Traction System Characteristics of Railway Vehicle

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Abstract: Recently, as the feasibility study shows that trans-Korea railway and trans-continental railway are advantageous, interest in high speed railway system is increasing. Because railway vehicle is environment-friendly and safe compared with airplane and ship, its market-sharing increases gradually. Korean High Speed Train has been developed by KRRI for last 7 years to satisfy the need. Korean High Speed Train (350km/h), composed of 2 power cars, 2 motorized car and 3 trailer cars, has been developed and is under trial test. To verify the design requirements for the functions and traction performances of the train, KRRI (Korea Railroad Research Institute) decided to evaluate traction performances of the train during trial test. For this purpose, torque, velocity, voltage and current must be measured. KRRI has developed a measurement system that can measure vast and various signals effectively. In this paper, we introduce traction performances of Korean High Speed Train. The traction measurement items are focused on the verification of motor block performances. Motor block consists of 2 motors. By this test, we verified traction performances of Korean High Speed Train

Keywords: railway vehicle, trail test, traction system, measurement system

1. INTRODUCTION

Because among the on-board equipments traction equipment is an important part that has influence on safety and performances of vehicles, careful performance test should be done. After part test and complete assembly of traction equipments, trail test on the test track is conducted now.

In this study, we described performance characteristics of domestic traction equipment developed through G7 project. We measured the performances of traction equipment during test running by the developed on-line measurement system.

After we save the input real-time data from each signal of Korean High Speed Train through the network line, we can acquire necessary information through post-processing program. We verify the motor block characteristics of Korean High Speed Train by this system.

2. MAIN SU JECT

2.1 Configuration and specification of main system

In order to verify the performances of KHST composed of 20 vehicles that is the basic trainset, a prototype train composed of 7 vehicles was manufactured. Arrangement and usage of the train is shown in Fig. 1. Table 1 describes the main specification of the prototype train.

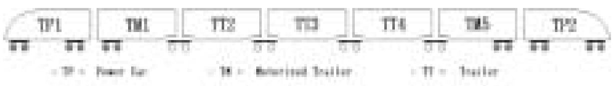

Fig. 1 Configuration of prototype train

The traction system drives 2 converters in parallel. An inverter in the motor block controls 2 traction motors. One power car has 3 motor blocks. Motor block has 4 stacks for converter, 3 stacks for inverter, 1 chopper stack, DC condenser, and current detector. The stack is composed of 1 bridge arm, which includes 2 IGCT and 2 diode into one stack, and consists of 4 stacks for converter, 3 stacks for inverter, and 1 stack for special chopper. Also, it includes dc capacitor, voltage/current sensor of each part, and control logic.

Table 1 Specification of commercial train

Item		Contents
Train Size	Length	145 m
	Width	2.97 m
Bogie Quantity	Power Bogie	6 Sets
	Trailer Bogie	4 Sets
Wheel Diameter	New Wheel	0.92 m
	Half	0.885 m
	Full	0.85 m
Traction	Motor Quantity	12 EA
	Motor Output (1EA)	1,100 kW
Train Weight	W0	321.8 ton
	W1	328.6 ton
	W2	331.0 ton
	W3	430.3 ton
Max. Axle Weight		17.0 ton

2.2 Specification of main power converter

2.2.1 Specification of converter

Table 2 Electric specifications

Item		Contents
Capacity		1,300kVA 2
Capacity	Rated Voltage	1,400VAC
	Rated Current	930A
Rated Voltage	Output Voltage	2,800VDC
	Output Current	884A

Table 3 System configuration

Item	Contents
Input % Impedance	20%
Configuration	Converter 2EA
Semiconductor Device	IGCT
Control System	PWM
Switching Frequency	540Hz

2.2.2 Specification of inverter

Table 4 Electric specifications

Item		Contents
Capacity (Max. Rate)		3,000kVA
Input	Rated Voltage	2,800VDC
	Rated Current	884A
Output	Output Voltage	AC 0~2,183V
	Output Current	747A
	Max. Frequency	143Hz

Table 5 System configuration

Item	Contents
Configuration	1C2M
Semiconductor Device	IGCT
Control System	VVVF Adjustable Speed Control
Switching Frequency	540Hz
Input Filter (FC)	16,000uF

2.3 Configuration of test instrumentation system

Test measurement system consists of 6 measurement modules, 2 monitoring equipments and main server (used for safety monitoring). Normal monitoring can be performed through each measurement module and special monitoring (braking, traveling) equipments. System configuration is shown in Fig 2.

4 measurement modules (DAM1, DAM2, DAM31, DAM32), 2 monitoring equipments and main server are linked with network line, and share measured data, and are controlled by main server. 4 measurement modules can always monitor measured signal, and normal monitoring can be performed by special monitoring (braking, traveling) and main computer equipments.

Fig. 3 and Fig. 4 respectively show the module configuration and the external view of the measurement system. Fig. 5 shows 3B Module that is used for noise shielding of the temperature signals, and the module is located on the trailer motor-car with the measurement system.

