KKU Engineering Journal

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# Article title - Potential evaluation of rolling stock manufacturing in Thailand

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Received October 2013

Accepted March 2014

## Abstract

In the capital city of Thailand, the first electric railway system so called Bangkok Mass Transit System (BTS) has been established since 1999. And Thai Government has the master plan to develop the network for such mass transport system in order to reduce traffic congestion and pollution. However, experience and technology knowledge of the rolling stock are still unknown among Thai industries. Besides, the automotive industry in Thailand has shown robust growth despite the political conflict and economic situation. With contribution of component and material suppliers for automotive industry, Thailand has possibly high potential to develop and build the train with local contents based on the international railway industry standards, etc. For this reason, this research focuses on essential component structures for the train, international standards for railway industry and relevant technologies for product, production and testing. In addition, the questionnaire for the component and material suppliers in Thailand has been established under international standards and essential car train components. As a result, it reveals that there are high potential possibilities to support the rolling stock industries under the knowledge of relevant standards in some product modules of the body-strength-structure and auxiliary groups. However, the core knowledge and technologies for the product designs and testing in Thailand are the least in the least in the platform-suspension group.

**Keywords** : Railway standards, Technology roadmap, Rolling stock

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## 1. Introduction

From year 2010 to 2029, Thailand is planning to invest infrastructure for railway system in development of both current and extended public mass transportation. Such an Investment requires more than one million-million baht. However, Thai industries can involve only in civil and track works except for rolling stock, electrical and signaling works. Even though, those Thai industries have high potentials to make standard parts for related fields such as automotive, electronic, electrical, metal industries. This is because Thai Government did not understand and lack fundamental development for mass transportation in the past. As a result, the Office of Industrial Economics (OIE) has a master plan to develop railway and related industries within Thailand together with development of potential Thai industries through researches of product and production technologies [1]. For this reason, potentials of Thai industries for rolling stock manufacturing are evaluated. In addition, technology road maps of the essential parts for the rolling stock are introduced.

## 2. Methodology

In Thailand, the rolling stocks for Bangkok Mass Transit System (BTS) are belonging to Siemens Mobility [2,3]. These companies normally have set up their own standard requirements which take various international worldwide standards from different countries in order to ensure safe and reliable performance under normal and abnormal operations with minimal risks to passengers, personnel and members of the public. For example, there are various international standards for railway such as British Standard European Norm (BS EN), International Organization for Standardization (ISO), National Fire Protection Standards (NFPS), International Electrotechnical Commission (IEC) Military Standard (MIL-STD), Japanese Industrial Standards (JIS), American National Standards Institute (ANSI), International Union of Railways (Union Internationale des Chemins de Fer, UIC) etc. [4-11]. Therefore, these standards are reviewed and used to classify product parts of rolling stock. In addition, the identification of product, production and testing technologies are implemented through those standard requirements.

To develop Thai industry potential, the list of questionnaire for various product groups is developed under the relevant rolling stock standards [13]. Product part design and raw material source are the key questions for product technology. In addition, the production techniques in manufacturing and assembly processes are listed for production technology. Finally, the testing technologies under standard requirements to evaluate the performance and function of product parts in the rolling stock are added in the questionnaire. With this questionnaire, there are three different answers to develop product parts of the rolling stock for raw material technology sources, design process, production and testing technologies. Such three different answers are based on where core knowledge and technologies are developed. In the first answer for “A: Completely inside Thailand” there are three points of score which represents high potential to develop the parts in a specific core knowledge and technology. The second answer has two points of score which represents “B: Joint venture outside Thailand”. Finally, the answer of “C: Completely outside Thailand” has one point of score. Therefore, the samplers should select the questionnaire among the rolling stock groups based on their expertise industries.

The target sampling groups which are exclusively selected to answer the questionnaire are from the leading companies in Thailand from Thai Auto Parts Manufacturers Association (TAPMA), rubber, plastic and textile industrial groups with 49 well-known companies [14]. Therefore, there are 23 samplers from metal industries to fill the questionnaire for the body-strength-structure group. In the hydraulic/ pneumatic and mechanic industries, 21 samplers

are selected for the platform-suspension group. Finally, the total sampler number of the auxiliary group is 40 for various industries such as the plastic, thermal insulation, composite, glass, rubber materials, the air-conditioning system and passenger seats. The average score results from expertise samplers in core knowledge and technologies are collected. The score results of each questionnaire are weighted for 50%. And the rest for 50% are raised from the mechanical engineering team based on standard regulation requirements in this research in order to eliminate the bias factor from samplers.

