International Journal of Advanced Research in Science Management and Technology
IJARSMT
ISSN(Online)-2454-4159 Volume 3, Issue 8, August 2017

Magnetic Driven Vehicle

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ABSTRACT— The term "MDV" refers to a class of technologies that uses magnetic levitation to propel vehicles with magnets. Today the world is encountering one of the most serious scarcity of fossil fuels. Due to the increasing gasoline price and pollution from the exhaust of IC engines, so there is a necessity of any kind of alternate. This brought us towards the technology of using Magnet as a substitute for driving the vehicle in this rapidly developing automobile field. This project aims at developing a highly cost-effective and eco-friendly Magnet. Driven Vehicle (MDV) which is reliable and economical in the current scenario.

- The Vehicle work on the principle of MAGLEV (Magnetic levitation).Through this principle we levitate the driven shaft of our vehicle.
- Once the driven shaft is lifted we provide the torque to the driven shaft with the help of battery (by induced EMF) through this the driven shaft starts to rotate & required RPM can be achieved by induced EMF.
- For successful levitation and control of all 6 axes (degrees of freedom; 3 translational and 3 rotational) a combination of permanent magnets and electromagnets or superconductors as well as attractive and repulsive fields can be used.
- The primary ones used in maglev trains are servo-stabilized electromagnetic suspension (EMS), electrodynamics suspension (EDS).
- If two magnets are mechanically constrained along a single axis, for example, and arranged to repel each other strongly, this will act to levitate one of the magnets above the other. Another geometry is where the magnets are attracted, but constrained from touching by a tensile member, such as a string or cable.
- If one moves a base made of a very good electrical conductor such as copper, aluminium or silver close to a magnet, an (eddy) current will be induced in the conductor that will oppose the changes in the field and create an opposite field that will repel the magnet (Lenz's law). At a sufficiently high rate of movement, a suspended magnet will levitate on the metal, or vice versa with suspended metal.

KEYWORDS- Magnet Driven Vehicle (MDV), fossil fuels, IC engines, education, MAGLEV (Magnetic levitation).

I. INTRODUCTION

Maglev (derived from magnetic levitation) uses magnetic levitation to propel vehicles with magnets rather than with wheels, axles and bearings. With maglev, a vehicle is levitated a short distance away from a guide way using magnets to create both lift and thrust. High-speed maglev trains promise dramatic improvements for human travel if widespread adoption occurs. Maglev trains move more smoothly and somewhat more quietly than wheeled mass transit systems. Their non-reliance on friction means that acceleration and deceleration can surpass that of wheeled transports, and they are unaffected by weather. The power needed for levitation is typically not a large percentage of the overall energy consumption most of the power is used to overcome air resistance (drag), as with any other high-speed form of transport. Although conventional wheeled transportation can go very fast, maglev allows routine use of higher top speeds than conventional rail, and this type holds the speed record for rail transportation. Vacuum tube train systems might hypothetically allow maglev trains to attain speeds in a different order of magnitude, but no such tracks have ever been built.

II. DESCRIPTION

Magnet: The magnets used for this project is Neodymium Magnet(N52).It is a permanent magnet made from an alloy of neodymium, iron and boron. Neodymium magnets are the strongest type of permanent magnet commercially available. They have replaced other types of magnets in the many applications in modern products that require strong permanent magnets, such as motors in cordless tools, hard disk drives and magnetic fasteners. Strong magnet, N52 magnets is the choice of many designers. Due to its high flux or holding power, in relatively small magnets, N52 magnets are probably the best choice. N52 magnets grade is still a great choice for strong magnets. Very useful and reliable grade of neodymium magnet with stable magnetic characteristics. Therefore recommend for our customers and used for a few years. It'smaximum energy (Bh max) is usually over 400 KJ/m3 or 50-53 MGOe.

A neodymium magnet (also known as NdFeB, NIB or Neo magnet), the most widely used type of rare-earth magnet, is a permanent magnet made from an alloy of neodymium, iron and boron to form the Nd2Fe14B tetragonal crystalline structure. Developed in 1982 by General Motors and Sumitomo Special Metals, neodymium magnets are the strongest type of permanent magnet commercially available. They have replaced other types of magnets in the many applications in modern products that require strong permanent magnets, such as motors in cordless tools, hard disk drives and magnetic fasteners.

Neodymium is a metal which is ferromagnetic (more specifically it shows antiferromagnetic properties), meaning that like iron it can be magnetized to become a magnet, but its Curie temperature (the temperature above which its ferromagnetism disappears) is 19 K (−254 °C), so in pure form its magnetism only appears at extremely low temperatures. However, compounds of neodymium with transition metals such as iron can have Curie temperatures well above room temperature, and these are used to make neodymium magnets.

