The role of non-ferrous metals in heavy electrical industry

T. V. BALAKRISHNAN and M. D. VIJAYAVARGIYA

SYNOPSIS

The H.E.E.P. at Hardwar (a unit of B. H. Ltd.) is scheduled to manufacture turbo sets of 100 to 300 MW hydrosets of various capacities as well as electrical machines (AC and DC) of medium and heavy sizes up to 9 000 kW. In general, the manufacture at Hardwar is based on the designs from USSR for these products, since evolving a new basic design for a complex equipment like turbo sets requires a vast amount of experience, detailed investigation and considerable time. The design requirements especially for turbo sets are very stringent. The specifications for various materials as also for non-ferrous ones are more stringent than those laid down by I.S.S. Standards. The main problem, which is being faced today, is in the substitution of imported materials by indigenous ones. There are a number of special materials required for the heavy electrical industries and a few examples include silver bearing copper for machine-conductors, cupro-nickel tubes for condensers and babbit material for turbines. The paper describes the difficulties that are faced in reducing strainghtaway the import of non-ferrous metals in the manufacture of heavy electrical machines and puts forward a few suggestions for implementation by all concerned.

THE heavy electrical industry in India is firmly established to reach self-sufficiency, with the setting up of three major heavy electrical equipment factories in the public sector. The first has been in production since 1960-61 at Bhopal and the other two, one at Hyderabad with Czechoslovakian collaboration and the other at Hardwar with Soviet collaboration, are entering the stage of production. With the attainment of full production in all the three units, it is envisaged that the production of thermal sets of unit capacities 100, 110, 120 and 200 MW will be in full swing by 1972-73 and hydro sets from 25 to 250 MW unit sizes at Bhopal and Hardwar during the same period. The three plants can manufacture generating equipment for an annual capacity of 5000 MW during the V Plan period and also industrial type motors and control-gear for nearly one million KW. It has now been recognised that export possibilities during the V Plan period should be studied seriously from now on.

Raw materials and components

These products are material-intensive and the raw materials and components form over 50% in terms of sale value for most of these items of equipment. These materials and components can again be classified into four major categories, ferrous (including alloys), non-ferrous (including alloys), insulation and miscellaneous items and it may be appreciated that the bulk will be ferrous items. Though the non-ferrous metals and alloys may not form a part of the bulk, these form a substantial portion by value and further the specifications are generally stringent.

It is estimated that the 3 plants will among themselves need about 8 000 tons of non-ferrous metals and alloys at full production and basically these will be covered by copper and aluminium with their numerous alloys. Those with lead, tin, nickel, magnesium, zinc bases, cobalt, chromium, tungsten, nickel and titanium will also be used in various combinations.

It is well known that the basic designs for such equipment have initially to be those of the collaborators, who had evolved them after considerable effort spread over a good deal of time including basic research, development, material technology, prototype tests, etc. Such basic designs received from the collaborators are modified in the Indian plants to suit each individual application in our country but such changes are kept to the minimum in order that production targets laid down are achieved in the quickest possible time. It follows, therefore, that the specifications for materials as evolved by the collaborators are initially followed in order that production gets under way and manufacturing techniques and skills are built up quickly under local conditions.

For this purpose, it may ever become necessary to resort to minimal imports, especially of such materials, the specifications of which are stringent, or the requirements of which do not warrant the installation of

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special or extra facilities for production in the country. At the same time an onerous responsibility devolves upon the designers and technologists to explore the availability of equivalents within the country, to analyse their properties and to examine whether they can as such be used or whether they have to be modified suitably. Though individual plants have their own laboratories for purposes of quality control, they cannot embark under present conditions on extensive research and it is in this context that National laboratories like NPL, NCL or NML have to aid the industry. Such help will also ensure that duplications in research or investigation-effort is avoided and optimum results are obtained in a resonable period of time.

Material technology

Further, the products manufactured by the Heavy Electrical Industry have to operate under stringent conditions and they are also normally built to render useful and trouble-free service for 25–30 years, with scheduled maintenance. Material technology is, therefore, all important in view of the conditions of operation which include highly corrosive media, erosive media, high pressures and high temperature stresses and lastly high speeds of rotation.

