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MAGNETIC SUSTENTATION APPLICATIONS ON THE RAILWAY TRACTION FOR HIGH SPEED MAGLEV TRAINS

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Abstract: *The term "maglev" refers not only to vehicles but also the interaction between them and race. This interaction is very important because each component is designed according to the other to create and control the levitation (sustentation) magnetic. One of these ideas is to train by lifting push and pull forces generated by magnets with the same polarity or with opposite polarities. The train can be driven by a linear motor installed on the rails and / or vehicle.*

Key words: *sustentation, levitation, magnetism, pulses, linear electric machines.*

1. Introduction to the History of Magnetic Suspension Technology

The first technology based on the phenomenon known as levitation or magnetic took practical application in rail transport phenomenon was subsequently developed and implemented successfully by railway.

The Maglev trains use powerful magnets to provide lifting and advance. What makes them special is that there is no contact with the rail, reducing friction and allowing forces train to reach very high speeds.

The Maglev trains can reach speeds above the threshold 1000 [km/h]. But do not get an airplane to speeds because of friction forces at altitude are lower than those at ground level.

In 1983 was built a subway line based on magnetic levitation in Berlin. The project proved to be a success, but the line was closed in 1992.

The world record speed for passenger trains Maglev trains was 531 [km/h] in 1997 and this year to reach a record 603 [km/h].

In the 1980s they were made at Electroputere Factory of Craiova, two practical achievements that have used magnetic suspension for the first time in Romania [3]. The first experience is to build a mini vehicle sustentation contactless

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magnetic floating, moving on a line length of 2 [m] of length for financial reasons could not be increased. This vehicle called VEMAG 01 could carry a load of approx. 80 [kg]. It was subsequently designed and manufactured a magnetic suspension bogie, which floated stable sustentation force is 2[t]. But political and economic problems since the beginning of the eighth decade of the last century in our country, Romania stopped further research into specific areas, but who continued theoretically [1]. There were thus developed under the guidance of specialized teachers even two doctoral theses in this field. A magnetic levitation or maglev train is a train that uses powerful magnetic fields to ensure sustentation and advance. As opposed to conventional train, there is no contact with the rail, thus reducing the frictional forces and allows the attainment of high speed. From *Earnshaw* theorem is known that only using electromagnets and permanent magnets cannot ensure system stability. On the other hand, the diamagnetic and the superconducting magnets, can stabilize the train. Some conventional systems use electromagnetic electronic stabilization, continuously measuring the distance to train and adjust the current in the electromagnet accordingly.

The weight of the large electromagnet is a major problem. It takes such a strong magnetic field to levitate a train large and therefore usually use superconducting materials for efficient electromagnets.

The first automatic trading system in the world was a low speed maglev shuttle between the airport terminal and Birmingham International train station in Birmingham, in the immediate vicinity. The shuttle operated between 1984 and 1995 [5]. The track length was 600 m, and trains "were flying" at a height of 15 [mm] rails. At the end of the operation, the system had become unsafe due to aging electronic components and was replaced by a funicular.

West Berlin was built in the 80s, M-Bahn system (Figure 1).

Fig. 1. *The German trains with magnetic suspension M-Bahn*

Maglev train was automated with a path length of 1,6 [km] and 3 stops. The tests began into August 1989 and the system was inaugurated in July 1991 [6].

2. The Peculiarities of Linear Rail Motorization Technology

Lifting is the property of a body to maintain a certain level into the mass of a fluid (in this case air). A magnetic suspension train, or maglev, is a train that uses powerful magnetic fields to ensure sustentation and advance. Raising the train is achieved by push and pull forces generated by magnets with the same polarity or with opposite polarities.

Mach number (named after the Austrian physicist *Ernst Mach*) is a unit of measurement used to express aerodynamic speed of a body moving in a fluid: projectile, aircraft, missile etc. The *Mach* number is a dimensionless value that shows how many times higher the speed of the mobile than the speed of sound in that medium [8]. *Mach* 1 is equal to the speed of sound into the fluid. In standard *Mach* 1 equals 1225 [km/h].

