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Conceptual Design of a Ramp Type Escalator Utilizing Magnetic Levitation Concept

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Abstract

Objectives: The objective of this research work is a prototype design of a new ramp type escalator utilizing the magnetic levitation technology for smooth, fastest and balanced traveling. **Methods:** The structure of this proposed escalator is modified so as to function as a ramp surface. The traditional electrical and electromechanical escalators are replaced by the high-temperature superconducting coils and magnetic bearings. This research work proposes a methodology expected that the method may be a utility system for the future days. The Electrodynamic Suspension (EDS) system has been utilized in the ramp escalator. **Findings:** The proposed prototype design of maglev ramp type escalator system is totally different from today's escalators system in the context of its design, structure, technology and operation though its objectives are same. This proposed escalator has been found in animation to better speed with greater passenger safety along with the ease and comfort of passengers during traveling. Analyzing and comparing the various characteristic of the present escalator, the proposed escalator adapting the principle of magnetic levitation technology with high-temperature type II superconductor found the better result in the context of low maintenance cost, fewer staffs for maintenance and in saving the time. There will be no interruption in traveling for a sudden power loss for a certain period of time; the system will work properly due to the superconducting phenomena the current will flow indefinitely in the ramp escalator system. **Novelty /Improvement:** The proposed prototype design of a ramp type escalator utilizing magnetic levitation technology with the EDS system is a novel concept.

Keywords: Animation, Escalator, Levitation, Magnetic, Superconductor

1. Introduction

Escalators are frequently used in building in place of stationary staircase structures to go to the upper floors of any multi-storied building. It is used widely as a substitute for electric lift system and high-rise buildings lifts[1]. There is a certain risk in the escalator as the staircases are continuously opening and folding back, and there is a chance of entanglement of shoes, part of dresses or feet's. Despite the significant technical advancement sometimes complain arise regarding slow moment rate of the escalator especially in the high rise sky skipper building. Breakings down escalators were likewise a reason for death or wounds. A large number of wounds including catching the hands and feet of kids and the catching of garments of grown-ups at the base or top of escalators and in the hole between moving stairs and sidewalls bring up the issue of whether escalators are balanced or composed appropriately[2].

All those problems of recent escalators in the context of safety, speed, and time saving may be circumvented by using the technology of magnetic levitation[3] in the proposed ramp escalator. In the present study, the materials of the escalator steps have been replaced by the magnetic materials and the balustrade. Two electromagnetic tracks made of electromagnets pair is

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proposed between the ramp escalator and side walls. The electromagnets quickly switch polarity and make the ramp escalator pushed towards the left and because of the symmetry of the circumstance; the ramp escalator will be pushed towards the right. In this way the extremity of the electromagnets switches and the ramp escalator pivot continuously. Here, the base guideway magnets make the escalator suspend it. The balustrade of the escalator is kept unchanged. Already many research works has been carried out in the field of the escalator and magnetic levitation. In the present study of the maglev escalator with high-temperature superconducting materials are applied to run the escalator system. The materials of the step have to be magnetic in nature and magnetic fields are created between the side walls. In the same way in the case of the maglev train[4]. The superconducting materials are fixed in the body of the ramp escalator system. The magnetic field lines are closed through this will and the step materials. The proposed escalator body components are made of the type II superconductor[5] with the cryogenic system[6] and another necessary component like steel, iron, etc. The speed of the rotation of the ramp type escalator depends on the magnitude of current. In the proposed work, as shown in the computer three-Dimensional (3D) modeling and animation the rotation speed of the ramp type escalator and screws plates are confined within the human ability e.g. with 150 km/hour for minimum ten passengers. The starting and finishing point of the escalator system will be fitted with the array of pressure gauge which will create some current under pressure, and this connects the current path momentarily, and this will enable the passengers for the safe landing to the destinations. The system will restart after the departure of the passenger on the floor as the pressure gauge is deactivated. The step and skirt plate concept can easily be replaced by step less smooth ramp with a slope of not more than 30 degrees of accessory system. The angel 30 degree[7] is found would yield human safety. In this case, the magnetic bearing system may be used as the ramp would run smoothly. Proposed escalator framework considers that escalators might work at places that are safe for the elderly user. Allow enough space on escalators with the goal that individuals have the opportunity to walk. No such study as a proposed in any published or online literature. A conceptual 3D computer design and animated overview of the ramp type escalator system is shown by one of the industries leading animation and 3D modeling software Autodesk Maya[8].

