EXECUTIVE SUMMARY

1. Copper has been known to man since 4000 BC and its popular alloys i.e. Bronze and Brass have been known since 3000 BC and 1000 BC respectively. The usage of copper increased substantially with the industrial revolution in 18th century. Copper and its alloys are widely being used today in electrical & electronics industry, construction, transportation etc. Its properties of high electrical and thermal conductivity, resistance to corrosion, ductility and malleability, lack of magnetism makes it a versatile metal.

2. Copper deposit exists as sulphide, carbonates or silicates and sulphide ores account for approx. 40-50% of the world copper reserves. Peru, Chile, Papua New Guinea, Indonesia, Philippines have large quantities of sulphide ores which have small copper content (0.3-2% range), Zambia and Zaire have copper deposits with higher copper content (2-6% range). The reserves of copper in the world are estimated at 525 million tonne in terms of metal content.

3. The first copper smelter was set up at Ghatsila (Bihar) in 1928. An electrolytic refinery for cathodes and wire bar plant was commissioned at Ghatsila in 1965. Flash smelter based on Outokumpu Flash smelting technology was set up in 1971. The first continuous cast rod unit was established in the country during 1984.

4. Hindustan Copper Ltd (HCL) was set up in 1967 for production of primary copper in the public sector. Presently HCL is the sole producer of copper in India and has following four units : Khetri Copper Complex, Rajasthan (31,000 TPA of Blister Copper. has the following operations such as Ore mining, Beneficiation, Smelting, Electrolytic refining etc; Indian Copper Complex, Ghatsila, Bihar (16,500 TPA of Blister Copper) has same operations as in Khetri and has a precious metal recovery plant (Gold, Silver, Selenium etc); Malanjkhand Copper Project, M.P. (2 million TPA mining and beneficiation) has operations of ore mining and beneficiation. The concentrate is sent for further processing to KCC and ICC and excess quantity is sent abroad for toll smelting; Taloja Copper Project, Maharastra (60,000 TPA) has C.C. rod facility.

5. The production of copper ore in India has remained stagnant over the years i.e. 51.36 lakh tonne in 1987-88 and 51.13 lakh tonne during 1992-93. This is because of low level of ore deposit establishment. The present ore deposits are estimated at 734 million tonne (with 9.4 million tonne of copper metal). Nearly 90% of the copper reserves are concentrated in the states of Bihar, Madhya Pradesh and Rajasthan.

6. During the year 1992-93 production of copper concentrates, blister copper and refined copper by HCL was as follow :

Concentrate	:	52.53 lakh tonne
Blister Copper	:	48006 tonne
Refined Copper	:	45275 tonne

The capacity utilisation at HCL plants was high about 98% in mining sector and 100% in metallurgical sector during 1992-93.

7. The demand of copper in India during 1992-93 was of the order of 1.8 lakh TPA which is expected to increase at a rate of 5-6% per annum. In order to meet the requirement, copper was imported to the tune of 70% of the requirement. With a number of smelters being planned & executed in the private sector as well at Malanjkhand by HCL, it is estimated that the imports could be reduced to a level of 35-40% by the year 1999-2000.

8. The dereservation of non-ferrous industry by the Government of India has opened doors to the private sector. Sterlite Industries (India) Ltd is implementing a 60,000 TPA Capacity (Cu Cathode) project with an estimated cost of Rs 700 crore. The technology has been provided by MIM Holdings, Australia and the input material would be copper concentrates which would be imported.

9. The plants of HCL to produce primary copper are based on technology of Outokumpu, Finland who are known world wide and have installed about 30 plants world over. The process is based on semi-autogenous smelting of copper concentrates in flash smelter followed by conversion in PS converter, Fire refining, electrorefining etc. The initial agreement

period is over and a new agreement has been executed effective from April, 1992 towards modernisation & expansion of KCC plant.

