com

Abstract

Transportation has continuously been a vital side of human civilization reflective the extent of general economic and technological advancement of a given society. The recent technological advancements in power electronics are pushing for Maglev train using Quantum locking. For levitation the most important factor is temperature which is affecting the efficiency of the train. In this work we have compared different prototypes of Maglev trains including Japanese, German and Chinese technologies. We also did mathematical modeling to relate the magnetic force required for a certain weight of the train to levitate. We suggest that Japanese maglev is better than Germany and china maglev.

Key words: Transportation, Quantum Locking, Maglev, Superconductor.

Introduction

Transportation has continuously been a vital side of human civilization reflective the extent of general economic and technological advancement of a given society. Transportation suggests that of assorted types are evolving for hundreds of years resulting in quicker, further, safer, and a lot of price economical visits on roads, rail, on the water, or within the air. It is, however, solely within the last half of this century that the development of holdup becomes predominant because of the fast increase of the quantity of vehicles and will increase in demand for nearly all modes of transportation. Holdup seems once too several vehicles conceive to use a standard transportation infrastructure with restricted capability. Within the best case, holdup ends up in queuing phenomena (and corresponding delays) whereas the infrastructure capability ("the server") is totally used. within the worst (and much more typical) case, holdup ends up in a degraded use of the accessible infrastructure (reduced outturn that will even cause fatal gridlocks) with excess delays, reduced safety, and recently, increase environmental pollution. The aim of developing the new ground transportation systems of the long run is worth it and so it ought to be pursued with great enthusiasm and dedication. This analysis notifies more technical and economic problems related to this promising transportation technology. The ever-growing base of rail technology information and skill is manufacturing advantages these days and holds nice promise for the long run. Quantum levitation or quantum locking is the ability of a superconductor to perfectly match the magnetic fields surrounding it. A superconductor is a material, that when cooled to a temperature below its critical temperature, its resistivity goes to zero[1]. Levitation of the superconductor above the magnet obey two properties i.e. Zero resistance which is also called perfect conductivity and the other one as the meissner effect [3]. To show zero resistance one has to cool the disk to the superconducting state with the help of liquid nitrogen and placed over magnets. Placing the disk upon the magnets and then cooling it afterwards will show the meissner effect. Before the discovery of meissner effect in 1933, the meissner effect was completely unbelievable. Other Traditional theories magnetism is not expected that a warm superconductor setting atop a magnet will be levitate when the superconductor is cooled below its superconducting critical temperature. By moving the superconductor towards the magnet gives a moving magnetic energy field which ultimately produces currents in the superconductor. These currents are produce in any electrical conductor in a changing magnetic field. This principle is called as Lenz's law [2].

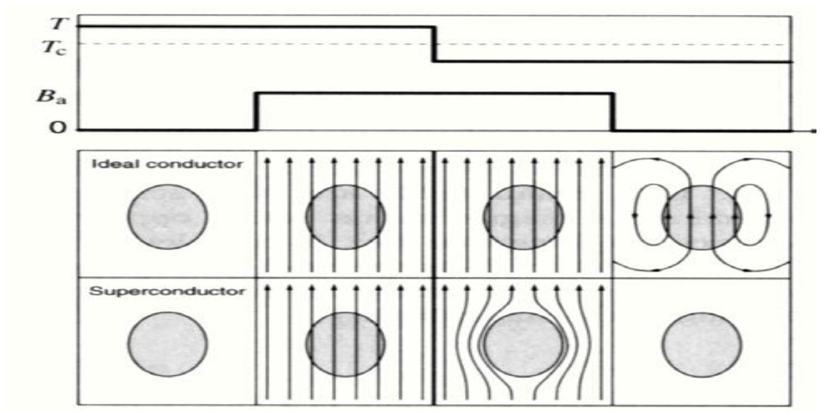


Figure1 Meissner Effect in a Superconductor [3].

Superconductor and Magnet

A disk of a white ceramic material yttrium-barium-copper-oxide called superconductor. It is covered in a copper chamber, and positioned in the center of a plastic foam container which is open by celled Styrofoam [12]. The copper chamber levitates the super conducting disk in such a way that levitation of the superconductor may be seen clearly. There is no need to immerse the superconductor in liquid nitrogen because copper provide enough conductivity.

