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UTILIZATION OF COPPER SCRAP:
TECHNOLOGY AND EQUIPMENT ^{1/}

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UTILISATION OF COPPER SCRAP; TECHNOLOGY AND EQUIPMENT

INTRODUCTION

The utilisation of scrap copper has developed rapidly in the industrialised nations of the world. Pressures arising from shortage of supplies of virgin copper, high prices and the need to improve balance of payments positions by reducing imports have all contributed to the development of secondary metal refining industries.

For developing countries this must be equally important, if not more so as capital required for the purchase of raw materials could well be more desirably employed in the acquisition of manufacturing plant and equipment.

Today the products of secondary refining plants compare very favourably with those of the primary metal producers and are no longer considered to be of inferior quality.

Advances in metallurgical techniques and in plant operation have enabled this dramatic rise in quality to be achieved.

In order to obtain the maximum value of copper scrap it must be converted to a form in which a consumer industry may use. This may be in the form of cathode or ingot for re-melting or alloying, or as a wirebar, billet or cake for rolling into wire, sheet and strip or for the drawing of tubes and sections.

Broadly speaking, therefore, a consumer industry to take the products of a refinery is of some importance otherwise it must be exported.

General Content of the Paper

The paper has been presented in the form of practical guidance in the establishment and operation of a pyro-metallurgical process plant. Electrolytic refining is mentioned in passing only and its omission explained by the fact that the establishment of a fire refining plant is a necessary step should the former be contemplated at any time.

Also, in the author's view, fire refined copper may be suitable for use in industries to be found in developing countries, whereas electrolytic quality may not be necessary. Thus it would be bad economically to produce with high cost capital equipment a product that a lower quality produced by a cheaper method could be effectively used.

Furnaces and ancillary plant are surveyed, the types being restricted to those well known and well tried by industry and similarly the operating practice explained in some detail is based upon standard practice.

The Origins of Scrap Copper

Scrap copper arises from two major sources, industrial process scrap and the discarding of capital equipment and consumer goods. Whilst a large part of the scrap arising from industrial processes is re-circulated within the industry or related industries, that arising from replacement is, in the main, material for recovery by refining.

In heavily industrialised countries the volume of scrap arising is large and grows consistently larger each year. Under pressure of steadily increasing copper prices the recovery of copper has become a major industry employing modern techniques and which is highly capitalised. The products of this industry are today of very high quality and find a ready market in the consumer industries.

Supporting this secondary smelting operation is usually an extensive merchanting operation engaged in the collection and classification of scrap and its sale to the smelters and refiners.

The pressures referred to earlier have had the effect of concentrating the recovery of secondary copper

into mainly large companies in which both pyro-metallurgical and electrolytic refining techniques are employed.

This does not mean that the successful utilisation of copper scrap must of necessity be carried out on a large scale. A small plant using good metallurgical techniques can support a profitable operation.

Industrial Process Scrap

Industries which use copper for the manufacture of sheet, strip, tube or wire purchase, cakes, billets and wirebars in large quantities from the primary producers and from the secondary metal industries. During manufacture, process scrap arises from edge slitting, trimming to length, the discard of tagged ends in tube and rod drawing operations and in extrusion processes. A common feature of many fabricators is that they possess melting facilities in which this process scrap may be simply melted and cast into shape for working. Similarly companies engaged upon the fabrication of copper based alloys may use process scrap for the basis of their alloy production, for example clean copper scrap is used in the manufacturing of brasses.

In general, therefore, little high grade copper scrap is marketed by the fabricating industry but slags, unusable swarf etc. is usually returned to the refiners.

The engineering and electrical industries on the other hand are not in the main, consumers of their own process scrap and this is usually sold directly to refiners or indirectly via scrap merchants. Usually materials in this class are of known composition, little contaminated and can be utilised with relative ease.

However, insulated electrical wire with plastic and paper covered coatings arises in considerable quantities and special methods have been developed for the separation of the insulant from the copper. These processes will be discussed at length later.

The Replacement of Capital Equipment and Consumer Goods

An ever increasing quantity of scrap copper is to be found under this heading and at any secondary

smelter an examination of the raw materials stock will reveal the sources of much of this scrap. Amongst many others will be found discarded busbar, telephone wire, copper water service tube, locomotive fire-box plate, tubes from ship-breakers, heat exchangers, motor vehicle radiators, plumbers scrap, electric motors etc.

Much of the scrap of this nature will be contaminated with tin, lead, iron, zinc and cadmium which has to be removed by refining processes. The extent of the contamination will decide whether the scrap should be fire refined or electrolytically refined.

Products of Secondary Smelting Operations

By the judicious usage of scrap a secondary smelting operation of the pyro-metallurgical type as opposed to the more complex electrolytic refining process, is able to produce a high grade copper comparable to that called for in British Standards 1037.

Cast in the form of wirebar it may be used for electrical wire production for all types except perhaps enamelled winding wires where special springiness properties are required.

For the production of sheet, strip and tube such a copper is very suited when cast into cakes and billets.

The requirements of British Standard 1172 would also be satisfied after deoxidation with phosphorus.

Ingot bars cast from this class of material can be used in the production of alloys of copper such as the brasses, bronzes, gun-metals and cupro-nickels.