10. The process of manufacture of primary copper at HCL's plants is summarised below :

Copper ore containing about 1% copper are reduced from 150 mm size to 25 mm size in cone crushers. The crushed ore is grinded in rod & ball mills to 74 micron size. The ore is further refined through Froth Flotation process comprising of rougher cells and second stage cell where xanthates and pine oil are used as reagents. Copper comes in the froth and slurry containing about 15% copper, is thickened in rake type thickner from a level of 30% solid content to 60% solid content. The thickened slurry is treated in vacuum disc filters to remove water and powder concentrate so obtained has 12% moisture. The moisture content in the concentrate is further reduced to a level of 0.2% in rotary air dryer. Concentrate along with preheated air enriched in oxygen is fed to the Flash Smelter where separate layers of molten material are formed i.e. Matte (rich in copper contains 43-50% Cu) and slag (4-5% copper). Gases rich in sulphur dioxide are formed in the smelter which are utilised to produce sulphuric acid. Matte is further refined in PS converter to obtain blister copper (99% purity) and fire refined in Anode furnace and casted in Anode Casting wheel to obtain 99.4% pure copper anodes. The Anodes are electro-chemically refined to obtain copper cathodes of 99.99% purity. Precious metals i.e. Gold, Silver, Tellurium, Selenium etc. are recovered by refining of Anode slime obtained from electrolytic refinery.

11. Malanjkhand Copper project of HCL, Madhya Pradesh has the largest open cast mine of capacity 2 million TPA with a matching concentrator capacity. The plant incorporates State-of-the-art equipments & techniques i.e. hydraulic excavators of large bucket capacities (10-12 cu.m) drill masters capable of larger diameter hole drilling (200 mm), computerised instream analysers and large capacity & energy efficient rougher floatation cells (120 cu.ft) etc.

12. Khetri Copper Complex (KCC) of HCL, Rajasthan is the largest copper mining-cum-metallurgical unit in the country. It comprises of three

mines Khetri (underground), Kolihan (underground), Chandari (open cast) concentrator, smelter, refinery etc. The Kolihan mine is the most modern underground copper mine in the country and is based on ramp system of mining. Mine development is carried with the help of jack hammers and drill jumbo. Blasted rock are removed by auto-loaders at sub-levels, trackless LHD on main levels. Principal stoping methods include sub-level stoping for narrower ore bodies and large diameter blast hole stoping for wider ore bodies. Ammonium Nitrate Fuel Oil (ANFO) is used as blasting agent. For loading & transportation of ore, trackless equipments are being used i.e. LHD's, dump trucks etc. to attain higher level of production and productivity. Modern concepts of mining i.e. drop raising for increased safety and higher progress, large diameter blast hole stoping for reduction in mining cost & stop preparation time, non-electric detonator for explosive initiation for greater safety etc. have been introduced.

13. Indian Copper Complex (ICC) of HCL at Ghatsila, Bihar is the oldest plant of HCL. The complex has five underground mines i.e Mosaboni, Surda, Rakha, Pathargora and Kendadih. There are three concentrators i.e. Mosaboni (2700 TPD), Rakha (1000 TPD), TPSB (1000 TPD). The processing plant (smelter, refinery etc.) is located at Moubhander. The main feature of ICC is the Precious metals recovery plant where anode slime is leached with sulphuric acid to recover Nickel as Nickel sulphate crystals. The slime is further processed in selenium furnace to recover selenium. The residues from the furnace are prerefined in Dore furnace and subsequently silver and gold are recovered by electrolysis.

14. HCL has taken up a number of modernisation measures at its units and a few major ones include the following :

i) Introduction of computerised auto weighing system at Anode Casting Wheel at KCC.

ii) Installation of Starter Sheet Straightening Machine and Anode Milling & Reforming Machines (both imported from Mitsubishi, Japan) in refinery of KCC.

iii) Gas poling instead of Green poling in Anode Furnace.

iv) Improvement in Smelter burner design (KCC).

v) Introduction of hydraulic device instead of manual adjustment of crushers.

vi) Oxygen enrichment facility at Furnaces operated by HCL.