The strength of neodymium magnets is due to several factors. The tetragonal Nd2Fe14B crystal structure has exceptionally high uniaxial magnetocrystalline anisotropy (HA ~7 T – magnetic field strength H in units of A/m versus magnetic moment in A•m2). This means a crystal of the material preferentially magnetizes along a specific crystal axis, but is very difficult to magnetize in other directions. Like other magnets, the neodymium magnet alloy is composed of microcrystalline grains which are aligned in a powerful magnetic field during manufacture so their magnetic axes all point in the same direction. The resistance of the crystal lattice to turning its direction of magnetization gives the compound a very high coercivity, or resistance to being demagnetized.

The neodymium atom also can have a large magnetic dipole moment because it has 7 unpaired electrons in its electron structure as opposed to (on average) 3 in iron. In a magnet it is the unpaired electrons, aligned so they spin in the same direction, which generate the magnetic field. This gives the Nd2Fe14B compound a high saturation magnetization (Js ~1.6 T or 16 Kg) and typically 1.3 teslas. Therefore, as the maximum energy density is proportional to Js, this magnetic phase has the potential for storing large amounts of magnetic energy (BHmax ~ 512 kJ/m3 or 64 MG•Oe). This magnetic energy value is about 18 times greater than "ordinary" magnets by volume. This property is higher in NdFeB alloys than in samarium cobalt (SmCo) magnets, which were the first type of rare-earth magnet to be commercialized. In practice, the magnetic properties of neodymium magnets depend on the alloy composition, microstructure, and manufacturing technique employed.

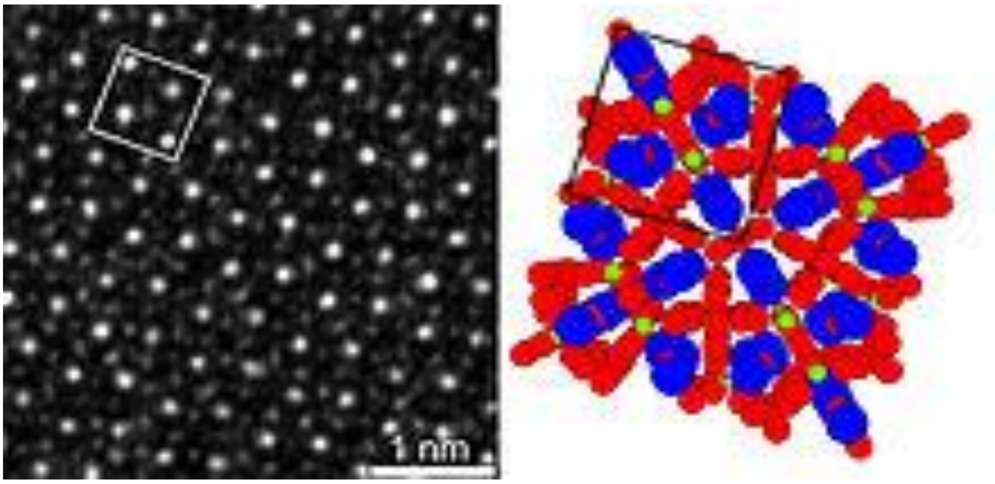

Fig.1 the Nd2Fe14B compound

III. GRADES

Neodymium magnets are graded according to their maximum energy product, which relates to the magnetic flux output per unit volume. Higher values indicate stronger magnets and range from N35 up to N52. Letters following the grade indicate maximum operating temperatures (often the Curie temperature), which range from M (up to 100 °C) to EH (200 °C).

Grades of Neodymium magnets

- N35-N52
- N33M-N48M
- N30H-N45H
- N30SH-N42SH
- N30UH-N35UH
- N28EH-N35EH

Magnetic properties

Some important properties used to compare permanent magnets are:

- Remanence (Br)

  Which measures the strength of the magnetic field.
- Coercivity (Hci)

  The material's resistance to becoming demagnetized.
- Energy product (BHmax)

  The density of magnetic energy.
- Curie temperature (TC)

  The temperature at which the material loses its magnetics.

IV. CORROSION PROBLEMS

Sintered Nd2Fe14B tends to be vulnerable to corrosion, especially along grain boundaries of a sintered magnet. This type of corrosion can cause serious deterioration, including crumbling of a magnet into a powder of small magnetic particles, or spalling of a surface layer. This vulnerability is addressed in many commercial products by adding a protective coating to prevent exposure to the atmosphere. Nickel plating or two-layered copper-nickel plating are the standard methods, although plating with other metals, or polymer and lacquer protective coatings are also in use.