In every case the impurity limits are tight and may only be achieved by the selection of the correct type of scrap and good refining techniques. The importance of correct grading and sorting of scrap cannot be over-emphasised.

The Sorting and Grading of Scrap

Scrap may be delivered to the refinery already sorted and graded. The U.S. National Association of Secondary Material Industries (N.A.S.M.I.) issues an internationally recognised Standard Classification for Non-Ferrous Scrap Metals. Not only does this included descriptions of the quality of various but codes of practice regarding such matters as delivery and alritration.

For example No.1 copper wire scrap code named **Berry** is specified to consist of clean, untinned, uncoated, unalloyed copper wire and cable, not smaller than No.16 B.& S. wire gauge, free of burnt wire which is brittle. Hydraulically briquetted copper subject to agreement.

It is usual to check a consignment to see that it is as specified and in the case of lower grades to sample and melt the sample and conduct an assay.

Mixed parcels are frequently obtained and after seperating the obvious higher grades the residue is assayed.

Good practice demands the higher quality grades to be carefully segregated and refined as a parcel. In this way high quality products may be obtained with the minimum of refining. Usually the cycle for this type of material is 24 hours but as more refining is required the cycle extends to 36, 48 or 72 hours.

In the extreme case of an assay as follows:-

Copper	92%		
Lead	greater than	0.5%	
Nickel	"	"	0.1%
Tin	0.1/0.2%		
Si	greater	"	0.2%
Te	"	"	0.02%

the parcel would regarded as being fit only for melting and for subsequent electrolytic refining and during this treatment the lead and tin would be reduced by about 60% and the non-metallic portion removed with the slag, the copper content of the final product would then rise to the order of 98/99%.

The Technology of Fire Refining

The major elements encountered in copper scrap are tin, lead and iron, all of which may be reduced to desirable limits in fire refining, arsenic which is a little more complex to remove and nickel which is not substantially removed. Cadmium and sulphur are volatilised if present and are exhausted with the furnace gases.

Therefore, from the analysis of the parcel of scrap to be treated it will be seen whether the total nickel content entering the charge will be below that required in the product or whether some nickel free scrap will be required to dilute the total nickel content of the charge to the desired level.

Similarly it will be seen from the lead and tin contents precisely the degree of refining which will be necessary in the case of these elements.

The formulation of the charge is very important and a successful result is obtained only if the sampling and assay has been carried out accurately.

The fire refining process is based upon the chemical reactions which occur when air is passed through a bath of molten copper. Volatile elements such as cadmium and sulphur volatilise but essentially elements such as lead and tin form oxides which float to the surface and can be collected or absorbed in the slags. In general the readiness with which elements are removed is dependent not only upon the heats of formation of the metallic oxides but also upon the extent of the solubility of the oxides in the metal, which is a most important aspect. For example, in the case of iron and nickel, their heats of formation are comparable but whereas iron is one of the easiest elements to eliminate, nickel is one of the most difficult. Thus the extent of the oxide solubility may reverse what would be expected from the heats of formation alone.

Essentially the copper becomes saturated with cuprous oxide and it is advisable to limit the oxygen content of the melt to 1.2% as after that point the loss of copper to the slag increases sharply. The control of temperature is also important as with ascending temperature the solubility of cuprous oxide in copper also increases. Thus at a temperature of 1120°C the solubility is 0.6% by weight whilst at 1180°C it is 1.2%.

It will be seen, therefore, that the success of the fire refining operation is dependent upon close control of the oxidising process. When the oxides have been formed by the reaction of the air blown through the bath they rise to the surface and are collected in a slag, usually of fused silica sand. If the impurity content is high, then repeated slaggings are required to reduce it to an acceptable level. The slag is skimmed off the surface. Plate 1.

During the oxidation of the impurities, the copper in the bath is also oxidised and the cuprous oxide formed dissolves in the bath and renders the copper brittle. Also as soon as the maximum amount of oxygen has been absorbed by the copper, little oxidation of the impurities proceeds and it is necessary to reduce the cuprous oxide by reduction. This is achieved by the insertion of green poles beneath the surface of the bath, the ensuing evolution of volatile hydrocarbons effectively reducing the cuprous oxide. This part of the process is known as 'poling'. Plate 2.

Practical Aspects of the Refining Process

Removal of lead and tin

Scrap copper charges generally require the removal of lead and tin which are the major impurities present.

Starting from the condition in which the charge is completely molten the air is introduced by means of clay coated steel pipes inserted beneath the surface of the bath. One or more pipes may be used depending upon the size of the bath. The air pipes are connected to air compressors and the air is delivered at a pressure of 25 lbs.p.s.i. The time of oxidation varies of course with the volume of the bath, typical times being 3 hours in the case of a 185 tons capacity furnace, 2 hours for one of 75 tons and 0.75 hours for a 5 tons capacity Sklenar furnace.

A carrier for the oxide on its formation is required and usually sand is used for this purpose. It should be added at a rate of 14 lbs. per ton of copper and it is important to ensure the sand is molten and fluid.

