Multidisciplinary Applied Research and Innovation Vol. 4 No. 3 (2023) 237-243

MARI

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN :2773-4773

Hyperloop Locomotive

Amri A. N.*, Shamri S. N. I., Nasir S. N., Mantari M. H. A. R.

Department of Mechanical Engineering, Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub,
84600 Pagoh, Johor, MALAYSIA

DOI: https://doi.org/10.30880/mari.2023.04.03.033
Received 01 March 2023; Accepted 01 May 2023; Available online 30 June 2023

Abstract : The Hyperloop system works with magnets and electricity that produce Eddy currents. An Eddy current is a loop of electric current induced in a conductor by a changing magnetic field in the conductor according to Faraday's law of induction or by the relative motion of the conductor in the magnetic field. This project aims to study and prove the working principle of the hyperloop by using easily obtained materials to be used as a construction model, which can then be used for display and knowledge transfer. The method used to create the locomotive body/case uses high-tech 3D printing. In contrast, the hyperloop mechanism uses 18650 lithium-ion batteries, neodymium magnets, and natural copper coils that produce Eddy currents and obey Faraday's Law. At the end of the study, the results showed that the hyperloop used Eddy currents as a working mechanism. The construction model successfully ran smoothly and quickly through various tests. Tests are conducted to study the effect of battery power, the number of magnets, battery type, and the load lifted on the speed of the hyperloop locomotive. Construction ideas the proposed hyperloop model has been designed in a 3D model and produced using a 3D printer to evaluate its functions and capabilities. Several model repair actions were discussed and improved; In short, the hyperloop locomotive has been successfully built and validated through proof-of-concept testing.

Keywords: High Speed, Hyperloop, Magnetic Levitation, Magnetic Transfer, Transportation

1. Introduction

The main goal is to empower the rail transport system in Malaysia by implementing knowledge transfer to raise awareness and foster the idea of hyperloop technology so that it can be used in Malaysia, which will eventually replace conventional trains that still use non-renewable energy sources[1]. The study's scope is to successfully create a hyperloop train design using 3D printing technology and prove the working principle of hyperloop technology. Upon completion of the hyperloop project, the students should be able to provide many benefits of the hyperloop technology to Universiti Tun Hussein Onn Malaysia and the community. The community will receive knowledge of hyperloop technology and its various benefits that can be upgraded and applied to Malaysia's transportation system.

*Corresponding author: aa200197@student.uthm.edu.my

Hyperloop technology should be the top topic until it reaches the Malaysian government and may be considered the next government plan for the Malaysian transportation system[2] For example, countries such as Japan and Germany have stepped up because their perceptions of technology are very high [3]. So, MEC 10 group will continue to improve its efforts to succeed in sharing knowledge with the community.

While using a similar concept to the train, the hyperloop is more sophisticated, where users travel in pods or locomotives [4]. These locomotives will travel a specific route that originates in a closed tube. This technology is more energy-efficient, quieter, and faster than any other transportation currently in use. Hyperloop technology vehicles can travel at speeds equal to or faster than the speed of sound. The hyperloop is propelled by two electromagnetic motors connected in series [5].

This project is implemented to increase the awareness of the people of Malaysia by introducing the latest rail transportation technology, namely hyperloop technology, which indirectly increases knowledge about magnetism, which is the mainstay of the working principle of hyperloop [6]. This project's scope is to compare conventional rail transportation to hyperloop transportation technology at a laboratory scale.