Especially under such conditions, it is necessary to go in for stringent specifications of materials in order to get the best out of them and reduce the sizes of equipment so as to facilitate transportation of finished equipment over long distances, erection without difficulty and ease of maintenance, thereby resulting in a reduction of overall costs of projects.

Though an amount of standardisation can be achieved in the case of thermal generating sets, the design and manufacture of hydro sets as well as electrical machines for industrial application have to be very often on a custom built scale so as to take care of individual site conditions. It will be difficult to achieve a good amount of a standardisation but a certain rationalisation of sizes of materials can be attempted, keeping the specifications stringent. If the progress in the manufacture of heavy electrical equipment all the world over is analysed, it can be seen that the basic materials have remained unchanged, but a lot has been achieved by alloying or altering certain compositions so that these take care of higher stresses and result in greater outputs with the same sizes. In other words, material technology keeps on advancing and basic research efforts in this direction all over the world have continued not only in industrial laboratories attached with manufacturing units but also in co-operative research institutions and national laboratories.

Non-ferrous materials for turbines

The few cases which account for most of such consumption in the manufacture of turbines are reviewed below.

Condenser tubes

For the turbo sets under manufacture at Hardwar, the condenser is of the surface type and will operate under vacuum. The condenser tubes are supported in tube plates suitably spaced to ensure that there is no risk of coincidence of the vibration frequencies of the tubes and the turbines. There are about 7700 tubes in one condenser for a 100 MW steam turbine. The outside diameter is to be accurate as the tubes pass through four supporting plates which have close fitting holes to avoid vibrations.

Because of the sheer sizes of the units and also the huge quantities of materials used in condensers and also the increasing use of relatively active types of cooling water, especially for new thermal and nuclear plants, great care is bestowed on the designs. The length and diameter and number of tubes are calculated on usual considerations of volume of steam to be condensed, volume of cooling water, Reynolds' co-efficient, conductivity of material, etc.

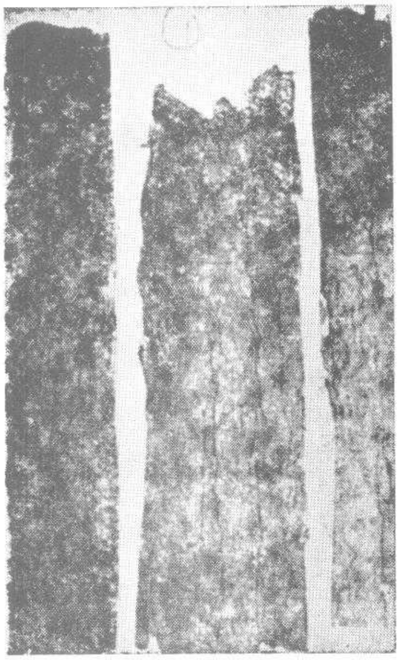
The choice of material for condenser tubes is normally based on the following factors:

(a) The nature of cooling water available for flow inside, the speed of flow and temperature;
(b) the nature of steam and condensate on the outer surface of the tubes, and the vacuum applicable;
(c) compatibility of the properties, especially strength, conductivity, technological feasibility and close tolerances with the design characteristics and types of service required of the power plant, and
(d) feasibility of adopting one material for tubes, sheets and water boxes.

Tubes of aluminium brass, cupro-nickel alloys and stainless steel are most commonly used in modern condensers.

The amount of water required to be pumped inside the tubes is so much that except screening, settling in storage and possible chlorination, no other treatment can economically be adopted. The water is, therefore, to be used in an 'as available' condition. Its corrosion and erosion action depends mainly on the contents of various salts and partly on matters soluble in water, insoluble gases and hard and organic matters. Chlorides in water in general increase its corrosion properties but the sulphides are more detrimental to copper and its alloys. The corrosion increases with the rise of temperature and greater velocity of flow of water and additional internal stresses in the end plates.

