CHINA High Speed Train

The key technologies and maintenance system

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Speed upgrade on existing railways: 200 ~ 250km/h, 8000 km

- 41 Passenger Dedicated Lines by 2012, more than 13000 km;
- 16000km by 2020
CRH R&D System
Contents

- Key technologies for High Speed Trains
- HSTs Maintenance System in China
- Challenges to CRH
Key technologies for HSTs

- EMU Integration
- Bodies
- CCU (Train Network)
- Pantograph
- Bogies
- Braking System
- TCU
- Transformer
- Convertor
- Motor
- Traction System
Key technologies -- System Integration

1 Technical Standard System for EMU

101 General, Basic Standards and Standard for System Integration

102 Standards for Car Body

104 Standards for Cab Layout and Equipment

106 Standards for Braking System

108 Standards for Electrical Connection

110 Standards for Water Supply and Sanitary equipment

112 Standards for Control, Diagnosis and Monitoring System

114 Standards for Disaster Prevention and Emergency

103 Standards for Bogie

105 Standards for Traction and Electrical System

107 Standards for Auxiliary Electrical System

109 Standards for Interior Environment Control System

111 Standards for Train Network

113 Standards for Maintenance

115 Standards for Informationization and Others
Key technologies -- System Integration

HSTs’ systems integrators – CSR & CNR

A high level of technology platform and R&D team of innovation

The world first-class bogie, car body, assembly, debugging production lines

- new-built 300 EMUs/year
- overhaul 200 EMUs/year

The whole manufacturing process technology design, craft standard system

Continuous improvement technology innovation system
Key technologies -- Bogies

Structure function

• Running Machinery
• The core of HSTs
• Loading, directing, suspension, traction and braking etc.

Keys

• Anti-roll movement
• Derailment safety
• Structural strength and reliability
Nonlinear critical speed >550 km/h

- Improving box positioning stiffness according to line conditions
- Selecting yaw damper parameters, and ensuring redundancy
- Determining the maintenance cycle to ensure a good equivalent conicity
Key technologies -- Bodies

Structure characteristics
• Thin-walled cylindrical aluminum alloy welding structure
• Drum wide body (3.3m), Large sections (11.2m²)
• Thin (1.5mm) and long (25m) profiles
• Overall carrying, hanging equipment to the base plate

Keys
• Structure strength
• Modal designing
• Vibration and noise reducing
• Drag reducing
Key technologies -- Bodies

Aluminum alloy car-body Parameters

- more than 20 years service life
- ±6000 Pa airtight strength requirements
- Weight: less 8.5t, under 15% of total

Airtight fatigue strength analysis
Key technologies -- Bodies

Vibration and Noise Control

- The conventional measures of sound isolation/absorption, have little effect on structure-borne noise.

- As shown in the Fig., the study needs to emphasize optimizing the structural design and controlling the vibration mode of structure.

- However, the body of the train is a 25m-long enclosed sheet. For such a structure of large enclosed strip, body mode and interior acoustic mode easily resonate due to external excitations like wheel-rail. The resonance might cause acoustic-structure coupling.
Key technologies -- Bodies

- Mastering the noise source distribution and spread rule
- Analyzing the interior noise spectrum

Measures to damp the vibration and noise

- Damping sources
  - Pantograph Dome
  - Wheel Coating
  - Gangways

- Isolating
  - Isolating roof frame
  - hollow chassis
  - Decorating Materials

- Absorbing
  - Using Sound-absorbing materials in decoration and frame

- Vibration reducing
  - Floating floor
  - Elastic suspension
  - Vibration-proof decoration
An optimization process to reduce drag, noise, pressure waves and lift
Key technologies -- Pantograph

Requirements

• Excellent aerodynamics
• Less drag and noise
• Good following
• Better matching between the skate and line

Keys

• Stable current-collection with simple catenary structure at 350km/h
• Stable current-collection with two pantographs
• Drag and noise reduction
• the fully compensated simple catenary system
• the novel copper base alloy contact wire with high tensile strength and well conductivity
• optimizing the space between the two pantographs
• optimizing the pantographs’ dynamic performance
• improving debugging technologies
Key technologies – **Traction system**