2. Materials and Methods

2.1 The list of materials

Table 1: List of materials used and their functions

No. Item	Material	Function
1	3D Printer Filament	To create a Locomotive HyperloopBody
2	Neodymium Magnet	When attached to a battery, to form electrical and magnetic force interactions
3	Lithium-ion 18650 Battery	Providing an electric current togenerate a magnetic field

Many materials and machines have been studied and selected to construct the prototype model for constructing the lab-scale hyperloop. The following materials are in **Table 1.**

As the weight of the 3D printing model can affect the hyperloop model's speed, a material with a low relative density or specific gravity is chosen because it is light for the hyperloop locomotive case so that the hyperloop can move at high speed based on the project. Information was examined and received from the research, as shown in **Table 1**. The primary materials used are lithium-ion batteries 18650 and magnetic because this material has properties that match the factors and principles of hyperloop technology which is a derivative of the magnetic field. This project also uses 3D printing filament (ABS) because it is a strong and sturdy material to create the body. ABS types have superior printing quality, mechanical strength, and heat resistance (Refer **Figure 1**)[7].

2.2 3D Machine Process

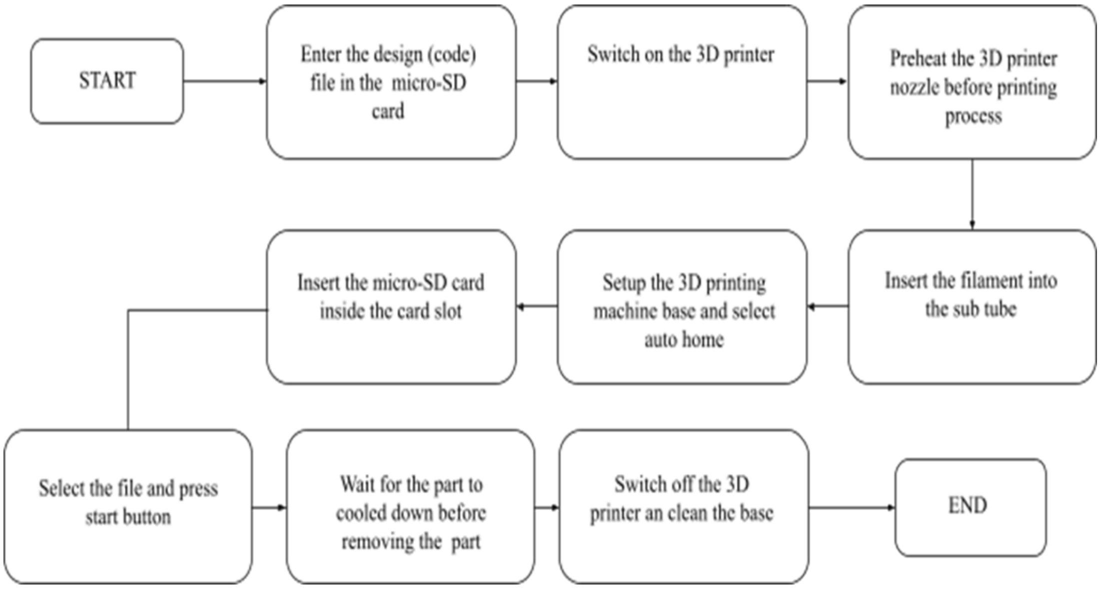

Figure 1: 3D Printer machine process flow chart

2.3 Method

In this project, Computer Aided Software (CAD) constructed 3D models, which were then used to manufacture the hyperloop locomotive using a 3D printing machine. Furthermore, this project has a magnet, battery, hyperloop locomotive body, and carriages.

Figure 2 shows an exploded image of the project. This project consists of eight separate elements in this product that collaborate. The figure also depicts all parts that are connected utilising CAD software. Magnets and batteries are the primary components; this project employs four magnets and one battery. In addition, the battery and magnet will be attached to the hyperloop locomotive body. Finally, the carriage will attach to the hyperloop locomotive.