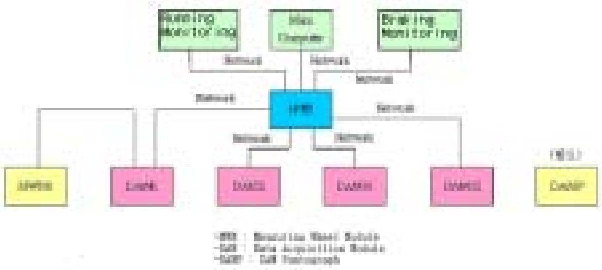

Fig. 2 Configuration of measurement system

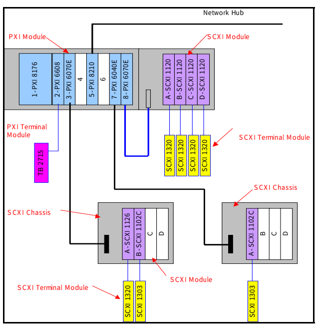

Fig. 2 Module composition of measurement system

Fig. 3 View of measurement system

Fig. 5 View of 3B module.

2.4 Development environment of program

A software system LabView offers the programming method that combine software objects called virtual instrumentation (VI) with graphics. Users can control the system through the intuitional graphic front panel and express the result.

To regulate function, users can program the combining block diagram intuitionally. Users can also collect data from the several equipments including GPIB, V I, serial device, PLC and plug-in data acquisition board (DAQ), and use data sources through networking communication between applications and SQL database link. After users collect data, they can convert the raw data to a significant result using the strong data analysis routines of the LabView. Therefore, the LabView is used for program development.

Table 6 Development environment of program

Classification	Environment
Operating System	Windows 2000 Server
System Platform	P I/Compact PCI
Database	MS SQL 2000 Server
Development Tool	LabView 6i

2.5 Re uirement of measurement module program

First, each data acquisition and processing program is created. According to the measured physical quantity and the measuring method, the program is made out so that an effective measurement may be possible. When measured data is changed, the program is made out an object-oriented module program so that it can be changed easily for this. At early configuration step for data acquisition, the program is designed so that each channel configuration can be possible.

The program was made out so that acquisition of measured data is easy. The algorithm of the necessary operation coding is included. Users define a signal conditioning of the measured data. Because the measured data and the operation result must be stored effectively, the standard parameter values for time and velocity are recoded simultaneously with signal data for each module. The program was designed to consider system unification so that synchronization between data may be possible in analysis.

All the measured data was designed so that files of the data can be stored efficiently. In order to collect and store and display the data in trial measuring process for several items, we composed system and designed interface.

To enable us to manage each measured data and to share monitored signals between modules, unified monitoring programs (braking/safety/traveling) are made out.

In development of this unified monitoring program, the following items are included.

1) Network connection and management for each measuring module

2) Synchronization set-up and start for each measuring module

3) Monitoring each performance (safety/traveling/braking)

4) Display of monitoring and storage of the converted data in addition, printing in special paper

5) Data analysis module (program) including printing in report form for the analyzed result

2. Contents of measurement program

Measurement program is classified into 4 significant functions i.e. hardware configuration, software configuration, diagnosis and test. The same program can be applied to all the measuring modules (DAM1, DAM2, DAM31 and DAM32) and modifying hardware/software configuration.

Hardware configuration is a part that defines the hardware of NI products that is used in each measuring module. Using the driver that is supplied by NI, actual used chassis no., module no. and model no. are configured by hardware.

Software configuration is a part that decides whether or not to use configured channels, and performs calibration, actual conversion of physical quantity, setting with max./min. values and setting with measure limit range. It also decides whether or not to transmit the unified monitoring module.

4. TEST RESULT

Fig. 6 shows variety of the torque reference and the real torque. The torque reference is sent to TCU according to speed change. So, we can see that the torque reference follows the real torque. Also, the real torque is displayed later than the torque reference.

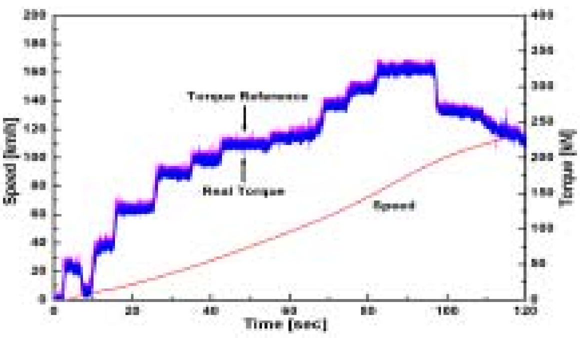

Fig. 6 Comparison of torque reference and real torque

Fig. 7 shows the comparison of the PWM pattern and the real torque. When master controller is regulated so that PWM rate with traction signal sent by an engineer is 100% simultaneously, we can see that the real torque represent 50KNm. In the case that PWM rate is 40% it represents 20KNm. We see that the manufactured motor block is operating normally from these results.