2. Proposed Ramp Escalator Design, Components and Operation

Figure 1 shows a side view of ramp type escalator utilizing the technology of magnetic levitation (maglev). There are many components in this maglev ramp escalator. Its shows various components like handrail that gives an advantageous handheld to travelers while they are riding the escalator, magnetic bearings to help rotate the ramp structure maglev escalator freely. Magnetic track with air gap approximately 6 cm for ramp escalator levitation, the ground slope for passengers over which they will walk to the escalator, there are stand attached to the ground to take a load of the complete system whenever needed. The maglev ramp escalator body can freely rotate by the force created by the guideway magnets. The magnetic bearings are used to smoothly rotate the ramp escalator. Type II superconductor magnets are employed in the escalator body.

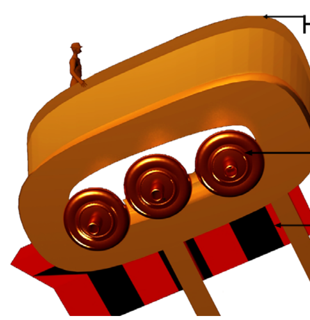

Figure 1. Side view of the maglev escalator.

The Electrodynamic Suspension (EDS) levitation[9] innovation utilizes repulsive force for the levitation. When the magnets joined on board push ahead on the inducing coils of the guideway, the induced currents flow through the coils and create the high magnetic field. When it experience repulsive magnetic force, it can levitate ramp escalator for 4-6 inches. Then the attraction and repulsion force from both side are applied to the maglev ramp escalator body and by the principle of magnetic levitation, it starts to rotate. Unlike the maglev train, it rotates in the same position with the help of magnetic bearings.

The superconductive magnetic bearing supports the ramp escalator components and accelerates the whole operation. These superconductive bearings are attached to the long pipes and employed with the pipes to rotate it smoothly. To make a balance sensor and controller are proposed to use in the ramp escalator.

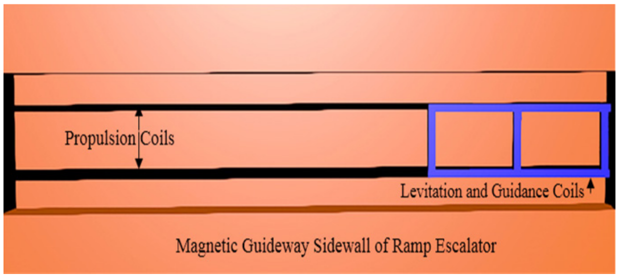

Figure 2. Coils utilized in ramp escalator.

Levitation guidance coils are utilized by interfacing the relating levitation coils on the magnetic track, and propulsion guidance coils are used on the left, and right sides of the both sidewalls are shown in Figure 2 of ramp escalator system.

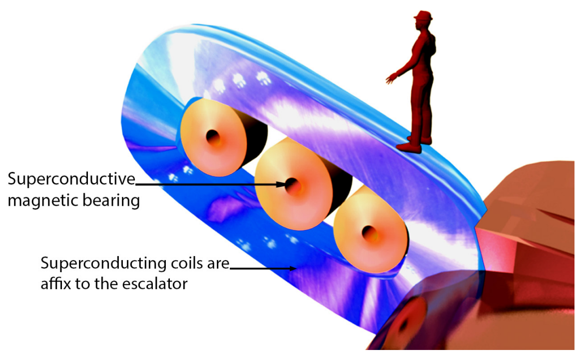

Figure 3. Ramp escalator made up with a superconducting material and superconductive magnetic bearing.

Superconducting coils are used in the ramp escalator system like Maglev train technologies is shown in Figure 3. Its shows the maglev escalator body. It is made up of type II superconductor and other light weight material such that it needs low magnetic force to rotate its self. The type II superconductors are proposed to be used here because it has much higher basic magnetic fields than type I superconductors[10].