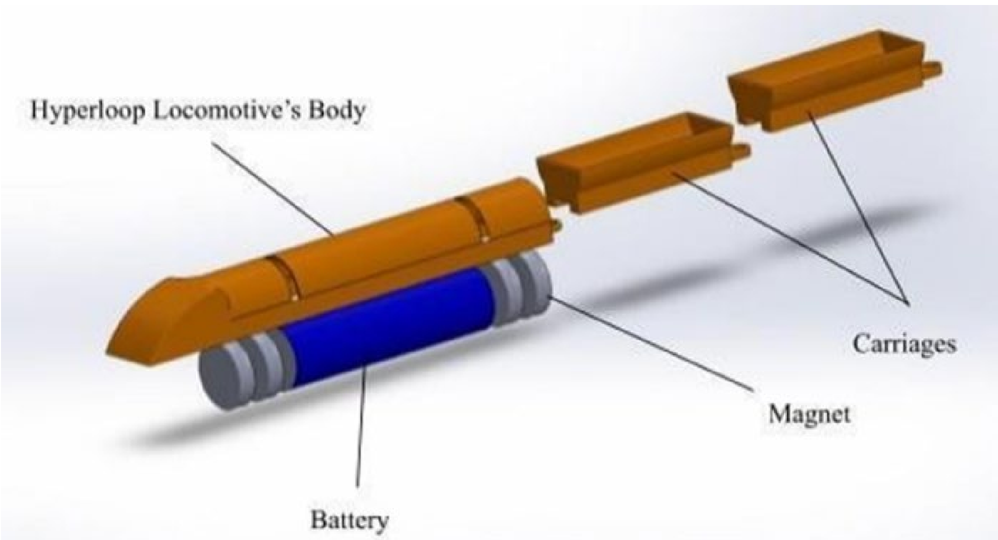

Figure 2: Exploded view of hyperloop locomotive model

i. Magnet

The magnets are chosen as the most powerful permanent magnets are neodymium magnets.

Neodymium magnets are often called NdFeB magnets, NIB magnets, or Neo magnets. They have supplanted a variety of different types of magnets in modern applications. Because it can handle the weight of the load necessary to power a hyperloop train, this magnet is ideal for hyperloop models.

ii. Battery

As the power source for hyperloop locomotives, 3.7 V Lithium-ion rechargeable batteries are utilised to generate alternating current, which is then sent through coils of wire to create a magnetic field. The force produced between the magnetic fields will result in a thrust force being applied to the design. The fact that it is lighter than a conventional alkaline battery was also a consideration, as the weight of the battery will impact the train's speed.

iii. Hyperloop locomotive Body

The body of the hyperloop locomotive serves as a case for batteries and magnets. Furthermore, the body form is meant to be aerodynamic to make it easier for the hyperloop totravel. This body is created using a 3D printing machine. Because the filament used in 3D printing is a polymer, the resulting body is sturdy and lasting.

iv. Carriage

This carriage determined the load weight the locomotive hyperloop could carry. This carriage uses the same process as the locomotive hyperloop body, a 3D printing machine.

3. Results and Discussion

3.1 Power Battery Affect Speed

The locomotive hyperloop had made several tests to measure the velocity of the hyperloop prototype by calculating velocity, time and displacement formula. **Table 2** shows the results of velocity between high-charge and low-charge batteries.

The displacement of an object is related to its velocity, acceleration, and time by equations of motion. An object's motion can take a variety of paths. In this experiment, the equation used to determine the speed or velocity of the hyperloop locomotive is the first equation of motion. Equations of motion that can be used to derive components such as displacement(s), velocity (initial and final), time(t) and acceleration(a).

The first equation of motion:

$$V = \frac{d}{t} \qquad \textbf{Eq. 1}$$

Whereas,

V = speed, d = distance travel, t = time

The results of the study in **Table 2**:

Table 2: Full charge battery and low charge battery

Battery Power	Charge (A)	Travel Distance (m)	Time Required for a Travel Distance of 0.6 m (s)			Average Travel Time (s)	Velocity (cm/s) V = d/t
High Charge	11.31	60	1.22	1.61	1.04	1.29	46.51
Low Charge	5.65	60	2.34	2.57	2.91	2.94	20.40

According to project findings, the voltage drop of the battery is minimum. Unfortunately, the currents drop by almost half. Magnetic force is precisely proportional to current. The electrical current that flows through the copper coils determines the strength of an electromagnet, not what causes that current to flow. The amount of charge that flows through the wires per unit of time is known as the current. After taking the test 3 times, for a fully charged battery, the time taken to move faster was an average of 1.29 s, while for a low charged battery, the time taken was longer, an average of 2.94 s. The more the battery current, the greater the speed. This is demonstrated by the fact that the velocity obtained from higher battery power is 46.51 cm/s while the velocity gained from lesser battery power is 20.40 cm/s.