15. Environmental pollution control measures have been adopted at HCL's plants at ICC & KCC. There is no pollution from liquid effluents which are treated and recovered, water is recycled.

Air Pollution Control measures undertaken by HCL include installation of the follwoing :

i) Double hood system

ii) Gas cleaning plant

iii) Sulphuric Acid Plant

iv) Alkali scrubbing System

Inspite of hood there is an escape of 2-5% of gas volume to the atmosphere which is called fugitive emission and this gas can not be diverted to the sulphuric acid plant. As per MINAS no gas from the copper smelter section is allowed to be sent to the atmosphere. Steps shall be taken by MINAS to stipulate limit for SO_2 content in the fugitive emission.

In the alkali scrubbing system, 4 Kg of sludge is generated for every one Kg of SO_2 removed.

Effluent Treatment : The long term plan of HCL is to make the existing units more eco-friendly. KCC, in particular, has undertaken several projects to comply with the guidelines of the Rajasthan Pollution Control Board. The projects include the following :

i). Installation of an acid-cum-fertiliser plant.

ii). Construction of a tailing dam

iii). Water conservation in mines.

iv). Emission control

v). Installation of a Gaseous Oxygen plant.

The pollution control board had also set a time-bound programme for implementation. KCC has completed, as per the time-table, work on the de-sulphurisation scheme by setting up a Fluorine Scrubbing System in the smelter plant and an effluent treatment plant. With the setting up of the effluent treatment plant, the discharge from the plant has been brought down to the zero level. KCC has made an investment of around Rs.10 crore on various pollution control related measures. KCC is also working on certain long-term plans at an outlay of Rs.38 crore. The long term plans include the setting up of another sulphuric acid plant at the cost of Rs.22 crore, establishment of a gas cleaning plant and an alkali scrubbing plant.

16. Major problems faced by HCL include the following :

i) High generation of reverts

ii) Bad anode quality i.e. fins, higher oxygen content than desired etc.

iii) Higher cost of production due to low grade of ore, lower percentage of oxygen enrichment in smelter which makes process semi-autogenous and reduces throughput & production scale, high cost of mining, highly labour intensive plants, high cost of captive power generation in absence of state supply, low by-product recoveries etc.

iv) HCL is facing a problem in maintaining steady supply of gas to sulphuric acid plant with respect to ratio of SO_2 content in the gas volume. Thus this can be solved to a great extent by installing and operating 3 converters in such a way that atleast 1 converter is throwing.

v) Inadequate ventilation in underground mines which leads to high temperature and humidity and leads to lower productivity.

17. The secondary copper industry (based on scrap) in India has just made a beginning and a few projects with downstream CC rod facilities have been set up i.e. Sterlite Industries (India) Ltd, Lonavala; India Extrusion, Hyderabad etc. A number of projects have also been planned i.e. SWIL Raigad; Usha Rectifiers, Singhgad Distt (Maharashtra) etc. Sterlite is manufacturing CC rods from imported copper scrap based on furnace technology of La Farga Lacambra Sa, Spain and equipments from Continuous SPA, Italy. Major production equipments include Reverberatory Tilting Furnace and Continuous Casting Machine.

18. Almost 70% of the World's reserves of copper ores are accounted for by 7 countries i.e. Chile, USA, CIS, Zambia, Peru and Zaire. Developing countries hold almost 60% of the copper ore, produce over half of world output and account for more than 60% of world ore exports. The current refined copper production (1992-93) is estimated at 12.9 million tonne. There has been a significant increase in the production of secondary copper in form of CC rods, where the SCR technology is the most widely used, accounting for 40% of the total installed capacity.

