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Two Application Issues of High Temperature Superconducting Maglev in the Evacuated Tube Transportation

Yaoping Zhang[1,a] , Jianyue Yu[1,b],Yong Zhao[2,c] and Benlin Liu[1,d]

[1] Institute of Evacuated Tube Transportation, Xijing University, Xi-an, Shaanxi 710123, China

[2] Superconductivity R&D Center, Southwest Jiaotong University, Chengdu, Sichuan 610031, China

[a]tubetrans@hotmail.com, [b]cr@991cr.com,[c]yzhao@home.swjtu.edu.cn, [d]benlinliu@hotmail.com

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Abstract. Based on some special merits such as self-stability, energy-consuming-efficiency, less pollution, high reliability, and so on, high temperature superconducting maglev (HTSM) is one of the promising potential technologies among present Maglev technologies for the future evacuated tube transportation (ETT). In this paper, the possibility, the merits, and the demerits of the applications of HTSM in ETT system are investigated. Especially, two application issues, liquid nitrogen vessel on the vehicle and isolated gate set in ETT, are discussed and solutions are suggested. On the first issue, this paper suggests to install a pressure relief valve on the sealed liquid nitrogen vessel so as to reduce the liquid nitrogen vaporization in the vacuum tube. As for the second issue, this paper recommends to use HTSM permanent magnet (PM) track structure with a streamline separated gap between the surface of track and the bottom of liquid nitrogen vessel. Those guideway structure could fit to the isolation gate setting in ETT.

1. Introduction

Compared with the developed Internet or IT technology, the situation of transportation appears to be so bad. People are looking forward to transport mode that will be faster, more clean and environmentally friendly. The speed of Shanghai Maglev in operation in China is 430km/h, and that of Yamanashi Maglev in Japan reached 581km/h. However, they aren't the ideal speed, and those Maglevs go with high aerodynamic noise and resistance. More and more clearly, it will be the right orientation for Maglev to combine it with evacuated tube transportation (ETT), namely putting the maglev in the vacuum tube of ETT. High temperature superconducting maglev (HTSM) which uses bulk high temperature superconductor (HTSC), such as YBaCuO disks, is one of the promising potential technologies among present Maglev technologies for the future ETT. In this case, it is necessary to pay special attention to a series of issues on running HTSM in ETT system. Thus, two application issues, liquid nitrogen vessel on the HTSM vehicle and isolated gate set in ETT, are discussed and solutions are suggested in this paper.

2. Some characteristics of HTSM

2.1 Liquid nitrogen vessels on HTSM vehicle

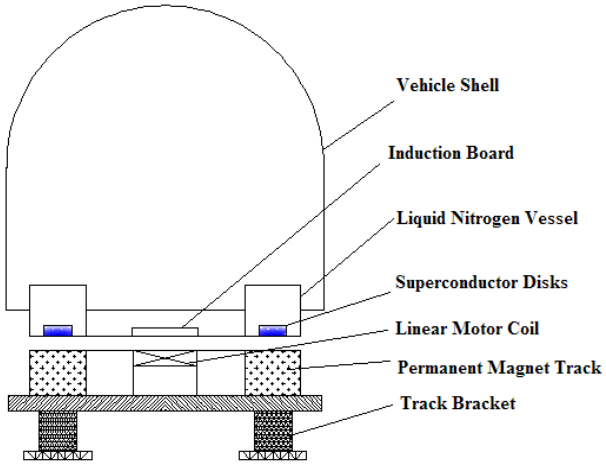
The existing liquid nitrogen vessels on HTSM vehicle commonly have open holes so that the pressure inside and outside vessels is balanceable, such as given in the paper "High Temperature Superconducting Maglev Equipment on Vehicle"[1] and the patent "A nonmetal dewar vessel to be used for high temperature superconducting Maglev experiment vehicle"[2]. However, when the HTSM vehicle with such liquid nitrogen vessels is put into ETT tube, liquid nitrogen will vaporize fast, even bubble up. It's a problem that needs to be solved.

