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NEXT GENERATION OF KOREA TRAIN EXPRESS (KTX) : PROSPECT AND STRATEGIES

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Abstract : Successful commercial operation of KTX in the high speed line (HSL), conventional line (CL) and at the interfaces between HSL and CL had been started since April 1st, 2004. During KTX project of 12 years, Korea high speed railroad technology had overcome many technical difficulties and acquired many precious experiences in terms of interfaces of R/S and infrastructures. Those things were adapted and integrated to develop the next generation of KTX which has technically compatible system for existing infrastructures. The new high speed train had successfully completed the 350km/h test run quite recently and now is commissioning to verify the full system reliability and safety. The major characteristics of KTX and the next generation of KTX will be compared and various technical experiences will be shared. And the strategic plan to export the next generation of KTX to the world market will be introduced. As it does, according to opening the KTX from Seoul to Busan, we have to think what the next step is. Like other countries of developing the high speed rail system, we have to try to export some kinds of system for further technology and industry development.

Key Words : KTX, HSR technology, railway market

1. INTRODUCTION

The KTX project was changed from the originally intended plan which constructs the new line through the whole sections between Seoul and Busan to the step-by-step revenue service plan which electrifies the conventional Kyeongbu line between Daegu and Busan in the 2nd amendment(1998.7.31) of master plan(1990.6.14), in order to solve the logistics difficulty of the Kyeongbu area[a)]. Since then, conventional Honam line between Seo-Daejeon and Mokpo was also electrified at the same time for the direct connection of KTX in view of balanced national land development. After completion of both projects, revenue service of KTX which had opened on April 1st 2004, has been accomplished successfully until now.

This successful operation of KTX system in the high-speed line, conventional line, and at the interfaces between HSL and CL is the results of a complete application of KTX system technology transferred and of an achievement of smooth system interface with the KTX system and conventional railroad technology. These kinds of experience of system interface and integration led to the rapid progress of the R/S design and system interface engineering technology related to the KTX and infrastructures(civil, track, power supply, signalling,....), and of the technology of the upgrading of existing railroad facilities and electrification of conventional lines.

Therefore, I intend to describe briefly the results obtained through KTX project which are high-speed train technology, system interface engineering, and system integration of the KTX with existing infrastructures. And I will also describe the characteristics of next generation of Korean eXpress Train(KTX) which has been developed through an implementation of new technology on the KTX system for the 350km/h of commercial speed, and prospect the entry of Korean high-speed train into foreign market.

2. KTX SYSTEM

Most of the KTX system designs are similar to those of the existing French TGV-R. That system had been adapted to be fitted to Korean environments designing a system based on "service proven" concept. Technical innovations are limited to those strictly needed to meet specific Contractual requirements. This kind of approach may contribute to the early stabilization of the performance of KTX system, but on the other it can make it difficult to approach the core technology applied to KTX system associated with R/S, Catenary, Power supply, ATC, CTC/IXL.

Actually, although in-depth preliminary design review and final design review were performed by Korean experts, a deep approach to core technology of KTX system was still difficult because of the contractual limitation and lack of expertise about technical know-how of high-speed train system at the early stage of the project. Thus, we made an various efforts to overcome technical uncertainty in terms of interface adjustment and integration. In spite of those things, we could not completely retrieve, analyze KTX system technology. So, we had concluded that it was necessary to launch so-called G7 project to trace and self-contain all the high speed train technology and upgrade performance and safety compared with existing KTX technology.

3. HIGH-SPEED TRAIN SYSTEM ENGINEERING

Regarding the high-speed train system engineering, the smooth interface between high-speed train and infrastructure should be obtained. For this, ICM(Interface Control Manual) was drawn up and managed concentratedly in order to control effectively a total 45 of internal and external interface items related to the core system, after interaction function, adaptation function, and technical function between high-speed train and infrastructure were decided from the functional analysis between systems.

This core system engineering management was implemented for overall technical coordination of the core system, based on the related information by R/S, Catenary, ATC, CTC/IXL. Core System Engineering management is organized 4 functions such as ① system interface management, ② system assurance and safety, ③ train control system technical management, ④ configuration, management, testing and commissioning. This integrated management system is a systematical approach by which problems can be induced immediately and technical solution can be extracted if a interface problem is occurred in an actual railroad system. However, comprehensive implementation of this kind of system engineering approach to high-speed train system was actually insufficient and incomplete. In spite of this status, it was good opportunities and experience to have application of system approach to the high speed train system for the first time.