To allocate high potential for the first short-term plan of each technology, the normal curve distribution is assumedly used together with categories of core knowledge and technologies. Thus, such result score should be between 2.50 and 3.00. For medium potential of the medium-term plan, score should be between 1.50 and 2.49. And Low potential for the long-term plan is between 1.00 and 1.49.

To simplify and develop and the technology roadmap for product, production and testing, research methodology is implemented as shown in Figure 1.

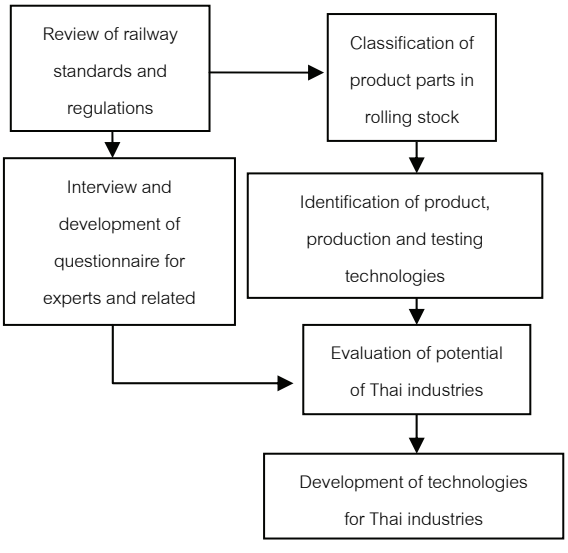


**Figure 1** Research methodology for evaluation of Thai potential industries

## 3. Results

Based on physical geometry of the rolling stock and relevant standards, it can be clustered into three groups i.e. body-strength-structure group, platform-suspension group, and auxiliary group. The first group consists of the car train main frame and the car body main structure as shown in Table 1. The second group is composed of the coupler and the bogie which includes the brake, suspension and the traction systems. The rest for the rolling stock is in the third group such as the interior accessories, car exterior, air conditioning system, pneumatic system, etc. The lists of rolling stock modules, section and relevant standards for second and third groups are shown in Table 2 and 3, respectively.

**Table 1** Standard based classification of rolling stock for body-strength-structure group

| Module | Part Unit | Relevant Standard No. |
|---|---|---|
| Car Train Main Frame | Main part; Front Bumper; | BS EN 10025; BS EN 10293; BS EN 10216-5; BS EN 3834-2; BS EN ISO 5817; BS EN 1999-1-3; BS EN ISO |
| Car body Main Structure | Roof; Side Panel; Floor panel; Front or rear end part; Car body Shell; Car body assembly; | 10042;BS EN 1993-1-9; ENV 1999-1-1; BS EN 12663; EN 287-1; DIN 6700; EN 473; Siemens SGP – Standard W01_75101245 |
| | Front mask; Water drainage; Rain gutter; Interior cable ducts; Cable duct partition wall; Conduit installation | DIN 5510-1; IEC 61133; DIN 5510 part 1-2; EN 50125-1, part 4.11; EN 50343 part 5.1-5.2.1-5.11-5.15; DIN EN 61373; DIN 5510-1; IEC 61133; |

**Table 2** Standard based classification of rolling stock for platform-suspension group

| Module | Part Unit | Relevant Standard No. |
|---|---|---|
| Bogie | Bogie main frame; Wheel; Axle; Bearing; Hard grease; Wheel speed sensor; Primary suspension coil spring; Secondary suspension air spring; Shock absorber; Stabilizer; Piping and wiring; Drive unit mounting arrangement; | DIN 5510-1; DIN 5510–2; DIN 5510-4; DIN 5510-5; DIN 5510-6; DIN EN 10204; DIN EN 1563; EN 287-1; EN 473; EN 13103; EN 13104; EN 60529; IEC 61133; IEC 61373; ISO 1005-3; ISO 2631-1; UIC 515-0; UIC 515-1; UIC 515-4; UIC 811-1; UIC 812-2; UIC 812-3; UIC 897-11; ASTM D4060-07; BS 3900-F4:1968; BS 7079-0; BS EN |