Fig.2 These neodymium magnets corroded severely after 5 months of weather exposure

V. HAZARDS

The greater forces exerted by rare-earth magnets create hazards that may not occur with other types of magnet. Neodymium magnets larger than a few cubic centimeters are strong enough to cause injuries to body parts pinched between two magnets, or a magnet and a ferrous metal surface, even causing broken bones. Magnets that get too near each other can strike each other with enough force to chip and shatter the brittle material, and the flying chips can cause various injuries, especially eye injuries. There have even been cases where young children who have swallowed several magnets have had sections of the digestive tract pinched between two magnets, causing injury or death.[21] The stronger magnetic fields can be hazardous to mechanical and electronic devices, as they can erase magnetic media such as floppy disks and credit cards, and magnetize watches and the shadow masks of CRT type monitors at a greater distance than other types of magnet.

VI. APPLICATIONS

Existing magnet applications

Fig.3 Ring magnets

Fig.4 Most hard disk drives incorporate strong magnets

Fig.5 This manually-powered flashlight uses a neodymium magnet to generate electricity.

Neodymium magnets have replaced alnico and ferrite magnets in many of the myriad applications in modern technology where strong permanent magnets are required, because their greater strength allows the use of smaller, lighter magnets for a given application.

VII. CAD MODEL

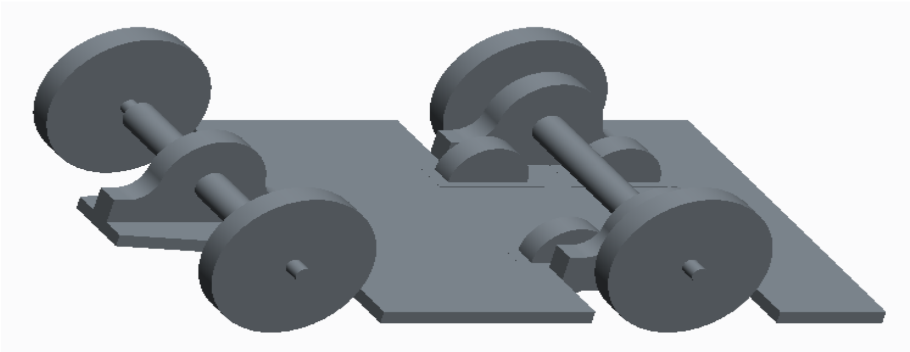

Fig.6 Prototype Design

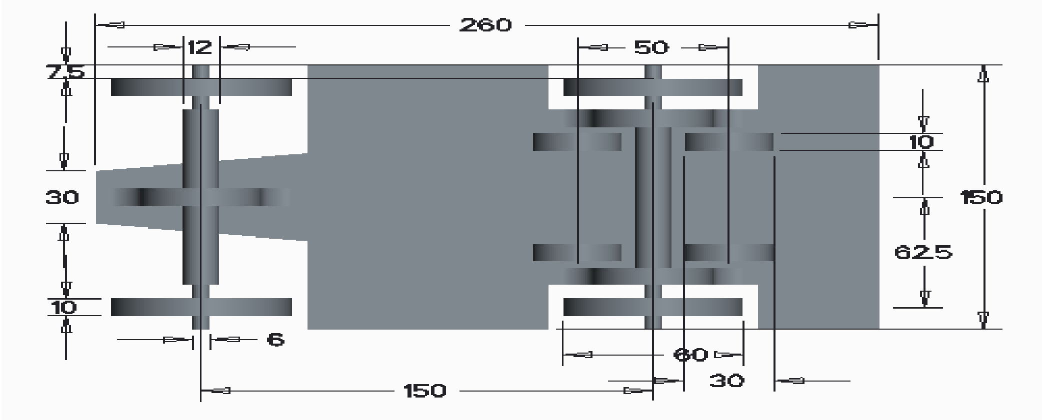

Fig.7 Prototype Dimensions

VIII. ANALYSIS

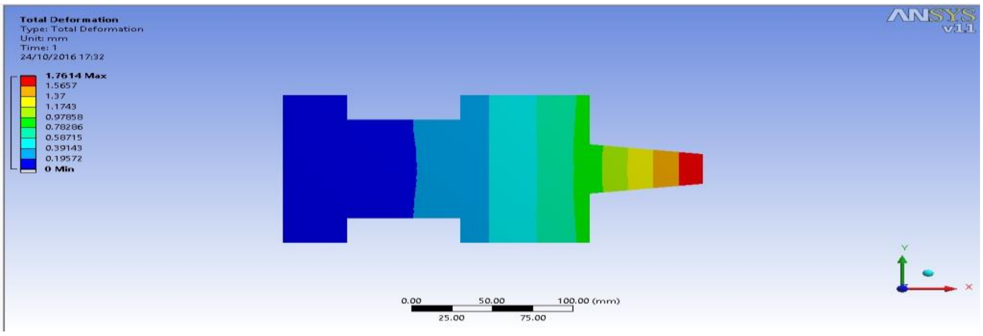

Fig.8 (I) FRONT IMPACT

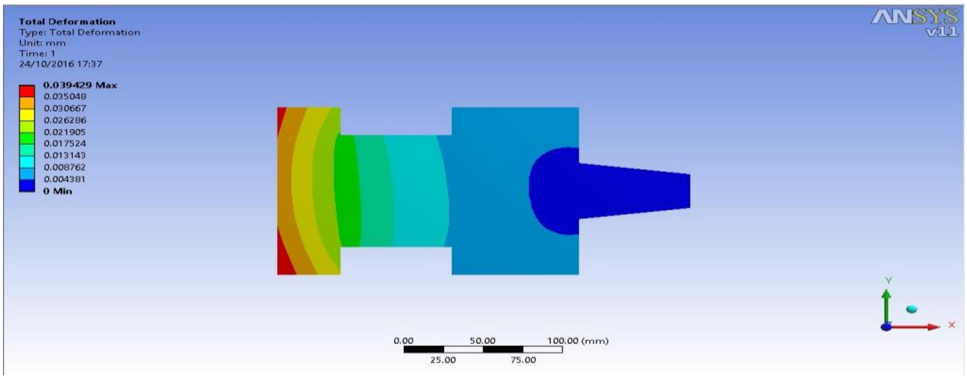

Fig.8 (ii) REAR IMPACT

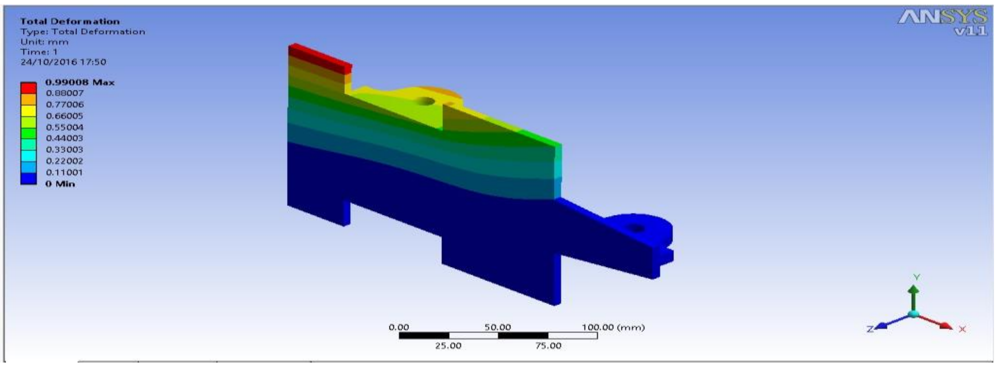

Fig.8 (iii) ***SIDE IMPACT***

IX. METHODOLOGY

In the vehicle there is no cylinder piston arrangement. The power produced due to combustion in cylinder is replaced by magnetic arrangement. This arrangement of magnets drives the power shaft. The power from rotating shaft is further transferred to wheel to produce torque and drive the vehicle wheels.

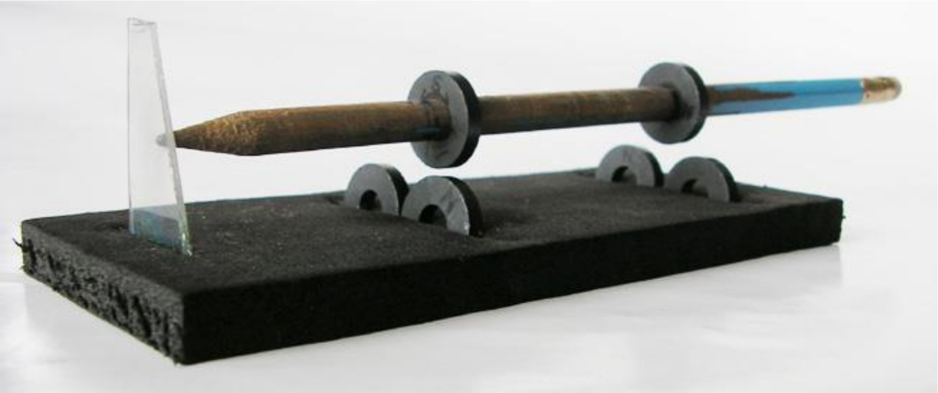

Fig. 9 Maglev Model

- Our Vehicle work on the principle of MAGLEV (Magnetic levitation).Through this principle we levitate the driven shaft of our vehicle
- Once the driven shaft is lifted we provide the torque to the driven shaft with the help of battery(by induced EMF) through this the driven shaft starts to rotate & required RPM can be achieved by induced EMF.
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- If two magnets are mechanically constrained along a single axis, for example, and arranged to repel each other strongly, this will act to levitate one of the magnets above the other. Another geometry is where the magnets are attracted, but constrained from touching by a tensile member, such as a string or cable.