Technical part of high-speed train system engineering which was applied to KTX system is divided into system integration, signalling system and power supply, and track system. The applied technology is as follows.

● Integration of system engineering

With the development of a program with which basic specification can be determined and interface adjustment of each system and performance of train can be analyzed in order to accomplish the target of KTX system, the technology has been obtained that suggests a test & evaluation procedure and standard of the high-speed train performance, and valuates the performance of each equipment. In addition, the method which analyzes and evaluates whether the target performance of train is met or not, has been established from the test of test track to evaluate the performance of high-speed train and main line, and, for this, measurement of the performance at each section.

● Signalling system and power supply

In case of signalling system, performance test of ATC, CTC, and IXL and adaptation test against the operating environment were carried out on the test track. And also, various technology such as EMI/EMC evaluation of signalling system and performance validation technology were accomplished. Regarding the catenary system, it was analyzed the current collection problem of KTX pantograph and tunnel catenary system.

● Track system

In case of track system, technology for performance evaluation of track and its structure and safety evaluation system, bridge design technology for securing the running safety of train, and technology for efficient bridge maintenance were accomplished in case that high-speed train is operated on the HSL.

● Example of Interface problem which was not forecasted in advance

The cases of solution for interface problem between rolling stock and infrastructure which occurred during the progress of project and testing & commissioning are as follows. First, it is because the understanding of interaction between rolling stock and track system is insufficient. Actually, the most famous issue encountered during testing and commissioning stage was obviously so-called "swaying" or "snaking" issue in the winter season. These interface problems between rolling stock and track had not been detected at the stage of design, and it was recognized during testing & commissioning stage. Various solutions were proposed to solve this kind of unexpected phenomenon. Among those things, it was decided to change wheel conicity from 1/40 to 1/16. That is not a satisfactory approach after all, but the unique vibration mode problem caused by KTX train formation which occurred near 150km/h has been solved with changing the wheel conicity from 1/40 to 1/16.

4. INTEGRATION WITH THE EXISTING RAILROAD SYSTEM [b), c), d)]

Before operating KTX at 300km/h of maximum speed, Korea already had experiences of different types of train operation including Saemaul(maximum speed: 150km/h) except the operation of high-speed train on conventional lines. However, such experiences were quite insufficient for safe and reliable operation of KTX on the conventional line. A sharp increase in maximum speed from 150km/h to 300km/h required totally different ideas and practices from conventional operation. The technical compatibility for ensuring KTX operation in terms of electrification of conventional lines, and upgrading the existing railway services should be perfectly maintained.

For this, new technology based on the KTX applied technology was adapted in the conventional lines and these kinds of technology will be applied for the standardization of double-track electrification in the near future. Some of results are suggested as follows.

● Application of hybrid rail which is suitable for KTX wheel

The compatibility with KTX wheel and hybrid rail was applied with taking running safety and wear into consideration, after designing hybrid rail which combined the head of existing KS50N rail with the web and bottom of KS60 rail.

● Application of 160km/h oblique encumbrance catenary system for narrow tunnel

In many tunnels on CL which don't have space to install catenary because of the height of existing tunnels, the catenary system with which train can be operated at 160km/h was developed and applied. It is because that tunnel bracket-type catenary, used in existing korean railway, was estimated that its critical speed was 120km./h in case of KTX. This system is a system that simple catenary system with reduced catenary height into the existing support structure of tunnel bracket catenary, and support point of catenary and that of messenger wire is crossed by means of dual catenary type which divides the structure supporting catenary and messenger wire.

● Application of common earth

The separated earth was general in Korean railroad with affected by Japanese railroad for the earth of the signalling/telecommunication/Power Supply/Facilities, but common earth type which is the same type as Kyeongbu HSL was applied for the electrification of existing lines.

● Determining power supply system for the electrification of conventional lines.

Comparing two different power supply systems with and without parallel connections in the normal operation scheme and also in the extended feeding, finally power supply system without parallel connection was selected.

5. KOREAN HIGH-SPEED TRAIN AND ITS PROSPECT

The Contract of core system technology transfer with Eukorail Consortium chaired by ALSTOM of France in 1993 and Contract had been a starting point of Korean High-Speed Train Project. According to the contract clause that ALSTOM transfers the technology related to the introduction of so-called core system such as rolling stock/catenary/train control system and localizes more than 50% of manufacturing cost, technology such as system engineering and design/production/testing of core system was transferred, and about 1000 persons a year had been dispatched to France and trained with theoretical education and on-the-job training. At that time, technology about system interface, system engineering, rolling stock system, manufacturing, next generation high-speed train was transferred. Based on the high-speed train technology transferred, KRRI(Korea Railroad Research Institute), KITECH(Korea Institute of Industrial Technology), and ROTEM jointly have developed Korean High-Speed Train, the world's 5th high-speed train, by themselves, chaired by Ministry of Construction & Transportation for 6 years from December 1996 to October 2002 for upgrading without following the former technology. It was selected as one of the Korean New Technology by Ministry of Commerce, Industry and Energy in 2003.

