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Modern Methods for Producing Metal Powders

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Abstract: This article discusses the issues of modern methods of production of metal powders used in mechanical engineering and other industries.

Keywords: Billet, molds, material, powder material, metal, mill, process, fine, clean.

Methods of production of metal powders are divided into two groups:

1) physico-mechanical — such technological processes in which metal powders are obtained as a result ofgrinding solid or liquid metals or alloys withoutchanging their chemical composition;
2) physico-chemical — such technological processes that result in physical and chemical transformations of the starting material and produce metal powders, as a rule, which differ from the starting material in chemical composition.

Physical and mechanical methods. Для механического измельчеBall mills, vibratory mills, hammer mills, and runners are used for mechanical grinding of hard and brittle metals and alloys. Grinding and abrasion of small pieces of material occurs due to their collision with heavy and hard bodies — steel balls, runners, hammers.

Ball mills can vary in size andconstruction. The drum capacity of these mills usually ranges from 0.05-0.20^{3}w3.

The intensity of grinding in ball mills depends on the correct choice of the drum rotation speed, the level of its loading, the ratio between the mass of the charge and the mass of crushing bodies.

When grinding hard alloy carbides and other hard materials in ball mills, in order to avoid contamination of the powder with wear products of the balls and drum walls,the inner part of the steel drums is lined with hard alloy plates and the balls are also made of hard alloys.

Vibratory mills are more efficient than ball mills; the grinding process in vibratory mills ismuch faster. The principle of operationof this millчается is that its body performs circular vibrations of high frequency, under the influence of whichthe crushed material together with the grinding bodies performs сложное двиа complex movement [1].

Plastic materials due to flattening are usually not ground in ball mills. If these materials are first brought to a brittle state by saturation with hydrogen or the addition of a small amount of sulfur, then grinding will be quite effective. After grinding, the metal powder is annealed.

Plastic materials are crushed in vortex mills. Grinding of the material in them occurs as a result of the collision of particles with each other and with the walls of a water-cooled casing lined with wear-resistant material.

Particles of the ground material collide under theaction of eddy currents of air or inert gas createdby two propellers. The resulting very fine and clean powder enters the separator and then the hopper.

During the grinding process in vortex mills, the metal is strongly riveted, so the powder is annealed before pressing.

Various methods of liquid metal grinding are based on spraying a metal jet with the kinetic energy of water, steam or gas, granulating the metal when casting into water, and spraying the metal jet when

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casting onto a fast-rotating disk. The resulting particles have a rounded shape.

These methods are used to produce powders from low-melting metals and alloys of tin, lead, aluminum and copper, as well as from iron, steel, cast iron and ferroalloys.Liquid metal grinding methods have high productivity and produce the cheapest powders.

Physical and chemical methods. These methods include recoveryof metal oxides, electrolysis, thermaldissociation, chemical grindingby intergranular corrosion, etc.

Metal oxides can be reduced by gaseous and solid reducing agents, including metals such as sodium, calcium, aluminum, magnesium, etc.

However, gaseous carbonaceous and hydrocarboncompounds (natural, blast furnace, and carbon dioxide), solid carbon (soot), and hydrogen are of the greatest practical importance as regenerators.

The most effective reducing agent is hydrogen, but it is expensive and requires special safety measures.

Hydrogen is used to reduce tungsten, molybdenum, nickel, cobalt, iron, as well as hard-to-recover oxides of chromium, aluminum, etc.

To obtain iron powder from oxides, scale is used as the cheapest starting product, and natural gas is used as a reducing agent.

Electrolysis of aqueous solutions of salts can produce fine and pure powders of various metals and alloys. By controlling the composition, acidity, temperature, current density, and electrolyte circulation, powders of the desired characteristics canbe obtained.

Electrolysis of molten salts and complex compounds is used to produce powders of some rare metals (tantalum, niobium, zirconium, titanium), which are difficult to obtain by other methods.

The thermal dissociation method is used to decompose carbonyl compounds of iron, nickel, and cobalt in order to obtain their powders. The essence of the process is that metal waste is processed in autoclaves with carbon monoxideat high pressure. As a result, carbonyl compounds of a particular metal are obtained.

