Role of non-ferrous metals and alloys in railway engineering

K. C. CHOUDHURI

THE non-ferrous metal industry in India has been passing through difficult periods due to successive emergencies and war crises in the country. As a consequence of these crises, a series of chain reactions have been set up notable amongst which has been the acute need for 'Import Substitution' and 'Self-Sufficiency'. These unforeseen events have undoubtedly cast their shadows on the general growth pattern of non-ferrous metal industry in India which is by and large still dependent on large quantities of import.

It is now well-known that while possessing some resources of non-ferrous metals such as bauxite, magnesite, ilmenite and manganese, India is highly deficient in copper, zinc, lead, etc., which are required for our fast developing economy. Metals such as nickel, tin, molybdenum and tungsten either do not exist or are, perhaps, found in isolated, uneconomic pockets even though with more intensified exploitation and prospecting, etc., some economic deposits may be discovered.

The Railways' role in the development of our country is not small and in fact Railways are the life line for the rapid industrialisation and their importance in our country is on the increase. The non-ferrous metals have important applications in almost all the fields of Railway Engineering due to their wide range of properties including resistance to corrosion and wear, strength with ductility, antifriction properties, etc., and are used mainly in the form of castings, extrusions, plates, sheets, wires, etc. Lately, due to scarce position of non-ferrous metals in our country and continued drive towards self-sufficiency, their consumption has considerably been brought down. Efforts are being continued to further bring down the figures for the requirement of non-ferrous metals in the field of railway engineering but the task is tremendous since Railways have to maintain large fleets of locomotives, carriages and wagons to keep the life line in a developing economy.

Demand and production trends for major non-ferrous virgin metals in India

To meet the incessantly growing requirements of the non-ferrous metals we have to depend largely on metals and semis imported from abroad. Therefore, development of non-ferrous industry in India is a vital necessity to enable this country to meet its fast growing industrial requirements under the tempo of successive five-year plans.

The estimated demands in India of some major metals by 1967-68, 1968-69, 1969-70 and 1970-71 are given in Table I.

The production trend of various non-ferrous metals during the last ten years is furnished in Table II which will give an idea of the development of this vital industry.

It will be seen from the above, that we are very much dependent on imports to meet our non-ferrous metal requirements.

Mr K. C. Choudhuri, Director (M&C), Research Design and Standards Organization, Lucknow.

SYNOPSIS

While possessing some resources in bauxite, magnesite, ilmenite and manganese, India has scant deposits of copper, zinc, lead, etc., and practically no resources regarding nickel, tin, molybdenum and tungsten. The development of non-ferrous industry is vital to India's industrial growth and recent successive emergencies and war crises have catalysed India's efforts in seeking self-sufficiency and import substitution. Figures are given by way of tables high-lighting the gap between the estimated demands and production trends of various non-ferrous metals in India. The extensive use of non-ferrous metals and alloys in railway equipment is then elaborated and the work done in the railways and railway research laboratories in subsituting indigenously available non-ferrous metals for imported ones, is explained item by item. The Indian railways have made large strides in their endeavours towards self-sufficiency from a position of 70% dependence on imports in 1920-21 to a mere 11% today. Railway engineers have sought to overcome shortages of copper, zinc, etc. by increased use of aluminium in which India is expected to be self-sufficient soon.

Use of non-ferrous metals and alloys on Indian Railways

Non-ferrous metals and alloys are used in the wide

TABLE I Estimated demands of the major non-ferrous metals (in thousand tonnes)

Metal	1967–68	1968–69	1969–70	1970–71
Aluminium	130	180	240	300*
Copper	90	120	150	175**
Lead	55	65	85	105**
Zinc	90	100	115	130**
Tin	5·50	6·00	7·20	8·52**
Antimony	1·10	1·20	1·35	1·50***
Nickel	3·30	4·00	5·00	6·00

* Estimate by the study group on the growth of aluminium industry appointed by the Department of Mines and Metals, Jan., 1968.

** Estimate by the Perspective Division of the Planning Commission, Sept., 1966.

*** Estimate by DGTD.

field of railway engineering for the manufacture of steam, electrical and diesel locomotives, carriages and wagons, signal and telecommunication, electrical equipment, and for coating of mast and structures for traction, telephone and telephone lines, etc. The main non-ferrous metals and alloys used are copper and copper base alloys, antifriction metals, known as white-metal and zinc for metallic coating against corrosion. Copper and its alloys are characterised by their moderate strength combined with ductility and are found to meet the service requirements in respect of mechanical properties while other advantages include high electrical and thermal conductivities, non-magnetic qualities, good bearing properties and excellent resistance to both corrosion and wear.

In the Railways, non-ferrous metals and their alloys are mostly used in the manufacture of castings due to ease in production. In addition to resistance to corrosion and wear, some types of castings such as boiler mountings have to meet pressure tightness. The castings used in railway engineering can be broadly classified in the following groups :

(i) Phosphor bronze is used for manufacture of heavily loaded details which are subjected to friction where anti-friction metal is not employed such as locomotive slide valves, oil lubricated side rod and motion brushes, steel axle box side and boss liners, pony pivot bushes, bogie centre plates, oil lubricated connecting rod, small end bushes, etc.