Two magnets repulse one another, and inverse shafts draw in one another. These standards administer the levitation and rotation of ramp escalator by the magnetic levitation innovation. The poles of the north and south poles of an electromagnet are changed when the direction of the current is switched. The escalator functions through the generated attraction and repulsion force. When the pole of magnets is same, a repulsive force is generated and when the poles of magnets are opposites of each other attractive force is generated.

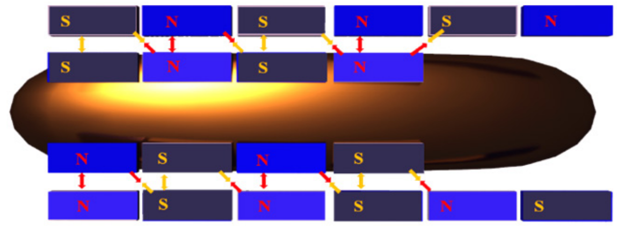

Figure 4. The Electrodynamic System (EDS) process of propulsion.

Figure 4 shows the relation between superconducting magnets and electromagnets in the ramp escalator system. The superconductor affix in the maglev ramp escalator body.

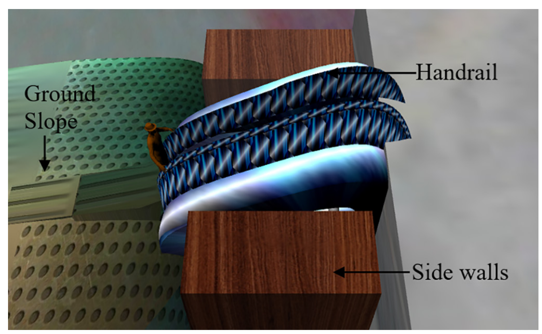

Figure 5. Ramp type escalator different components.

Figure 5 shows the ramp type escalator different components like ground slope, side walls made of woods and its movable such that it can shift another place to repair any components of the escalator. Handrail intended to be gotten a handle on by the hand to give security or support.

Sensor and controllers are also employed for vehicle stability, smooth operation and balancing like maglev train principles. The ramp escalator system is proposed to have batteries with battery recharging system. Electric power supply from the ground side is necessary for levitation, propulsion and attraction force. The transfer of energy all along the track involves the use of a linear motor on the operation speed like the Maglev train technologies.

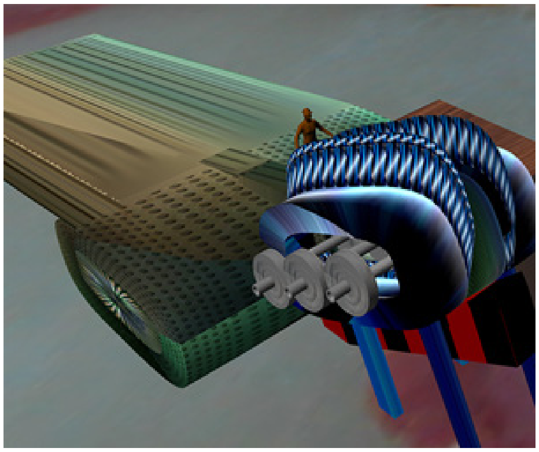

Figure 6. Maglev Escalator levitation guideway magnet and other parts.

Figure 6 shows the magnetic guideway system, the electromagnetic track made of pairs of electromagnets, stands to hold the magnetic guideway system which is attached to the grounds and the view of side wall where the long pipes are attached to the system to rotate the system smoothly. The electromagnetic tracks are build of pairs of electromagnets. These pair of electromagnets repel and attract the superconducting magnets of the ramp type escalators. By the attraction and repulsive force the ramp escalator rotates with the help of magnetic bearings. To levitate the maglev escalator body pair of electro-permanent magnets are proposed in the magnetic guideway track. Type II high-temperature superconducting magnets are proposed to use in the ramp escalator for the extremely high magnetic field. There is a standard air gap between the escalator body and magnetic track on which the escalator levitate. As previously said, type II superconducting electromagnets are employed in the ramp type escalator for the electrodynamic suspension system. Superconducting coils are used to construct superconducting magnets. Which generate the cryogenic temperature below 150 kelvins and this cryogenic temperature eliminate the electrical resistivity of superconducting materials for a certain period of time.