| | | |
|---|---|---|
| | Bogie connection; Painting bogie | ISO 180; ISO 11341; ISO 11998; ISO 12944-1; ISO 12944-4; ISO 1514; ISO 1518; ISO 2409; ISO 2808; ISO 2813; ISO 6860; ISO 7784-2; ISO 8501-1; ISO 8501-2; ISO 8504; ISO 8503 -1 |
| Brake | Dynamic brake resistor; Brake cylinder; Brake disc; Brake pad; Brake control unit; Pneumatic system; Sanders | BS 3682-1; BS EN 13452-1; BS EN 13452-2; UIC 540; UIC 541-1; UIC 541-3; UIC 541-4; UIC 541-5; UIC 541-05; UIC 547; EN854 |
| Coupler | Automatic coupler; Semi-permanent coupler | BS EN 60529; BS EN 12663; EN 1993-1-9; IEC 61373 |

**Table 3** Standard based classification of rolling stock for auxiliary group

| Module | Part Unit | Relevant Standard No. |
|---|---|---|
| Door | Door Main Structure; Door drive system; Door control system; Door switch; Emergency door system | BS EN 1993-1-9; BS EN 1999-1-3; NFPA 130; DIN EN 1288; DIN EN 52306; DIN 5514; DIN 5510-1; EN 50128; EN50129 |
| Lighting system | Exterior lighting cab; Interior lighting; Operator's cab lighting; Failure indication light; Electrical equipment for lighting | BS EN 60598-1; BS EN 60061-4: 1992 |
| Air condition and ventilation system | Compressor; Condenser; Evaporator; Fan; Roof ventilation hatches; Air ducts; Temperature sensor | DIN 5510-1 |
| Pneumatic system | Air compressor; Air tank; Air pipes; Air dryer unit; check valve; Safety valve | DIN 59753; ISO 2151; BS EN 10216-5; EN 854; BS EN 286 - 3 |
| Car exterior | Information board; Inter-car gangway; windscreen window; Wiper system; Stanchions; Footsteps; Door area cover; Warning horn; Spoiler; Labeling and painting; Conduit and wiring | DIN 5510-1; DIN 5512-3; DIN 5513; DIN 25200; UIC 566; BS 857; JIS R 3205; DIN 1249-10; DIN EN 1288; DIN 52306; UL 94-V1; DIN EN 356; ASTM D4060-07 |
| Car Interior | Seat; Rail and hanging handle; Interior cladding; Information board; Switch cabinet; Sidewall window; Ceiling Passenger Area | DIN 5510-1; DIN 5512-3; DIN 5513; DIN 25200; UIC 566; BS EN ISO 2439; BS EN ISO 3385; BS 6853; BS 476-6; BS 476-7; BS 857; JIS R 3205; ANSI Z26.1; DIN 1249-10; DIN 52306; UL 94-V1; DIN 25200; DIN EN 356; |
| Operator's cab | Operator's seat; Windshield complete; Insulation; Cab interior cladding; partition wall; Ceiling cab; Operator's desk; Operator's cab electrical arrangement | DIN 5510-1; DIN 5512-3; DIN 5513; DIN 25200; UIC 566; EN ISO 13920; DIN EN 61373 |

**Table 4** Thai industry potential score results for the body-strength-structure group

| Classification | Core knowledge and technology | Score |
|---|---|---|
| Product | 1. Metallurgy | 2.50 |
| | 2. Fatigue design for aluminum and steel structures | 2.17 |
| | 3. Computer - aided design | 2.50 |
| Production | 1. Arc welding for aluminum and alloy connectors | 3 |
| | 2. Fusion welding for iron, nickel, titanium and alloy connectors | 3 |
| | 3. Jig assembly | 2.5 |
| | 4. Metal forming | 2.5 |
| | 5. High precision machine | 2.5 |
| | 6. Measurement for foundation structure | 2.5 |
| | 7. Assembly and installation | 2.5 |
| Testing | 1. Non-distractive testing | 2.5 |
| | 2. Corrosion testing | 2.5 |
| | 3. Impact testing | 2.5 |
| | 4. Nonflammable testing | 2.5 |