Of paramount importance is the necessity to ensure the bath is brought to 1.0% of oxygen, which practice has shown to be the minimum required for the formation of tin oxide. Greater tin removal results when the oxygen



PLATE 1

**Slagging a 185 tons capacity Reverberatory
Furnace.**



PLATE 2

Poling a 185 tons capacity Reverberatory Furnace.

content is further increased but due to the formation of cuprous oxide which passes to the slag it is usual to work with a maximum content of 1.2%. Under these conditions the maximum removal of tin is effected and the copper losses to the slag are minimised.

The removal of lead occurs from the formation of lead silicate, the oxide of lead combining with the silica of the sand. It does appear in practice that too much oxygen inhibits the removal of lead, particularly if tin is present in large quantities i.e.

An oxygen content of 0.8 - 1.0% offers the best chance of effective lead removal.

It should be noted that a treatment for the removal of lead may be quite lengthy since the sand must be molten and thoroughly dispersed through the bath. On a 75 tons capacity furnace a period of about 2 hours is required and the bath is agitated by blowing or poling between the oxygen range of 0.8 - 1.0%.

The use of steel blowing pipes results in some iron entering the bath as they erode and this has been found beneficial in helping the sand to become fluid more quickly and also to increase the reactivity of the ensuing slag. This does not apply, however, to the removal of tin.

Other treatments of the bath are sometimes used for lead and tin removal. In the case of lead, phosphorus in the form of 15% phosphor copper and ferro-phosphorus may be used but the ensuing attack upon the furnace lining in contact with the slag leads to rapid erosion of the refractory. If phosphor copper is used the application of sand with it helps to shield the bricks from the resultant lead phosphate slag. It plays no part in the reaction. When phosphor-copper treatments are used the oxygen content for the formation of lead phosphate is critical and should be controlled to between 0.4% and 0.6% for the best results to be achieved.

Below this level of oxygen content there is insufficient for the reaction to proceed readily whilst if it is exceeded the phosphorus reacts with the excess oxidation to form volatile oxides of phosphorus which escape as gases from the furnace.

Soda ash (sodium carbonate) may also be used as an agent for the removal of tin and lead. In this case it is added to the bath at an appropriate rate and into the melt. Sand must not be used, however, as silica will replace the tin in the slag and cancel out any tin removal which has occurred.

A similar treatment is used in the removal of arsenic.

Oxygen Control

From the foregoing the efficiency of the operation will be seen to be vested in the accurate control of the oxygen content of the melt. For the operation to be successful and copper losses in slags minimised, attention must be paid to this feature at all times.

An indication of how the absorption of oxygen by the bath is proceeding may be obtained by pouring a sample ingot and observing the viscosity of the metal as it is poured together with the nature and contour of the set produced on the ingot surface. Differences in bath temperature and varying amounts of tin and lead in the sample may give misleading results.

The use of a 'spoon sample' obtained by dipping into the bath and quenching quickly a button of metal is very indicative of the oxygen content when it is fractured and the nature and colour of the fracture examined. If the fracture is brick red in colour coarsely crystalline and lustreless and behaves in a brittle fashion then the oxidation of the bath is at its peak.

Whilst the foregoing methods can be used the optical oxygen method is the most accurate of the methods other than by chemical analysis. In this method a sample is taken, sliced and polished and examined under a microscope, the oxygen content revealed by the extent of the cuprous oxide at the grain boundaries being judged against standard photographs. It is simple and quick and furnacemen can be quickly trained in this method.

When the treatment has been completed the blowing pipes are withdrawn and the slag is removed from the surface of the bath by skimming and is collected in steel boxes. The skimming tools are usually given a coating of bone ash to prevent the adhesion of liquid copper.

At this stage it is necessary to determine the chemical composition of the bath and to check the progress of the removal of impurities. This is most efficiently carried out by means of a direct reading spectrograph. Upon the results of the analysis the decision is made regarding the necessity for additional treatments.

Poling

At this stage the dissolved cuprous oxide must be reduced and this is usually accomplished by the immersion of green poles beneath the surface of the bath. The process is referred to as poling and the cuprous oxide is reduced to metallic copper by the reaction with carbon and hydrogen from the poles, the products of the reaction being water, carbon dioxide and carbon monoxide which leave the furnace as gases.

As this part of the refining process must be carried out in a reducing atmosphere precautions are taken to ensure that furnace burners run on a reducing flame and that of doors and apertures. If the furnace is equipped with a flue damper this is adjusted to provide a slight pressure at the surface of the bath. That is to say the rate at which the products of combustion are formed is slightly greater than the rate at which they are exhausted from the furnace.

Optical oxygen checks are taken to ensure that over-poling does not occur. When the oxygen content has been reduced to about 0.1%, the bath is skimmed off and the blowing pipes immersed once more. The oxidising process is repeated followed by poling etc. until the impurities are reduced to the specification limits.

Upon completion of the refining process the bath is finally skimmed and poling continued until a tough pitch copper of 0.03/0.05% oxygen is obtained. Reducing conditions are maintained in the furnace as described above and a charcoal cover is placed on the surface of the bath to assist in this.

A spoon sample at this stage would show a level 'set' and on fracture reveal a rose coloured silky appearance with a metallic lustre and fine radiating grains.