The magnetised coils at the bottom of the track, which was rejected magnets under the train, allowing it to levitate between 1 and 10 [cm] above the runway. Once the train is in levitation, loaded coils inside vertical walls to create a unique magnetic fields that pull and push the train.

Constantly alternating electric current supplied coils to change the polarity of The magnetised the turns. This change in polarity determine the magnetic field located in front of the train to pull the vehicle forward, while the rear magnetic field adds an additional force in the same direction.

The Transrapid, a German company, has a test track in Emsland district of 31,5 [km] in the federal state of Lower Saxony (Niedersachsen). On 22 September 2006 around 10 o'clock mornings here there was a big accident: a Transrapid train collided with a car workshop which is on the same route of human error. The accident resulted in 23 dead people and 10 wounded.

On 31 December 2000, the first manned maglev high temperature was tested at Jiaotong University, Chengdu, China. This system is based on the principle that high-temperature superconductors can be levitated with over a permanent magnet. Vertical load train set was 530 [kg] levitation distance was 20 [mm] above the tread. The system uses liquid nitrogen to cool the superconductor electric [7].

Transrapid has launched also the first commercial service with a high-speed maglev in the world, between downtown Shanghai and the city's airport. The line was inaugurated in 2002. The highest speed was 501 [km/h], the line having a length of 30 [km]. Transrapid uses EMS technology. The line was later extended to 160 [km] in 2010 with the inauguration by the Chinese state events occasioned by the commencement of the exhibition in Shanghai in the same year.

This technology would enable virtually train speeds exceeding 6437 [km/h] in a vacuum tunnel. The "maglev" term refers not only to vehicles but also to railroad systems, specifically designed for magnetic levitation and propulsion. Sustentation train technology built magnetic levitation is made using permanent magnets mounted on trains interact via the electromagnetic field line generated path (Figure 2). This is basically a train engine .

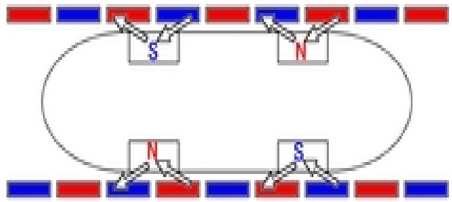

Fig. 2. *Schematic diagram of the vehicle magnetic sustentation*

Japan has a test track into Yamanashi, where trains are tested maglev MLX01 series (Figure 3) JR is the acronym for Japan Railways - Railways Japan).

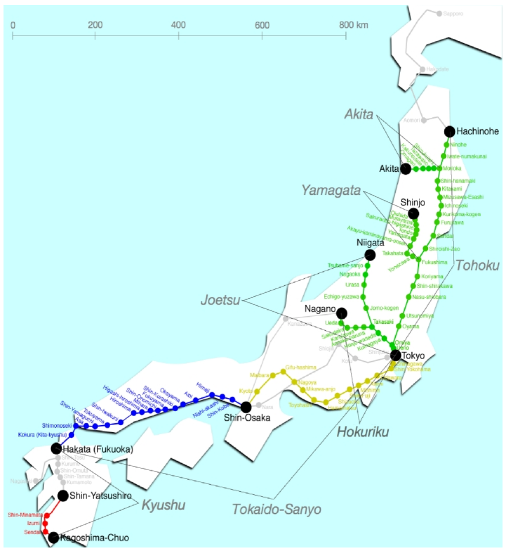

Fig. 3. *Map of Shinkansen high speed railway network.*

Lines in green: Operated by JR East
Lines in yellow: Operated by JR Central
Lines in blue: Operated by JR West
Lines in red: Operated by JR Kyūshū
Lines in gray: Planned

These trains using EMS technology. These magnetic trains and their counterparts on wheel, known as the Shinkansen. They are designed and developed by Central Japan Railway Co. institute - "JR Central - Railways central Japan" and the consortium Kawasaki Heavy Industries, which are currently the fastest trains in the world, reaching a record speed of 581 [km/h] on December 2, 2003 and respectively, 603 [km/h] this year.