Magnetic levitation, maglev, or magnetic suspension is a method by which an object is suspended with no support other than magnetic fields. Magnetic force is used to counteract the effects of the gravitational acceleration and any other acceleration. The two primary issues involved in magnetic levitation are lifting forces: providing an upward force sufficient to counteract gravity, and stability: ensuring that the system does not spontaneously slide or flip into a configuration where the lift is neutralized. Magnetic levitation is used for maglev trains, contactless melting, and magnetic bearings and for product display purposes.

Lift- Magnetic materials and systems are able to attract or press each other apart or together with a force dependent on the magnetic field and the area of the magnets. For example, the simplest example of lift would be a simple dipole magnet positioned in the magnetic fields of another dipole magnet, oriented with like poles facing each other, so that the force between magnets repels the two magnets. Essentially all types of magnets have been used to generate lift for magnetic levitation; permanent magnets, electromagnets, ferromagnetism, diamagnetism, superconducting magnets and magnetism due to induced currents in conductors. To calculate the amount of lift, a magnetic pressure can be defined.

For example, the magnetic pressure of a magnetic field on a superconductor can be calculated by:

$$\mathbf{P_{mag} = B^2/2\mu_0}$$

Where, $\mathbf{P_{mag}}$ is the force per unit area in Pascal's,

B is the magnetic field just above the superconductor in teslas, and

$\mu_0 = 4\pi\times10^{-7}$ N·A^{-2}is the permeability of the vacuum.

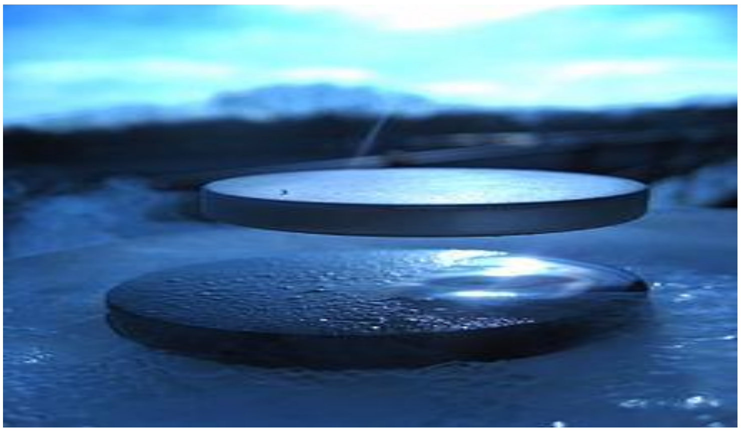

Fig.10 A superconductor levitating a permanent magnet

Stability- Earnshaw's theorem proves that using only paramagnetic materials (such as ferromagnetic iron) it is impossible for a static system to stably levitate against gravity. For example, the simplest example of lift with two simple dipole magnets repelling is highly unstable, since the top magnet can slide sideways, or flip over, and it turns out that no configuration of magnets can produce stability. However, servomechanisms, the use of diamagnetic materials, super conduction, or systems involving eddy currents allow stability to be achieved. In some cases the lifting force is provided by magnetic levitation, but stability is provided by a mechanical support bearing little load. This is termed *pseudo-levitation*.

1) Static stability-

Static stability means that any small displacement away from a stable equilibrium causes a net force to push it back to the equilibrium point. Earnshaw's theorem proved conclusively that it is not possible to levitate stably using only static, macroscopic, paramagnetic fields. The forces acting on any paramagnetic object in any combinations of gravitational, electrostatic, and magneto static fields will make the object's position, at best, unstable along at least one axis, and it can be unstable equilibrium along all axes. However, several possibilities exist to make levitation viable, for example, the use of electronic stabilization or diamagnetic materials (since relative magnetic permeability is less than one); it can be shown that diamagnetic materials are stable along at least one axis, and can be stable along all axes. Conductors can have a relative permeability to alternating magnetic fields of below one, so some configurations using simple AC driven electromagnets are self-stable.

2) Dynamic stability-

Dynamic stability occurs when the levitation system is able to damp out any vibration-like motion that may occur. Magnetic fields are conservative forces and therefore in principle have no built-in damping, and in practice many of the levitation schemes are under-damped and in some cases negatively damped. This can permit vibration modes to exist that can cause the item to leave the stable region.

Damping of motion is done in a number of ways:

- External mechanical damping (in the support), such as dashpots, air drag etc.
- Eddy current damping (conductive metal influenced by field).
- Tuned mass dampers in the levitated object.
- Electromagnets controlled by electronics.

Method- For successful levitation and control of all 6 axes (degrees of freedom; 3 translational and 3 rotational) a combination of permanent magnets and electromagnets or diamagnets or superconductors as well as attractive and repulsive fields can be used. From Earnshaw's theorem at least one stable axis must be present for the system to levitate successfully, but the other axes can be stabilized using ferromagnetism. The primary ones used in maglev trains are servo-stabilized electromagnetic suspension (EMS), electrodynamics suspension (EDS).