19. Most of the output of the copper concentrates is supplied to the smelters in Japan & USA. Japan has more than 50% of the world's copper smelting capacity. The current price of copper ('A' grade) on the LME are ruling at US $ 2390-2400 per tonne. The consumption of copper is the highest in USA, followed by Japan and Germany (FR).

20. Various technological improvements have taken place in the copper industry abroad in various areas such as the following :

i) Mining

ii) Beneficiation of Ore

iii) Smelting

iv) Refining

21. MINING

The major technological developments have taken place by way of the improved and more efficient explosives to more accurate and greater mobility drills. In blasting new metallized ANFO (Ammonium Nitrate Fuel Oil) formulations have been used, whose plant cost is lower and the process is simpler as compared to conventional ANFO explosives. Highly efficient all hydraulic rock drills have replaced pneumatic air drills resulting in lower energy consumption and improved efficiency. Large diameter rotary drills have replaced the conventional drills, rotary drill bits have also been redesigned by using new alloys and inserts.

Substantial improvements have also been affected in shovels and draglines. Open pit transport of ores and waste is handled mainly by trun haulage, accounting over 50% of the total cost of mining. In the recent years, there has been a shift towards new portable crusher and belt conveying system for easier ore handling. In the underground mining, Vertical Crater Retreat (VCR) method is being used which is advantageous for bulk mining is less labour intensive and safer than the conventional methods. This technique has been made possible with the introduction of crater blasting and the use of In-the-hole (ITH) drills.

Continuous Mining Systems employing the state-of-the-art features such as advanced mechanical handling devices, electrification and automation & microprocessors, is being used extensively abroad. There has been a substantial reduction in the Mining costs abroad, over a period of years in operations such as Drilling, Blasting, Loading, Hauling, Crushing & Stock-piling etc.

22. BENEFICIATION

Communition (Crushing and Grinding) represents over 50% of the total mineral processing cost. There has been a development towards Autogenous Grinding, which is the grinding of ore by itself rather by special metallic or non-metallic grinding bodies distinct from the ore. Various foreign companies have resorted to Dynamic Heavy Media Separation which is the most efficient pre-concentration process. The other developments have taken place in the field of Better Instrumentation and Improved Crusher Control & Grinding Circuits.

Tremendous upgradation has taken place in the technology for classification operations by replacement of conventional rake and bowl classifiers with hydroclones, which offer a number of advantages such as effective classification and separation of fines, low consumption of spare parts, small size equipment and adaptability to automatic controls of the grinding circuit.

In the concentration process, large floatation cells (27 cu.m) are being increasingly used abroad. The technological impact of the giant cells lies in the reduction of the operating and maintenance costs. A new system, called Column Flotation Cell was developed in Canada and is now used in majority of the plants abroad. Its principal characteristic is that the column has no moving parts and solids are kept in suspension by rising bubbles alone and concentrate produced is of higher purity. These cells are also useful in the recovery of Molybdenum.

23. SMELTING

Flash Smelting with oxygen enrichment upto 60% makes the process completely autogenous and the copper content of the matte is increased to 65-70%. Various smelting processes are used woldwide such as Outokumpu, INCO Process, Noranda Process, Mitsubishi Process, El Teniente Process. However the most widely used technology for smelting is based on the Outokumpu Flash Smelters, which have been installed at 35 plants, the world over.

There are two major smelting technologies and two converter processes currently recommended. Newer technologies undertake smelting and converting in one process. Two Smelting alternatives are the Flash Furnace or the Electric Furnace, followed by the Peirce-Smith or Hoboken Converter. Continuous Smelting was developed in the 1970 to overcome the batch-wise operations inherent in traditional processes and is a major alternative to the combination of Flash Smelting and converting. The Mitsubishi & Noranda integrated processes aim to produce copper on a continuous basis, using oxygen as the sulphur oxidant. However these processes are not very successful commercially.