2.2 Structure characteristics of HTSM guideway

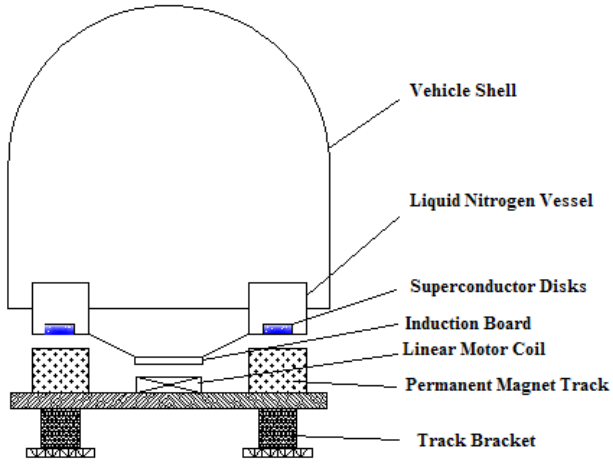
According to some finished HTSM for testing, patents or schemes of HTSM [3-6], there are three basic guideway types:

(1) Type Ⅰ: Levitation system on vehicle is separately above on the guideway.

In this guideway structure, a streamlining separated gap exists between the surface of track and the bottom of liquid nitrogen vessel on vehicle. This type includes three specific types, respectively shown in Fig. 1a, Fig.1b and Fig.1c.



a)



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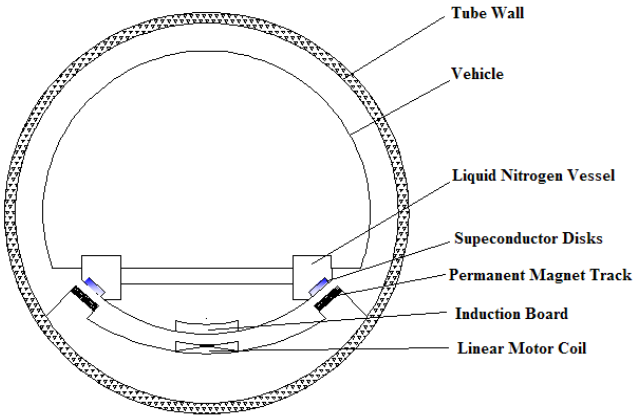

c)

Fig. 1 Gauideway type Ⅰ: Levitation system on vehicle separately above on the guideway
a-Guideway with a smooth linear surface, b-Guideway to which that is possible to be made into zigzag surface, c-Guidway with an arc track surface

(2) Type Ⅱ: Levitation system on vehicle surrounds the guideway.

It's possible for HTSM to design the levitation system and have it surround the guideway, just like that of Shanghai EMS maglev in operation in China. Its basic structure is shown in Fig.2.

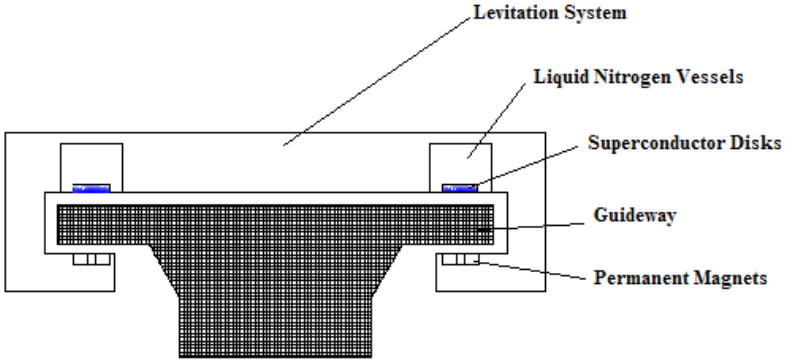

Fig. 2 Gauideway type Ⅱ: Levitation system on vehicle surrounds the guideway

(3) Type Ⅲ: Levitation system on vehicle joggles with the guideway.

In this type, levitation system on HTSM vehicle joggles with segments of the guideway (see Fig. 3).

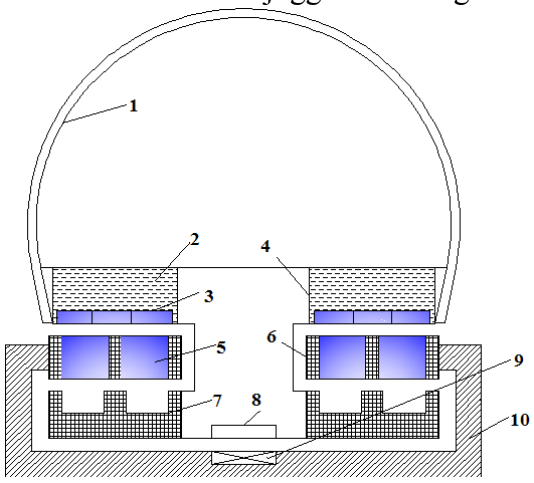

Fig. 3 Gauideway type Ⅲ: Levitation system on vehicle joggles with the guideway: (1) Vehicle body, (2) liquid nitrogen, (3) HTS bulk, (4) liquid nitrogen vessel, (5) permanent magnet, (6) iron, (7) iron, (8) induction board, (9) linear motor coil, (10) elevated girder