It should be noted that during the blowing and poling operations, slag may be splashed onto the side walls, roof and end walls of a furnace and in the case of reverberatory furnaces, in the uptake. It is not unusual to find the lead content of such slag as high as 6-7% and if this is allowed to find its way back into the bath it can seriously interrupt the refining cycle and at worst it can put a charge out of specification if it enters during casting when the metal had already been refined to specification. The most effective ways of combating this so called 'run-back' effect is to take the bath when under the final sand cover, allow it to remain quiescent and raise the furnace temperature until the slag has dripped from the roof and walls and has been absorbed by the sand cover and also to put in the uptake a slag-pocket into which molten slag collects when it runs back down the uptake.

Slag from refining operations may contain between 30 and 35% of copper and this is recovered by processing it through a simple blast furnace. It is mixed in appropriate quantities with limestone, coke and scrap iron and charged to the blast furnace. The limestone acts as a flux, coke the fuel and iron as a reducing agent. In principle the air-blast oxidises the copper of the charge to cuprous oxide which is reduced to copper by the iron. A black copper rich in impurities is obtained and a spent slag containing about 1% of copper which is dumped.

Reduction of Arsenic

Tin and lead are the major impurities found in the higher grade copper scrap but occasionally arsenic may be above specification requirements. After the elimination of tin and lead and the final slag removed, sodium carbonate is added at an appropriate rate to the actual arsenic content and allowed to react for approximately 30 minutes and the melt skimmed of slag. A reduction of 50/60% of the arsenic content in the charge is achieved by treatments of this kind.

The Casting of Copper

Tough pitch copper produced by conventional fire refining techniques may be used for electrical purposes providing the electrical conductivity is sufficiently high.

Although continuous and semi continuous casting techniques are used extensively for shape casting, the horizontal solid copper mould is used for most of the world's production of wirebars.

The moulds are simple to make and require the minimum of machining and at the end of their useful life are returned to the furnace for re-melting.

For large volume production they may be multi-pocketed and mounted on a casting wheel but the use of static moulds is practicable.

Plates 3, 4 and 5

The mould pockets are dressed with a bone ash slurry to prevent welding of the molten copper to the mould.

Control of the casting temperature is of prime importance and is usually established on a trial and error basis to suit any particular set of casting conditions. The use of an immersion pyrometer is the best practicable means to ensure temperature control.

During casting the furnace is maintained under a slightly reducing atmosphere to keep the oxygen content around 0.03% and whilst casting is in progress oxygen checks are taken and the 'set' of the surface is constantly reviewed.

Copper of the normal tough pitch high conductivity type may be deoxidised by the addition of phosphorus, sufficient to leave a residual content of 0.02"0.05%. Deoxidised coppers are cast usually in copper moulds and a mould dressing of oil and carbon used as a separating agent. The quality of the castings produced is a function among many others of temperature, the rate of rise of the liquid metal in the mould and the nature of the stream of metal entering the mould. Care and attention to the casting process is of fundamental importance if a good quality product is required upon subsequent extrusion and rolling.

Plate 6

Equipment

If full realisation of the value of scrap copper is to be made then parcels of scrap must be assayed as accurately as possible and prepared for refining to a product giving the maximum profitability.

To achieve this adequate concrete storage areas are necessary to prevent lots or parcels of scrap from being mixed. The use of mobile cranes equipped with



PLATE 3

Casting ingot bar on Walker Casting Wheel.