Hydrometallurgical methods of leaching are mainly used to treat copper oxide ores (Carbonates and Silicates). These processes avoid the smelting step required for sulphide concentrates. Copper is finally recovered in this process by solvent extraction. This process has an advantage over the Pyrometallurgical methods as the SO_2 emitting smelting step is avoided, though problems of waste disposal exist. Other advantages are the recovery of sulphur in elemental form and economies for small scale applications. However hydrometallurgical methods are more energy intensive than Pyrometallurgical route as they do not take advantage of heat which can be generated by the combustion of the sulphides.

The Silver lining of hydrometallurgical process is, its economies available from small operations. The plants abroad are operating at 12 to 20 tonne per day of copper metal extraction.

24. REFINING

Refining of copper is done electrolytically, commencing with blister, cement copper or electrowon copper. Blister copper is treated in an anode furnace from where anodes are cast for electrolytic refining. Cement copper must be first treated in a converter before casting to anode. An electric current is applied to Dilute Sulphuric Acid solution and copper ions are attracted from the anodes to the negatively charged cathode sheets, forming a coat of pure copper.

In the final step the copper cathodes are remelted and cast, either batch-wise or continuously, into shapes for use in semi-fabrication. Originally, wirebars were produced from moulds, but today Continuously Cast Rod(CCR) is produced in coils from a furnace sequentially feeding a casting wheel and a rolling mill. Various technologies for manufacturing CCR used worldwide are as follows :

i)	SCR	ii)	Contirod
iii)	GE Dip	iv)	Properzi
v)	Outokumpu		

25. R&D - INDIAN INDUSTRY

i) Khetri Copper Complex has a strong in-house R&D Department staffed with about 115 personnel. The annual spendings on R&D is estimated at Rs 80 lacs. Major R&D projects undertaken include the following :

- Better fragmentation of ore, reduction in explosives consumption.
- Study on effective reagents for better recovery of copper during beneficiation.
- Recovery of magnetite from ore tailings.
- Column floatation cell option.
- Improvement in smelter burner design.
- Optimisation Study on oxygen enrichment.
- Extraction of Copper from ocean nodules.

ii) ICC's R&D Department has worked/is working on the following areas :

- Bio-leaching (SX-EW) process in underground mine

- Process automation in beneficiation

- Recovery of Cobalt & Nickel from Converter Slag, Magnetite from ore Tails, Molybdenite from Copper Concentrates

The R&D Department has about 130 persons. Future thrust areas include better recovery of by-products, development of alloys etc.

iii) Taloja Copper Project of HCL for manufacturing of CC rods has a full fledged R&D and Q.C. Department. Annual expenditure is estimated at Rs 40-45 lacs. Major R&D projects include the following :

- Indigenisation of rolls of Morgan No - Twist rolling mill.

- Indigenisation of Thermocouples and cables.

- Implementation of online process control system.

- Quality control measures i.e. Control Oxide levels, rod diameter, spiral elongation etc.

Thrust areas for future include cathode analysis, development of chemicals to improve surface quality of rods etc.

26. R&D - NATIONAL LABORATORIES/INSTITUTIONS

i) National Metallurgical Laboratory (NML), Jamshedpur is a leading R&D Institute in metallurgical & allied areas. Major R&D work carried out at NML related to copper are pilot plant investigations, design & development of beneficiation flow sheet for Rakha & Malanjkhand Concentrators, Design of vertical column floatation cells for HCL's Malanjkhand project, Processing of polymetallic sea noduler for recovery of metals i.e. copper, nickel etc. The main attraction is the pilot plant for mineral beneficiation studies which has been imported from USA.

ii) Indian Bureau of Mines (IBM), Nagpur has a central Ore-dressing Laboratory. They are well equipped with modern equipment and instruments to carry out both laboratory and pilot plant beneficiation investigations, and ancillary facilities for instrumental and chemical analysis as well as minerological studies. The prime objective is to develop the process know-how and flow sheet for beneficiation to obtain saleable products from low grade ores and mineral rejects.

iii) A few other R&D institutions working in the area of copper include the following :

- DMRL, Hyderabad : Development of Oxygen free copper for electronic industry
- BARC, Bombay : Recovery of cobalt powder from cobalt cake obtained from converter slag
- RRL, Bhubaneshwar : Recovery of molybdenum from copper concentrates

27. The Government of India in the recent budget for the year 1993-94 have liberalised import of Copper and its products substantially in order to reduce cost, boost consumption and to make the Indian Copper Industry competitive in international market in terms of price, quality, etc. The customs import duty has been reduced from 95% to 50% and the items have been decanalised (earlier MMTC was the canalising agency).