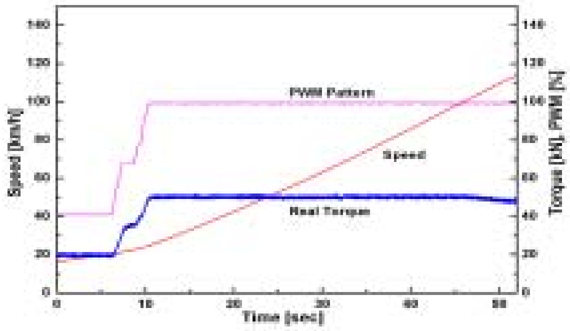

Fig. 7 Comparison of PWM pattern and real torque

Traction motor has the temperature criterion of 180^oC, and exceeding the criterion may cause a fatal fault. To prevent this, we cut off signal outputs of the gate drives of the converter/inverter and the contactor, and suspend the operation of motor blocks.

Fig. 8 shows the effects of external air temperature, on the motor temperature for 24 months from 2002/08 to 2004/07.

Table 7 includes all the running results for 24 months according to month and running speed. The number of dates for actually performed tests is about 86. In case of on-line test at 150km/h, we rounded off 149km/h or 151km/h to 150km/h in Table 7. There was no on-line test in March, because the schedule of on-line test is not appointed for regular vehicle maintenance. Most of the tests are performed on the new line, but the tests from 2003/11 to 2004/01 are performed on the conventional line at the speed of 150~160km.

Table 7 Performance table of on-line test

Month	~100 km/h	~150 km/h	~200 km/h	~250 km/h	~300 km/h	~350 km/h	Sum
1	0	1	5	5	1	0	12
2	0	0	1	3	10	0	14
3	0	0	0	0	0	0	0
4	0	1	0	2	3	0	6
5	0	0	0	2	10	6	18
6	0	0	0	1	16	2	19
7	0	0	0	1	19	8	28
8	1	1	2	1	3	0	8
9	0	1	0	0	5	0	6
10	1	4	4	1	0	0	10
11	0	4	6	2	3	0	15
12	0	2	13	1	2	0	18
Sum	2	14	31	19	72	16	154

Fig. 8 shows the temperature of traction motor classified form month to month. The temperature of external air is the highest in July and is the lowest in January, and the difference of the temperatures is about 40^oC. (a) and (b) in Fig. 8 are the results of the on-line test performed on the conventional line from November and January.

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conventional line from November and January.

Considering the fact that the external air temperature is low in the winter, the temperature of traction motors is somewhat higher for 3 months. Because acceleration and braking is repeated frequently on the conventional line and the train is in service for many hours, these results shown in Fig. 8 are obtained.

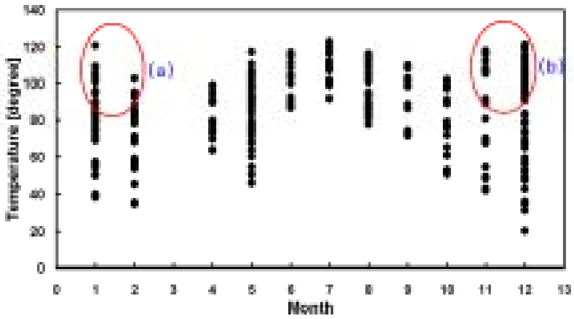

Fig. 8 Motor Temperature considering the Month.

Fig. 9 shows the temperature changes according to the running speed. The motor temperature rises as the running speed increases. Fig. 9 (a), shows the high temperature in the neighborhood of 130~170km/h resulting from on-line test for 2 hours on the conventional line.

Fig. 9 (b) shows the motor temperature that is measured with the speed of 300km/h. It is high like (a). From these results, we can guess that motor temperature is much influenced by operating time and running speed.

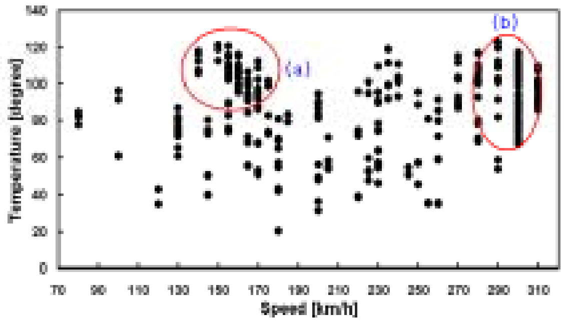

Fig. 9 Motor Temperature considering the Speed

5. CONCLUSION

In order to secure safety and reliability of high speed train, to verify performance characteristics of traction system are important. In this paper, measurement system was configured to understand the characteristics of motor blocks and traction motors on KHST. We examined torque reference and real torque of motor block, and temperature of traction motors.

From the test results, we saw that the performances of the manufactured motor block are normal. Also, we investigated the motor temperature changes according to month. Thus, we verified that the motor temperature is within the standard limit.

Hereafter, we think that we should research the characteristics of motor block driving vehicles for long running time at high speed.

ACKNOWLEDGMENTS

We gratefully acknowledge that this High-Speed Railway System Development Project has been supported by Korean Ministry of Construction and Transportation.

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