3. Two application issues of HTSM in ETT and relative solutions

According to the above states, two application issues of HTSM in ETT come to us. One is the liquid nitrogen evaporation in vessels on HTSM vehicle in ETT. Another one is how to set vacuum isolation gate in ETT that fits to HTSM guideway. Here two issues are discussed and relative solutions are presented.

3.1 Liquid nitrogen vessel with a pressure valve

In order to reduce fast vaporizing and possible boiling of liquid nitrogen in low pressure environment, a pressure valve exit which is adjustable should be installed on the above of the cover of liquid nitrogen vessel. Fig. 4 is the sketch map of such a liquid nitrogen vessel with a pressure valve. Then the continuous running time of HTSM in ETT also could be extended after each operation to add liquid nitrogen. If necessary, you can connect the pressure valve exit to a container for reclaiming nitrogen gas or for recycle through a pipe.

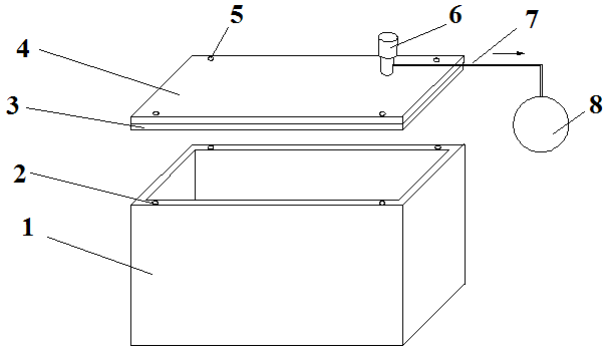

Fig. 4 Liquid nitrogen vessel with a pressure valve: (1) liquid nitrogen vessel, (2) screw on the vessel, (3) thermal insulation, (4) cover of the vessel, (5) screw on the cover, (6) exit with a pressure valve, (7) pipe to connect the exit and the reclaiming container, (8) container for reclaiming nitrogen gas

3.2 Some possible isolation gate settings in ETT that fits to HTSM guideway

For the guideways shown in Fig. 1a, Fig.1b and Fig.1c, some possible isolation gate settings in ETT that fits to HTSM guideway has been put up, and respectively shown in Fig. 5a, Fig. 5b and Fig. 5c.