In the modern power stations now a days it is a general practice to add a basic substance to the feed water of boilers as to remove the acidic contents, ionic oxygen, etc. A good amount of hydrogen (N_2H_4) is added for this purposes, which reacts with active oxygen to form ammonia. This ammonia in its turn as a condensate in presence of oxygen reacts with the copper alloys and dissolves the copper from the outer surfaces of the condenser tubes; the thickness of tube walls may, therefore, get affected and pitting may result and some of them may in course of time result in through holes. This creates a two-fold problem: that of leakage of water in the condensate and that of the increase of copper content in the condensate

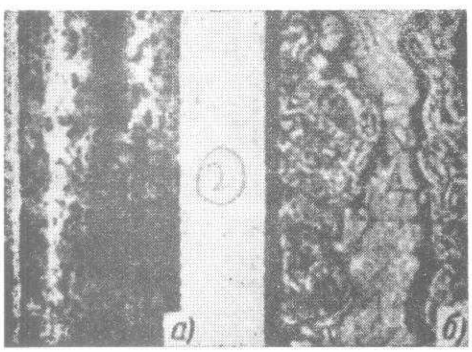


1 *Intensive zinc extraction on the inner surface of tubes made of λ-68*

which will have a detrimental effect when it passes along with the steam in the working path of the steam turbine. A compromise is necessary to have a limited copper content in the condensate which is preferred as 2 mkg/kg and must not exceed 5–10 mkg/kg. This can be achieved to a great extent by using cupro-nickel tubes.

For condensers cooled with fresh or slightly brackish water, aluminium brass is finding an increasing competitor in stainless steel. The use of aluminium brass in modern sea-water cooled condensers raises certain aspects of particular interest owing to erosion and attack by impingement.

It is understood that tube failures have sometimes been experienced owing to erosion associated with deposits that were difficult to eliminate even by continuous mechanical cleaning method. In fact, in some cases of extensive erosion, good results have been obtained by adding iron as ferrous sulphate regularly to the cooling water. It is also gathered that impingement attack has been observed on the coolant inlet side. However, because of iron oxides resulting from the corrosion of ferrous components in the system, which include water boxes of steel, a protective film on Al-brass had formed and these had operated satisfactorily for prolonged periods.



2 *Local extraction of zinc on the inner surface of tube of λ-68*

An arsenic content of over 0·06% can considerably increase the susceptibility of Al-brass to inter-granular attack and there is, therefore, a tendency to reduce the figure and condenser manufacturers and users now specify an arsenic content between 0·02% and 0·03%, a maximum phosphorous content of 0·005 and strict limits on certain impurities.

Hence cupro-nickel alloys find favour for sea-water-cooled condensers. Where clear sea-water is used, cupro-nickel alloys and specially Cu-Ni, 90–10 tend to compete directly with Al-brass notwithstanding their higher cost. However, by reducing the thickness of tubes and also by increasing higher flow-rates, the higher costs may partially be offset. Cupro-nickel of 90–10 or even 95–5 offers greater resistance to corrosion and erosion in the conditions that exist nowadays and will be selected for conditions of sea-water.

The use of stainless steel has been on the increase only in the USA and more than 50% of requirements of condenser tubes are of stainless steel. The technical advantages include a slightly higher heat-transfer co-efficient and higer resistance towards corrosion and erosion.

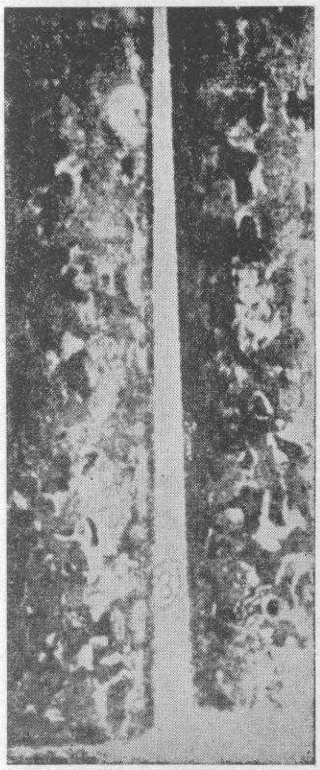
A systematic and detailed study of the behaviour of condenser tubes made out of various alloys is necessary. One such study was undertaken by the Soviet Institute of Thermal Power a number of times. The team of engineers deputed for the above work went round various Thermal Power Stations and studied the existing conditions of the condenser tubes. A few details of their actual findings are detailed in Table I.