**Power-distributed, AC-DC-AC traction drive system**

**Keys**

- Lightweight shell-type transformer
- High-power, small size converter
- Lightweight traction motor and gearbox
- Traction Drive Control Technology
- High-power IGBT module

[Diagram of traction system components]
Key technologies – Traction system

**Target:** Modular, lightweight, small size, high power, high efficiency

**Improving:**
- Synchronous control technology
- Changing the ratio of motor and trailer cars
- Increasing the power of traction motors
Key technologies – Braking system
Key technologies – Braking system

Emergency brake: only for safety
Service brake: ED brake preferred, environment friendly.
Parking brake: Parking reliable
Backup brake: Perfectly safe
WSP: Special for High Speed
Fault diagnosis: Real-time Monitoring
High capacity brake discs: heavy load
Key technologies – Braking system

Fault-safety principle:

Abiding “Safety First”
Avoiding “out of brake”
“unexpected brake”
“Breakdown”
Key technologies – Braking system

**Keys:**

- ED-EP blending control
- High speed WSP
- High capacity brake discs
- Deceleration acc.to adhesion
- Short brake distance at 350km/h
Key technologies — Network Control System

Network Structure and Composition

Maintenance for system operation fault

Combined adjusting and test on System

- Communication protocol test
- Control logic test
- Diagnosis logic test
- Subsystem function test
- Subsystem fault simulation

Software System

- Train control
- Train diagnosis
- Simple control
- Control monitor

Communication protocols’ configuration

Hardware system

- Central control
- MMI
- I/O unit
- Sub-control unit

Semi-Physical Simulation and testing platform

Software test platform

Hardware test platform
Key technologies — Network Control System

TCU and CCU Simulation

Semi-Physical Simulation platform
For 16-car-electrical-multiple units
Key technologies — Network Control System

Wireless transmitting device:
transmit real time EMU fault information and operation status
provide maintenance guidance and advices;
inquire and statistically analyze faults through established website
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Application characteristics of HSTs in China

- High speed
- Long running mileage
- Complicated operating environment
- Large passenger flow

Technical elements of CRH maintenance

- Conditions Monitoring and Faults Diagnosis Technology
- Information-based Technology of Life-span Prediction
- Technology of Reliability
Key technologies

(1) Damage consistence

According to the damage consistence criteria of load spectrum, the load spectrum of complicated structures of EMU were edited to provide the definition of maintenance period or life with the quantitative basis.

(2) Nondestructive testing

The initiation and spread law of fatigue crack were studied continuously. The test interval of EMU hollow axle, wheel and bogie were adjusted and optimized.
Key technologies

(3) Wheel-rail relation

The matching relationship of wheel-rail materials and the wheel-rail contact fatigue were systematically studied, and the wheel rotary cutting cycles were optimized to ensure the dynamics performance of EMU and the traveling comfort of passengers.

(4) Lubrication

In connection with rotating components just like the bearings, the continuous studies of friction, wear and lubrication were implemented. Based on the statistical data analysis, the oil filling and replacement periods of bearing were reasonably adjusted so as to suit the operational conditions of high speed and long running distance.
Key technologies

(5) Information system

The application and maintenance management information system of EMU was established to realize the real-time control of dispatching, on-site operation, parts management and so on.