The first commercial service maglev automatic type came into use in March 2005 into Aichi, Japan. It Tobu line - Kyuryo, known as Linimo bus. The line is 8.9 [km], 9 stations and is able to support magnetic suspension trains running with maximum speed of 100 [km/h]. The minimum radius of transition curves is 75 [m] and the maximum permitted gradients of this line was only 6%. This line serves the local communities and sites where the Expo was held in 2005. The trains were designed by the Japanese consortium Chubu hsst Development Corporation, operating and test track in Nagoya (Figure 4).

Fig. 4. *Japanese trains maglev series MLX01*

2.1. The operating principle of magnetic sustentation - Maglev Turbine

The movement of vehicles is subject to the general laws of physics (especially those of the movement). Because a means of transport can be set in motion on his force must act *F*, oriented in the direction of movement, which has a value large enough to transmit its acceleration - zero and positive, and to overcome the drag *R* (the rudiments of action and reaction) due to friction. The transmission speed and torque (generally power) plants developed by bodies that driving the moving means of transportation and realization of traction, meaning they capitalization, is what is called a propulsion problem. Along with this problem, for the transport means, there is another problem, that of sustentation, which consists in forces that ensure permanent stable position of the means of transport or the environment in which it operates. The current carrying coils repel magnets, and just train to levitate at a distance of 1-10 [cm] above the rolling track. Once the train is suspended coil creates a magnetic system that pulling and pushing on the guide rail tracks [4].

Alternating electrical current applied to the coils to change their polarity. It makes alternating magnetic field in front of the train to pull in front of train, while the magnetic field behind it pushes ahead.

Due to non-contact forces acting system offers superior quality classical system running without excitation (mechanical) from the guide way, together with higher flow speeds while providing full traffic safety. Thus, with regard to passenger transport, non-conventional transport systems Maglev type still has an advantage over conventional system.

But here it must be mentioned limits higher travel speeds due to aerodynamic drag resistance. In terms of freight transport capacity of maglev systems are currently low, in this case the conventional system due to long liners and large transport capacity (250 kN/wheel). It has a clear advantage over maglev system.

Motion Magnet Maglev system, called

the M3 system is currently focused on travel speeds of up to 45 [m/s] (162 [km/h]) but with slight modifications, the system can compete with any other transmission system guided path, including the high or low speed.

The linear synchronous motor (LSM) has been used for several applications of high-speed maglev but only recently applied in urban transport. The maximum speed of movement of vehicles this transport system is only half the speed at which the train maglev "Transrapid" operating into China, but the use of vehicles small, with a small interval between two vehicles which run on the same thread way and quick accelerations, it is possible to achieve exceptional performance at prices much lower cost.

The combination of LSM technology and small vehicles represents an efficient alternative in terms of cost for all trains operated by rotary motors and linear induction motor (LIM), all applications in transport, including conventional and monorail. The urban transport system, Magne Motion - Urban Maglev System, called M3, is designed as an alternative to conventional transport systems guided all the way. The advantages of this system include major reductions in travel time, operating costs, the costs, and the noise level and energy consumption.

Vehicle size of a minivan, intervals between vehicles operating automatically with just a few seconds, with the possibility of operation in platoons of vehicles can achieve transmission capacity of over 12,000 passengers per hour and direction [2].

The vehicles with low weight, leading implicitly to a guide way with a light weight, a less wait time for the travelling public needs at low power inverter located on the outskirts of the guide way, an electric regenerative braking more efficient and smaller stations'.

The result is a system that can be built for about $ 20 million per mile of track, including related vehicles but without the costs of expropriation of land. Emphasis is placed on urban applications, with standard vehicles designed to carry 24 seated passengers and space for 12 passengers still standing, for rush hours.

Line System Maglev - LSM is designed to provide speeds up to 45 [m/s] (162 [km/h]) and acceleration and deceleration of up to 2 [m/s], all without having to board a space for propulsion equipment or proper equipment. M3 system installation and operation costs are less predictable than those of any other competing system, and the average journey time is reduced by half. From the point of view of environmental protection, the advantages of this system include a halving energy consumption, a low visual impact due to the cross section of the guide way small and low noise levels.

