The Research on Power Test of Shanghai High-Speed Maglev Transportation

Liming Shi, Yinan Yang, Gang Hu, and Yaohua Li
National Maglev Transportation Engineering R&D Center
2520, Longyang Road, Shanghai, P.R China
Phone: +86-21-2890-7234, Fax: +86-21-68569979, E-mail: limings@mail.iee.ac.cn

Keywords

Operation test, Power supply, Propulsion, Shanghai, Transrapid.

Abstract

Shanghai commercial demonstration line of high-speed maglev transportation (SMT) is 30 km long with maximum operation speed 430km/h. It links Pudong international airport (PIA) to Longyang road station (LYR)[1]. The high-speed experiments were carried out in last November at maximum speed up to 501km/h. In this paper, we present some operation test results of the power consumption from speed 200km/h to 501km/h. Although SMT is only 30km long, the test results show it has excellent characteristics of power-energy consumption/speed and it is the best tool for long distance transportation.

1 Introduction

The world-first high-speed maglev commercial demonstration line has started successfully its normal operation from last year in Shanghai at maximum operation speed 430km/h. This commercial demonstration line links through 30 km double tracks the Pudong international airport with the Longyang road station on metro line 2[1]. This high-speed maglev system is based on the technology of Transrapid from Germany. The power supply and propulsion system was configured specially for this demonstration line as shown in Fig. 1. The H3 means 3 set of 15MVA high power converter block, M2 refers 2 set of 7.5MVA medium power converter blocks, and L2 is that of low power converter block. The wide shadow line in Fig.1 is the running mode used when we tested the power consumption.

Shanghai-maglev consists mainly two substations including propulsion blocks in each one, the trackside transformer stations and the trackside switches. The whole route consists 5 propulsion segments. The main route is a double-track guideway with length of approximately 30 km from LYR to PIA including tunning area behind PIA. The stator sections are fed by two propulsion blocks from

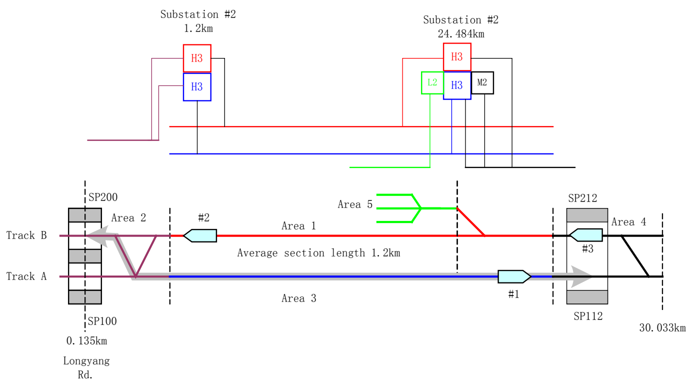

Fig. 1 the configuration of the propulsion system

ajacent substations. The main track is divided into four drive control zones. Stator sections in main tracks (area 1 and area 3) are fed by three-step method.

2 Description of Power Supply System

Fig.2 shows the configuration of the power supply system. It consists two 110kV substation, one in LYR and another in PIA. Both 110kV substation use two 110kV/20kV transformer and have static filter equipments and the dynamic compensation system that is static var generator (SVG).

The main consumer naturally is the propulsion converters feeding from the double-end to long stator windings of the synchronous motor. Besides, the power is also supplied to the power rail for the on-board supply of the vehicles, the auxiliary power supply for the propulsion control and the operation control system, guideway switches and the reactive power compensation. The power supply of air condition, lighting and so on for LYR station, mantenance area and the two substation building is also provided from substations. The tie switch S3 in Fig.2 is to connect the two 20kV bus to realize the standby each other of the two 110kV/20kV transformers when one does not work .