Domestic and foreign up-to-date technology was applied to the Korean high-speed train, and its rolling stock system has been designed and manufactured as a Korean own model(localization rate is 92%) for a competition with international high-speed trains by

Korean researchers. Main core equipment such as, especially, 1100kW large-output inductive traction motor for the 3th time in the world and propulsion control system using IGCT electric semiconductor element for the first time in the world have been localized.
The main technical specification of KTX and NG-KTX is as follows.

Table 1. Comparison of Technical Characteristics between KTX and NG-KTX

Classification		KTX	NG-KTX
Maximum speed		300km/h	350 km/h
Train formation		1 train composed of 20 cars (Double unit impossible)	1 train composed of 7 cars (Double unit possible)
Material of carbody		high tensile steel (mild steel)	aluminum
Traction motor		synchronous	asynchronous
Traction system	Inverter type	PFC+phase control converter +current-type inverter VVVF control	PWM control inverter + voltage-type inverter VVVF control
	Power component	SCR	IGCT
Traffic control system		analog control	digital control
Braking system	Type	friction+rheostatic +regeneration braking	friction+rheostatic +regeneration +eddy current braking
	Blending	electric/air braking blending of power bogie	electric/air braking blending of power bogie +power bogie/trailer bogie blending
Pressure compensation system		None	Yes

It is needed to diffuse these results and maximize the effect of development of new technology in the Korean railroad industry. For this, it is judged that Korean high-speed trains will be served first as trains necessary for the additional trains besides 46 KTX trains. In conclusion, the business showings of commercial operation will be the key to the entry into

foreign market, so it is necessary to validate actual reliability and safety by means of commercial operation of Korean high-speed train in the country. After getting reliability, safety, and operation know-how with making a stepping stone of this, we should make another new challenge, that is, the entry of Korean high-speed train into foreign market.
The detail strategy in order to concretize this is to compare the technology of Korean high-speed train with that of international high-speed train, and also the method (international cooperation system, independent system,...) to participate foreign high-speed train project and strategy to enter into high-speed train market to participate international high-speed project should be embodied. Especially, as the largest high-speed train project in 21th century has been started in neighbor China, it is expected that the entry into China can be accomplished in the field such as construction engineering and project management. With this, it is considered that there will be some opportunities in the field such as testing & commissioning of high-speed train and management, so it is required to establish various flexible strategies related to proper field for foreign market and its method.
The high-speed train business can create high value added from new technology. Therefore, a conference group which can concentrate the ability of an educational-industrial complex related to railroad, is required in order to expand the technical basis of domestic railroad industry and maximize the effect of development of HSL technology. and it should be promoted to develop a domestic railroad industry through positive overseas expansion of railroad industry. In addition, with considering the demand for high-speed train in the northeast Asia, management of northeast high-speed train technology conference group is worth consideration in order to discuss the standardization of high-speed railroad system for interoperability in Korea, China, and Japan.

6. CONCLUSION

One of main achievements from high-speed railroad project is that understanding of high-speed train technology and a firm standing for technical take-off of Korean railroad are prepared. First of all, the accumulated technology, from solving several technically difficult problems during the project and successful commercial operation until now, is precious experience and assets. By feed-back of these experiences, the basis for railroad system engineering, testing & commissioning, maintenance and operation was expanded. With utilizing the technology accumulated after paying much price for Kyeongbu HSL construction project and next-generation high-speed train development project, value added should be created by overseas market extension as well as construction of another new line and double-track electrification of existing lines in Korea.

REFERENCES

a) High speed railway headquarter, KNR (2000.11) High speed railway construction and operation plan, **Korea National Railroad Document**

b) Jong-Hwan Chung, (2004) Korea's High Speed Railway : Continuing Challenge, **KTX International Symposium**, Seoul, Korea, 11-20, 29, March 2004

c) Hisung LEE et…, (2001) Report on the advisory services of upgrading of existing railway facilities and electrification of conventional line**, KRRI Report 2001**

d) Hisung LEE et…, (2002) Report on the advisory services of upgrading of existing railway facilities and electrification of conventional line, **KRRI Report 2002**