The recommendations based on the above investigations were made as under (mainly on the basis of zinc extraction) :

1. In cases of slow extraction of zinc (from the bronze during the corrosion and erosion process) the tubes should be replaced in 20 years and above.
2. In cases of intensive zinc extraction (as shown in Fig. 1) the tubes should be replaced in 8–10 years.
3. In cases of local extraction of zinc (as shown in Fig. 2) the tubes should be replaced in 2–5 years.

The corrosion on the external surface of the tubes where ammonia was added in feed water is shown in Fig. 3.

As already described, the detrimental effects of ammonia on copper were studied in various experiments conduc-



3 *Corrosion of tubes due to ammonia on the outer surface*

TABLE I Corrosion observed in condenser tubes generally made of λ-68 after different periods of operation

No. of years in operation of condenser tubes	No. of condenser		
		Corrosion of tubes	
	Total	Noticed	Unnoticed
1. Less than 15 years	57	18	39
2. Between 15–20 years	7	4	3
3. Between 20–25 years	31	7	24
4. Between 25–40 years	7	4	3

TABLE II Effect of ammonia on copper

Particulars of turbine	Tube material	Copper content in Mkg/kg.			
		In condensate		In feed water	
		Avg.	Max.	Avg.	Max.
1. 50 MW*	Al-brass	—	—	3	8
2. 100 MW	Al-brass	2	5	—	—
3. 200 MW	MH κ 5-1	1·5	5	1·5	10**

*Exploitation data after 16 months of working.
**Tubes of high pressure heater made of steel and that of L.P. heater made of brass λ 1-68. Exploitation data after18 months of working.

ted in laboratories on tubes made of different materials. The results are detailed in Table II.

From the above analysis, it will be clear that depending upon the conditions of cooling water available, it will be possible to select a suitable grade of material for the production of condenser tubes. But this may result in a multiplicity of grades for different conditions with the result that production of different grades may be uneconomical. Owing to such considerations, the standardisation of one or two grades of aluminium-brass or cupro-nickel is of vital importance and here there is a pressing need for close investigation to be done on an urgent basis, as the requirement of tube material is of the order of 30 tonnes for each thermal set.

Depending on the conditions of cooling waters at various places where the turbines will be installed it may be possible to select more than one grade of material for the production of condenser tubes. The difficulty will, however, arise for adopting different designs for various grades of materials as also to procure the various materials in small quantities. Due to these considerations the cupro-nickel alloy MH κ 5-1 tubes have been adopted for all condensers which (though costlier than alloys λ –68, λ 0 70-1) can be used, generally in all severe corrosive and erosive conditions.

For condenser of 100 MW capacity we require cupro-nickel MH κ 5-1 tubes to the following chemical composition :

Main alloying elements percentage				Impurities % not more than			
Nickel+ Cobalt. Ni+Co	Iron Fe	Manganese Mn	Copper Cu	Lead Pb	Carbon C	Zinc Zn	Total
5-6, 5	1·0-1·4	0·3-0·8	Remainder	0·01	0·03	0·05	0·7

Note : Impurities not described in the table have been taken into sum of total impurities.

Mechanical properties

Mechanical properties of tubes shall be the following :

(a) Tensile strength 30 kg f/mm^2
(b) Relative elongation 8%.