28. TECHNOLOGY GAPS

Major areas of technological gaps in the Indian Copper Industry when compared to the foreign industry include the following :

i) Underground mine construction costs and construction periods are substantially higher when compared to foreign countries i.e. 48-72 months in India when compared to 20-36 months abroad which leads to lower viability of the projects.

ii) The rates of shaft sinking in mines in India are considerably lower when compared to foreign countries i.e. 10 m/month and 25-30 m/month for tunneling/raising operations when compared to 160 m for shaft and 150 m for tunneling/raising per month abroad.

iii) The low levels of oxygen enrichment in smelters (25% O_2) when compared to about 60% O_2 abroad deprives advantages i.e. enhancement of capacity without much of capital investment, higher copper content in Matte, savings in total energy consumption, higher SO_2 content in gases etc.

iv) In India the route of leaching and electrolysis of lean sulphide ores and oxidised ores for recovery of primary copper is at experimental stage, whereas abroad about 15% if primary copper produced is from this method.

v) Energy consumption in recycled copper from scrap is only 1700 KWH/tonne when compared to about 13500 KWH/tonne of metal when produced from ore. In India secondary copper producing plants have just made a beginning when compared to the world where about 40% of the copper is from recycled scrap and the industry is well established.

vi) Special alloys of copper are still being imported in the country i.e. conductivity copper, beryllium copper etc. due to lack of production technology.

vii) Mine exploration technologies being used in India are obsolete and substantial technology gap exists in exploration techniques, equipments etc.

viii) Technology for manufacture of downstream copper products i.e. ultrafine copper wires, dual coated/self bonding super enamelled copper wire, copper tubes for refrigeration/air-conditioning etc. have not been fully developed in the country and need to be imported.

ix) The manpower requirement/tonne of finished metal is quite high in India when compared to foreign countries basically due to factors i.e. excess employment, manual nature of production technologies specially in mining etc.

x) Substantial Air pollution is caused because of higher percentage of sulphur dioxide in the exhaust gases from Acid plant converters etc. than the permissible limits and pollution control measures need upgradation.

xi) Recovery of precious metals i.e. Cobalt, Nickel, Magnetite from copper concentrates, tailings etc. is inadequate due to lack of appropriate technology which leads to high cost of production of copper.

29. CONCLUSIONS

i) The consumption of copper in the world is around 10 million tonne per year out of which India has a meagre share of only 1 per cent mainly due to high cost of copper in the country and availability of cheaper substitute metals.

ii) Till now only Hindustan Copper Ltd (HCL) was the sole producer of primary copper in India. With the opening of the Industry to Private Sector by the Government the competition is increasing and new mega scale projects are coming up i.e. Sterlites 60,000 TPA project based on technology provided by MIM Holdings, Australia which is based on imported copper concentrates, leading to lower cost of production & metal.

iii) There is a huge gap between Demand & Supply of Copper in India which leads to imports which are estimated at 70% of requirement. It is estimated that with the coming up of smelter at Malanjkhand and a number of smelters in the private sector, imports could be reduced to a level of 35-40% by 1999-2000 provided the price of indigenous copper is competitive and matches the price of imported copper (the current gap estimated at Rs 7000-Rs 8000/tonne).