**Table 5** Product priority of the body-strength-structure group for development in Thailand

| Essential product parts | Potential conditions |
|---|---|
| Floor and main structure | - Overall potential in Thailand is medium.<br>- Medium potential for designing, manufacturing and testing.<br>- Some of manufacturers have experienced in related industries e.g. car manufacturing.<br>- Local material can be used. |
| Roof, Side wall,floor plate, Side wall plate, Front wall plate, Back wall plate, Body shell of rolling stock, Passenger room ceiling | - Overall potential in Thailand is medium<br>- Medium potential for designing, manufacturing and testing<br>- High potential for welding technology<br>- Some of manufacturers have experienced in related industries e.g. car manufacturing. |
| Car train main frame of rolling stock and bumper | - Local material can be used |

**Table 6** Thai industry potential score results for the platform-suspension group

| Classification | Core knowledge and technology | Score |
|---|---|---|
| Product | 1. Metallurgy for brake pads | 1.5 |
| | 2. Product design with mechanic-dynamic controlled systems | 1.5 |
| | 3. High compression air | 1 |
| | 4. Metallurgy | 2 |
| | 5. Strength of Material | 1 |
| | 6. Design of automatic control system | 1 |
| | 7. Design of coil and air springs | 1.5 |
| | 8. Design of shock absorber | 1.5 |
| | 9. Design of stabilizing system | 1 |
| | 10. Strength design of bogie | 1.5 |
| | 11. Computer-aided design | 1.5 |
| Production | 1. Arc welding | 3 |
| | 2. Fusion welding | 2.25 |
| | 3. Assembly and installation | 1.5 |
| | 4. Coil spring forming process | 1 |
| | 5. Brake pad forming process | 1.5 |
| | 6. Jig assembly | 2 |
| | 7. Metal forming | 2 |
| | 8. High temperature product treatment | 1.5 |
| | 9. High precision machine | 2 |
| | 10. Measurement for bogies | 2 |
| Testing | 1. Vibration testing | 1 |
| | 2. Load test | 1.5 |
| | 3. Visual inspection for welding | 2 |
| | 4. High speed bearing test | 1.5 |
| | 5. Sensor testing | 1.5 |
| | 6. Corrosion testing | 1.5 |
| | 7. Leaking test | 1.25 |
| | 8. Brake efficiency testing for rotor and brake pad | |
| | 9. Impact testing | 1.5 |
| | | 1 |

**Table 7** Thai industry potential score results for the auxiliary group

| Classification | Core knowledge and technology | Score |
|---|---|---|
| Product | 1. Design of rack for baggage | 3 |
| | 2. Strength of Material | 3 |
| | 3. High strength of glass for high speed train | 2 |
| | 4. Laminated glass | 2 |
| | 5. Plastic, rubber, polymer and microfiber | 2.5 |
| | 6. Ergonomic design for chair and seat | 3 |
| | 7. Aerodynamic design of body accessory e.g. spoiler | 3 |
| | 8. Paint and varnish technologies | 3 |
| | 9. Fatigue design for aluminum and steel structures | 2.83 |
| | 10. Software design for automatic controlled valve | 2.75 |
| | 11. Computer-aided design | 2.83 |
| | 12. Heat transfer and air conditioning | 3 |
| | 13. Ventilation system | 3 |
| | 14. Sensor technology | 2 |
| | 15. Air compressor technology | 3 |
| | 16. Design air and nitrogen system | 2.25 |
| | 17. Design of aluminum pressure vessel | 2.5 |
| Production | 1. Metal forming | 3 |
| | 2. Polymer forming | 3 |
| | 3. High precision machine | 2.57 |
| | 4. Glass melting technology | 3 |
| | 5. Heat forming technique of glass | 3 |
| | 6. Laminated glass | 3 |
| | 7. Glass Coating | 3 |
| | 8. Plastic mold injection | 3 |
| | 9. Rubber Mold and extrusion | 3 |
| | 10. Paint and varnish process | 2 |
| | 11. Painting technique for metal and non-metal surfaces | 3 |
| | 12. Forging technology | 3 |
| | 13. Arc and fusion welding | 3 |
| | 14. Assembling and installation | 3 |
| Testing | 1. Flame distribution testing | 2.75 |
| | 2. Nonflammable testing | 2.8 |
| | 3. Ball and Bending tests | 3 |
| | 4. Strength and fatigue testing | 3 |
| | 5. Load test | 3 |
| | 6. Drag force testing for body accessory | 3 |
| | 7. Windshield wiper test | 3 |
| | 8. Scratch and wet-scrub test | 3 |
| | 9. Film thickness test | 3 |
| | 10. Welding cracks | 3 |
| | 11. Automatic system test | 3 |
| | 12. Safety system test | 3 |
| | 13. Air conditioning and ventilation system test | 3 |
| | 14. Leak test in the cooling system | 3 |