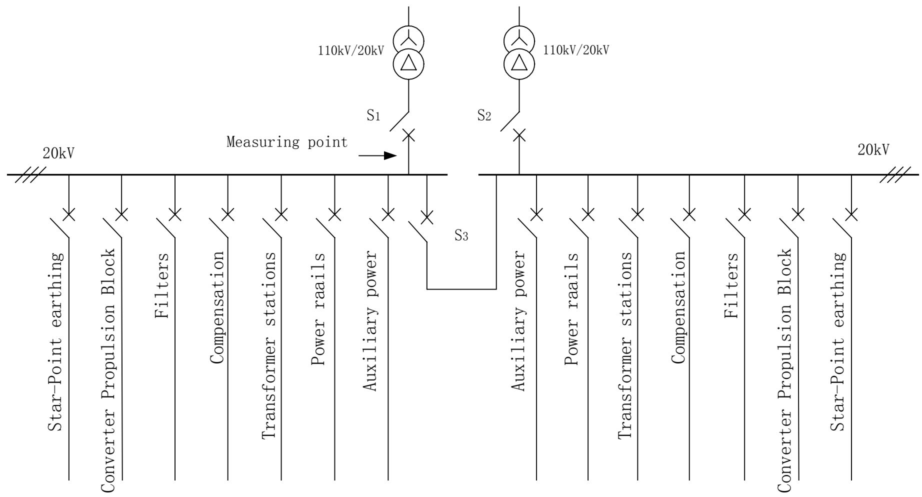

Fig. 2 the configuration of the power supply system

3 Test and results

The measurement of the power consumption was carried out for vehicle operation with 5-section vehicles including total 462 seats, on track A at different speed profiles. For each measurement, the vehicle performed a shuttle run from LYR to PIA and in back direction from PIA to LYR as the shadow line shown in Fig.1. Power analyzers were fixed at 20kV bus both in LYD substation and PIA substation. The total power consumption includes the value obtained from the two power analyzers in the two substations. Measurements are carried out for speed profiles at maximum speed from 200km/h to 501km/h. In this paper, the results for several typical speeds are presented.

Fig. 3 gives the typical full curve of power consumption when vehicle run from LYD to PIA with maximum speed up to 430km/h. It shows the different power with speed variation including acceleration, constant speed and deceleration. The consumed power reaches maximum just before the speed arrives the peak value. Fig.4 shows the power consumption with different speed. Because the distance is only 30km, the higher the speed is, the shorter the constant speed period. Especially, there is almost no constant speed period for the operation up to 501km/h because of the distance limitation. Table 1 gives the detail values of the power for different constant speed. Meanwhile, the propulsion power, which is obtained by subtracting auxiliary power consisting air-condition and lighting for maintenance zone, LYR station and two substations from total consumed power, is also listed in the table. Because the auxiliary power dependent on the scale of station, substation and maintenance zone, and it occupy rather much in total power consumption for such a short demonstration line, so the propulsion power is especially important to judge the power consumption.