iv) Over the years, HCL has introduced a number of modernisation measures at its plants i.e. computerised auto-weighing system at Anode Casting Wheel (KCC), installation of starter sheet straightening machine and Anode milling & reforming machine (KCC), Gas poling instead of green poling in Anode Furnace (ICC & KCC) etc., but still substantial technological gaps exists in the industry i.e. high cost of mine development low levels of oxygen enrichment, lack of technology for special alloys of copper, obsolete mine exploration techniques, high cost of production, air pollution from SO_2 etc. which need to be minimised for the development of the industry.

v) Environmental pollution aspect has also been provided top priority at HCL's plants at KCC, ICC. All liquid effluents are treated and recovered water is recycled back to the process without any discharge. However there is air pollution caused due to higher percentage of sulphur dioxide in the gases emitting from converter, smelter, acid plant and in order to control air pollution various measures have been planned i.e. installation of double hood system on converter mouth, alkali scrubbers in acid plant to scrub tail gases etc. but their implementation needs to be expedited.

vi) Since there is no smelter at Malanjkhand, the concentrate has to be transported to Khetri for processing or send abroad for toll smelting which involved high cost of transportation (since concentrate contains only 36% Cu). This could be economised if a smelter is installed at Malanjkhand at the earliest.

vii) Solvent Extraction - Electro Winning process (SXEW) has great potential in India for copper ore processing since India has huge dumps of low grade ores and low grade ore bodies of uneconomical dimensions for pyrometallurgical route. This process is at experimental stage in India and needs to be developed and commercialised.

viii) In the absence of strong R&D in the equipment design and availability of special materials of construction, technology/equipment imports are essential, but lately it has been observed that based on design & drawings provided by Foreign Collaborator/Technology Supplier even critical equipments i.e. Smelters are being fabricated in India.

ix) The major problems existing at HCL's plants include the following :

i) Higher generation of reverts and lack of technology for revert recycling and balancing

ii) Inferior quality of anodes i.e. fins, high oxygen content etc.

iii) High cost of production due to various factors i.e high cost of mining, plants are highly labour intensive, high cost of electric power due to captive generation in absence of State Supply, poor quality of ores etc.

iv) Inadequate ventilation/airconditioning inside underground mines (specially at ICC) lead to uncomfortable conditions of high temperature & humidity and lead to lower productivity.

v) The D.G. sets for ICC mines are of Russian make and there is a lot of problem of repair & maintenance and spares which leads to unsteady electric supply to Mines and hampers operations and productivity.

x) Salient Features of Technology (International Status)

The salient features of technology relate to the following sub-sectors :

- New metallized ANFO
  (Ammonium Nitrate Fuel Oil)
  slurry explosives with varying proportions of aluminium with increased sensitivity to the initiation of detonation.

- Shovels and draglines with 90 to 95 percent availability. Electric shovels with 12 to 25 Cu.m capacity are the prime choice for large open pit copper mines.

- Portable crusher and belt conveyer systems have been introduced to save on high cost of truck haulage for both ore and waste

- Vertical crater retreat (VCR) has been introduced to bring down the cost of mining and improve safety in underground copper mine.

- Continuous Mining System (with remote controls, continuous loading machine and portable jaw crusher) has added to the safe working of underground copper mines.

- In the beneficiation technology pre-concentration, autogenous/semi-autogenous grinding were introduced at the international level more than decade ago. But recut instrumentation and improved crusher control and grinding circuits help to ensure smooth operation and maximum machine loading.

- Hydro cyclone have brought revolution in classification of desired sizes of ore. This technology has resulted in (i) effective classification and separation of fines (ii) low consumption of spare parts, (iii) very small size permitting of double grinding capacity under same roof and (iv) their easy adaptation to automatic controls of the grinding circuit.

- Introduction of unit floatation cell has facilitated reduction of over grinding and consequent loss of values as slimes and lowering of moisture content in the concentrate.

- The capacity of the conventional flotation cell has been upgraded ten times with the computerised control on the parameters having impact on the performance of the cell.