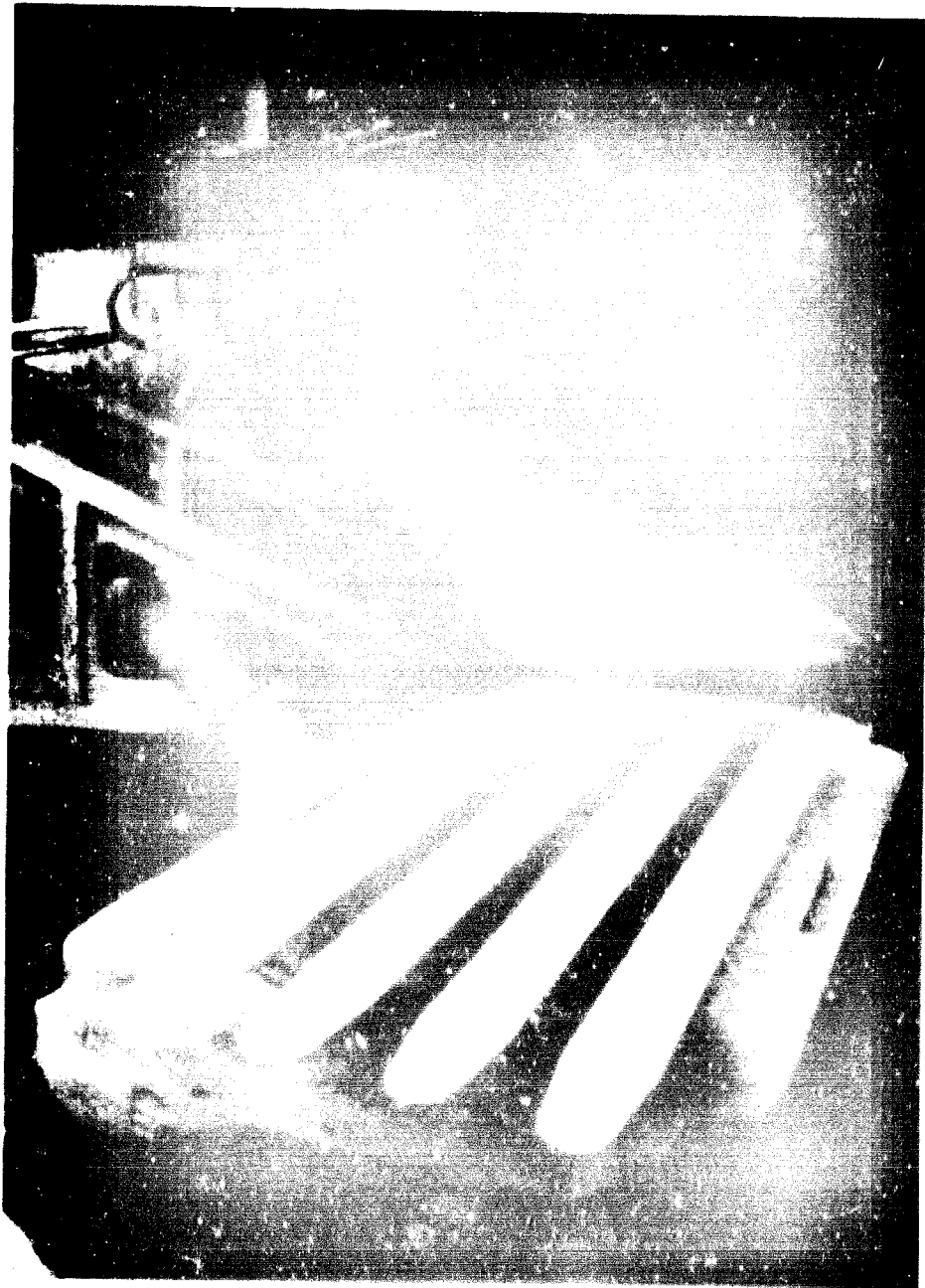


PLATE 1

Multi-Pocket Wire Bar Mould.

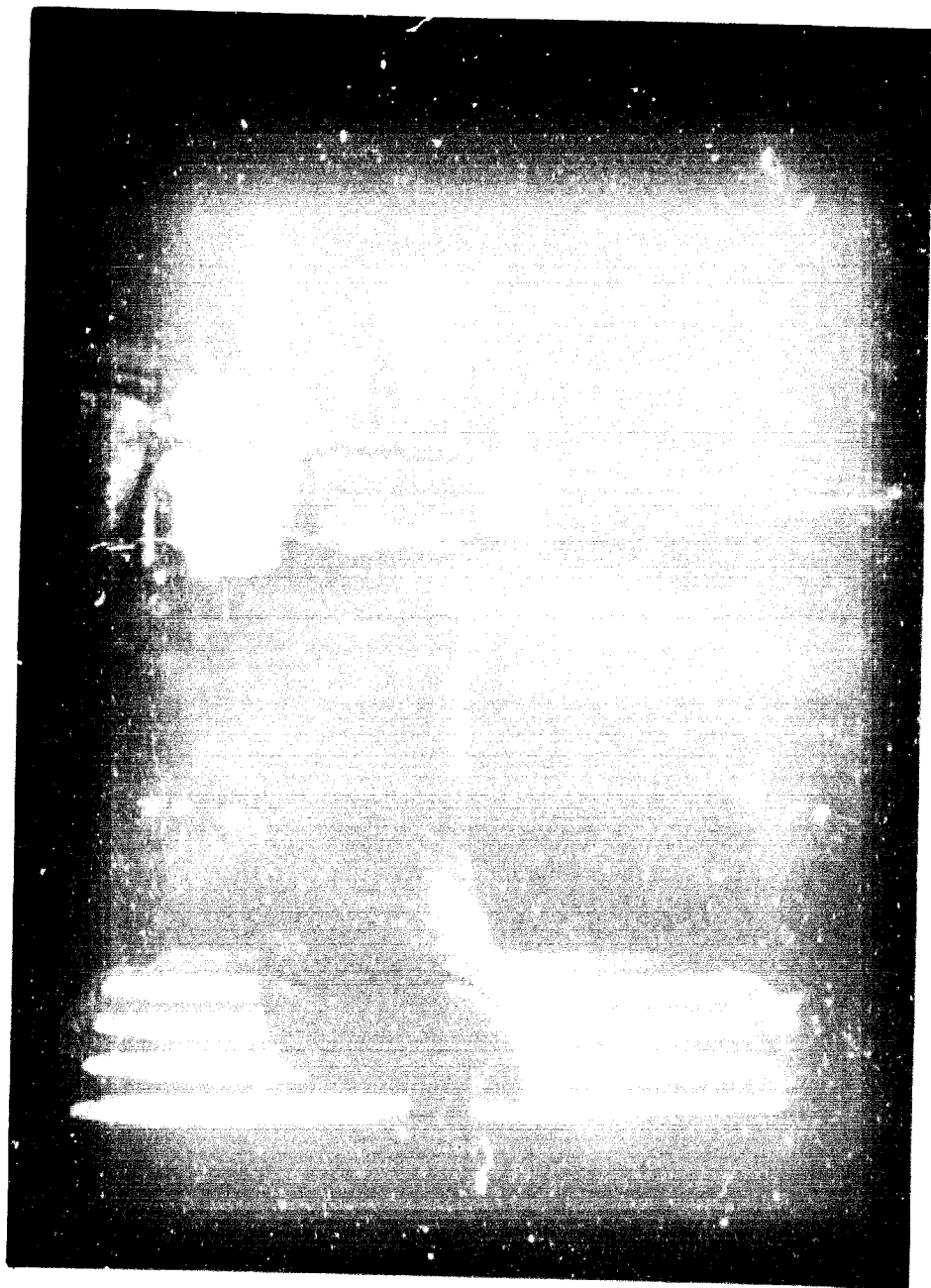


PLATE 5

Tap-Hole and Pouring Arrangement.

