TECHNOLOGY AND PROPERTIES OF POWDERS AND CERMET PARTS

DEVELOPMENT PROSPECTS IN THE PRODUCTION OF
ELECTROLYTIC COPPER POWDER

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Electrolysis is at present the main method of making copper powder; the process is readily controlled, and the product has the advantages of being pure, of dendritic structure, of having a wide range of particle sizes, and of being available in a range of densities. The powder is now an essential material in powder metallurgy, in the production of electrode carbon, etc. Advances in power engineering, automatics, and machine tools have given rise to an increasing demand for copper powder.

### Composition of Copper Powders Made in the USSR

<table>
<thead>
<tr>
<th>Grade</th>
<th>Granulometric composition, %</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>exceeds 0100</td>
<td>residue 0080</td>
</tr>
<tr>
<td>PMO and PM</td>
<td>100</td>
<td>≤ 1.5</td>
</tr>
<tr>
<td>PM-1</td>
<td>100</td>
<td>≤ 0.3</td>
</tr>
<tr>
<td>PM-2</td>
<td>100</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The powder is made at current densities of 1400-1800 a/m²; the electrolyte contains 9-14 g of copper and 140-160 g of free sulfuric acid per liter, and it is used at 48-55°. The anode is made of M-1 grade electrolytic copper; the cathode is a copper grid. The powder is sold in grades PM, PM-1, PM-2, and PMO. The table gives brief details of these.

The copper content is 99.6% or more. The usual impurities (in %) are water 0.05, Pb 0.05, Fe 0.02, As 0.05, Sb 0.01, and 0.05 residue after firing and treatment with nitric acid.

The problem of protecting the powder from corrosion was studied and solved in this institute during 1949-1951 [1,2]. The particles were rendered hydrophobic by treatment with solutions of soap or (nowadays) of soap with naphtha; this not merely suppresses oxidation during preparation, but also ensures an almost unlimited storage life.

The current yield is 89-90%, the potential drop across the cell is 1.2-1.6 v, and the energy consumed is 3600 kw-hr per ton, of which 1800 kw-hr is used in electrolysis.

The copper powder produced here is now as good as the best produced abroad, but the volume of production is too small to satisfy the continually rising demand. Means of increasing the output are at hand; primarily this relates to increased output per plant, reduction in energy consumption, and mechanization of the manual operations. The various stages of the process will be considered in this context.

### Electrolysis

The composition of the electrolyte and the conditions used control the grain size and the apparent density. These features also affect the current efficiency.

These factors are not given their due weight in the design of the equipment; the powder at the bottom of the tank is extracted and transferred by hand in existing designs. The distance between the electrodes varies between 35 and 80 mm, which causes an unnecessary increase in voltage and has an adverse effect on the powder, which becomes variable in grain size and density.
The particle size increases with the time spent by the particle on the cathode; the specified time between cycles is seldom maintained in manual working, so the grain size varies.

A standard product can be made only if the electrolyte is of constant composition, especially as regards copper content. The composition should be monitored and corrected continuously, whereas, at present, it is tested and adjusted only two or three times a day. This has the result that only 52-53% of the powder passes the first sieve, 40-45% being scrap that must be ground in a ball mill to reduce the waste to 14-15%. This treatment is expensive in equipment, labor, and time; moreover, the required grain size is attained only by destroying the dendritic structure, so the product is of poor quality.

This is not a sound method of making the powder. The best method would be to ensure that the powder is produced with the correct grain size at the cathode, to which end the relevant parameters must be kept strictly constant. This is possible only if the process is fully mechanized in an automatic cell of special design. Several such cells are at present under development; it is an urgent task for the industry to bring them into use as soon as possible.

**Washing and Stabilization**

This operation is performed in apparatus of percolator type, but the throughput is low and the washing, drying, and stabilization are not very good (the powder passing to the drier often contains 30-35% of water); moreover, the plant is worked by hand. Special centrifuges, Oliver filters, and other efficient units should be brought into use at once.

**Drying**

This is performed at present in batch-type stationary electric ovens consisting of steel drums of capacity up to 500 kg, which carry a heater winding and an outer jacket for coolant (this is used when the drying is complete). The drying process takes over two days and up to 10% of the powder becomes oxidized. The ovens are loaded and unloaded manually. The electrical energy is used with an efficiency not higher than 20%.

Here again we need better techniques. Some plants abroad use rotating driers fed with air heated by steam; such a drier has an output of 200 kg/hr. A fluidized bed and a reducing atmosphere give even better drying. Vacuum drying is another possibility.

The above examples show that there is plenty of room for radical improvements. Designers and technologists must produce advanced apparatus of high output; but the apparatus must be designed with full consideration of all features of the electrolysis, and so the design must be done in the closest collaboration with those directly concerned with the electrolytic production of powdered metals.

There have been several studies on the electrolytic production of copper powder in the last decade; these have revealed the main features of the process and should enable us to provide the best conditions for making the powder.

Our theoretical understanding of the process is now such as to enable us to envisage making the powder to specified grain size, density, and even dendritic structure while ensuring that the costs are minimized. The plant should be modernized to allow automatic control of the composition, temperature, circulation rate, etc.; this should also produce a reduction in energy consumption.

The location of new facilities for making the powder must be considered carefully. It is widely held that production should be concentrated in factories making electrical carbon, because this requires the most careful attention and continual testing. This is especially the opinion in copper electrolysis plants (the producers of copper powder).

Some in powder-metallurgy works consider that it would be better to concentrate production in their hands, for the powder they receive does not always have the necessary properties. Both arguments are unconvincing; the decision should be based on general economic grounds, not on narrow specialized requirements.

Some serious problems would arise if the production of the powder were divorced from copper electrolysis. The composition of the electrolyte would have to be adjusted by means of special regenerative baths, which consume much energy. The preparation of electrodes and processing of scrap would require extra equipment (even melting furnaces). There would be extra costs of shipping metal, sulfuric acid, and other materials, which, at present, are available without special expenditure. Moreover, the production of the powder has much in common with electrolytic refining and would be more difficult to organize in a powder-metallurgy plant.