Mechanical constraint (pseudo-levitation)- With a small amount of mechanical constraint for stability, achieving pseudo-levitation is a relatively straightforward process. If two magnets are mechanically constrained along a single axis, for example, and arranged to repel each other strongly, this will act to levitate one of the magnets above the other. Another geometry is where the magnets are attracted, but constrained from touching by a tensile member, such as a string or cable. Another example is the Zippe-type centrifuge where a cylinder is suspended under an attractive magnet, and stabilized by a needle bearing from below.

Fig. An example of magnetic levitation with a mechanical support (wooden rod) providing stability.

Servomechanisms- The attraction from a fixed strength magnet decreases with increased distance, and increases at closer distances. This is unstable. For a stable system, the opposite is needed, variations from a stable position should push it back to the target position. Stable magnetic levitation can be achieved by measuring the position and speed of the object being levitated, and using a feedback loop which continuously adjusts one or more electromagnets to correct the object's motion, thus forming a servomechanism. Many systems use magnetic attraction pulling upwards against gravity for these kinds of systems as this gives some inherent lateral stability, but some use a combination of magnetic attraction and magnetic repulsion to push upwards.

Fig.12 The Trans rapid system uses servomechanisms to pull the train up from underneath the track and maintains a constant gap while travelling at high speed

Either system represents examples of Electro Magnetic Suspension (EMS). For a very simple example, some tabletop levitation demonstrations use this principle, and the object cuts a beam of light or Hall Effect sensor method is used to measure the position of the object. The electromagnet is above the object being levitated; the electromagnet is turned off whenever the object gets too close, and turned back on when it falls further away. Such a simple system is not very robust; far more effective control systems exist, but this illustrates the basic idea. EMS magnetic levitation trains are based on this kind of levitation: The train wraps around the track, and is pulled upwards from below. The servo controls keep it safely at a constant distance from the track.

Fig.13 Floating globe. Magnetic levitation with a feedback loop

Induced currents- These schemes work due to repulsion due to Lenz's law. When a conductor is presented with a time-varying magnetic field electrical currents in the conductor are set up which create a magnetic field that causes a repulsive effect. These kinds of systems typically show an inherent stability, although extra damping is sometimes required.

Relative motion between conductors and magnets - If one moves a base made of a very good electrical conductor such as copper, aluminium or silver close to a magnet, an (eddy) current will be induced in the conductor that will oppose the changes in the field and create an opposite field that will repel the magnet (Lenz's law). At a sufficiently high rate of movement, a suspended magnet will levitate on the metal, or vice versa with suspended metal. Litz wire made of wire thinner than the skin depth for the frequencies seen by the metal works much more efficiently than solid conductors. Figure 8 coils can be used to keep something aligned. An especially technologically interesting case of this comes when one uses a Halbach array instead of a single pole permanent magnet, as this almost doubles the field strength, which in turn almost doubles the strength of the eddy currents. The net effect is to more than triple the lift force. Using two opposed Halbach arrays increases the field even further. Halbach arrays are also well-suited to magnetic levitation and stabilisation of gyroscopes and electric motor and generator spindles.

Maglev transportation- Maglev, or magnetic levitation, is a system of transportation that suspends, guides and propels vehicles, predominantly trains, using magnetic levitation from a very large number of magnets for lift and propulsion. This method has the potential to be faster, quieter and smoother than wheeled mass transit systems. The technology has the potential to exceed 6,400 km/h (4,000 mi/h) if deployed in an evacuated tunnel. If not deployed in an evacuated tube the power needed for levitation is usually not a particularly large percentage and most of the power needed is used to overcome air drag, as with any other high speed train. Some maglev Hyper loop prototype vehicles are being developed as part of the Hyperloop pod competition in 2015–2016, and are expected to make initial test runs in an evacuated tube later in 2016.

The highest recorded speed of a maglev train is 603 kilometers per hour (374.69 mph), achieved in Japan on April 21, 2015, 28.2 km/h faster than the conventional TGV speed record.

Ironlev levitation- The ferromagnetic levitation technology comes from an application exploiting the principle of magnetic induction between materials with different permeability. The FLT allows vehicles to levitate in a stable and extremely safe way, without the need of electricity and with a cost that is lower than other magnetic levitation technology.

