Talk on Railway Power Supply & Distribution (PS&D) Systems
by Ir. Chew Weng Yuen

Ir. Chew Weng Yuen is currently a committee member in the Engineering Education Technical Division (E2TD).

The Engineering Education Technical Division had co-organized a talk entitled "Railway Power Supply & Distribution (PS&D) Systems" with Engineers Australia Malaysia Chapter, and the Institution of Mechanical Engineers Malaysia Branch, on 3rd May 2018, at Wisma IEM. The talk was delivered by Ir. Dr. Ling Chen Hoe who is currently the Senior General Manager and Director of Meiden Malaysia.

There were 22 participants in the talk, and Ir. Dr. Ling commenced by giving an overview of the railway power supply systems. Both the AC System and the DC System were illustrated. AC System is used to power the high speed Inter City or long-distance railway whereas the Intra City or short-distance railway (e.g. the MRT and LRT) used the DC System.

It was mentioned that the Rail Electrification systems are classified by three main parameters namely,

1. **Voltage** (25kV AC, 1500V DC, 750V DC);
2. **Current** (either Direct current (DC), or Alternating current (AC));
3. **Contact System**
   - Third rail (running rails as return current conductor)
   - Overhead Line Electrification (Catenary)

Railway electrification system supplies electric power to railway trains and trams without a local fuel supply. Electricity is generated in large generating stations, transmitted to the railway network and distributed to the trains. The railway usually provides its own distribution lines, switches and transformers while purchasing power from power utility suppliers.

Modern electrification systems take AC energy from the grid and convert it to DC to power the DC traction motors. Alternatively, AC motors with power electronics speed control characteristics are also used.

Ir. Dr. Ling informed that railways operate at variable speeds that is achieved via the usage of brush-type DC motors, although such DC can be supplied from an AC catenary via on-board electric power conversion. Speed was controlled by connecting the traction motors in various series-parallel combinations, by varying the traction motors' fields, and by inserting and removing starting resistances to limit motor current.

Because transformers (prior to the development of power electronics) cannot step down DC voltages, trains were supplied with a relatively low DC voltage that the motors can use directly. The most common DC voltages are 1500V and 750V. Third (and fourth) rail systems almost always use voltages below 1 kV for safety reasons while overhead wires usually use higher voltages for efficiency.

Since utilities supply high-voltage AC, DC railways use converter stations to produce relatively low-voltage DC. Because electrical power is equal to voltage times current, the relatively low voltages in existing DC systems imply relatively high currents. If the DC power in the contact wire is to be supplied directly to the DC traction motors, minimizing resistive losses requires thick, short supply cables/wires and closely spaced converter stations. Typical substation spacing are 1.5 – 2km for 750V DC systems for a six-car train operating at two-minute headways, and 3 – 4km for 1500V DC systems for the same operating criteria as mentioned above. The distance between stations is dependent on the power demand (load: no. of cars per train); operating headways (frequency of trains); system design (voltage, AC or DC); land availability (terrain, physical constraints).

Power is supplied to moving trains with a (nearly) continuous conductor running along the track via either the overhead line (catenary), suspended from poles along the track, or third rail mounted at track level and contacted by a sliding "pickup shoe". Both overhead wire and third-rail systems usually use the running rails as the return conductor but some systems use a separate fourth rail for this purpose.

Converter station is required every 2 kilometers on a 750V DC system as compared with every 20 to 50 kilometers for a 25kV AC line. It is easier to boost the voltage of AC than DC and to send more power over long distance transmission lines with AC. Notwithstanding, DC is the preferred option for shorter lines and better suited for urban applications. Apart from only requiring a simple control system for the motors, the smaller size of urban operations meant that trains were usually lighter and needed less power.

AC electrification system consists of traction transformers which convert 3-phase alternating current into 2-phase alternating current. The advantage of high voltage (25kV) AC traction system is its bigger capacity. The disadvantage is that the AC overhead contact line system is prone to failure requiring regular maintenance plan on a 24-hour basis. Another factor for consideration is the potential electromagnetic interference and the impact of the magnetic fields on properties and activities that are close to the line.

The major components and typical configuration of railway power supply and distribution systems were next discussed. The AC traction power supply equipment are the traction transformer (for main power supply); auto transformer (installed in substation for power feeding to trains); railway static power conditioner; and switchgears. The DC traction power supply equipment are the 750V / 1500V DC switchgears; rectifier; re-gen power product (inverter, energy storage system); and others such as the overhead contact system inspection system (catenary eye).

Prior to ending the talk, Ir. Dr. Ling gave a brief review of the high-speed rail (Shinkansen) in Japan and also some insight into the future train systems such as the non-electric traction system (i.e. Maglev that uses superconducting magnets); the hyperloop that speeds along a “magnetic river”, propelled by linear induction motors and levitated by powerful magnets; and the hydrogen-powered trains.

Ir. Dr. Ling Chen Hoe discussing a topic during his talk on Railway PS&D Systems.