(ii) Gun metal castings are used for boiler mountings and steam and water pressure fittings, such as injector starting valve body, fusible plugs, relief valves, drifting valve body, whistle valve body, steam stand stuffing box, etc., where resistance to corrosion and high steam pressure tightness are of primary importance.

(iii) Two types of leaded bronze castings are used ; one with higher lead content 14–16% and the other with 9–11%. These castings are mainly used for the manufacture of grease lubricated non-ferrous axle boxes, carriages and wagon bearing shells, grease lubricated side rod motion bushes, grease lubricated connecting rod bearings, etc., where bearing properties are of prime importance.

(iv) Leaded gun metal castings are also used for the manufacture of carriage and wagon bearing shells which require fair strength, soundness and good machining properties in addition to bearing properties.

(v) Antifriction metals of both tin base and lead base are in use on the Railways for lining of

TABLE II Production trends of non-ferrous metals in India* (in tonnes)

Metal	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Aluminium	7909	8312	17372	18245	18381	35208	55222	56182	63742	83627
Copper	7974	7967	7674	8911	8336	9781	9587	9475	9360	9428
Antimony	510	543	674	812	619	661	909	840	848	876·5
Lead	3225	3388	3959	3731	3662	2851	3537	3624	2905	2478
Zinc concentrates	7597	7361	9810	9788	9256	10024	10627	10699	9591	8900

* The Eastern Metals Review—Annual Number, 16 February, 1967.

such components which are subjected to friction in service such as axle boxes of locomotives, carriage and wagon bearing shells, cross-head of locomotives, etc.

(vi) Aluminium bronze castings are in use on the Indian Railways for over-head fittings of electrical traction whose strength combined with high resistance to corrosion is of great importance.

Lately, high conductivity copper wires and sheets are being used for the manufacture of traction motors for electric locomotive in the Chittaranjan Locomotive Works. This is the new specialised field in which Railways have gone in.

An idea about the importance of non-ferrous metals on Indian Railways can also be had from the fact that the total holding of non-ferrous metals on Indian Railways is approximately 47 000 metric tons of value approximately Rs 22 crores (cost figures based on scrap values) while the approximate annual requirement of non-ferrous metals is about 6 200 tonnes of value approximately Rs 4 crores.

The scrap arisings of non-ferrous metals are substantial in Railways. Scrap non-ferrous metal arisings have been categorised as (i) solid scrap in lump, (ii)bronze borings free from whitemetal and iron, (iii) bronze borings mixed with iron, (iv) bronze boring mixed with whitemetal, (v) lead battery scrap, and (vi) whitemetal scrap. In addition to the conventional method of reclamation of these by melting with other alloy additions wherever necessary and possible, methods for separation of whitemetal and bronze from the mixed borings and reclamation of lead from lead battery scrap have been evolved and adopted. These steps have helped considerably in cutting down consumption of virgin non-ferrous metal resulting in large savings in foreign exchange.

Substitutions

The Indian Railways are the pioneers in achieving almost self-sufficiency by reducing dependence on imported materials. The total assets of Indian Railways today are valued at over Rs 3 000 crores and total value of stores purchased annually is about Rs 230 crores, of which 26 crores, i. e., about 11% accounts for direct import. This was about 70% in 1920-21, 50% in 1939-40, 15% in 1960-61. Thus from a position of 70% dependence on imports about four decades ago the Indian Railways have become self-sufficient to the tune of about 90% at present.

It has been mentioned earlier that we are highly deficient in copper, zinc, lead and tin. Bauxite occurs abundantly in India and the applications and potentiality of aluminium as a substitute metal have been examined by the National Metallurgical Laboratory and have shown great promise. The Railways are trying to attain self-sufficiency by substitution of imported non-ferrous metals with indigenously available ones and as such considerable work has been done in the Railways and the Railway Research Laboratories. Some of the important items in which work has been done or has been planned for finding out indigenous substitues are as follows :

(i) Substitution of conventional bronze bearing shells by SGCI for carriage and wagons

The technical feasibility has been established by extensive service trials and the substitution has already started paying dividends. During the last five years, savings to the tune of about Rs 50 lakhs in foreign exchange has been effected. A saving in foreign exchange to the tune of about Rs 2·31 crores is estimated to be effected per year on full implementation.

(ii) Substitution of gun metal boiler mountings of steam locomotives by SGCI boiler mountings

After service trials, substitution of non-ferrous boiler mountings with SGCI is progressively being effected. A saving in foreign exchange of about Rs 2·5 lakhs per year is estimated to be effected per year when the substitution is fully implemented.