For auxiliaries like tube materials, ejectors, heaters, oil coolers, etc. of 100 MW steam turbine manufactured by B.H.E.L. Hardwar

The considerations for the choice of material for the above are also on the same lines as the condenser tubes and presently λ 68 alloy is being adopted for the same. The outside dia. required is 16–19 mm with 0·75 mm to 1 mm wall thickness and of various lengths up to 7 m. In terms of weight the requirement will be about 30 tons for one turbine. The mechanical properties after annealing are as under :

Ultimate tensile strength	33 kg/mm^2
% Elongation	56
Brinell hardness	52

It may be mentioned here that blocks with supercritical steam parameters call for additional requirements in the choice of tubes for heat exchanging equipments. These additional requirements are placed with a view to reducing to minimum the copper contents in the boiler feed water. To eliminate the loss of copper from tubes due to erosion which contaminates the condensate, it may be necessary to use stainless steel tubes in place of cupro-nickel tubes especially in case of blocks with super-critical parameters. Owing to prohibitive costs of stainless steel tubes, it will be long before non-ferrous metals are taken out of the field for tube materials. However, extensive studies are to be undertaken to decide quickly one or two rationalised specifications which may result in quantity-manufacture locally.

Babbit material for bearings

These are used as bearing metals or antifriction alloys for lining bearings.

The operating conditions of a bearing liner determine its principal requirements and the main properties of this material are :

1. Sufficient hardness but not as high as to cause excess wear of the journal ;
2. Enough plasticity to be capable of deforming under local stresses ;
3. Ability to retain a layer of lubricant on its surface ;
4. Low co-efficient of friction between the journal and the bearing ; and
5. Good machinability.

In addition to the above they should also possess the following properties :

1. Should not have a high melting point (one of its constituents must have a relatively low melting point).
2. After being poured into the bearing they must adhere tightly to its walls.
3. Must have good thermal conductivity, fluidity and corrosion resistance.
4. Should be capable of forming a solid soap with normal lubricants and should form a strongly bonded oxide surface film which minimises pressure welding ; and
5. They should be economical.

From the above requirements, it can be seen that the bearing metals must have a structure inhomogeneous in respect to hardness i.e. they must consist of a plastic matrix into which hard particles are embedded.

During rotation the shaft journal is supported by these hard, wear-resisting particles, while microscopic channels are formed in the softer matrix which is more subject to wear. The lubricant finds place to flow through these channels and also carries off the worn out materials.

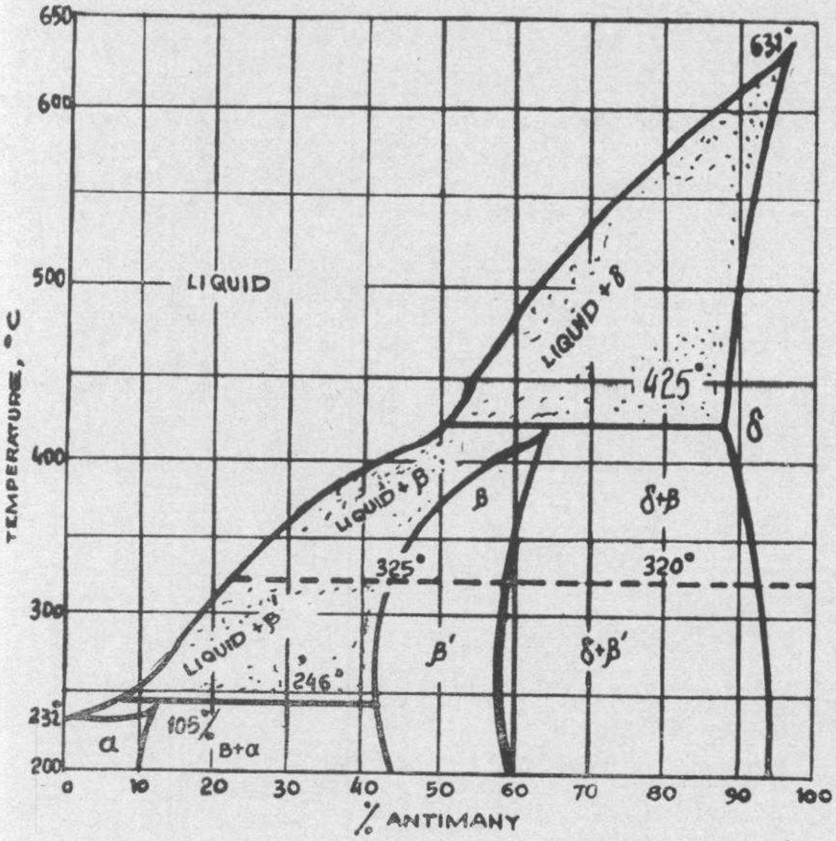
Table III below gives the grade of babbit required along with its chemical composition and application.