Figure 7 shows the superconductive magnetic bearing pipes and supporting gears attached to the pipes to help the escalator rotate smoothly and safely. The magnetic bearing is made of strong permanent magnet. It is easily replaceable. These magnets are attached to the body of ramp type escalator. It helps the escalator to rotate freely, taking the body mass of the escalator and to keep it in a safety mode where all the magnetic bearings and associated pipes play an important role in the whole system. In the maglev system, the risk factor is less compared to another similar system. Superconductor works for a certain longer period of time without any power[12]. Still for any emergency requirement if the system needs to stop suddenly and superconductivity is lost then with the proposed system this kind of risk can be avoided. When this condition arises, ramp escalator body will remain in the balance due to the use of auxiliary magnetic bearings and long pipes which will take the overall load of the passengers. These pipes are attached to the ground walls. One pipe with smaller diameter connected with the main pipe is isolated with the latter to produce more feasibility and ease of rotation of the pipe fitted because the bearings.There is little sub-pipe attached with the long pipes which work with general gearing mechanism.

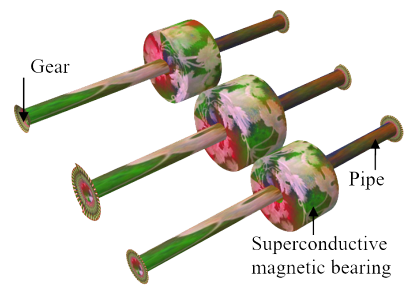

Figure 7. Ramp escalator supporting bearings and pipes.

3. Discussion

3.1 Assumption of Total Repulsive Force is Need to Rotate the Escalator.

Figure 8 shows the force calculation of proposed ramp type escalator.

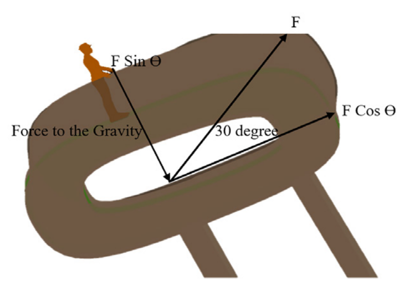

Figure 8. Force calculation of proposed ramp type escalator.

Guesstimate solution of total force calculation in ramp type magnetic levitation escalator is done in following steps.

Here F sin theta will balance the total downward weight arisen due to the passenger weight and F cos theta will push the system in the horizontal directions.

Considering, Mg = 700 Kg = 688 Newton, F sin theta = 688 Newton, F= 688/ Sin theta = 688/0.5= 1376 newton.

F= i*dl * B (1)

Here B will be created by different current intensity.

L = 1 meter, F = 1376 newton

B= 8 tesla

Current passing through superconducting coil = i= 1376/8*1 = 172 amperes.

Current required for the magnetic induction will depend on the number of turn in the wire per unit length, diameter, resistance and permeability of the ferromagnetic substance. Here the resistance is finite and current is limited.

3.2 The Angle of Escalator

The angle of the escalator is considering 30 degrees for the high comfort of passengers as mentioned earlier. But the angle of 30 degrees in an escalator is not a fixed one. However, it depends on the friction force between passenger shoes and escalator plane. The escalator force depends on the angle between the forces.

3.3 Maximum Load

An escalator can carry more than 700 kg, but there is a risk for this. If any system exceeds this load, then the current intensity of the superconducting magnet need to be increased. The current passing through superconducting coils is extremely high amperes. A movement sensor may be joined at either end to the direct speed of ramp escalator by superconducting magnets.

3.4 Critical Magnetic Field and Critical Current

The relationship gives the critical magnetic field at any temperature below the critical temperature:

$$B_c = B_c(0)\left[1-\left(\frac{T^2}{T_c}\right)\right] \quad (2)$$

Considering, B_C is the critical magnetic field; $B_{C=}$ T. T implies temperature. B_c (0) is a critical magnetic field at zero kelvins. T_c is the critical temperature below which material is a superconductor and in a superconducting state, there is no a magnetic field.

Table 1. Guestimate critical magnetic field at any temperature

Critical temperature (T_c)	Critical Magnetic Field B_c(0)	Wire Radius	Magnetic Field (B_c)
90 Kelvin	25 Tesla	30 Cm	25 Tesla
100 Kelvin	20 Tesla	30 Cm	20 Tesla
150 Kelvin	50 Tesla	30 Cm	50 Tesla

Table 1, gives the guestimate values of the critical magnetic field at any given temperature.

