Technology Development to Improve the Eurasian Freight Transportation in KOREA

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Jang-ho Yun & Hee-seung Na

Korea Railroad Research Institute
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- Development of Gauge Changeable System
- Development of Multi-shape Coupler and New Brake System
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Overview on KRRI
Mission and Roles

Mission

Contribute to the Development of Korean Railway Industry through R&D in the Fields of Railway Technology, Operation, Policy, and Applications

Roles

- R&D on Core Technology, Policy, Safety & Logistics
- Development & Application of HSR, LRT, TTX
- Rail Network Expansion & Continental Connections
- System Standardization, Assessment & Certification
Timeline of KRRI

- **1996. 3** Established as research institute of Korea National Railway
- **2000. 8** Certified as an authorized testing agency (KOLAS)
- **2004. 12** HSR-350X reached records 352.4km/h on test run
- **2010. 3** KTX-Sancheon(KTX-II) started revenue service
- **2011. 3** K-AGT started revenue service in Busan
- **2013. 3** HSR (HEMU 430-X) renewed top speed (421.4 km/h)
- **2014. 12** Awarded two UIC 2014 Innovation Awards (Trams, Power T.)
- **2015. 4** Korea HST awarded as one of 70th top technologies in Korea
- **2016. 12** Awarded one UIC 2016 Innovation Awards (IoT based freight Monitoring)
As of June. 2017

**Workforce**

- Total: 411
- Researchers: 335

**Budget**

- 113 mil. US$ for 2017

- 43% Private R&D funds
- 15% Government R&D grants
- 42% Government R&D project funds

As of June. 2017

**Workforce and Budget**
Major R&D Facilities

- Over 300 testing facilities including 20 real-scale test equipments for experiments and tests of railway systems and components ($100 million)

- Bogie dynamic simulator
- Brake performance tester
- Propulsion equipment performance tester
- Traction motor tester
- Multi axial test system for track components
- Integrated test system for infrastructure
- High speed wheel/rail contact simulator
- 6-DOF seismic table
Achievements of KRRI

High-Speed Train
- Max speed: 350km/h
- Commercial operation since 2010

HEMU-430X
- Max speed: 430km/h
- Commercial operation in 2020

Tilting Train
- Max speed: 200km/h
- Max tilting angle: 8 degree

Light Rail Transit (K-AGT)
- Max speed: 70km/h
- Driverless operation

Bimodal Tram
- Max speed: 80km/h
- Automatic Operation

Catenary-free Tram
- Max speed: 70km/h
- Powered by batteries

Personal Rapid Transit
- Max speed: 40km/h
- Driverless, Door to door Service

Advanced EMU
- Max speed: 130km/h
- Directive drive motor
Technology Development to Improve Eurasian Freight Transportation
Technological Obstacles against Eurasian Transportation
Due to geographical location of Korea, it is inevitable to pass through TSR, TCR, TMR, or TMGR in order to connect Korea and Europe by railway.
## Comparison of Railway System by Country

<table>
<thead>
<tr>
<th></th>
<th>South Korea</th>
<th>North Korea</th>
<th>China</th>
<th>Russia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Track Gauge (mm)</strong></td>
<td>1,435</td>
<td>1,435</td>
<td>1,435</td>
<td>1,520</td>
</tr>
<tr>
<td><strong>Catenary System (kV)</strong></td>
<td>25 (AC)</td>
<td>3 (DC)</td>
<td>25 (AC)</td>
<td>25 (AC), 3 (DC)</td>
</tr>
<tr>
<td><strong>Signal System</strong></td>
<td>ETCS L1, L2</td>
<td>Block tablet</td>
<td>CTCSL3</td>
<td>KLUB-U</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(ETCSL2)</td>
<td>(ETCSL2)</td>
</tr>
<tr>
<td><strong>Coupler</strong></td>
<td>Height</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>880~830mm</td>
<td>890~835mm</td>
<td>880mm</td>
<td>1050~950mm</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td></td>
<td>AAR</td>
<td>CA-3</td>
</tr>
<tr>
<td><strong>Brake System</strong></td>
<td>P4a</td>
<td>N.A</td>
<td>Type 120, 120-1</td>
<td>GOST No.483</td>
</tr>
<tr>
<td></td>
<td>KRF-3 System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Freight train formation (cars)</strong></td>
<td>25</td>
<td>35</td>
<td>50</td>
<td>70~140</td>
</tr>
<tr>
<td><strong>Tolerance to Cold</strong></td>
<td>-35°C</td>
<td>-</td>
<td>-50°C</td>
<td>-62°C</td>
</tr>
<tr>
<td><strong>High Speed (freight, km/h)</strong></td>
<td>120</td>
<td>40</td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td><strong>Max axle load (ton)</strong></td>
<td>22</td>
<td>16.8</td>
<td>23</td>
<td>23.5</td>
</tr>
</tbody>
</table>
Technological Obstacles and Efforts to Overcome

