MAS System Maglev

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Abstract: A MAS (Magnetic Array Suspension) system has been presented and constructed. Its levitation propulsion and guidance are described as follows:

1. Levitation System

Levitation System consists of rail magnet array (Fig. 1)

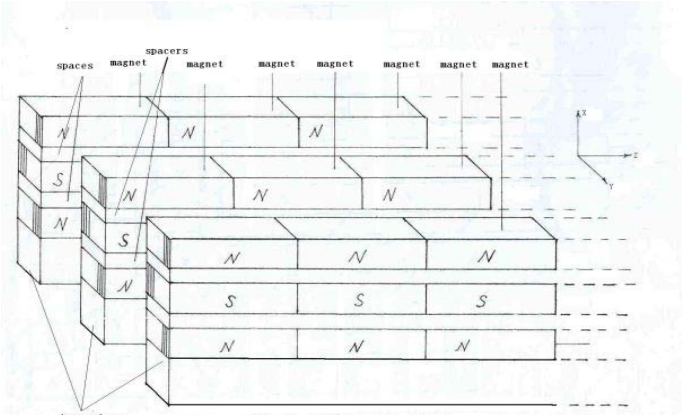

Fig. 1 rail magnet array

and vehicle magnet array (Fig. 2).

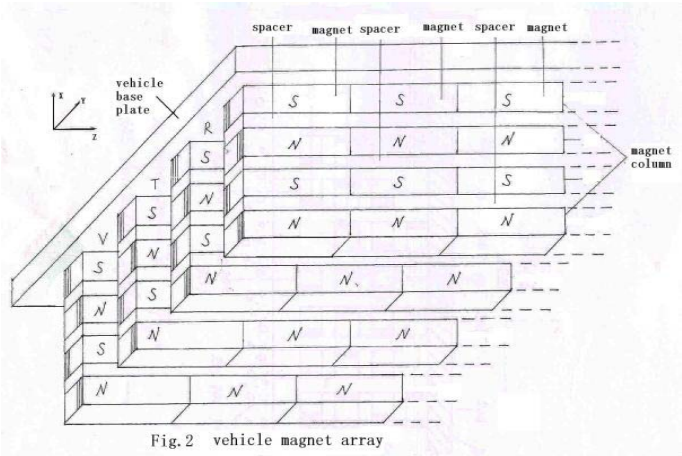

Fig. 2 vehicle magnet array

Each magnet array consists of n (n=1, 2, 3…) magnet columns. Each magnet column consists of m (m=1, 2, 3…) magnet strips and (m-1) spacers (Fig. 3).

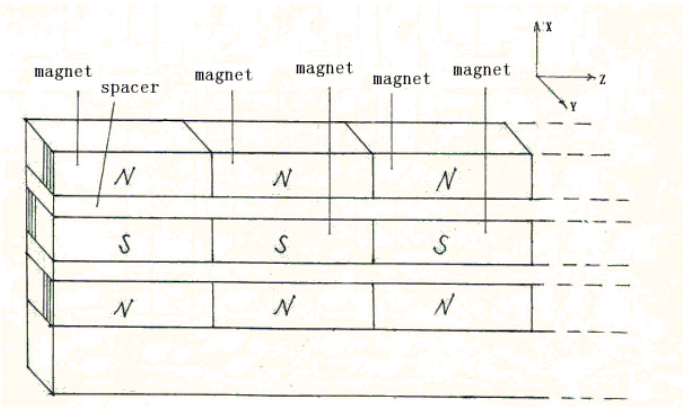

Fig. 3 magnet column

Inserting the vehicle array into the rail array forms the MAS levitation System (Fig. 4).

The levitation force comes from both attraction and repulsion between magnets on rail and magnets on vehicle. Now we take the vehicle magnet 7 (Fig. 4) as a sample to explain how the levitation force produces.

