Performance Characteristics of Conductors for Electric Traction on Indian Railways

This paper describes the trend of Railway Electrification, as planned in the coming years followed by the options available for Copper conductors, which may replace the material being used currently, offering a long term solution for higher speeds and increased traffic."

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1. Electric Traction in India

Indian Railways System covers a network of 64,600 Route Kilometers (approx.) with a total Track Km of 1,15,000 (approx.). It deploys both mode of traction system i.e. Diesel & Electric to operate the train services. The Electric Traction mostly operates at 25kV, single phase, a.c., 50 Hz system.

A total of 30,012 RKM stands electrified as on 31.03.17, which represents 51 % of total Broad Gauge route kilometers of IR (58,825 RKM) and electrification works are in progress on other routes. At present almost 66% goods traffic and 51% passenger traffic are being hauled by Electric Traction.

Railway Board has advised an ambitious plan of electrification of balance route kilometres, to be carried out in the next 3 years, which means an average of 11000 RKMs in a year.

The electrification is planned to be undertaken through various agencies such as CORE,RVNL,RITES,IRCON and PGCIL (PSU of Ministry of Power)

2. Present & Future Demand

The analysis based on the existing designs, reveals that electrification of 100 route kms require copper to the tune of 670 tonnes for various conductors, equipments and cables provided in the system. Out of this, 450 tonnes copper meant for overhead conductors is purchased by Railways and OHE Contractors and the balance 220 tonnes is supposed to be arranged by the respective manufacturers of the equipments. The annual demand would depend on the electrification work sanctioned and targeted for Electrification from time to time.

With the planning of electrification of 33000 RKM over a period of 3 years, the requirement of copper wire rod for various conductors shall be approximately 48,600 MT on an average every year. Apart from this, there will be requirement on account of annual replacement work. In addition there shall be requirement for Metros and Dedicated Freight Corridors also.

3. Challenges ahead and scenario development

The scenario ahead appears to be promising. The tempo at which the electrification is taking place is most visible at this time than in any other period. Not only is the Indian Railways going ahead with its plan of electrification, the pace of Metro systems coming up is terrific. The cities having population more than 10 Lakhs have been earmarked for rapid rail transit solutions, be it Metro or Local (as is the case of Rapid Metro in Gurgaon). Add to this, the Dedicated Freight Corridors and you are looking at multiple opportunities.

The OHE components employed in the new electrification works are also drawn from different specifications, thanks to international experts being at the helm of affairs , as far as technical advice to Metro and DFC is concerned. Indian Railways is also looking at various options to capitalise , so that a long-term strategic plan is able to be put in place.

4. Major copper items of Electrification

The Contact & Catenary Wire comprise of the major share of cost of Electrification works and are vital components to run the train services. The size, type of material and specification used in manufacturing of Catenary Wire & Contact Wire employed on different Sections of Indian Railways on 25 kV AC are given below.

Sl.No	Catenary Wire			Contact Wire		
	Size (mm^2)	Material	Specification No.	Size (mm^2)	Material	Specification No.
1	65	Cu-Cd	ETI/OHE/50 (6/97) with A&C Slip No. 1 to 5.	107	Hard drawn copper	ETI/OHE/76(6/97) with A & C Slip No.1, 3, 4, 5 6 & 7, 8 & 9

RDSO has developed the Specification No.ETI/OHE/50(6/97) of Cadmium Copper Catenary Wire drawn through Cadmium Copper rod, Wire bars, Electrolytic Copper Cathode and Specification No. ETI/OHE/76(6/97) of joint-lessHard Drawn Grooved Copper Contact Wire drawn out from Continuous Cast Copper (CCC) Wire Rod of Southwire process. These specifications have been amended time to time based on development, field performance and quality control.