For some applications it is preferable to use smaller vehicles with lower maximum speed of movement or the use of larger vehicles able to reach speeds of movement. Both options can be used using the same guide path and the same lifting system. The only change required, refers to the size of power plants used for propulsion of the vehicle. A vehicle designed for transport of 12 passengers, with a maximum speed of 30 [m/s] (108 [km/h]), is the option discussed in this report, if the app requires trips short and transport capacities low, with an important advantage in low cost.

An articulated vehicle with 36 seats, is a possible option for speeds of at least 60 [m/s] (216 [km/h]). What is important is that paying adequate attention to the design phase, it is possible to enhance M3 system and its adaptation for vehicle speeds and increased transport capacity, where the future of importance such requirements.

The evolution of the classic railway system, revealed a weak capacity to adapt it to the necessary changes with time.

The calculations made by specialists Magne Motion revealed that the transmission system powered using LSM has investment costs are much lower than transport systems Conventional-based vehicles electrically operated, whether operated by electric motors for traction rotary or linear induction motor systems (LIM).

Vehicles are greatly simplified, energy and maintenance costs are reduced, and the most important aspect is the fact that this transport system users benefit from greatly reduced the journey time. In fact, the energy the train uses to levitate above the tread is less than the energy consumed by its air-conditioning system.

The electromagnets with electronic stabilization (1) at the bottom of each vehicle of the train set, and the composition of the magnetic coils at the bottom of the tread (2) raise the train until the distance between the two sets of magnets is approximately 1 [cm].

Other magnets (3) ensure alignment of the train along the vertical walls of the track (Figure 5). The spool coils (4) installed in the raceway produce a magnetic field that propels the train.

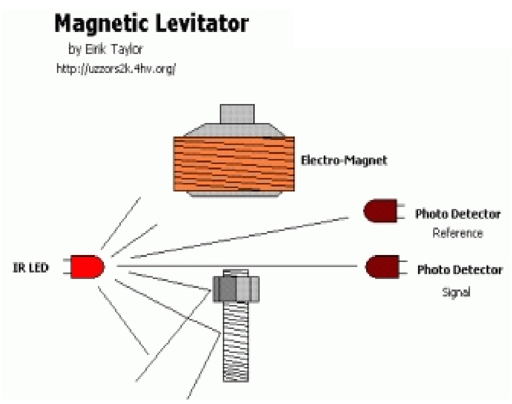

Fig. 5. *Operating diagram magnetically the Levites*

To reduce electricity consumption, central control point that sends electricity sector tread (5) where the train. It takes more energy in areas where the train must accelerate to climb a slope. When the train must slow down or to go in the reverse direction, the polarity of the coils of the tread.

Although the maglev train travels at a high speed in the bottom of the vehicle in the train gasket surrounds (6) making it almost impossible path train derailment.

The passengers do not need to put his seatbelt, but can rise from their seats even when travelling at maximum speed train. If a power outage, special brakes powered by batteries on board the train which produces a magnetic field opposite reduce train speed to 10 [km/h], and finally it stops.

Maglev trains use powerful magnets to provide lifting and advance. They are used in Scheme systems (Figure 6) a number of devices such as generator homopolar generator electrostatic capacitive (operating in vacuum under pulses), chambers of plasma radio HF without electrode inside, klystrone, facility electrolytic regenerative microclimate and the discharge chamber of Z-pinch [4].

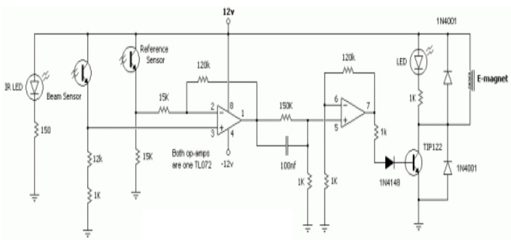

Fig. 6. *Scheme operating principle of linear electric machine*

3. Determination the Mathematical Model and Transfer Function on Magnetic Suspension

The characteristic equation of vertical movement trains. It is desirable that lifting distance *d* to be controlled so that it does not exceed the limits of proper operation of train.