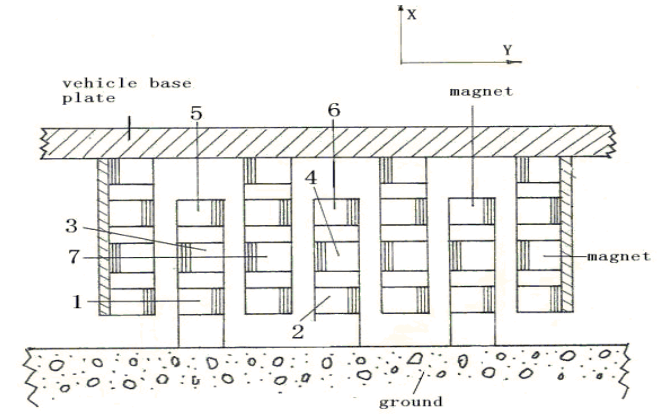

Fig. 4 The Cross-section of MAS levitation system

When the vehicle descends Δx, the magnet 7 goes down Δx, too. Than magnet 7 is attracted upward by rail magnets 3 and 4. Simultaneously, the magnet 7 is repulsed also upward by rail magnet 1 and 2. Similarly when the vehicle rises Δx, the magnet 7 rises Δx, too. Then magnet 7 is attracted downward by rail magnet 3 and 4. Simultaneously magnet 7 is repulsed downward by rail magnet 5 and 6. The other vehicle magnets are acted similarly as the magnet 7.

After the vehicle magnet array is inserted into the rail magnet array, neither can the vehicle be pressed down nor can be raised upward. So the levitation is two-way stable.

In another point of view, the levitation force comes from that the magnetic lines of flux are condensed laterally and stretched longitudinally. Thus we get the expression of levitation force f

$$f \approx \frac{1}{\mu\alpha} bcmnB^2(\Delta x)$$

eq.1 f

(here b is the height of magnet in x direction, c is the length of vehicle magnets in z direction, a is the gap between magnets in y direction.)

The advantages of the MAS system are:

1. Levitation force is large. It can exceed 500 kN/m^2
2. Levitation is two-way stable.
3. Energy is not consumed for levitation (generally permanent magnets are used).
4. The levitation rigidly is very large.
5. Controlling System for levitation is unnecessary.
6. The magnetic flux density is low both in carriage and nearby the rail.
7. The structure is extremely simple.
8. The cost is low.
9. The load to dead weight ratio can greater than 10.

2. Propulsion

In MAS System the propulsion is achieved by magnetic gear wheel on vehicle and magnetic gear rack on rail (Fig. 5). The magnetic gear wheel consists of (k+1) (k=1, 2, 3…) rotating discs on which the magnets are arranged equidistantly. The axes of the magnets are arranged alternately and parallel to rotating axis of the magnetic gear wheel. Spacers separate the rotating discs. The magnetic gear rack consists of k fixed strips on which the magnets are arranged equidistantly. The magnet axes are arranged alternately, too. When the magnetic gear wheel is driven by motor or engine on vehicle,

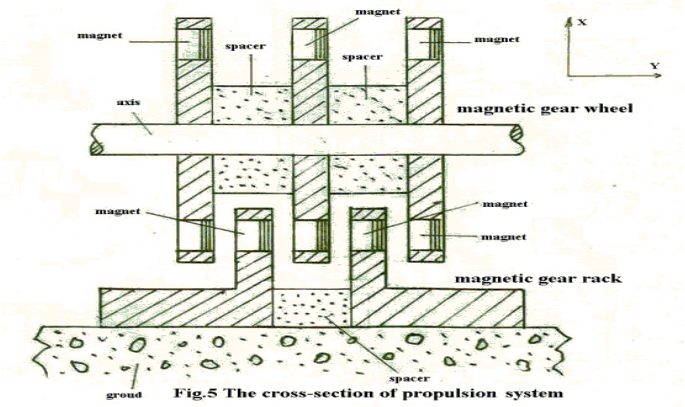

Fig.5 The cross-section of propulsion system

the magnetic interaction between magnets on wheel and magnets on rack propels the vehicle forward (Fig. 6).