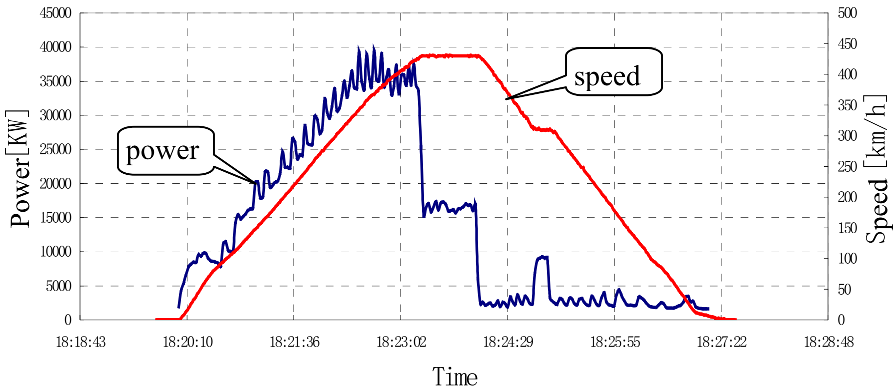

Fig.3 power consumption of maximum speed 430km/h

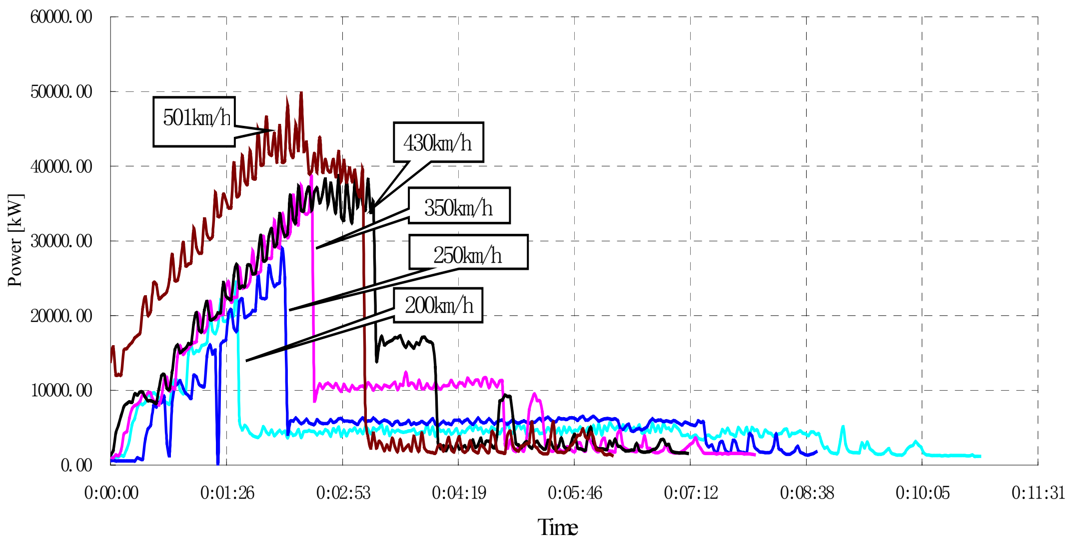

Fig. 4 power consumption of different speed

Table 1 Power consumption at different constant speed

Speed (km/h)	Maximum power at 20kV side(kW)	total power consumption at 20kV side (kW)	Propulsion power (kW)
200	24100	4521.7	3591.7
250	30000	5755.7	4825.7
300	30500	7708	6778
350	38200	10673.4	9743.4
400	38700	13963.6	13033.6
430	38730	16240.5	15310.5
450	45580	17661	16731
470	46710	19327	18397
501	49750		

It is known from Table 1 that the energy consumption increases rapidly with the speed. This is because the energy consumption is greatly effected by running resistance. Resistance includes mainly the aerodynamic resistance, magnetism resistance and the on-borad electric-generating resistance. It is known that aerodynamic resistance is propulsion with the square of the the vehicle speed. So it is not always correct to increase vehicle speed for the maglev transportation system, but it is also important to consider the cost of power supply and propulsion, running cost and benifit.

Table 2 gives the energy consumption per seat per km for different speed. Meanwhile, the data of high speed wheel train is also listed for comparision.

Table 2 energy consumption under different speed

speed (km/h)	Wh/seat.km (converter output)(1)	Wh/seat.km (propulsion)(1)	Wh/seat.km (20kV side)(1)	high speed wheel train ICE(2)
200	35.7	38.9	48	41
250	38.4	42	50	57
300	46.3	49.2	55.9	74
350	55.6	60.3	66.1	
400	65.4	70.6	75.6	
430	70	76	80.5	
450	74.3	81	84.7	
470	79.1	86.2	90.5	

Note : (1) 5-section vehicle, 462 seats
(2) the data for high speed wheel train was obtained from [3].

As a typical example, it is know from Fig.3 that the total consumed energy is about 1662 kWh when vehicle runs at maximum speed 430km/h. The most energy was consumed for acceleration because the running distance is very short. Energy consumed for constant 430km/h is only about 200 kWh and the Wh/seat • km is only 76 Wh.

The measurement results show that high-speed maglev transportation has much less energy/speed than that in high speed wheel train. Contactless characteristics contribute maglev train strong competency in energy/speed. This shows high speed maglev train is the best tool for long diatance transportation.

4 Conclusions

This paper described the power and energy consumption of Shanghai maglev transportation from 200km/h to 501km/h. Teat results show that high-speed maglev transportation have very good characteristics of seat • km energy consumption, energy/speed, which are much better than that of high-speed wheel train. It is clear the configuration of power supply and propulsion system have the most characteristics suitable for long distance maglev transportation. Meanwhile, it is verified that PPS can guaranty Shanghai maglev transportation to run at high speed up to 500km/h safely and reliably.

References

1. X. Wu: *Construction of Shanghai Transrapid Demonstration Lines*, Proc. of International Conference on Magnetically Levitated Systems and Linear Drives, 2002.
2. Dr. –Ing. Rolf Hellinger, Dipl.-Ing. Markus Engel and Dipl.-Ing. Jurgen Nothhaft. *Propulsion System and Power Supply for Transrapid Commercial Lines,* Proc. of International Conference on Magnetically Levitated Systems and Linear Drives, 2002.
3. X. Wu: *Maglev Train*, Shanghai science and technology press, 2003, Shanghai.