The lifting distance d, between the track and the train magnets is determined by equation (1).

$$d=z-h \tag{1}$$

The magnet produces a force which is dependent on the residual magnetism and the current that runs through magnetized circuit.

For small changes in distance d and current magnetized i, that strength is calculated by equation (2), where G and H are positive constants.

$$f1= - Gi+Hd \tag{2}$$

The force necessary to accelerate the train mass M in the vertical direction being shown by the equation (3).

$$f1=M = - Gi+Hd \tag{3}$$

For higher current distance d diminishes and z decreases as a result of attraction towards the rail track train according to the relation (4).

$$Ri+Li=v \tag{4}$$

A network model for magnetic circuit is defined by its magnetic circuit primarily. This circuit is a generator that controls a coil wrapped around the magnet out on the train (equation 5).

$$Ri + Li – (LH/G)d = v \tag{5}$$

The induced voltage in the coil of the train movement is represented by term *(LH/G).d*, which presumably magnetic flux losses are negligible.

For this type of circuit is valid equation of state (6) and three state variables are shown in relations (7).

$$x1=d \text{ and } x3=i \tag{6}$$

- Tc-zinc =0.88 K, (7)

The superconductors (Figure 7) are electrical conductors whose resistance becomes practically zero at certain temperatures.

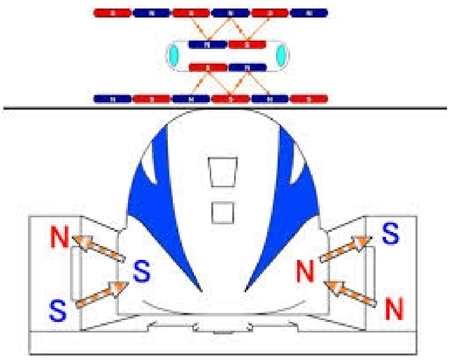

Fig. 7. *Scheme magnetic polarity magnetic suspension trains*

This property allows the development of technologies that, for instance, propelled by magnetic levitation trains.

Some ceramic materials and some metals, when they are brought to a temperature between absolute zero, and the temperature of liquefaction of nitrogen (77 K) completely lose their electrical resistivity.

The temperature at which the electrical resistance becomes zero is called the critical temperature (Tc) varies from one material to another.

The state of superconductivity is achieved by cooling various materials usually helium or liquid nitrogen. Some critical temperatures ranging from metals used are shown in relations (8 and 9) and category ceramics, temperatures are given in (10).

Tc-aluminiu = 1.19 K (8)
Tc-mercur = 4.15 K (9)

For if the compound, the relation (11) gives operating temperatures that are designed to are functioning optimally.

$$u1=U1cos2\omega t;\ u2=U2cos(4\omega t+\alpha) \quad (12)$$

When rising magnet superconductor and he will leave the container, remaining suspended and stable under magnet. This phenomenon is called magnetic suspension.

Both levitation and suspension magnetic clamping effect generated by the magnetic flux. When separating superconducting magnet forced to close then again, very slowly magnets, superconductors will be attracted by the magnet and brought it close. However, it is the same behaviour as in the case of two magnets whose opposite poles attract leading to sticking together.

Superconducting magnet attract each other, but also opposed to each other keeping a constant distance from each other. If returning to the superconducting magnet and put the other pole of this approach, the latter will be pushed away from the magnet. Furthermore, superconductors will tend to overthrow to realign and can thus be attracted by the magnet again. After various processes of magnetization, superconductors behave differently, highlighting various effects and phenomena as *Meissner* effect, magnetic levitation and suspension, and the effect of magnetic flux fixings.

Based on these characteristics of superconductors, many technologies are in the design phase, both for large-scale applications as if the train Maglev for transport, but also for applications smaller scale, as is the case in the industry semiconductor manufacturing.

The operating principle underlying the object circuit is applying a magnetic force equal to the gravitational force, and the opposite at the same time. The two forces cancel each other and the object remains suspended.