In the body-strength-structure group, most of manufacturers in Thailand have high potential to develop the structure for rolling stock in term of manufacturing process and testing especially for welding knowledge as shown in Table 4. However, knowledge and technology for fatigue design for aluminum and steel structure are the weakest point. Thus, most manufacturers require cooperation for aboard knowledge in the fatigue design. The essential product parts and potential conditions for manufacturing and their priorities in this group can be summarized according to product function as shown in Table 5.

Non-similar to the car-strength-structure group, manufacturers in Thailand have the least knowledge and technology especially in term of design and part testing for the platform-suspension group as shown in Table 6. In addition, overall potential in Thailand is low because most products are imported. For manufacturing process, modules of the brake and coupler units are very low. These are because these modules are safety parts which are related to the risk of passengers under the operation. However, the bogie module has medium potential due to the well-experience usage of welding technology in Thailand.

From Table 7, overall potential for manufacturing in Thailand is high, if the specification and standard requirement are declared under the usage of local material for the auxiliary group. In addition, most manufactures have high potentials in designing, manufacturing and testing the product modules. However, core knowledge and technology in the sensor of the air conditioning-ventilation system and testing for the drag reducer part should be supported from well-known manufacturers outside Thailand. In addition, the windshield wiper, Handrail, rack, interior wall and passenger door are safety parts which are related to the risk of passengers under the operation. Therefore, the safety requirement of these products should be studied for manufacturing these products in Thailand.

Generally, human resource development is significant in developed countries. For examples, a Canadian Railway company implemented the short-term and long-term plans for coordination design criteria and assigning of responsibilities and human training in the organization [15]. In China, the electric development plan for railway sectors started before 1978 under government controlled electricity sectors in formulating and enforcing regulations such as entry, pricing, and system security [16]. In 2005, there were large-scale railway manufacturing development and plan from urban to national areas resulting in the establishment of joint-venture network, technical experiences and human knowledge [17].

To develop railway industries in Thailand, the strategies for the short-term, medium-term and long-term plans can be related to the core knowledge and technologies of Thai industries where they are developed in locally, International joint venture and completely outside Thailand, respectively. Therefore, strategies for encouraging and developing railway technologies can be accomplished through products, production and testing for each product group. Specialization in standard and technical requirements of products, production and testing should be established in the medium-term plan for the body-strength-structure group. Furthermore, partner relationship among national and /or international organizations should be developed in order to transfer systematically knowhow and knowledge of safety products such as bogie, brake system and coupler for the long-term plan due to the safety parts. For example, the railway safety in Finland was developed over the past five decades [18]. For the body-strength-structure, auxiliary groups, the stimulation for bidding project conditions under Thai government support about the railway products in which local material usage of product parts and

manufacturing process should be initiated for the first short-term plan. Furthermore, specialization in the air conditioning–ventilation, producing and supplying units for the pneumatic system under standard and technical requirement should be established in the medium-term plan. In the short-term plan, the 2nd tiers with high potential in production technology in this group should be involved and supported in Thailand projects auction.

## 4. Conclusion

In the rolling stock, there are number of relevant standard requirements based on the product parts. These standards can be classified in three groups such as the body-strength-structure, platform-suspension, and auxiliary groups for a set of modules and part units. To involve national and global rolling manufacturing industries, Thai manufacturers should take relevant standards into account.

Most manufacturers from TAMPA, rubber, plastic and textile industrial groups have high potentials to produce some unit parts of the body-strength-structure and auxiliary groups for the rolling stock industries. Nevertheless, design and testing knowledge and technologies should be transferred and cooperated from the international organizations for the platform-suspension group.

For the development plan of the rolling stock industries in Thailand, local usage of material and manufacturing process should be initiated and supported from Thai government in the short-term plan. For medium-term plan, the air conditioning – ventilation and pneumatic system in the rolling stock should be established under the standard requirements together with the product and testing for the body-strength-structure group. Partner relationship with international rolling stock industries for the bogie, brake system and coupler should be developed for long-term plan due to high requirement of safety issues in term of design and testing.

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