International Journal of Advanced Research in Science Management and Technology
ISSN(Online)-2454-4159 Volume 3, Issue 8, August 2017

CALCULATIONS:-

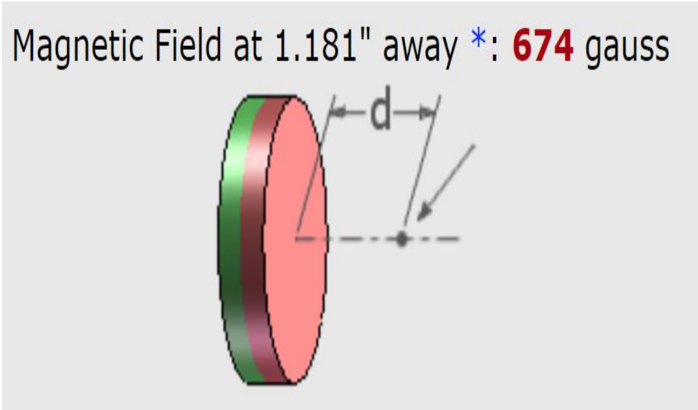

Fig.14 Magnetic Field

Case 1:- **Case 2:-** **Case 3 :-**

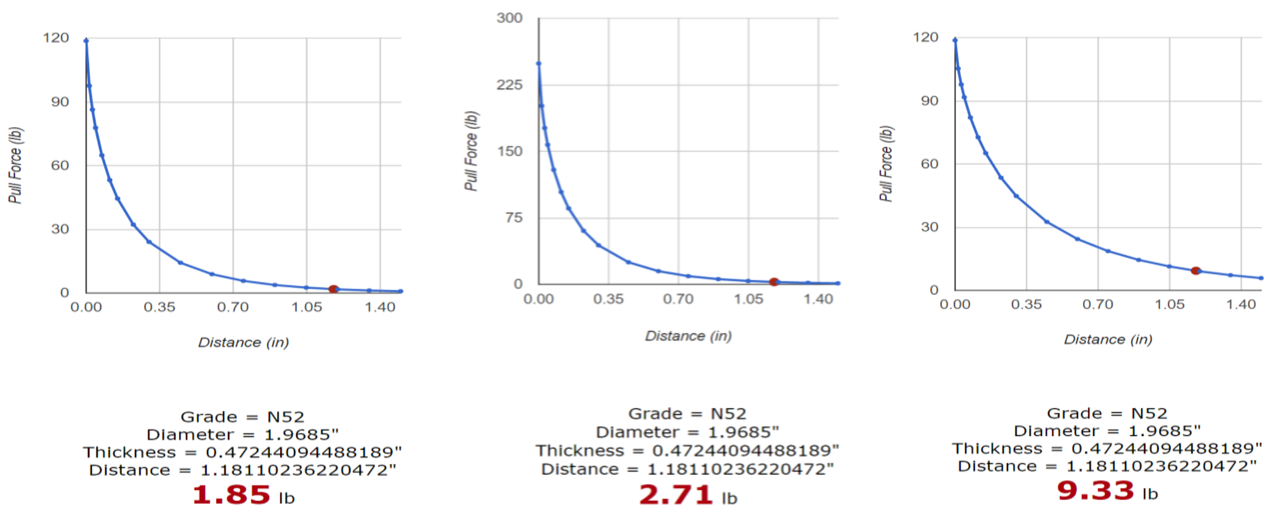

Fig.15 (i)(ii)(iii) Magnetic Pull Force

Formulas:-

A. For Disc cylinder Magnet

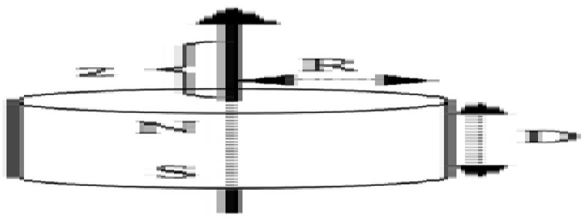

Fig.16 For Disc cylinder Magnet

$$B=\frac{B_r}{2}\left(\frac{D+z}{\sqrt{R^2+(D+z)^2}}-\frac{z}{\sqrt{R^2+z^2}}\right)$$

Where,

B_r=Remanence field, independent of the magnet's geometry

z = Distance from pole face on the symmetrical axis.

D = Thickness (or height) of the cylinder.

R = Radius of the cyclinder.

The unit of length can be arbitrarily, as long as it is the same for all lengths.

ISSN(Online)-2454-4159 Volume 3, Issue 8, August 2017

B. For Ring Magnet:-

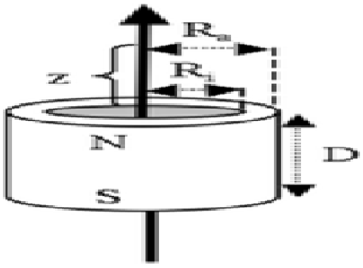

Fig.17 For Ring Magnet

$$B=\frac{B_r}{2}\left\{\frac{D+z}{\sqrt{R_a^2+(D+z^2)}}-\frac{z}{\sqrt{R_a^2+z^2}}-\left(\frac{D+z}{\sqrt{R_i^2+(D+z^2)}}-\frac{z}{\sqrt{R_i^2+z^2}}\right)\right\}$$

Where,

B_r=Remanence field, independent of the magnet's geometry

z = Distance from pole face on the symmetrical axis.