Basically this is done by a circuit that reduces the electromagnetic force when an object gets too close, but a larger and when the subject comes within range.

This circuit works by magnetic levitation comparing the sensor signals with the first operational amplifier and emitting a voltage proportional to the difference (error) them.

The error signal is then sent through a network of compensation which plays a high pass filter, allowing fast changes of error for the flow more easily than slow changes.

This is needed for establishing the continuity of control and without it just would brandish objects near the electromagnet due to system instability.

The signal is then amplified to its original value after compensation mitigate network after reaching TIP122 Darlington transistor that controls the current electromagnet.

Further around the transistor diodes are designed to prevent damage. The diode prevents the signal based on the polarity reversal of the base to be damaged, while the two 1N4001 provides a path for the magnetic current when the electromagnet is switched off [6].

Optical components used are not essential as long as the wavelengths fit well and how the angles of detection / emission are not too narrow. IR LEDs are TIL38 that are up 940 [km] have opening of 15 degrees, 35 [MW] and a maximum 100 mA. The detectors are type PT204-6B that are phototransistors IR. In addition, there are magneto dynamic suspension (MDS) recently invented and least tested yet.

3.1. Stability of Movement with Magnetic Suspension Systems

Using only electromagnets and permanent magnets cannot ensure system stability. On the other hand, the diamagnetic and the superconducting magnets, can stabilize the train.

Using only electromagnets and permanent magnets cannot ensure system stability. On the other hand, the diamagnetic and the superconducting magnets, can stabilize the train.

Stability and magnet causes weight based on the great, whose size is a major issue for planners. It takes a very strong magnetic field to levitate a train large, so they are usually used for superconducting electromagnets efficient materials.

The superconductors are a type of electrical conductors whose resistance becomes practically zero at temperatures lower than specified amount of materials they are made of.

This property allows the development of technologies such as vehicles powered by magnetic levitation and operated using a higher superconductivity temperatures, quieter vehicles, moving without friction and are very easy to accelerated.

After various processes of magnetization, superconductors behave differently, highlighting various effects and phenomena such as *Meissner* effect, magnetic levitation and suspension, and the effect of magnetic flow fixings.

The *Meissne*r Effect describes how a material that undergoes the transformation from normal to superconducting state - exclude magnetic field inside it.

3.2. Practical Application - Results and Discussions

The distance between the magnets fixed - within the array of magnets, according to this aspect are a series of magnetic forces - the interaction between two magnet fitted forces "parasite" that occur when they interact with a moving magnetic repulsive force, but the possible interaction of these forces with areas of two magnetic poles mobile, the more evident and depending on the angle to the plane of plan freely magnet fitted, open plan angle to the plane of the magnet fitted. *Tesla* envisioned a new situation taking fixed magnet wire and wrapped, resulting in a cylinder with magnets fixed to the inside and a satisfactory diameter. Specifically, these applications rely on energy conservation but also the conservation of momentum through a very simple magnet phone is so positioned relative to the mounting magnet fitted that when the balance is always a few millimetres before the position where they are. There are areas in which equilibrium is reached when, but there comes inertial conservation of momentum, which help to overcome their impulse just because gained during the interaction forces were maximum. Calculating the point of balance can be done if decomposition is appropriate forces "crude" acting between magnets participants.

The calculation can be done by calculating weights momentum, friction forces and comparing them to the above. It is also obvious that when such an application under load, the aforementioned parameters and change them. This is an issue closely related to the fact that there are a number of demonstrations of applications that "revolve" but actually revolve alone, doing nothing else than to demonstrate the existence of these phenomena.

The oscillation in the contact area can be achieved with one or two elements. Option "a" involves feeding the two electrodes of the piezoceramic converter 3 out of phase "α" so that the item. In step 2 is an overlap longitudinal oscillations at a resonant frequency (12).

$$v0 = 2r/T = \omega\ r/\pi = f1l/p = 2rf1 \quad (12)$$

The DC linear motor has armature windings and ferromagnetic equipped with linear collector and inductor with poles, put on one or both sides of the armature.