**Obstacles**

- **Difference in Track Gauge**
  - Korea and China use standard gauge (1,435mm), while Russia uses wide gauge (1,520mm)

- **Compatibility of Coupler**
  - Coupler's shape and mounting height is different among Korea, China, and Russia

- **Operability of Brake System**
  - Brake system may cause some problems when applied to trainset that is composed of more than 50 cars and operated in extremely cold region

**Technological Solutions**

- **Gauge Changeable System**

- **Multi-Shape Coupler**

- **Cold-resistant Brake System**
  (Also Applicable to Long Trainset)
Gauge Changeable System
## Technical Alternatives for Different Gauges

<table>
<thead>
<tr>
<th>Method</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transshipment</td>
<td>Easiest method</td>
<td>Large Yards High Cost Labor-intensive Increase of damaged goods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bogie Exchange</td>
<td>Decrease of damaged for lost goods</td>
<td>Long time (4~6 hours, 25 bogies) Lifting jack and exchange devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gauge-changeable System</td>
<td>Short time (less than 1 hour) Silent movement Proper way for dangerous goods</td>
<td>Large initial cost Difficulty of maintenance in long distance service</td>
</tr>
</tbody>
</table>
Research Period: 2007-2014

Objectives
- Development of gauge-changeable bogie which can cope with both standard and wide gauge

Participating Organization: KRRI, Sungshin RST

Future Plan: Large-Scale National R&D Project
- Full-scale locomotive with gauge-changeable system
Specification of Gauge-changeable Bogie

- Gauge: 1435 / 1520mm
- Allowed Axle Load: 20 ton
- Max Velocity: 120km/h (Empty), 100km/h (Full)
- Distance of Axels: 1,800mm
- Diameter of Wheel: 860mm
Performance Test

- Laboratory test
  - Pass the lab test such as operation test, fatigue test, and impact test in the extreme environment -80°C

- Dynamic Test
  - Bogie is stable up to 200km/h in both standard and wide gauges in the indoor driving test

- Test-track Driving Test
  - Bogie switches normally between standard and wide gauges in short-distance driving test

Standard Guage (1,435mm)  Wide Guage (1,520mm)  Short-distance Test-track (15m)
**Comparison with Other Country System**

- Operation is possible in very cold regions
- Low failure rates and high durability due to relatively small number of parts
- Increased speed and efficiency due to low weight

<table>
<thead>
<tr>
<th></th>
<th>Korea (KGCW-85)</th>
<th>Poland (SUW2000)</th>
<th>Germany (DBAG RAFIL-V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modular Equipment</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
<td>![Diagram]</td>
</tr>
<tr>
<td>Safety Catch (Locking Device)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Number of Parts</td>
<td>23 (including safety catch)</td>
<td>39</td>
<td>23</td>
</tr>
<tr>
<td>Weight of Wheelset (kg)</td>
<td>1,535</td>
<td>1,700</td>
<td>1,750</td>
</tr>
<tr>
<td>Weight of Locking Part (kg)</td>
<td>302</td>
<td>449</td>
<td>499</td>
</tr>
<tr>
<td>Axel Load (ton)</td>
<td>22</td>
<td>20~22.5</td>
<td>23.5</td>
</tr>
<tr>
<td>Diameter of Wheel (mm)</td>
<td>860</td>
<td>920</td>
<td>920</td>
</tr>
<tr>
<td>Examination with Naked Eye</td>
<td>Easy</td>
<td>Difficult</td>
<td>Difficult</td>
</tr>
</tbody>
</table>
Multi-Shape Coupler and New Brake System
Project to develop multi-shape coupler and new brake system

- Research Period: 2016.7 ~ 2020.4 (4 years)

- Participating Organization: KRRI, Yujin Inc, Cheonho Casting Inc, Whashin ELT Inc, LeeNTech Inc

- Objectives
  - Multi-shape coupler applicable to both AAR-type and CA-3 Type
  - Brake system that operate normally at less than -50°C and can be applied to long freight train that have more than 50 cars
Due to the difference in coupler shape and mounting height, AAR type and CA-3 Type are not compatible.