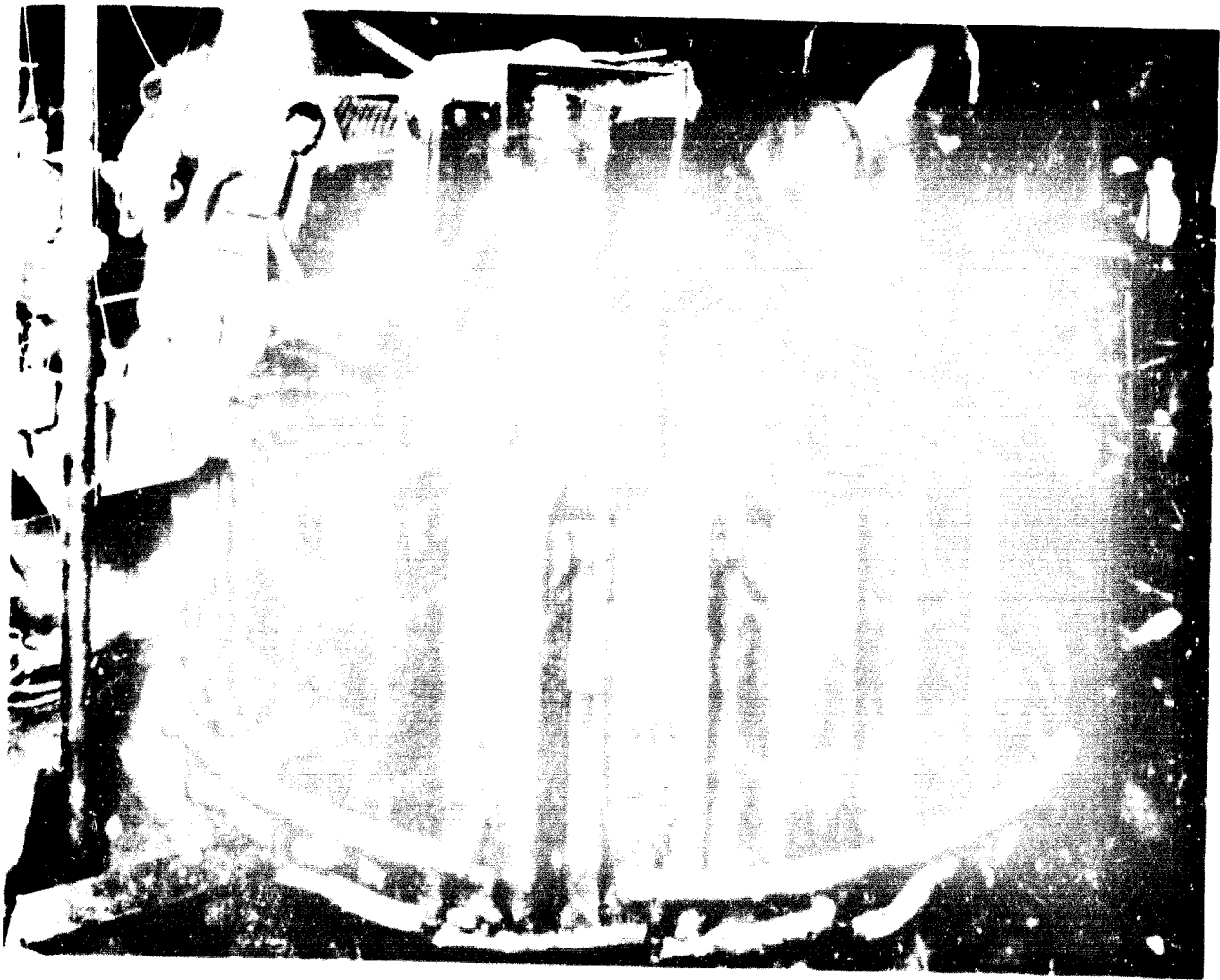


PLATE 6

Copper Billet Production.

cactus grabs enables large tonnages to be economically and quickly handled and the swivelling heads of cranes of this type can deal adequately with the tangled masses into which scrap tends to deteriorate.

In order to make the most effective use of refining furnaces, scrap needs to be compacted and reduced to a size suitable for charging.

Heavy scrap is usually sheared to size using heavy duty shears whilst light scrap is compacted in a baling press. A very wide range of shears and baling presses are available. For the latter, fully automatic machines are used in major refineries but smaller and less sophisticated machines can be used where large outputs are not required.

For large or small outputs, however, the prepared or baled scrap should be palletised and the design of the pallet should be such that any type of lifting mechanism may be used to lift it. In this way overhead cranes and fork lift trucks may be used in concert. Attachments to fork lift trucks may be used for furnace charging.