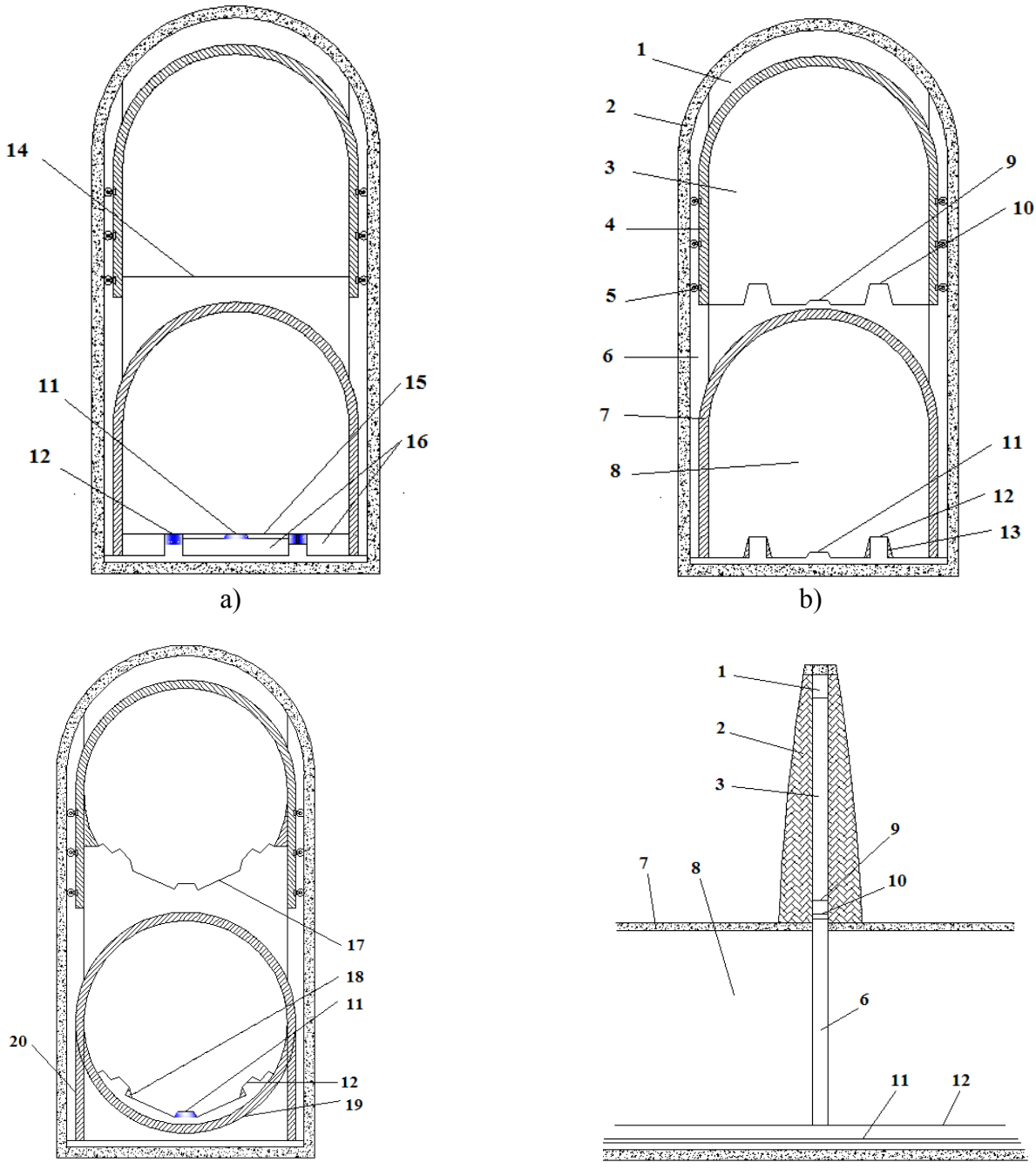

Fig.5 Isolation gate settings in ETT that fits to HTSM guidway: (1) isolation gate chamber, (2) wall of the isolation gate chamber, (3) isolation gate, (4) airproof gasket, (5) wheel, (6) channel for moving the isolation gate, (7) wall of the ETT, (8) vacuum tube, (9) segment on the isolation gate which faces linear motor on guideway, (10) segment on the isolation gate which faces PM track on guideway, (11) linear motor, (12) PM track, (13) pad, (14) linear side down the isolation gate, (15) plane up the guideway, (16) pad, (17) segment on the isolation gate which faces PM track on arc guideway, (18) pad, (19) wall of the ETT, (20) airproof gasket

a-Isolation gate setting for fitting to guideway with a smooth linear surface, b-Isolation gate setting for fitting to guideway with a zigzag surface, c-Isolation gate setting for fitting to an arc guideway with a zigzag surface, d-Section of isolation gate setting

3.3 Some suggestions for developing HTSM guideway

The guideway shown in Fig.2, like Shanghai Maglev's, is feasible for isolation gate setting in ETT. Therefore, it's significative you design such guideway structure for your HTSM. In this case, an isolation gate setting with two pieces of doors which move from two sides for closing or opening needs to be considered.

As for the structure shown in Fig. 3, because the levitation device joggles with the guideway, it's difficult to set a vacuum isolation gate in ETT. Perhaps it wouldn't fit to ETT. Therefore, it's better you don't spend much energy and time on it.

4. Conclusions

Two application issues of HTSM in ETT have been investigated. Respectively they are liquid nitrogen vessel on the vehicle and vacuum isolated gate setting in ETT. On the first issue, this paper suggests to install a pressure relief valve exit on the sealed liquid nitrogen vessel so as to reduce the vaporization and avoid boiling of liquid nitrogen in the vacuum tube. As for the second issue, this paper recommends to use HTSM permanent magnet (PM) track structure with a streamline separated gap between the surface of track and the bottom of liquid nitrogen vessel. Such guideway structure may fits to the isolation gate setting in ETT. In addition, three specific isolation gate settings have been put up.

This paper also pointed out: (1) Guideway structure surrounded by levitation device would fit to isolation gate setting. (2) A levitation device that joggles with the guideway perhaps woudn't fit to the vacuum isolation gate setting in ETT.

Acknowledgement

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