The track of train is made of magnet which creates magnetic force to lift the train. There are four types of magnets i.e. Neodymium Iron Boron (NdFeB or NIB), Samarium cobalt, Alnico and Ferrite. Neodymium magnet is a powerful magnet that can easily levitated the superconductor when the superconductor is cooled below its transition temperature.

The rest of the paper is organized as follows: Firstly, we discuss the basics of Magnetic levitation. We did a detailed survey about the already deployed technologies for magnetic. Further we present a prototype model for magnetic train using quantum levitation. Before the prototype implementation we found mathematical modeling to find the relationship between the weight of the train and the force required to levitate it. In the last section we conclude the paper.

Basics of Magnetic Levitation

The basis of all magnetic levitation is due creation of magnetic forces. There are different ways of creation of a magnetic field. One way is to use a permanent magnet which is made of a solid material and consists of two poles north and South. The second way is to produce magnetic field through an electric field by changing linearly with time. The third way is to produce by means of using direct current [10].

There are two basic principles for the concept of magnetic levitation. The first law states that if there is a change in the magnetic field on a coil of wire, there will be induced emf. It can be illustrated that the changing magnetic field produces current which can be seen in From Figure 2.

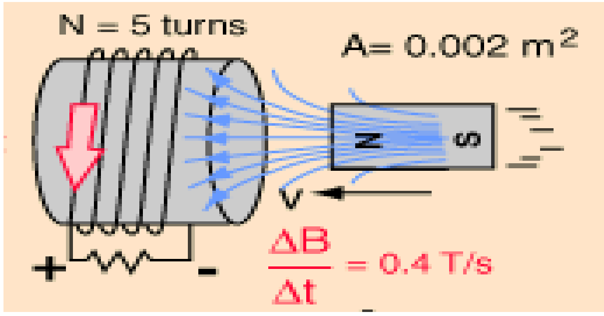
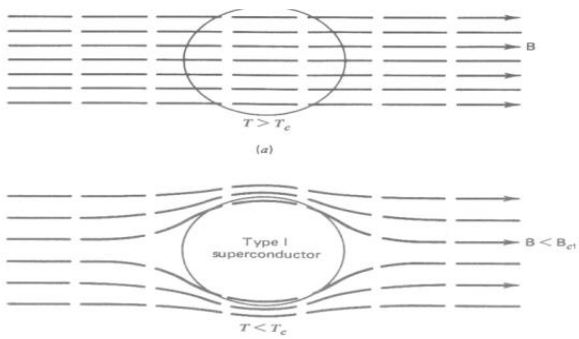


Figure.2 Induced Current from Change in Magnetic Field [9].

Direct diamagnetic levitation and levitation of superconducting materials

These concepts are well known for several years, that diamagnetic materials have skill to partially screen out external magnetic field from the volume. This effect can also be used for levitation at room temperature. But there are two important limitations: there is no too strong diamagnetic material in the nature, high magnetic field is required. Very strong magnetic field (about 16 Tesla) is required for levitation for example water drops or some (diamagnetic material) at human fingertips. This effect is sometimes known as "diamagnetically stabilized levitation".



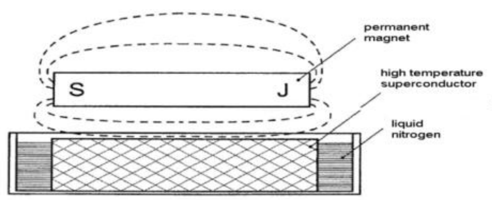


Fig. 3(a) screening out of magnetic field from the volume of the Type I superconductor [7].

Figure. 3(b) Simple superconducting bearing [6].