Furnaces

The following types of furnace are available to the secondary copper refiner the choice being dependant upon the output required to a large extent.

1. Reverberatory Furnaces

These range from 20-400 tons capacity and whilst the design and principle are old they are still the main furnaces used by refiners.

Plate 7

Usually they are rectangular in shape and with sides of steel plate. Heavy steel girders are used to keep the plating in place as the furnace is subjected to expansion and contraction during its heating up and operating cycles. The vertical girders are called 'buckstays' and they are tied across the roof with steel rods. By the adjustment of large nuts on the screwed ends of the tie rods the shape of the furnace may be retained during the life of the furnace.



PLATE 7

Charging a 185 tons capacity Reverberatory Furnace.

The body of the furnace is provided with burner ports at one end, charging door or doors along one side, skimming and poling door at the other end and a number of air ports for blowing along the length.

Reverberatory furnaces are usually stationary, a tap-hole being used for the discharge of metal. On tilting furnaces this is not necessary, enabling flexibility in the casting operation.

The furnace is preferably mounted on concrete piers to permit cooling of the hearth and experience has shown that a well laid hearth adequately cooled and of high grade chrome-magnesite refractory will last for as much as eight years when engaged upon the refining of scrap copper. The construction of the hearth is very important and the section of the reverberatory furnace shown in Fig. 1 shows a well tried and well proven method. The furnace bottom is constructed by the laying of steel plates on the piers and forming on top a concrete dish, 10" thick at the sides and 6" at the centre. The concrete is covered with 0.040" thick mild steel plate and a layer of fireclay 0.5" in thickness is laid dry on top. The first course of brick is then laid on the dry fireclay layer. It is a 12" course of 42% Alumina, 52% Silica brick. Upon completion of this course a 0.5" thick layer of magnesite powder is laid wet and when dried a 12" course of chrome-magnesite brick put down. The chrome-magnesite composition is about 53% magnesia and 35% chromium oxide. The bricks used in the hearth show a slight taper and care must be taken to ensure that they are laid with the top uppermost, indicated by a notch, or there is a danger that the bottom will rise when in use.

Chrome-magnesite brick is continued in the construction of the side walls to a point above the metal line, above which the use of a basic brick with improved resistance to spalling is desired. Bricks for this application are of the following composition -

Magnesia	Chrome-oxide	Aluminium	Iron oxide	Silica
39%	24%	16%	14%	5%
48%	19.8%	18%	9.6%	

As in the hearth the wall bricks are backed with an insulating course.

The roof may be either of the sprung-arch or the suspended type. The latter enables easier repairs to be carried out. Bricks of the composition quoted above are used for the roof where spalling tendencies are greatest.

Oil burners are provided in the back wall, usually two or three suitably rated to burn up to 60 or 70 gallons of heavy fuel oil per hour. It is customary to provide a gas oil as well as a heavy oil circuit to the burners, the former being used for the melt-down and the latter because of its substantially lower sulphur content, for the poling and casting portions of the furnace cycle. Heavy oil is of 3,500 secs. viscosity with a sulphur content of about 3%, whereas gas oil is 35 secs. viscosity and contains about 0.3% of sulphur.

For efficient operation of burners whether of the more efficient self-proportioning type or of the manual adjustment type, heavy oil needs to be heated to 250°F although this is not necessary for gas oil. Failure to maintain the temperature leads to the carbonising of the burners and the consequent loss in melting efficiency.

Self proportioning burners require less control than other types and are more economical in fuel consumption.

Recent developments have included the use of oxygen-fuel melting burners which has reduced the cycle time for higher purity charges by 50%, thus greatly increasing the furnace throughput.

When the furnace is tapped the charge may be cast into ingots, wirebars or taken for casting into billets and cakes. For ingots and wirebars the metal flows from the furnace into an intermediate launder or spoon which tilts and allows the metal to flow into the moulds which may be mounted on the periphery of a wheel or on a conveyor.

2. Rotary Furnaces

Furnaces of this type consist of simple cylindrical steel shells with conical ends. A refractory lining similar to those employed in reverberatory furnaces is used and an oil burner on a movable stand fires through one of the conical ends and at the other a refractory lined hinged flue removes the exhaust gases to the main flues. The body is mounted on rollers and can be rotated, the thermal efficiency being improved in this way as the charge is in contact with the refractory lining and takes up heat as well as that received by radiation from the flame.

Frequently these furnaces are made end tilting to facilitate charging, particularly with a fork lift truck. When the charge is in, the furnace is rotated to the horizontal position, the exhaust cone assembly placed in position and the burner lit. Rotation commences when the charge is about molten and the movement tends to assist in melting the entire charge. When completely molten the refining procedures are carried out as in the case of reverberatory practice and the slag is skimmed off from the flue cone end.

The choice of refractories is as for the reverberatory furnace.

Overall the rotary furnace is exceedingly useful as it can be used continuously or intermittently and is extremely simple to operate with low labour content.

3. Sklenar Furnaces

A third type of furnace employed in the refining of scrap copper is the unique Sklenar furnace which is essentially a small tilting reverberatory furnace with an interrupted uptake. Oil burners are located in the opposite end wall and the charge is lodged in the uptake, melting taking place there and the liquid metal flowing into the hearth.