The turbines normally operate at 3 000 r.p.m. and tremendous load is shared by the bearings. The perepherial speed is high and, therefore, the load is significant. Hence, the babbit of highest quality grade Б 83 is used.

From the Sn–Sb equilibrium diagram it will be seen that there exists alpha solid solution of antimony in tin which is a soft matrix while the β-phase has hard crystals. Copper is added to babbit to eliminate segregations, due to differences in density of the compound

TABLE III Chemical compositions and applications of bearing alloys (babbits)

Grade	Chemical composition per cent Sb	Cu	Cd	Pb	Sn	Others	Applications
Б 83 Gost 1320-55	10–12	5·5–6·5	—	—	Rem.	—	Babbitting bearings of highly loaded machinery (steam turbines, turbo-pumps, etc.)



4 *Sn–Sb equilibrium diagram*

Sn-Sb and forms the compound Cu_3-Sn. The latter solidifies first in the form of well branched dendrites which run through the whole of the liquid alloy and on which crystals of the Sn-Sb compound settle. Besides this, the Cu_3-Sn crystals form hard inclusions in the babbit favourable for bearing service.

The micro-structure of the tin-base babbit Б 83 is shown in Fig. 5. Here the darker background is the plastic matrix, consisting of the alpha solid solution, the light hard cube shaped crystals are the compound Sn-Sb (50·4 per cent Sb) and star-shaped crystals are the compound Cu_3-Sn which is even harder than the Sn-Sb crystals. The Sn-Sb and Cu_3-Sn crystals constitute the projecting parts of the bearing liner which support the rotating journal.

Babbit, grade Б 83 contains a large amount of tin and so it is very expensive. The physical and mechanical properties/characteristics of Б 83 are described below:

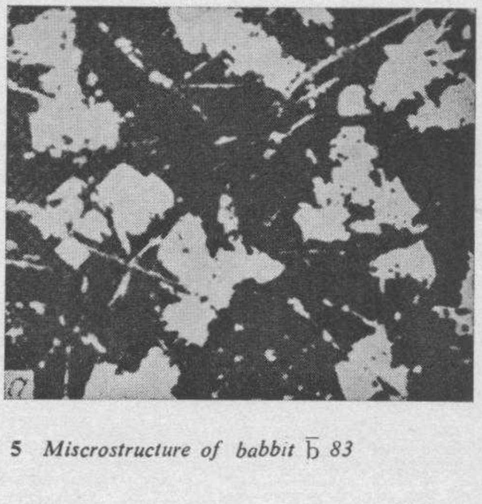
1. Critical temperature (a) upper point: 351°C
   (b) lower point: 240°C
2. Pouring temperature: 400°C
3. Backing surface temperature of bearing: 250°C
4. Working temperature: (a) normal 60°C
   (b) limiting 100°C
5. Hardness at different temperatures (a) at 17°C 30 HB
   (b) at 100°C 13 HB
6. Limiting multiple factor of load (kgf/cm²) and peripheral velocity (m/sec.) = 500.
7. Load, characteristics: dynamic.

The nearest Indian equivalent grade is 84-IS: 25-66 which specifies the following properties only:

1. Pouring temperature of alloy—430÷460°C. It is, therefore, essential to establish all the above specified data for grade 84 IS: 25-1966 to determine if it can replace the babbit Б-83.