3.2 Number of magnets affects speed

Another test was carried out under two conditions to determine whether the amount of magnets affects the current flowing. One is when one magnet is on each battery side, and two are on each. Observations have been made in **Table 3**.

Table 3: Lithium-ion battery with one and two magnets on each side

Number of Magnets on Each Side	Charge (A)	Travel Distance (m)	Time Required for a Travel Distance of 0.6 m (s)			Average Travel Time (s)	Velocity (cm/s)
1 magnet	11.31	60	4.20	4.69	4.52	4.47	13.42
1 magnet	5.65	60	6.63	6.25	5.59	6.16	9.74
2 magnets	11.31	60	1.22	1.61	1.04	1.29	46.51
2 magnets	5.65	60	2.34	2.57	2.91	2.94	20.40

For the session, the time required for one magnet on each side took a long time to travel. The average for the three tests was about 4.47 s for a full charge and 6.16 s for a half charge. Next, the velocity was also very slow, with 13.42 cm/s for a full charge and 9.74 cm/s for a half charge. Furthermore, there was more improvement for two magnets than for one magnet. The average of one magnet for three tests was only 1.29 s and 2.94 s for a full charge and half charge, and the velocity was 46.51 cm/s and 20.40 cm/s for a full charge and half charge. The current on the two magnets may affect the battery, which can make more than one magnet.

3.3 Varies in Load

Two train cars were added to carry a variety of materials. Stone signifies hefty objects among the items carried, whereas paper denotes light items. Before beginning the experiment, the battery charge was assured to be fully charged, the same sort of battery, a blue lithium-ion battery (18650) shown in **Table 4**.

Table 4: The carriages full of paper and stone

Varies in Load	Charge (A)	Travel Distance (m)	Time Required for a Travel Distance of 0.6 m (s)			Average Travel Time (s)	Velocity (cm/s)
Stone	11.31	60	1.29	3.15	1.38	1.87	32.08
Paper	11.31	60	1.29	1.77	1.37	1.47	40.81

Based on the analysis and calculation in **Table 4**, the train carriage that carried the stones was moving slowly due to the load being carried. However, it still runs smoothly on the track despite being heavy to carry. Adding stone to the model adds up the mass of the hyperloop prototype while the battery power and magnetic force that moves the train stay the same. The velocity of a load of stone was about 32.08 cm/s. Next, the train carriage moved faster than carriages full of stone because the load was light and running smoothly. The average travel time was 1.47s, and the velocity was 40.81 cm/s. All the gear that train carriages brought stayed in the carriages even without lids.

3.4 Sustainable

This hyperloop is a form of transportation that does not rely on fuel, such as coal, but instead on electromagnetic fields. This demonstrates the hyperloop's capability to reduce carbon dioxide (CO2) into the atmosphere, creating the greenhouse effect. Furthermore, the hyperloop does not cause noise pollution due to using electromagnetic ideas. This hyperloop can be employed as part of a technology that is not harmful to human health and the environment [9].

3.5 Cost Implementation

Table 5: Data obtained from cost implementation.

Material	Quantity (m / g /unit / hour)	Price
Neodymium Magnet	4 units	RM 13.73
Lithium-Ion Battery18650	2 units	RM 4.00
Copper Coil	0.2 m	RM 3.09
Percentage Cost of 3DPrinting	1 hours 13 minutes	RM 1.20
Filament	0.84 g	RM 4.70
	TOTAL	RM 26.72

This was the cost implementation doing hyperloop locomotive marketing. **Table 5** filled all the inventory and prices that marketing needed while creating the model for one model.