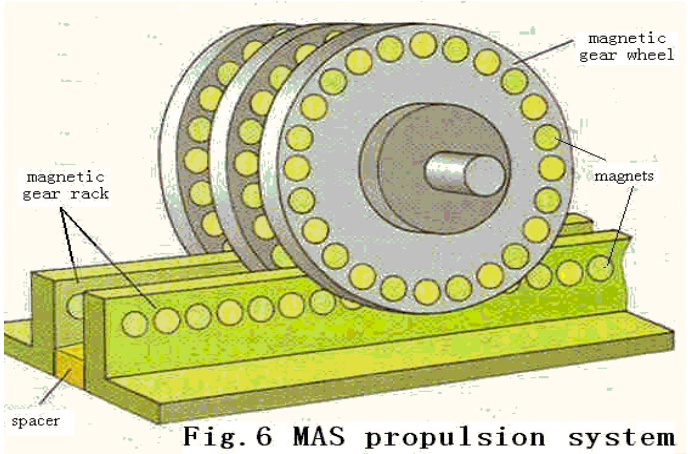

Fig. 6 MAS propulsion system

The advantages of this propulsion system are:

1. The propulsion is mechanically contactless.
2. The efficiency is high, it is decided basically by the efficiency of the driving motor or driving engine.
3. The engaged force is large, the acceleration can be greater than 1.0 g.
4. The structure is simple.
5. The cost is low.

3. Guidance

MAS system is very stable in x direction (vertical direction), free in z direction (going forward direction), but it is in unstable equilibrium in y direction (horizontal and perpendicular to rail). As soon as the vehicle magnet columns deviate the balance position, they suffer a magnetic force in y direction. And this force increases rapidly when the deviation distance Δy increases. Therefore a guidance device with large rigidity is necessary. In MAS system maglev every car has 8 mechanical wheels, which guide the vehicle to go forward or backward along the rail which is in groove shape.

4. Project Progress

Three MAS maglevs (MAS1, MAS2, MAS3) have been constructed. Now I would like to give a brief introduction to MAS2 (Fig.7) , MAS3 (Fig.8, Fig.9)

Fig.7 MAS 2

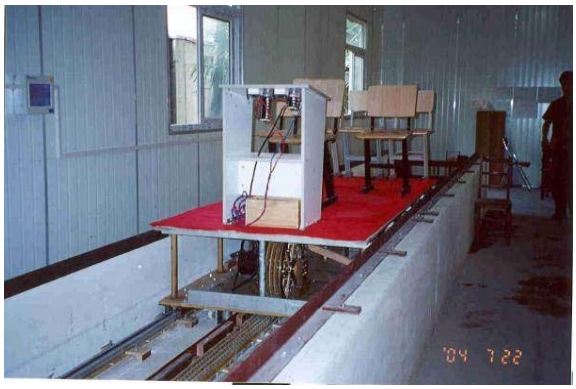

Fig.8 MAS 3

Fig.9 MAS 3

rail length 10 m
rail width 1.35 m
vehicle length 2.63 m
vehicle widths 1.25 mm,
magnet NdFeB, N40, size: 18*15*125mm
n=4, m=2
vehicle dead weight: 380 kg
loading passengers: 6
levitating ability > $8*10^4$ N
diameter of magnetic gear wheel: 430 mm
k=4
maximum propulsion force: 1300 N
maximum acceleration > 3 m/s^2
driving system: motor and accumulators (36v)
cost of rail: 1500 USD/m
complete date: 16, July, 2004

5. Conclusion

MAS System maglev has been invented and constructed. This system has a few excellent advantages as described above. We have not found any technical and project difficulties to construct the practical MAS maglev.