Refractory practice is again the same for the reverberatory furnace, the walls of the truncated uptake consisting of a high grade firebrick.

Melting is extremely rapid and a five tons capacity furnace will readily melt on a three hour cycle to produce 40 tons per 24 hours of operation.

The depth of the hearth allows blowing to be carried out but not poling by conventional means.

Normal practice is to refine in the Sklenar furnace and to tap into a cylindrical holding furnace for poling purposes as the depth of metal enables a pole to be submerged.

Plate 8.



PLATE 8

5 tons capacity Holding Furnace.

The Sklenar furnace is extremely versatile and needs a minimum amount of manpower to operate and as a prime melting and refining unit it is extremely efficient.

Repairs are simple to effect as everything is readily accessible and a complete re-bricking of a 5 tons capacity furnace will take not more than 400 man hours.

Casting Equipment

The simplest arrangement for casting a product is to bring a mould beneath the tap-hole or pouring spout of a furnace. The mould may be positioned by the use of an overhead crane, a fork lift truck or man-handled into position. Usually, however, the capacity is such that more than one mould is required for emptying the furnace and then a series of moulds can be brought into position on a mould trolley or mounted on the periphery of a wheel which when turned presents a mould to the pouring orifice.

Moulds may be manufactured from good quality cast iron, copper, steel and employ water cooling. In a copper refinery, however, it is usual to use copper which is freely available during the casting stage to be cast into blocks for subsequent machining or cast into a block in which the mould pockets are formed by the use of cores inserted into the liquid pool of the mother mould block. The advantages of using copper are the high thermal conductivity, a basic requirement for any shape casting mould, the ease with which it can be formed and that its intrinsic value is not lost as after a long life it may be remelted and re-used.

The greatest disadvantage in adopting such a mould philosophy is the capital employed question and in many of the larger refineries the use of semi and continuous casting techniques in which the copper content of the moulds is very small is being increasingly used as a means of reducing the considerable lock-up of copper in moulds of the conventional pattern.

Provision should be made for pneumatic chisels so that inspectors can remove minor defects and blemishes from the surface of product destined for further working.

Periodically check sections should be taken of cast product and machined and polished. Etching will not only reveal the crystal structure but accentuate major and minor porosity. Deterioration from the accepted standards usually indicates some aspect of the casting operation being out of control.

Laboratory Facilities

The most important item of laboratory equipment is a direct reading spectrograph to enable rapid and accurate evaluation of the refining processes. The multi-channel instruments enable tin, lead, iron, arsenic, nickel, bismuth and antimony to be estimated in the space of a few minutes from a sample drilled from a cast block. This enables the refinery to act quickly and little delay is experienced in the operation of the furnace.

Optical oxygen checks have been referred to earlier and equipment for cutting samples and rapidly polishing them is as essential as the microscope used in determining the oxygen content.

For more accurate oxygen determinations, however, equipment which measures the oxygen content by reduction with hydrogen is available.

Elements such as phosphorus are determined by absorptiometric means.

Copper for electrical purposes demands the measurement of conductivity and this is usually done by casting a rod and rolling and drawing it into wire. The usual test is to draw the wire to 0.080", anneal at 500-550°C for not less than 30 minutes and measure the conductivity with a suitable electrical bridge.

British Standard 1037

Fire Refined tough pitch high conductivity copper.

Copper (silver being counted as copper)	not less than	99.90%
Bismuth	" more "	0.0025%
Lead	" " "	0.005%
Total (excluding oxygen and silver)	" " "	0.04%

British Standard 1172

Phosphorus deoxidised non-arsenical copper

Copper (silver being counted as copper)	not less than	99.85%
Phosphorus	" " "	0.013%
	nor more than	0.05%
Antimony	not more than	0.005%
Arsenic	" " "	0.05%
Bismuth	" " "	0.003%
Iron	" " "	0.03%
Lead	" " "	0.01%
Nickel	" " "	0.1%
Tellurium	" " "	0.01%
Selenium and Tellurium together	" " "	0.02%
Tin	" " "	0.01%
Total (excluding silver, arsenic, nickel and phosphorus)	" " "	0.06%

A restriction on bismuth to 0.0015% applies if the copper is to be severely hot worked in the temperature range of 400°C - 700°C.

UTILIZATION OF COPPER SCRAP: TECHNOLOGY AND EQUIPMENT

Resumé of the paper

It has been written essentially as a practical guide to the recovery of copper from scrap. An attempt has been made to reveal the potential use of fire-refining methods, as opposed to electrolytic-refining, for the production of copper shapes for subsequent working. In this way, it is felt, the maximum use of a valuable raw material asset is to be realised with a considerable contribution being made to the copper consuming section of the economy.

The fire-refining process is well known and is well documented in metallurgical literature and in the paper no attempt has been made to deal with the purely metallurgical considerations of the process. Accent has been placed rather upon the more practical aspects of the operations in order to provide a guide to the scale of operations required and to indicate the ancillary and support activities in the way of scrap collection and sorting, which must precede the actual refining process.

An indication of appropriate equipment has been given for the establishment of a refining operation for certain levels of activity. In this context the paper has been generalised so that a common form of good practice may be presented, being appropriate for very small to comparatively large installations.





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