D = Thickness (or height) of the cylinder.

R_a = Outside Radius of the cylinder.

R_i = Inside Radius of the cylinder.

The unit of length can be arbitrarily, as long as it is the same for all lengths.

Grade:-

Neodymium Magnet (N52)

Diameter = 50mm

Thickness = 12mm

Magnetic field for 1 Magnet **= 3160.5 gauss = 0.31605 Tesla**

Magnetic field for 4 Magnet =**12642 gauss =1.2642 Tesla**

Future Scope & Reference:-

- **Magnetic driven vehicle Advantages:**
  - Zero pollution and eco-friendly.
  - Independency from refueling.
  - Zero fuel cost.
  - Less components makes design simple than IC engine.
  - Less maintenance.
  - Less costly.
- **Magnetic driven vehicle Disadvantages:**
  - Over a long time magnetic property decreases.
  - High temperature can also affect the magnetic property.
  - Pick up is one its major drawback.
- **Innovativeness & Usefulness:**

  The MDV is one of its unique kinds, based on the principle of conversion of magnetic energy into mechanical work.

Due to use of magnets there is no refuelling problem. So the future problem of fossil fuel can be overcome. Zero dependency on fuels. To overcome the problem of decreasing the magnetic property Neodymium Magnet.

- **Feasibility:**

This project can be easily designed and developed. All the resources needed is available to us, magnets are common to our use and is available as per our requirements so there is nothing to worry about fuel anymore. The design is very feasible because it is very similar designs are already gone practical like in toys. But with this design the magnets can also be put to do works on load also. The entire complex power generating component is replaced with this simple conceptual design of magnetic arrangement. This makes our concept for magnetic driven vehicle less complex and more reliable and can easily be manufactured.

- **Market Potential & Competitive advantage:**

Since fossil fuels (gasoline) are going to be extinguish in near years. Such an alternative can play a big role for the future of automobile. The increasing cost of gasoline is also major drawback for IC engine and great opportunity for magnetic driven vehicle. In a way we can say that MDV is future of automobile fulfilling all our requirements.

X. CONCLUSION

As per our complete research the decrease in magnetic property is one its main drawback in its mass production and commercial use and according to our study, it can be eliminated by using electromagnets, which use current from battery source to form magnetic field. Hence our project is feasible with practically applicable and very economic with no doubt of being eco-friendly. This makes the MDV with no flaws and can be used continuously.

- We were able to successfully demonstrate with our model the feasibility of Levitation as a “Powerful Source” to propel vehicles.
- Dimension of the magnets and vehicle should be accurate in order to get better results.

REFERENCES

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

[2] **Jayawant, B.V., Electromagnetic levitation and suspension techniques, Edward Arnold, London, 1981.**

[3] **Sinha, P.K., Electromagnetic suspension – Dynamics and control, Peter Peregrinus, London, 1987.**

[4] **Moon, F.C., Superconducting levitation – Applications to bearings and magnetic transportation, John Wiley&Sons, New York, 1994.**

[5] **Geim, A.K.; Simon, M.D.; Boamfa, M.I. &Hefflinger, L.O., Magnetic levitation at your fingertips, Nature, Vol.400, 1999, pp.323-324.**

[6] **Berry, M.V. &Geim, A.K., Of flying frogs and levitrons, Eur.J.Phys.18, 1997, pp.307-313.**

[7] **Hull, J.R., Superconducting bearings, Superconducting Science and Technology 13, 2000, pp. R1-R15.**

[8] **Earnshaw, S., On the nature of the molecular forces which regulate the constitution of the luminferous ether., Trans.Camb.Phil.Soc.,7, 1842, pp 97-112.**

[9] **Genta, G.; Delprete, C. &Rondano, D., Gyroscopic Stabilization of Passive Magnetic Levitation, Meccanica 34, Kluwer Academic Publ., 1999, p.411-424 28.**

[10] **Lang, M. &Lembke, T.A., Design of permanent magnet bearing with high stiffness, ISMB-10, Martigny, Switzerland, 2006, pp.221-224.**

[11] **Budell, R. & Bus, W., Transrapid Maglev projects in the U.S.A., MAGLEV’2006 - 19th International Conference on Magnetically Levitated Systems and Linear Drives, Dresden, Germany, 2006.**

[12] **Neumann, B.Utilisation of the TRANSRAPID in Europe, MAGLEV’2006 - 19th International Conference on Magnetically Levitated Systems and Linear Drives, Dresden, Germany, 2006.**

[13] **Adaptive robust nonlinear control of a magnetic levitation system Zi-Jiang Yang*, MichitakaTateishi 29th January, 2001.**

[14] **venusproject.org/new-energy/magnetic-levitation-or-maglev-propulsion.html.**