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INTRODUCTION OF TECHNOLOGY FOR MANUFACTURING PRODUCTS FROM METAL POWDER COMPONENTS

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Annotation: In our country, the production of spare parts for automobiles and equipment using a combined method of metal and non-metal materials is developing year by year. This article highlights the successful application of metal powder (powdered) products in various sectors of the national economy, their significant importance in the production machinery and automotive industries, as well as the new models and methods of their technological processes currently being developed.
Keywords: Metal, powder, technology, metallurgy, semi-finished product, mixture, alloy, non-ferrous metal, steel, quality, filters, bearings, resistant, contact, chemical, physical, mechanical, thermal, press, shape, blank, part, device, form, spraying, electrochemical, ultrasonic, electrodynamic, grinding, mill, particle, stone-based, metal-ceramic, organic, inorganic, temperature, dispersion, synthetic, plastic, ductile, wear, spectral, property, characteristic, density, granular, porous.

Powder metallurgy is understood as a technological process that encompasses the production complex of metal powders and metal-like compounds, semi-finished products, and final products made from them or their mixtures with non-metallic powders from base component solutions[1].

The rapid development of powder metallurgy has created the necessary conditions for the development of a wide range of alloys that are used as materials with properties unattainable through traditional casting and forging or other technological processes, and that can replace steel and alloys.

Advantage**s** of powder metallurgy compared to other methods of producing parts and equipment components include:

The ability to obtain products that cannot be manufactured by other methods (filters, porous bearings, contacts based on refractory metal alloys, etc.);

Significant metal savings, use of waste (e.g., chips, scale, shavings, etc.) to obtain powders, and the possibility of producing products (such as bushings, gears, cams, etc.) without the need for further mechanical processing, which leads to a significant reduction in the cost of materials and final products[2].

Along with its advantages, powder metallurgy also has a number of disadvantages: expensive

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equipment (although cost-effective in serial and mass production), instability of properties, and challenges in manufacturing large and complex-shaped products.

Main technological operations in the production of powdered products:

a) preparation of powder mixtures with a given chemical and granulometric composition;

b) forming – shaping (pressing);

c) sintering of pressed blanks to give them the required strength and physical-mechanical properties;

d) additional processing depending on the purpose of the products and the requirements placed on them (mechanical, thermal, etc.)[3].

Table 1

Methods of Powder Production and Processing

Production of Metal Powders		
Chemical Processes	Physical Processes	
Reduction of oxides Deposition from alkalis and salts Thermal decomposition Electrochemical deposition	Grinding of Solid Bodies Mill: Disc; Ball; Slag; Wet (or Liquid-based)	Fusion Spraying: Dropwise (or Drip); Rotational; Vacuum; Impact (or Hammering); Ultrasonic; Electrodynamic

Metal powders and powders of non-metallic materials are the main raw materials for the production of powdered products. The industry produces metal powders such as iron-based, copper-based, nickel-based, chromium-based, cobalt-based, tungsten-based, molybdenum-based, titanium-based, and others.

There are various methods of obtaining metal powders: mechanical grinding (fragments, pieces), metal spraying, recovery of slags or pure oxides, carbonyl process, electrolysis, and other process methods (see Table 1). The physical methods of powder production can be divided into two large groups, which currently cover approximately 95% of all applied technological processes: mechanical grinding of solid materials and spraying of solutions[4].

Grinding, milling, or rubbing can be an independent method of obtaining metal powders or an additional operation for other production methods. For coarse grinding, jaw crushers, roller crushers, and conical disc crushers, as well as sieves, are used. The product of coarse grinding consists of particles ranging from 1 to 10 mm in size, similar to sand grains. The final grinding of the material is carried out in ball rotary mills, vibrating mills, planetary centrifugal mills, sharp-edged hammer mills, and hammer mills. Powder particles have sizes ranging from 0.2 to 0.002 mm[5].

Reduction of metals from their oxides is one of the most widespread methods for obtaining metal powders. Using this method, powders of iron, copper, nickel, tungsten, and other metals, as well as powders of steels, metal alloys — alloyed and corrosion-resistant steels — are obtained. Reduction methods are classified depending on the reducers and aggregates used, the type of charge and the method of delivering it to the reduction zone, the pressure of reducing

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gases, and the temperature of the process.