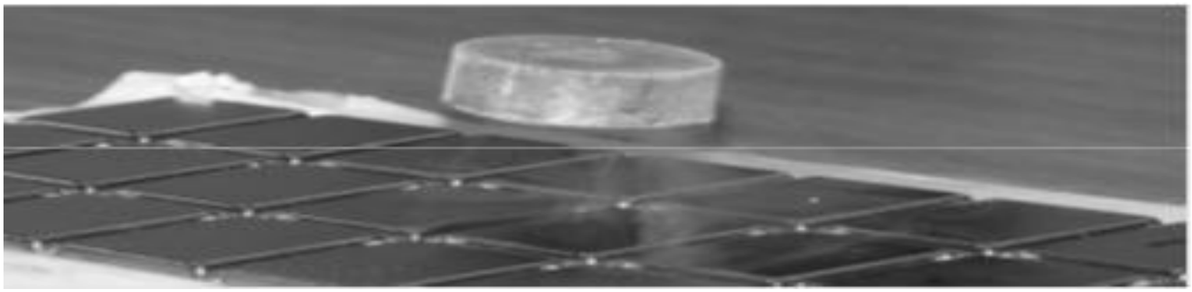


Figure 4 Levitation of a YBCO pellet above a set of permanent magnets [8].

The two scientists Meissner and Ochsenfeld discovered that superconducting material is best diamagnetic material; therefore it can levitate in magnetic field. Few types of magnetic suffering based on this principle were given. This term has one significant limitation – very low temperatures are required. With the fast development of new superconducting materials allows using of cheaper thing for cooling – liquid nitrogen. Nowadays, a critical temperature of superconductors is about 130K. For the levitation purposes the most widely material used is YBCO (a material based on Yttrium-Barium-Copper-Oxygen - melt textured YBa2Cu3O7-x with Y2BaCuO5 excess) with a critical temperature about 92K.As liquid nitrogen is used for cooling [4, 5].

Comparison of Maglev Technologies Deployed

In 1900's century First time two scientists named Robert Goddard and Emile bachelet give the idea of frictionless train. Both scientists was fail to explain their idea, so the concept of frictionless train is ended. After 60 years in 1960 the German and Japanese started research on this concept and they are succeeded.

Table.1 Germany maglev compared with Japanese and china maglev.

Properties	**Germany maglev**	**Japanese maglev**	**China maglev**
Working principal	EMS (electromagnetic suspension)	EDS (electrodynamics suspension)	EMS (electromagnet ic suspension)
Speed	500km/h	581km/h	470km/h
Gap between train and track	8mm to 10mm	10cm	8mm
Cost	Low	High	Low
safety	Low	High	Low

Review on Japanese maglev VS Germany maglev

Japanese maglev works on EDS principal and Germany maglev work on EMS. Japanese maglev is more expensive than Germany maglev due to the cost of superconductor. But Japanese maglev is safer and faster than Germany maglev. Japanese maglev is better than Germany maglev.

Demonstrated Method

Quantum locking demonstrated on two parts: A magnetic track and YBCO with a critical temperature Of 93 K (-292 F) cooled by liquid nitrogen. The track is made up of 250 magnets organized in two parallel rows, oriented such that the magnetic field is directed up at the centre and down at the edges. When the superconductor is cooled below Critical temperature in the presence of the magnetic field tracks. Due to the maximum degree of defect in the material the vortices are strongly pinned, creating a stable imprint of the magnetic field at the time of cooling. A small displacement of the superconductor will mismatch the magnetic field and the "frozen in" sides, and give rise to a restoring force. The restoring force acts in both directions (perpendiculars to the track as well as in the vertical direction). Only along the direction of the track have a uniform magnetic field and the superconductor will move freely [1, 13].

Prior to the prototype implementation, we did mathematical modeling to find the relation of the weight of the train and the force required. We assumed a circular track of diameter D. The other parameters are:

Diameter of track = 40cm

Radius of the track = 20cm

Mass of train

Let mass of train = 300 gram

For the length of track, we have the following equation because we are considering a circular track.

$$L = 2\pi r \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

As we have D= 0.4m, the length of the track is:

$$= 2 \; x \; 3.14 \; x \; 0.2$$

$$L = 1.256m..$$

$$W = mg \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

By applying the above eq. (2) we can find weight as:

$$W = .3x9.8$$

$$W = 2.94N$$

Force per unit (Magnet)

$$F = AB\string^2/2u \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

$$=0.01 \text{ x} (0.0179)^2 / 2x1.667x10^{-6}$$

$$= 1.263N$$

Force of total track is:

1.263 x 249 = 314.48N

Force of magnet under the train

$$F = AB\string^2/2u \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

$$= 0.04 \text{ x} (0.0179)^2 / 2x1.667x10^{-6}$$

$$F = 5.04N$$

As from the above calculations, we show that the force of magnet is greater than the weight of train so the train is levitated. Now for the prototype implementation, we have the following parameters for the train, track, the magnet we used and levitator.