The synchronous linear motor can be heteropolar or homopolar with conventional or superconducting excitation (Figures 8 and 9).

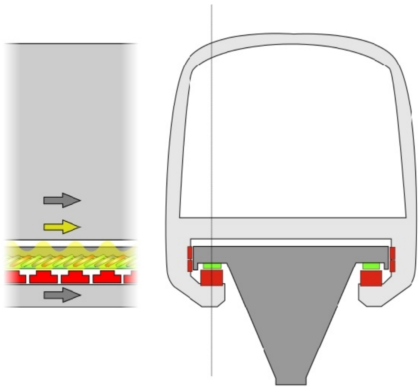

Fig. 8. *Modelling scheme moving the vehicle magnetic suspension*

The fact that mobile magnets are placed in the magnetic field energy movements are participants and the law of conservation of energy conservation but the moment.

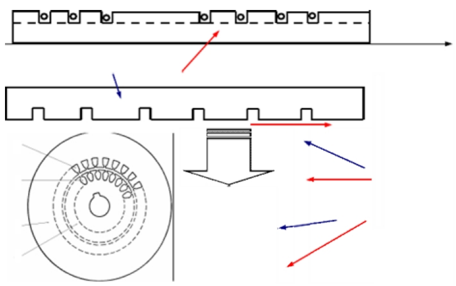

Fig. 9. *Scheme interaction runway vehicle when the pulse levitation*

The most common asynchronous linear motor is a linear motor (induction), corresponding rotary asynchronous motor with squirrel cage.

The balance between the forces of interaction between magnets data - fixed and mobiles - It is highly precarious. There can calculate the optimal angle obtain a force that mobilizes mobile magnet so that it always be pushed forward. It also uses a range of materials that are permeable to obstruct the magnetic field or field guide so as to achieve maximum effect and attenuation of the interaction forces "parasitic" areas between the magnetic poles generated at each magnetic pieces.

There are a number of configurations positioning magnet fitted so if we add inertia, mobile magnet to pass repeatedly in areas with high intensity of interaction - thus obtaining the moving force tops.

The magnetic field produced by the coil has a constant amplitude and is travelling along the inductor, for the purposes of the rotating with the speed given in equation (13), where r It is the polar step, l is the length of the inductor, p is the number of pairs of poles, $f1$, T, ω is the frequency, timing periods and voltage pulsation.

$$dF = (JxB)dv \qquad (13)$$

The alteration of energy level of the magnet components - exhaustion while, due to the consumption resulting from stress during operation or due to interactions with the environment - lead to changes in initial conditions that cause and maintain phenomena therefore and significant changes in operation. By moving the magnetic induction field B to the armature consists of a plate of copper, aluminium, steel or a combination thereof, the induced electromotive voltage, which gives rise to eddy currents density J.

On the volume element of the armature (valve) is exercising a basic electro-magnetic force (14).

$$s = (v_0 - v) / v_0 < 1 \qquad (14)$$

The three-phase variant inductor (improperly stator as it can be phone), located in notches practiced wrapping stacks of sheets, symmetrical three-phase voltage is supplied. The driving force set in motion induced or inductor (if the armature is fixed). The velocity v of the armature must be less than the synchronous speed (15) thus sliding s. In generator conditions (regenerative braking over-synchronous), $s<0$; under the brake (by reverse connection), $s>1$.

$$YBa_2Cu_3O_7\,(YBCO)\ \text{have}\ T_c=91K \quad (15)$$

The operating characteristics differ from those of rotary asynchronous motor due to unbalanced magnetic circuit, which produces undesirable effects.

The effect of the longitudinal or end important, in particular, at a speed close to the synchronous, is the non-uniformity and distortion of the distribution of magnetic flux density across the inductor, compared to the case of a rotary engine, due to establishment or extinction of eddy currents in the input and fitting out portions of the field, seeking to delay the establishment of magnetic induction.

The longitudinal effect lead to parasitic forces (opposite thrust) and additional heat. The transverse or the marginal effect consists in the fact that induced in the edges of the inductor currents have longitudinal components which do not contribute to the production of force, but the distribution of magnetic flux density in the air gap deformed transversely. Both effects are negative, causing decreased performance linear motors.