- Column flotation cell, a technologically new system for replacement of traditional flotation cell was developed during the past decade in Canada. It produces concentrates of high purity in single stage.

- In pyrometallurgy, a number of continuous processes have been introduced viz. (i) Outokumpu Flash Smelting (ii) INFO process (iii) Noranda process (iv) Mitsubishi process, (v) El Teniente process. Amongst these processes Outokumpu Flash Smelting accounts for more than 30 installations all over the world. With the introduction of oxygen enriched air (60%) Outokumpu process becomes :-

  - Completely autogenous and the copper content of the matte increases to 65-70%

  - With a higher grade of matte the required converting capacity and energy consumption falls sharply by as much as 40 to 50 per cent

  - Also addition of oxygen, reduces the volume of gases and increases their SO_2 content from normal 10-15% to as much as 20%.

  - By changing the ratio of concentrates to oxygen in the process air, the concentrates of varying composition can be treated in this process.

  - Hydrometallurgy has emerged as a process to supplement the copper production through pyrometallurgy. The solvent extraction - electrowinning (SX/EW) process reduces the overall cost of production of copper through pyrometallurgy.

In semies manufacture a revolution has come in the continuous cast technologies. The prominent processes are the following :

i) Continuous proportion process
ii) South wire continuous Rod
iii) Outokumpu process
iv) Contirod process
v) GE Dip Forming process
vi) GE Levitation casting process
vii) Secor, casting process etc.

Innovations have been introduced to bring the economies of scale so that these technologies have ready acceptability in developing countries having lower level of consumption of copper.

30. RECOMMENDATIONS

Mining

i) Hydraulically operated Jack hammers, computerised long hole drilling machines instead of manually operated machines, Jumbo machines (multi drilling machines) to increase productivity in mines and reduce mining cost may be introduced.

ii) Instead of mixing AN & Diesel and transportation, on-site mixing machines could be introduced.

iii) In present and future planned open cast mines hydraulic excavators, showels of larger bucket capacities (10-12 cu.m) could be adopted.

iv) Drilling machines to drill larger diameter holes for blasting (200-500 mm diameter) could be introduced to reduce drilling cost.

v) Mine exploration activities may be technologically updated and taken on top priority basis for locating copper ores rich in copper which make recovery of copper economical.

vi) Insitu mine leaching which is an economical method of extraction of copper from small deposits may be explored.

Beneficiation

i) Replacement of smaller flotation cells by larger flotation cells in existing plants and introduction in new projects which are energy efficient may be adopted.

ii) Introduction of instream analysers, process automation and instrumentation to measure and control flotation cell parameters and provide greater quality control i.e. % of copper, reagents quantity etc. may be explored.

iii) Column flotation for improvement of grade of copper and reduction of insoluble matters may be introduced.

Smelter

i) Oxygen enrichment to a level of 60 percent may be adopted to make smelting autogenous, increase throughput, decrease cost of production, minimum revert generation.

ii) The oxygen content in Anodes should properly be checked and controlled so that problems faced during refining are minimised.

iii) Application of Ausmelt technology for treatment of reverts/ secondaries and enhancement of recovery of precious metals and initiation of recovery of nickel/cobalt being lost in slag dump may be examined.

Refinery

i) Changing the copper mother blanks with S S Blanks which have better corrosion resistance against electrolyte, may be explored.

ii) Anode Unloading, Cooling etc. may be automised to increase productivity.

iii) Energy efficient processes i.e. periodic reversal of current, ISA process with stainless steel cathodes could be explored.

Products

i) Development and commercialisation of Oxygen Free Copper (OFC) for specialised applications and other alloys which are being imported to promote demand & consumption of indigenously produced copper may be undertaken.

ii) Development and commercialisation of technologies for recovery of valuable materials i.e. Magnetite from ore tailings, molybdnite from copper concentrates, cobalt & nickel from converter slag etc., may be explored.