The presence of a large amount of reduced substances predefines the possibility of obtaining metal powders by various methods. Oxidized ores and rolling slags are used as raw materials for the production of iron powders through reduction. Copper, nickel, and cobalt powders are obtained from oxides by reduction in aqueous solutions and electrolysis[6].

The chemical properties of metal powders depend on the main metal composition or the main components constituting the alloy powder, the composition of mixtures, various mechanical impurities, and gases. In technical classifications for powders, supplying enterprises usually indicate the composition of the base metal and alloys, so sometimes it becomes necessary to determine the complete chemical composition. In such cases, the properties of the components are determined by chemical and spectral analysis.

Depending on the method of powder production, particle shapes can be spherical (carbonyl and sprayed powders), droplet-shaped (sprayed), angular (reduced), dendritic (electrolytic), plate-like and fragmented (powders obtained by grinding in vortex and ball mills, vibrating mills), fibrous and petal-shaped (from the fragmentation of liquid metals)[7].

The shape of powder particles greatly affects their bulk density and compressibility, as well as the uniformity of density, strength, and compaction of the pressed material.

According to particle size, powders are classified as ultra-fine powders with particle sizes less than 0.5 microns; very fine (VF) – sizes from 0.5 to 10 microns; fine (F) – 10 to 40 microns; medium (M) – 40 to 150 microns; and coarse (C) – 150 microns and above.

The apparent density, pressing pressure, shrinkage during sintering, and mechanical properties of finished products depend, along with other characteristics, on the particle size of the powders. The finer the powders, the higher the pressure required during pressing to achieve a certain compact density, resulting in stronger green compacts that sinter at lower temperatures[8].

Formability is the ability of a powder to retain a given shape at specific density values. The formability of the powder is described by a density range limited by minimum and maximum density values within which the compact does not get damaged after being removed from the mold.

Brief Description of Powder Materials

Preparation of powders for pressing is a decisive stage in the production of powder products, since the quality of the mixture manifests itself in the properties of the finished product. Preparation of the mixture involves batching powders with a specified chemical and granulometric composition, followed by mixing. Characteristics of materials used in powder metallurgy are presented in Table 2.

Table 2

Characteristics of Materials Used in Powder Metallurgy

Material	Powder Bulk Density, 10^3 kg/m^3	Compact Material Density, 10^3 kg/m^3	Poisson's Ratio, ν
Aluminum	1,0…1,7	2,5…2,7	0,36
Iron	1,8…3,0	7,8…7,85	0,28
Copper	1,5….2,5	6,8…7.2	0,35
Lead	3,2…3,8	7,3	0,33
Zinc	5,4…5,7	11,3…11,4	0,44

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Mixing is carried out in mixers, among which mixers with an inclined axis of rotation and conical mixers are the most widely used. Both powders of various components and powders of the same component prepared by different dispersion or preparation methods undergo mixing. To improve the mixing of powder components, sometimes a liquid (mineral oil, alcohol, gasoline, distilled water, glycerin) is added to the mixture. In this regard, mixing is divided into "dry" (without adding liquid) and "wet" types. The duration of mixing depends on the properties of the mixture and components and can vary from several minutes to several hours.

During the mixing process, plasticizing additives (solutions of paraffin, organic liquids, wax, rubber, compounds in organic liquids, etc.) are introduced into the mixer to improve powder compaction and granulation. These additives create additional strength when pressed and reduce the friction between the mold walls and the particles themselves (external friction), facilitating their bonding during granulation. Along with additives that improve pressing, additives that form certain specific properties can also be introduced.

Pressing (molding) of metal powders and their mixtures is an operation in which relatively strong semi-finished products or blanks with the shape and dimensions of the finished product are obtained from freely flowing powder, taking into account dimensional changes during the sintering process; it is also related to subsequent processing or treatments. This process consists of filling the mold with charge, pressing, holding under pressure for a short time, and ejecting compacts from the presses. The obtained blanks after pressing usually have 15…25% porosity and low mechanical properties.

The height of the blank is usually 3.5 times less than the height of the powder poured into the die, which leads to anisotropy of the compacts' properties (mechanical, pore shape and size, permeability). To obtain sufficiently strong working parts by cold pressing, significant pressures ranging from 600 to 1000 MPa can be applied depending on the given porosity and properties of the powder mixture.

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