When carbonyl is heated to300-500° C and at a high pressure(up to 20-30 $Mn/\ m2^{2})$, it undergoes dissociation according to the followingscheme:

$Me_x\ (CO) \rightarrow xMe + y\ (CO)$.

In this case, a fine powder with particle sizes of 1– 7 *microns* is released [1].

Carbonyl powders are characterized by high chemical purity and good technological properties. However, due to their high cost, these powders are only used for special purposes.

Chemical grinding by intercrystalline corrosion, based on the ability of metal to corrode mainly at grain boundaries, is used to produce powders from non-rusting steel.

When processing thin plates or stainless steel shavings with a solution of sulfuric acid, corrosion develops along the grain boundaries. As a result, the integrity of the metal is broken and a stainless steel powder is formed.

Preparation of powders for pressing consists of classifying them by size, mixing and pretreatment.

Powders with particle sizes of 40-50 *microns* or more are separated by sieving on sieves, and smaller particles are separated by air separation.

After composing a mixture of powders of the required granulometric and chemical composition, mixing begins. For mixing powders, drums with an eccentric axis of rotation, ball and vibration mills and other mixing devices are used. If particularly thorough mixing of the charge components is required, wet mixing is used in mills with the addition of alcohol or distilled water to the charge.

During the mixing process, you can introduce technological additives for various purposes: plasticizers

that facilitate the pressing process and produce a more durable briquette (paraffin, stearin, glycerin, rubber solution in gasoline, oleic acid, etc.); low-melting additives that activate the sintering process and volatile substances that allow you to get products with a given porosity.

To increase the fluidity of the powder and the possibility of volumetric dosing during automatic pressing, it is subjected to granulation, i.e. granules (grains) of a certain size are made from individual roche particles that have sufficient strength to maintain their shape until the moment of pressing.

Pretreatment of powders-mechanical or thermal (annealing) - is used to increase the ductility, compressibility and sinterability of спекаемостиpowders.

Classified, mixed, and pre-processed powders in the form of a charge are sent for pressing.

Forming of blanks of products is carried out by pressing (cold, hot, mouthpiece, hydrostatic) or proo roller, or suspension (slip) casting.

The main method of obtaining blanks of products is powder pressing.

Cold pressing. When pressing metal and пoplastic parts in the mold, the contact between the powder particles sharply increases части, the porosity decreases, and individual powder particles are deformed or destroyed. In результате полуthe cutter, a blank of the desired shape and sufficient strength is placed. Preservation of the shape and strength of workpieces after pressing is caused primarily by the action of mechanical coupling forcestof powder particles, electrostatic for cesof attraction andиfriction. Therefore, the strength of the resulting blank depends both on the degree of compression and on the shape and size of the particles, the nature of the material, the surface state and plasticity of the particles.

The higher the pressing pressure, the higher the strength of the resulting workpiece is usually. Fine powders$_{\text{of obr}}$a3$_{\text{ЮТ}}$ бо produce stronger workpieces than coarse-grained ones under the same жpressing conditions.

Powders consisting of complex shaped particles are used to produce stronger workpieces, as the probability of their particles sticking together and the contact surface increases.

Powders with an oxidized surfaceare poorly pressedя andprepared from them have low strength [2].

The blank removed from the mold undergoes a volumetricelastic expansion, i.e. an increase in size. The elastic aftereffect is larger for brittle materials $_{\text{й в}}$ средand is 0.3–0.6% in height and 0.1–0.2% in diameterin the medium. This value and sintering shrinkage are taken into account when прооктировcleaning the molds.

Pressing of products is carried out on hydraulic or mechanical presses in molds.

The pressing process consists of four operations: assembling the mold, dosing and filling the powder into the press$f_0p_m$atthe press, and removing the blank from the mold.

Depending on the complexity and configuration$_{\text{елия}}$ примеof the product, all-in-one and split molds can пресс-формыbe used with single-sided or double-sided pressing.

Single-sided pressing is used forлий, products whose height - to-diameter $\frac{ratio\ h}{d} \leq 1$. In this case , a uniform density of the briquette is ensured over the entiresection and blanks with a diameter and height of up to 60 *m can be obtained.*

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