3.5 The Magnetic Field of Current Measurement

The Ampere's law measures the magnetic field of current measurement.

$$B = \frac{\mu_0 I}{2\pi r} \quad (3)$$

Considering for a current I = 37500000, radial distance r = 0.3 m, the magnetic field is B= 25 Tesla.

3.6 Tables

All the information presented in Table 2-7 are guesstimate information and values proposed to be utilized for ramp type escalator utilizing magnetic levitation concept with type II superconductor. These proposed materials and their properties may change in real ramp escalator system development in the manufacturing company.

Table 2. Ramp type escalator components and parameters guesstimate values

Escalator properties	Approximate values
Escalator length	1490- 1493 cm
Escalator width	81 cm wide escalators accommodate a single person and a suitcase or package. These are used in moderate traffic areas.
Number of superconducting magnet pair	20+20+2+2=44. Total ten pairs of each side and one pair at corner side. 400cm/20cm=20 pieces' / superconductor magnets
Dimension of superconductor magnets	20 cm x 15 cm x 10 cm. Length x height x width
Superconducting magnet mass (m_p)	Approximately 1000kg
Escalator body mass)	500 kg
Escalator position angle	30^0

Table 3. Maglev ramp escalator guide way properties

Guide Way Properties	Approximate values
Number of pairs of magnet	Total 10 pair each side of ramp type escalator and 1 pair at corner side. 400cm/20cm=20 pieces' / electro magnets. 20+20+2+2=44.
Mass Per magnet	100 Kg
Solenoid length L	0.2 Meters
Total length of wire N	80 Cm

Table 4. Maglev ramp escalator electromagnets wires properties

The Diameter of Wire	Approximate Values
Turn density N/L	1500
Total number of turns	300
Permeability, K	200
Magnetic field generates from each magnet	376.99
Turn density N/L	1500

Table 5. Materials used in Maglev ramp escalator

Escalator Component	Proposed Materials
Escalator body	Plastic, fiber, rubber
Superconductor	Type II superconductor made of metal alloy superconductors.
Superconducting wire	High-temperature superconductor wires are made of Yttrium barium copper oxide (YBCO)[13] and Bismuth strontium calcium copper oxide (BSCCO)[14].
Permanent magnets	Neodymium strong magnets
Electromagnets	Magnetic material, iron
Track	Steel
Magnetic bearing	Neodymium strong magnets
Pipes (small and large)	Steel

Table 6. Superconductive coil parameters

The diameter of wire	Proposed Materials
Total length of wire	Depends on total length of escalator
Total number of turns	For each piece of superconductor approximately turn to create high superconductivity
Type of coil	Propulsion coil, levitation coil and guidance coil
Coil current	Can take extremely high amount of current

Table 7. Other parameters in Maglev ramp escalator

Escalator component	Proposed materials and approximate values
Energy source	High longevity batteries
Approximate total infrastructure cost	Cost is high (approximately US $ 0.12 billion)
Maintenance cost	Very low
Total service time hour/ day)	Approximately 12 hours/ day
Type of superconductor	Type II superconductor
Cooling techniques	Cryogenically cooled refrigerator

4. Conclusion

The present study has dealt with a ramp type escalator driven by magnetic levitation system. An optimized structure has been proposed with a capability of learning about ten passengers at a time. The slope of the ramp, rotation per minute, structured components have been designed and animated with a view providing maximum safety of the passengers. The initial expenditure along with the installation cost, although may become high, still, the maintenance cost becomes very low compared to other existing electrical or electromechanical based escalator systems. The proposed system is expected to be useful for physically weak and elderly persons.

5. Future Work

Similar escalator system based on magnetic levitation system may be constructed with folding staircase escalator. In this case, better attention will be required for the design of geometrical shape and size of each staircase, their folding and unfolding rate and overall rotation per minute. The staircase type study will become more expensive due to its complex structural nature. Still, this kind of structure i.e. escalator system will provide more flexibility compared to other electrical or electromechanical escalator system.

6. Acknowledgement

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7. Dedication

I Kuldip Acharya (author one) dedicate my work to my loving father Dr. Kalidas Acharya with my endless love and eternal memory of him.

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