To reduce the effect of special end windings can be used (in stages), the more complicated technology, or increases the length of the inductor. The margin effects can be limited by choosing the optimal ratio of the width and pace polar inductor.

4. Conclusions

The operating mechanism of the railway path "running" magnet suspended relies on the magnetic properties, that opposites attract and rejection poles with identical tasks. The magnetic fields are generated allowing trains to travel with the help of coils located on runway.

The Maglev system to operation, the essential elements are a source of very strong current, magnetic coils, which are arranged in the path of travel and large magnets, positioned below the high-speed train. The Shanghai Maglev train operates regularly EMS speed of 430 [km/h] and a Japanese prototype, JR Central EDS the Maglev can run more than 500 [km/h]. There are even the Maglev technology that can push the speed up to 600 [km/h]. The system works by sequential supply of electromagnetic aboard the vehicle. In turn, these passive electromagnets coils induce a magnetic rail structure opposite.

The resulting magnetic repulsion is what drives the vehicle forward.

The sensors monitor the exact position of electromagnetic coils relative to passive rail, controlling their power and, implicitly, the propulsion force or, respectively, the brake.

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References

1. Dósa, A, Ungureanu, V. V. - *SCFJ – model discret de pierdere a stabilității căii fără joante (SCFJ – discrete model for continuous welded rail buckling)*, "Timisene Academical Days: 10th Edition, Timisoara,

Romania, 24th –25th of May 2007 - Symposium: Efficient infrastructure for the terrestrial transport" – Solness Publishing House, Timisoara, ISBN 978-973-729-101-1.

2. Dumitru, G. and al: "*Dynamic Characteristics of Interraction Between Railway Vehicles and Railway Track Path*", in RailwayPRO Science & Technology - Official Magazine For Club Feroviar Conferences & Technical Colloquia, ISSN 2284-7057, pp. 61 - 70, April 25 - 26, 2012, Constanţa.
3. Mazilu, T., *Vibraţii* (Vibrations), Editura Matrix Rom, Bucureşti, 2012.
4. Sebeşan, I., Mazilu, T., *Vibraţiile vehiculelor feroviare* (Vibrations of the railway vehicles), Editura Matrix Rom, Bucureşti, 2010.
5. Ungureanu, V. V., Comănici, M. - *Sensitivity study of a model for the stability analysis of continuous welded rail*, Intersections / Intersecţii, Vol.4, 2007, No.1, "Transportation Infrastructure Engineering", ISSN 1582 – 3024.
6. Ungureanu, V. V., Dósa, A. - *Parametrical study of the effect of the torsional resistance of the fastenings on the stability of continuous welded rail*, Intersections / Intersecţii, Vol.4, 2007, No.1, "Transportation Infrastructure Engineering", ISSN 1582 – 3024.
7. Ungureanu, V. V. - *On Elimination of Interior Rail Joints and the Including of Welded Railway Switches in Continuous Welded Rail Track* (2009), SUSTAINABILITY in SCIENCE ENGINEERING, Volume II, Proceedings of the 11th WSEAS International Conference on Sustainability in Science Engineering (SSE '09), Timisoara, Romania, May 27 - 29, 2009, ISSN: 1790-2769, ISBN: 978-960-474-080-2, WSEAS Press.
8. Ungureanu, V. V., Dósa, A. - *Algoritm pentru determinarea probabilităţii de pierdere a stabilităţii cadrului şine - traverse (Algorithm for determining the probability of continuous welded rail track buckling)*, Proceedings of Scientific Conference Civil Engineering – Building Services CIB 2007, 15th – 16th of November, Braşov, România, *Transilvania* University Publishing House – Braşov 2007, ISSN 1843-6617.
9. Ungureanu, V. V. - *Cercetări privind simularea pierderii stabilităţii căii fără joante (Research about simulation of continuous welded rail buckling)*, Ph.D. Thesis, *Transilvania* University of Braşov, Braşov, Romania, 2007.