Length of train L=20 mm

Diameter of track D=40cm

Magnet:

Neodymium Iron Boron (NdFeB or NIB)

Flux density B = 0.0179T

Length of the magnet l1=10mm

Width of the magnet w1=10mm

Thickness of the magnet h1=5mm

Number of magnets in track N= 249

Levitator:

Length of levitator l2=20mm

Width of levitator w2=20mm

Mass of the (levitator Train) m=300gm

Prototype Design

The principle selected for the experiment is levitation of a superconductive material (ideal diamagnetic material) above a guide way with permanent magnets. The guide way of the model was designed as a circular track, 20mm wide and 1.25 meters long track, made out of rare-earth NbFeB permanent magnets (PM).PMs are arranged in circle with the same orientation of magnetic field. The vehicle model was designed to enable keeping of YBCO pellet in the considerable amount of liquid nitrogen. One pellet with diameter 20mm and thickness 20mm were used as the main levitators, which lift the vehicle above the guide way. Pellet with diameter 20mm and thickness 20mm were used as auxiliary levitators, which should stabilize lateral swinging of the vehicle.

Conclusion

Maglev train using quantum locking is advance type of railway having latest technologies in power electronics .Temperature is important factors affecting the efficiency of the maglev train. Maglev train (ybco) which is levitates on 92K or-181 C. For bringing the temperature at that level we use liquid nitrogen .If the temperature increases from that specific level will not levitate. Initial cost is high than the running cost of the maglev train because of the cost of superconductor. The main property of the superconductor is diamagnetism. This property helps to know about a vertical repulsion force through which superconductor levitates and the magnet (circular track).

References

[1] Nicholas R. Anderson and Morten Ring Eskildsen *Department of Physics, University of p f y , y f Notre Dame, Notre Dame, Indiana 46656, USA.*

[2] Tombe, F.D. “Cathode Rays, Gravity, and Electromagnetic Radiation” http://www.wbabin.net/science/tombe53.pdf.

[3] Joe Khachan and Stephen Bosi “Superconductivity” Online:sydney.edu.au/science/ physics/pdfs/schools.../Superconductivity [last visited: July 13, 2016].

[4] Yang W M, Chao X X, Bian X B, Liu P, Feng Y, Zhang P X and Zhou L 2003 The effect of magnet size on the levitation force and attractive force of single-domain YBCO bulk *Supercond. Sci. Technol.* **16** 789–92.

[5] F.C. Moon, S*uperconducting Levitation.* John Wiley & Sons, Inc. New York, 1993.

[6] R. Nicolsky. R. de Andrade Jr., A. Ripper, D.F.B. David, J.A. Santisteban, R.M. Stephan, W. Gawalek, T.Habisreuther, T. Strasser, "Superconducting-electromagnetic hybrid bearing using YBCO bulk blocks for passive axial levitation". *Superconductor, Science and Technology*, vol. 13, pp. 870-874, 2000.

[7] Venusproject.org/new-energy/magnetic-levitation-or-maglev-propulsion.html.

[8] An Introduction to Magnetic Levitation And it's Applications Kevin J. Van Dyke, Student Member, IEEE.

[9] www.eclipsemagnetics.co.uk/ToolsAndBases/1244.htm.

[10] Mayer, D., *Magnetic levitation and it's applications,* in Czech, *ELEKTRO* 1/2003, pp. 4-12.

[11] Overview of magnetic levitation principles and their application in maglev trains1 čermák, R.; Bartoň, L.; Spal, P.; Barták, J. & Vavřík, J.

[12] S.J. Blundell, *Superconductivity: A Very Short Introduction* (New York, NY: Oxford University Press), 2009.

[13] www.astc.org/blog/2011/10/26/quantum-levitation

[14] http://www.californiaprogressreport.com/site/conventional-high-speed-rail-vs-magnetically-levitated-trains-was-maglev-ever-contention.