(iii) Substitution of solid bronze axle boxes by steel boxes with bronze bearing insert/roller bearing

In the manufacture of steam locomotives leaded bronze axle boxes are used weighing approximately 2896 kg costing Rs 17 376 per WG loco. Substitution or reduction in weight of leaded bronze in axles boxes has been effected by use of either roller bearing axle boxes or steel axle boxes with pressed in leaded bronze insert at the bearing surface. It is estimated that per 100 WG locos about Rs 10 lakhs could be saved by the use of roller bearing axle boxes while about Rs 17 lakhs in foreign exchange could be saved by the use of steel axle boxes having pressed in leaded bronze inserts.

(iv) Substitution of solid bronze bearing and bushes by aluminium base bearing alloys

The bearing alloys at present in use in the Indian Railways contain a large quantity of imported non-ferrous metals. Some investigations on aluminium base bearing alloys have been carried out in other countries. However, no systematic investigation into the evolution of suitable aluminium base alloys for use as solid bearing or bushes, and antifriction metal has been carried out, though such development of the same was considered necessary. This problem was therefore farmed out to National Metallurgical Laboratory, Jamshedpur, and they have recently developed an aluminium base alloy and have prepared a few floating bushes for YL class locomotives for trial purposes.

(v) Substitution of copper cables by insulated aluminium cables for train lighting and signalling

Insulated aluminium cables are now being used for train lighting.

In case of signalling cables, railways have been experimenting to replace copper by aluminium. Trials are in progress in the Southern Railway.

(vi) Substitution of copper overhead electric transmission line by aluminium for distribution of power to town supply

All high and low tension overhead lines are now of Aluminium Conductive Steel Reinforced (ACSR) cables and all-aluminium conductor.

(vii) Substitution of galvanising by aluminising

The development council of non-ferrous metals and alloys had studied the problem of aluminising ACSR wire instead of glavanising. It has been recommended by the council that the aluminising of ACSR wire is technically feasible and economically adoptable.

Aluminising of vacuum break cylinder casing instead of galvanising has been recommended.

(viii) Substitution of lead by PVC for sheathing of power cables

A sub-committee of the development council for heavy electrical industries studied the problem of substituting lead sheathing of power cables by PVC sheathing. The PVC sheathing in place of lead has been enforced up to 1·1 kV cables with effect from 1967-68 period and the government have decided to extend the change over to cables for higher voltage also and a target date has been tentatively fixed for the change over up to 11 kV in PVC with effect from July 1969, but the pace of change over will depend on the indigenous manufacturers installing the necessary plant and equipment and producing the cables.

(ix) Development of contact springs based on indigenously available materials for use in signal equipment

Phosphor bronze contact springs are used in electro-mechanical and power signalling equipment. This material has, however, to be imported. The problem of development of contact springs based on indigenously available material was farmed out to the National Metallurgical Laboratory, Jamshedpur. They have been able to develop the technique of production of phosphor bronze springs and tests on samples supplied by the National Metallurgical Laboratory have been completed by R.D.S.O., Lucknow. Results in the case of one of the samples are encouraging.

(x) Development of electrical contacts based on indigenous materials used for signal relays

Imported electrical contacts are used in various circuit controls and signal relays. Silver diffused carbon contacts are normally used for this purpose. Requirements of the non-fusible type of silver carbon contacts for signalling relays is nearly Rs 2 lakhs per annum. Metal to metal contacts have also been used in some cases in imported equipment but their reliability against fusion is still not free from doubt. Work on the development of silver carbon contacts is being carried out by the National Physical Laboratory, New Delhi.

Conclusion

Non-ferrous metals and their alloys play an important part in railway engineering due to special service requirements. Therefore, entire substitution of non-ferrous metals is neither possible nor feasible. However, continued efforts have to be made to substitute the imported non-ferrous metals with the indigenously available metals wherever possible.

The railway engineers have already realised that if industrialisation is to be quickened in India and if shortages of copper, zinc, lead, tin, etc., cannot be met during the Fourth Plan period, there is no choice but to welcome increased use of aluminium in various spheres of railway engineering as aluminium is an indigenous material in which our country is expected to be self-sufficient in the near future.

References

1. Presidential address on "Non-ferrous Metal Industry in India" at the Twentieth Annual Technical Meeting of the Indian Institute of Metals by Dr. B. R. Nijhawan.

2. Use and Application of Non-ferrous Metals in Railway Engineering by K. C. Choudhury, presented at the Symposium on 'Use of Non-ferrous Metals and Alloys in Engineering Industry' held at Rourkela from 14th to 16th Nov., 1966.

3. Report on Substitution of Imported Copper and other Non-ferrous Metals by Aluminium and Other Indigenous Metals by Dr B. R. Nijhawan and K. N. P. Rao.

4. Report by Sub-group for other Non-ferrous Metals, Technological Studies and Manpower of the Planning Group for Non-ferrous Metals Industry.

5. Indigenous Substitution of Imported Materials in Chittaranjan built Locomotive by K. C. Choudhuri, published in the Journal of the "Indian Railway Engineers—Indian Railways Chittaranjan and Diesel Locomotive Works Supplement, 1966".