5. Focussing on performance and linking to product manufacturing

For a long time, IR has been devotedly zeroing on the product specifications and methods of manufacturing and testing. In course of this endeavour, at a number of times, the specifications have been bound by stringent composition or specific methodology. While it has served us well till now, the opening up of the sector has prompted us to take a deeper look and if required, review some of the long-standing practices.

One such area is the Conductors for Electric Traction. As explained earlier, we use different material for Contact and Catenary wires. For contact wires, the 107 sqmm Hard Drawn Grooved Copper contact wire has been used. For catenary wire stranded Cd-copper wire of 65 sqmm is employed universally.

The main features required by IR for sustained performance of these conductors can be summed up as under:

(a) Tensile strength
(b) Conductivity

Therefore, if one were to focus on the performance requirement and leave it to the manufacturer to opt for a suitable method, keeping the quality control check-points pre-defined, it should be technically possible to get a high quality product, without specifying in great detail the composition, manufacturing method or specific testing apparatus.

This is what is being professed through this paper, so that once such proposals take shape, they are accorded approval at the required levels.

6. Contact Wire

At present we are using 107 sqmm contact wire made by CCC Rod of specified diameter, produced by Southwire Licensees only. This is on account of the proven performance of the product manufactured though this process.
It is pertinent to state that with higher speeds, the use of Cu-Ag contact wire is being considered. Use of silver will make the wire sustain higher currents without any loss of strength. Again, mentioning of CCR process should be good enough for the properties to be achieved. RDSO has, therefore, proposed to Railway Board that the Cu-Ag wire should be allowed to be manufactured from this process, notwithstanding the proprietory licensees. Once the proposal is approved and the various stakeholders converge on the brass-tacks, the future of Indian Railways shall be only 107 sqmm Ag-Cu wire, till such time we upgrade to speeds in excess of 200kmph.

While going through the designs submitted by one of the Metro systems, it is seen that their experts have proposed use of higher diameter wire rod (extruded

out of low dia CCC Rod) for manufacture of Contact Wire. This is an area hitherto untried by railways and this is being tried out. If successful, the dependence on foreign sources for higher dia HDGC contact wire may be a story of the past.

7. Catenary Wire

In case of Cadmium-Copper Catenary wire, the replacement is more of a necessity. This is on account of Cadmium being a material hazardous to environment , already banned by several countries .

Cadmium is not an element that is used by the body, and it is toxic. It mainly affects kidneys and bones. It is also a carcinogen by inhalation. Cadmium can accumulate in liver, kidneys and bones, which may serve as sources of exposure later in life.

In the environment, cadmium is toxic to plants, animals and micro-organisms. Being a simple chemical element, cadmium is persistent – it cannot be broken down into less toxic substances in the environment.

While going for the replacement by Copper-Magnesium, the retention of properties is a major technical challenge. The tensile strength is a function of percentage of magnesium. However, the increase in magnesium may lead to reduced conductivity, which suggests a trade-off.
Discussions with leading manufacturers is indicative of the possibility of meeting both criteria with a specific chemical composition.

Since the manufacturing of Cadmium -laden and Magnesium -laden Copper is entirely different, due to inherent properties of materials involved, RDSO proposes to specify no more that Vertical Upcast method, refraining from mentioning the proprietory references. Since it is truly an R&D -centric project, the sizes of rods and wires and number of strands also may need to be worked out in the laboratory.

8 . The Possible Solution

The final combination could be a 107 sqmm Copper-Siver Contact Wire and 65 sqmm Copper-magnesium catenary, capable of handling the increased currents as well as sustain higher mechanical strength.
This would be a desirable situation for Indian Railways.

9. The way forward

From the above, it must be clear that exciting times are approaching for the R&D, manufacturing and entrepreneurs alike, so that, by pooling of their resources, they are able to make the future of electric traction much better than the present. With international expertise at hand and Make-in-India concept as the cornerstone, I am sure that in coming years, Indian railways will present before the world technically strong, transparent and performance-oriented choices, to opt from.