As mentioned above, the cost used is meagre and affordable. For information, the 3D printer has as much as 150 watts during the period it is used, equivalent to the total electricity consumption of 5.49 kWh in a month. [10] After being research the cost implementation, this model can be sold at RM 30 a set because the buyer can feel the uniqueness of the price given, and the possible price in the market is much different from this price.

4. Conclusion

To educate and inform UTHM students about hyperloop technology, this project has successfully created a hyperloop locomotive. The construction process is smooth, as seen by the hyperloop train's inability to move in a loop. Magnetic and electric currents can only be created when the Hyperloop contacts the copper coil. The manufacturing process is repeated numerous times to produce an excellent model that can move due to the strong walls of the hyperloop locomotive and the fact that the magnet does not touch the loop. This hyperloop train was made with the aid of a 3D printer. The knowledge of the principles and ideas employed in building this hyperloop has been improved as a result of the development of this project. During the project's fabrication, team spirit and the desire to learn new things also start to build. Knowledge about running a 3D printing machine is also created to be understood appropriately and acquire more time to be more skillful. The future generation will be able to transform this existing concept into a fresh, more original idea to address the project's shortcomings and enable the development and widespread application of hyperloop technology.

Acknowledgement

The authors would like to thank the Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, for its support and guidance in accomplishing the product.

References

[1] Mohit Bansal and Pravin Kumar, "A Review on Hyperloop Transportation System", International Journal of Trend in Scientific Research and Development (IJTSRD)., vol 3, no 3, Mar-Apr 2019.

[2] Rajshri Tukaram Shinde, Vaishnavi Balasaheb Raijade, Abhishek Sunil Lahare and Vijay B. Sarode, "Hyperloop Transportation System", International Research Journal of Engineering and Technology (IRJET)., vol: 4, no 4, Apr 2017.

[3] Pankaj Singh Rathore and Prof. Sabjiv Kumar, "Hyperloop Transportation System", International Research Journal of Engineering and Technology (IJERT)., vol 6, no 17, Jan 5, 2019.

[4] "Apa itu Hyperloop?" (2022). Retrieved 27 July 2022, [Online], Available: https://ms.history-hub.com/apa-itu-hyperloop

[5] "Ender-3 Pro 3D Printer." (2022). Retrieved 24 July 2022, [Online], Available: https://www.creality.com/products/ender-3-pro-3d-printer

[6] "The future of Malaysia's rail industry." (2022). Retrieved 24 July 2022, [Online], Available: https://www.mida.gov.my/mida-news/the-future-of-malaysias-rail-industry/

[7] Discover Capgemini Engineering: Leader in engineering and R&D. (2022). Retrieved 27 July 2022, [Online], Available: https://capgemini-engineering.com/uk/en/

[8] Media, K. (2017). Mengenal Kereta Hyperloop, Bagaimana Bisa Bergerak Setara Kecepatan Suara? Halaman all - Kompas.com. Retrieved 10 March 2017, [Online],Available: https://sains.kompas.com/read/2017/03/10/13165641/mengenal.kereta.hyperloop.baga%20i%20mana.bisa.bergerak.setara.kecepatan.suara.?page=all

[9] "How Will Hyperloop Systems Affect Society and Transport?" (2018) Global Railway Review, Retrieved 19 December 2018, [Online], Available: https://www.globalrailwayreview.com/article/76047/hyperloop-systems-society-transpor t/

[10] Nisya Aziz, "Bil Elektrik Mahal? Jom Kira Kos Penggunaan Elektrik Rumah Korang." (2020) Retrieved 23 July 2020, [Online], Available: https://loanstreet.com.my/ms/pusat-pembelajaran/cara-pengiraan-kos-penggunaan-elektr ik-rumah