(6) Life cycle cost

Through implementing the modeling, calculation, analysis, and evaluation of life cycle cost for high speed trains, the foundation of economy were provided for the selection of design, material, craft as well as maintenance strategies.
HSTs Maintenance System in China

the EMU Inspection and repair layout in China
Primary contents of all levels of maintenance procedures

(1) Level-1 maintenance-- Routine inspection

including the routine inspection of bogie, braking and pantograph as well as the toilet sewage discharge and cleaning, etc.
Primary contents of all levels of maintenance procedures

(2) Level-2 maintenance-- Special maintenance

mainly including the crack detection of hollow axle and wheel, tread surface modification, gearbox oil replacement, bearing lubrication and functional tests of important systems and components, etc.
(3) Level-3 maintenance—decomposition inspection of some important components, esp. bogies

mainly including the decomposition inspection of those key spare parts, such as bogies, traction motors, braking system, air-conditioning and ventilators etc, as well as the implementation of functional test of each important system.
Primary contents of all levels of maintenance procedures

(4) Level-4 maintenance—overall decomposition inspection of some important systems

mainly including decomposition inspection of important system and its subsystem of EMU, such as bogies, pantographs and braking systems, performance tests of motors and electric devices, painting and repair of vehicle bodies, as well as the maintenance and decoration of facilities in vehicles.
(5) Level-5 maintenance—overall decomposition inspection of the whole vehicle

Including the decomposition inspection of the whole vehicle and renewing the spare parts in a large scope, as well as the modernization upgrading and improvement, such as the train decomposition, inspection, repair, overall cleaning, pressure seal inspection and vehicle body repainting.
Basic Process Flows of Overhaul

- Evaluating Reception
- Lifting EMU and lowering steering wheel
- Inspect the bogie
HSTs Maintenance System in China

- **Dynamic debugging**
- **Weighing**
- **Delivery**
- **Lowering EMU and marshalling**
- **Static debugging**

图 5 大修基本流程图
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- Key technologies for High Speed Trains
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Challenges — EMU seriations

- Over 5000km from south to north and east to west
- Climatic conditions: cold, high temperature, and high humidity, sand, strong corrosion
- Transport requirements: High density, high speed, short-long combined with large-capacity
Challenges — EMU seriation

Design and manufacture of integration platform and customization techniques
Requirements Database

Mapping/description

Challenges — EMU seriation

Requirements

Subject Req.

- 沿海
  - 适应盐雾、高湿、高温及强风运行环境
- 城际
  - 大容量、中短途、快速乘降

Key Req.

- 定员
- 速度
- 动力学
- 制动距离
- 强度
- 轴重

Passenger Req.

- 客室布置
- 车内环境
- 旅客设施
- 娱乐
- 餐饮
- 特殊文化
Challenges — Intelligent EMU

Holographic information perceptual system

Data transmission and processing platform

Intelligent EMU System application platform
Challenges — Intelligent EMU

Functions:
- **Clearly seeing**: real-time Space-time location and synchronous reiteration
- **Well controlling**: safety judging and decision-made
- **Good maintenance**: conditions monitoring and maintenance suggestions
- **Quality service**: Travel information, plan and ticket services

Difficulties:
- Engineering application of content network to EMU
- Efficient mass data processing, safety and reliability
- Modeling technology to system evaluation
- Expert system construction
- Personalized human-computer interaction
### Challenges — Intelligent EMU

#### Intelligent Monitoring
- **Application**
  - 状态监控: 列车监控、自然环境监控、牵引系统监控
  - 交互查询: 即时状态查询、历史数据查询
  - 异常报警: 列车运行状态、供电系统运行状态、线路运行状态

#### Intelligent Decision
- **Application**
  - 实时再现: 数据显示与状态监控
  - 应急响应: 应急响应策略、应急预案模拟
  - 决策管理: 预测预警、决策支持、安全评估

#### Intelligent Maintenance
- **应用**
  - 数据接入: 多源异质异构数据接入、转换集成
  - 可视查询: 实时动态数据、专家系统
  - 修竣工评估: 专家系统、数字化模型

#### Comp.
- 大型高分辨率显示设备: 实环境拟虚拟现
- GB级列车模型真实感绘制软件: 列车三维声响高保真表现软件
- 列车及运行环境动态监测数据实时可视化软件: 天气环境真实感模拟软件

#### Tech.
- Mass data real-time visualization: 高分辨率显示
- Hi-Fi virtual sound simulation: 多通道人机交互工具
- Multi-mode Human-computer interaction: 空间索引和空间查询软件
Thank you for your kind attention!