Requirements for electrical machines

Seemingly, a wide range of conductor materials have been available to the electrical engineer for many years



5 *Miscrostructure of babbit Б 83* ×200

but these have been based on high conductivity metals such as copper, aluminium and silver. Copper supported by aluminium will, undoubtedly, remain the mainstay for current conduction in future also. Some of the newer materials being tried abroad and showing improvements from some limited points of view include sodium conductors and copper-alloy conductors but the improvements obtained so far have not been sufficient to warrant large scale manufacture of these materials.

The resources of electrolytic copper are, however, meagre and aluminium is steadily replacing copper where its greater volume and lower strength are not of critical importance. The resistivity values (micro-ohm/cm) for aluminium and copper are 2·83 and 1·72 respectively and the electrical conductivities are in the ratio of 61 : 100 (Al : Cu). The replacement of copper by aluminium has been done for a few small transformers and small electric machines but such replacement for larger machines like turbo-generators or large size industrial machines is not possible without considerable investigation.

The precise properties obtained in these materials depend, to some extent, on their source and manufacture. Both alloys are used continuously in service at temperatures of up to 350°C. Both these alloys again retain a useful proportion of their strength after brazing at 650°C for short times. Many complex alloys, including arsenic or magnesium have been produced in an attempt to develop materials having improved characteristics, higher strength, better response to precipitation hardening, improved ductility and improved resistance to softening at elevated temperatures without appreciable loss in electrical and thermal conductivities.

The elementary conductor in turbo-generator is required to be insulated with glass fibre or asbestos which should be vacuum dried and impregnated under pressure. This process is yet to be developed to a satisfactory level in the country. In addition to the solid strip, the manufacture of large turbo-generator with water-cooled stator windings requires the use of hollow conductors through which the cooling medium flows. The manufacture of this hollow conductor is achieved by the process of extension and no extrusion plant has yet been set up in the country owing to low demands.

In case water cooling can be effectively used for other machines, the demand for hollow conductors may justify the setting up of an extrusion plant in our country. The use of hollow conductor will result in overall economy as far as utilisation of copper is concerned and will reduce the weight of the machine per unit capacity.

The rotor winding for the turbo-generator is made of silver-bearing copper containing 0·03-0·1% silver. The addition of silver with the extent of cold working makes the copper stronger, increases its creep resistance at high temperature and elevates the softening temperature. Table IV shows the extent to which the addition of silver improves the properties of E. H. C. copper. It is modern practice to make use of silver-bearing copper strips with 10% cold-work for the manufacture of rotor winding. The rotor windings are subjected to high centrifugal stresses and repeated thermal cycling owing to start-stop operation and variation of load. These phenomena lead to residual deformation or creep under which circumstances it will not be possible to use ordinary hot or cold drawn E. H. C. copper strips. The resources of silver-bearing copper are yet to be tapped in our country and until then this material is to be imported.

TABLE IV Comparison of mechanical properties of E.H.C. copper and silver bearing copper

Grade	Proof stress Kg/mm²	Percentage elongation	Electrical conductivity Ohm mm²/m	Hardness
E. H. C.	6-8	35-40	0·0175	35-80
Silver bearing copper annealed	3·5	68	0·0185	48
Silver bearing copper 10% cold worked	20-5	41	0·0182	94
Silver bearing copper 25% cold worked	27	19	—	105
Silver bearing copper 50% cold worked	31	14	—	115

The most important among the aluminium alloys is duraluminium, which is used for rotor wedges, busbar-holders and press fingers in the core. The use of duraluminium for rotor wedges reduces the stresses caused owing to centrifugal forces by its lightness, compared with steel or bronze, and yet its strength is in speeds of 3 000 rpm. The profiles of the rotor wedges can be achieved either by machining or by the process of extrusion, the latter being more economical at the places where the requirement is large. But in order to use extruded sections and reduce variety, it will be necessary to standardise the various profiles of these wedges.