<table>
<thead>
<tr>
<th></th>
<th>Korea</th>
<th>China</th>
<th>Russia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>AAR &quot;E&quot;</td>
<td>AAR &quot;E&quot;</td>
<td>CA-3</td>
</tr>
<tr>
<td><strong>Shape</strong></td>
<td><img src="image" alt="Korea Coupler" /></td>
<td><img src="image" alt="China Coupler" /></td>
<td><img src="image" alt="Russia Coupler" /></td>
</tr>
<tr>
<td><strong>Size (L x W x H)</strong></td>
<td>850.9 x 420 x 422 mm</td>
<td>850.9 x 420 x 422 mm</td>
<td>1,000 x 440 x 421 mm</td>
</tr>
<tr>
<td><strong>Mounting Height (mm)</strong></td>
<td>880</td>
<td>880</td>
<td>1,060 ± 20 mm</td>
</tr>
<tr>
<td><strong>Compression Load (ton)</strong></td>
<td>220</td>
<td>232</td>
<td>N.A</td>
</tr>
</tbody>
</table>
Couplers with different heads that can rotate 90 ° on one axis
Possible to select required coupler head regardless of whether it is AAR type or CA-3 Type
Mock-up of Multi-shape Coupler

- Full Scale Mock-up

Connecting cars between Korea and China (AAR type)

Connecting cars between Korea and Russia (CA-3 Type)
Korea, China and Russia use different brake systems such as P4A, TYPE 20 and GOST respectively.

<table>
<thead>
<tr>
<th></th>
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<th>China</th>
<th>Russia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brake System</strong></td>
<td>P4a KRF-3 System</td>
<td>Type 120</td>
<td>GOST No.483</td>
</tr>
<tr>
<td><strong>Braking Pressure (Kg/Cm²)</strong></td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Braking Method</strong></td>
<td>Rubber Diaphragm</td>
<td>Rubber Diaphragm</td>
<td>Rubber Diaphragm</td>
</tr>
</tbody>
</table>
Expected Problems When Operating Freight Train in Eurasian Railway

- Both brake delay and over-braking can be occurred due to the differences in the number of cars that compose a freight trainset, operation speed, and weight of freight.

- Extremely low temperature can cause malfunction of brake due to hardening of Rubber Diaphragm, lubricant and etc.

- Hose coupler can not be connected directly due to the difference of size.

<table>
<thead>
<tr>
<th></th>
<th>Korea</th>
<th>China</th>
<th>Russia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trainset (cars)</td>
<td>20~30</td>
<td>50~100</td>
<td>50~100</td>
</tr>
<tr>
<td>Speed (km/h)</td>
<td>120</td>
<td>60~70</td>
<td>60~70</td>
</tr>
<tr>
<td>Operating Temperature (℃)</td>
<td>-35</td>
<td>-50</td>
<td>-60</td>
</tr>
<tr>
<td>Hose Coupler</td>
<td>![Hose Coupler Image]</td>
<td>![Hose Coupler Image]</td>
<td>![Hose Coupler Image]</td>
</tr>
</tbody>
</table>
Key Features

- Switching valve to adjust build-up and release time of brake
- Switching device to control braking force according to speed, number of cars, and etc
- Cold-resistant rubber diaphragm which can operate normally below -60°C
- Adapters for connecting various types of hoses

Diagram of Improved Brake System
The project for coupler and brake system is in the beginning stage

We expect to complete the project in the next three years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology Development Objects</th>
</tr>
</thead>
</table>
| 2017 | - Detailed Design  
     | - Durability and Collision Analysis                |
| 2018 | - Prototype Production                             |
| 2019 | - Performance Evaluation of Prototype              |
| 2020 | - Field Test                                       |
Concluding Remarks

- Cooperation among countries will contribute to the development of Eurasian railway technology.
- We are looking forward to the day when the railroad is connected from Korean peninsula to Europe in the near future.
Thank you