The only requirement for silicon-brass casting is for the brush-holder. Owing to high peripheral speed and vibrations encountered at the slip-ring or the collectors, it is necessary to make use of ductile material with high mechanical properties. Efforts to replace brass by aluminium resulted in failure, and major break-down in certain instances. Pressure die-casting is employed to get the finished sized body of the bush-holder which is strong enough to resist the severe conditions encountered at the collector.

Conclusion

The importance of achieving a rationalisation of the requirements of non-ferrous metals and alloys for the

Heavy Electrical Industry in India has to be realised and it is so essential to cut down imports thereby to the barest minimum. In this vital task, extensive investigations have to be undertaken immediately and these will have to be planned with co-operative effort from the manufacturing plants, the RDOEI at Bhopal and the National Metallurgical and National Physical Laboratories. While all efforts are to be made to substitute or find indigenous equivalents for imported materials, such efforts will not be complete without adequate data and experience. Great caution is also to be exercised in accomplishing this huge task, as any faulty or hasty substitution of such stringent material may result in a loss of reliability of operation and possible breakdown of larger machines.

Acknowledgement

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Discussions

Mr **Y. P. Bhasin** (Tata Engg. and Locomotive Co. Ltd., Jamshedpur) : We should not take it for granted that certain non-ferrous components have still to be imported without making a continuous survey of the facilities being progressively developed in the country. For instance, silicon-brass castings of any description should be readily available locally.

As regards standardisation of Babbit metal to suit the requirements of the heavy electrical industry, I am sure that if this specific case is taken up with the Indian Standards Institution, the requisite properties could be specified together with the chemical composition which already satisfies the range stipulated in similar Russian specifications.

Mr **T. V. Balakrishnan** (Author) : Before taking a decision to import non-ferrous components a broad survey is made on the availability of these items indigenously. In the particular case of silicon-brass castings, it has not been stated in the paper that silicon-brass castings are not available in the country. However, I may point out that the response to our demand for pressure die-castings for silicon-brass was very poor. Only one firm agreed to supply the pressure die-castings but when our order was placed we were informed that the works had closed due to lack of orders and they were unable to supply the material.

The standardisation of Babbit, metal to suit the requirement of heavy electricals industry, is being taken up separately with the Indian Standards Institution.

Mr **S. N. Mukherjee** (National Test House, Calcutta) : Regarding inclusion of certain properties for bearing metals in I.S.S., it is hardly possible to lay down all the requirements mentioned by the speaker as these will vary with different uses. It would be necessary for manufacturers like Bharat Heavy Electricals to find out these properties by themselves.

The requirements of several non-ferrous metals by Bharat Heavy Electricals would be very low and it would not be economical to manufacture them indigenously. Perhaps it would be better to import these for the time being till the requirements become sizeable and indigenous production economically feasible.

Mr **T. V. Balakrishnan** (Author) : The properties of Babbit material as described in our paper are similar to those specified in Russian standards. It is very essential to establish some of the main properties before we can make use of the Babbit material as per I.S.S.

in our industry, especially for the thrust journal bearings of steam turbine. The laboratories installed in our industries are not so well equipped to ascertain the specified properties and on this point we want the help of National Metallurgical Laboratory and National Test House.

I agree with Mr. Mukherjee that for the present time we should meet our requirements of several non-ferrous metals by imports.

Mr U. P. **Mullick** (Institute of Consulting Engineers, Calcutta) : Depreciation on electrical equipment is about 10%. Even taking it at 5%, service life may be taken as 20 years and not 30 years and less rigorous specifications may be adopted. Besides, technology may change in 20 years and necessitate a change of equipment.

Have Bharat Electricals drawn the attention of the concerned Ministry and ISI on the strength requirements of Indian products for winding and other equipments ?

Mr T. V. **Balakrishnan** (Author) : Equipment like turbo sets and hydro sets have to render long and trouble-free service in continuous operation with minimum maintenance and are also expensive to install and commission. Hence rigorous and stringent specifications have to be rigidly adopted for the materials and components. We are therefore unable to agree with the suggestion made.

We are periodically bringing to the notice of the appropriate Ministry and ISI our special requirements of various products. It is only on their acceptance that import clearance is obtained.