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Research Article

PREPARATION OF ALUMINUM POWDER BASIC RESEARCH SAMPLES AND EFFECT OF POWDER PARTICLE SIZE AND COOKING TEMPERATURE ON THE MECHANICAL PROPERTIES OF SAMPLES

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ABSTRACT

The article shows the method of preparation of research samples based on aluminum powder and particle size of raw powder, as well as the effect of heating temperature on the mechanical properties of samples on the basis of experimental results. The results of research on the preparation of a mixture based on aluminum powder, the heating of briquettes prepared for research from the obtained powder mixtures in a vacuum furnace and the study of the mechanical properties of the prepared samples are presented.

KEYWORDS

aluminum powder, powder mixture, powder particle, press mold, press briquette, research sample, vacuum furnace, heating, mechanical properties of the sample.

INTRODUCTION

The technological process of production of structural parts is determined by how the part works under the influence of loads. As the loading rate on a part increases, its production technology becomes more complex, for example, small-loaded parts are subjected to one-way pressing and heating, while medium- and heavy-duty parts are subjected to double-pressing and hot-pressing or simultaneous pressing. undergoes a heating process [1].

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In the manufacture of aluminum powder-based parts, first a powder mixture (slag) with the required composition is prepared, then the slag is made of sheet metal with the required shape and size by means of press molds, and then the sheet is processed by hot baking [2].

In order to achieve high physical and mechanical properties in the production of structural parts based on aluminum powder, aluminum powder can be added to various other powder components in the amount of 0.1 .... 10%. In this case, the quality of mixing the powders with each other depends on the method of mixing, speed and duration [1].

Methods

According to the analysis of the literature on methods and technologies of powder mixing, when mixing aluminum powder obtained in a ball mill with powders of other metals, the addition of "white" alcohol (GOST 1204-95) in the amount of 1 ... 1.5% by weight of the powder especially with Cu, Zn, Sr and Ni powders. The technological procedure developed by us for mixing powder components based on the analysis of the literature on the technology of production of aluminum powder-based parts and the equipment selected for its implementation are given in Table 1.

Table 1

Technological procedure for mixing powder components in a humid environment

Device name	Mass of powder, kg	Alcohol content, l	Rotation speed, rpm	Mixing time, hours	Ambient temperature, °S
Drunk barrel mixer	25	1	50	6	22

After confirming the complete mixing of the components in the charge, in order to expel the "white" alcohol from it, we dried the charge in a hermetically sealed cabinet at a temperature of 50 ... 700S.

From the mixture of aluminum slag powder we obtained blanks with the required shape and size for research, by pressing at different pressures using the P-250 model hydropress in press molds for each shape and size. We used the following formula to determine the amount of powder mixture in the press mold [3]:

$$M = Vd_c\left(1 - \frac{П}{100}\right)K_1K_2 \quad (1)$$

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in this, V – the size of the sample blank, sm3;

dC – zagatovka density, g/sm2;

П – the planned porosity in the sample, %;

K1 – coefficient-factor, which takes into account the reduction of powder in the formation, for aluminum powder (K1 = 1,1);

K2 – a coefficient that takes into account the reduction of powder in baking, for aluminum (K2 = 1,15).

Preparation of blanks of research samples from slag powder was carried out by double-pressing methods. Samples of the prepared research are shown in Figure 1.

In order to prevent the aluminum powder from sticking to the surface of the mold parts (sternum and die) during the pressing process of the ingot, before pressing the ingot, we applied a special emulsion oil "Elitol E13M1" to the surface of the press die, punch and stem. As a result, the problem of sticking aluminum powder to the surface of the mold is eliminated.

The process of heating is the final technological stage, in which the press blank, consisting of individual different powder particles, turns into a whole solid with complete physical and mechanical properties [4]. The process of heating aluminum powder-based press blanks consists of heating, keeping at this temperature and cooling to room temperature from 5400 S to 6400S, depending on the chemical composition of the blanks [3, 5].

1 - rectangular cut; 2 - circle cut; 3 - cylindrical.

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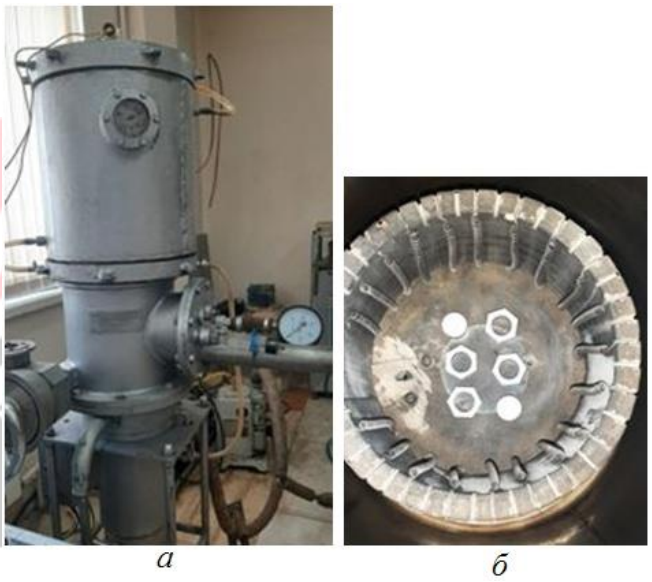
Figure 1. Press blanks of aluminum powder based research samples.

In order to qualitatively carry out the process of baking aluminum powder-based materials, the slag mixture contains 1 ... 3% of NaCl, NaF or ZnCl2. These substances dissolve Al2O3-oxide membranes on the surface of aluminum powder particles during the heating process of pressed blanks [6,7].

We used a laboratory furnace operating in a vacuum or gaseous environment with an operating temperature of 800 0S to carry out the process of heating and baking aluminum powder-based press blanks. The location of the furnace and sample blanks in it is shown in Figure 2.



a - vacuum oven; b - Place the samples in the oven chamber.

Figure 2. Preheat oven.

In order to ensure the quality of the heating process, we added 3% ZnCl2 to the slag, the mass of the slag. During the heating process, it reacts chemically with the oxide film on the surface of the aluminum particle as follows:

$$Al_2O_3 + ZnCl = Zn + AlCl_2 \quad (2)$$

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The products of Zn and AlCl2 formed as a result of chemical (2) reaction are in the vapor state and are absorbed into the aluminum base [8].

RESULTS AND DISCUSSION

Determination of the effect of the particle size of the raw powder and the heating temperature on the mechanical properties of the samples. In order to determine the dAl-particle size of aluminum powder used as a raw material and the effect of heating temperature on the mechanical properties of the sample, we prepared research samples based on aluminum powder with a cross section of 6.5x5.2 mm and a length of 35 mm. Table 2 shows the particle size of powder dAl in the preparation of samples and the technological parameters determined in the preparation of samples from them.

Table 2

Defined technological parameters for the preparation of samples

№	d_{Al}, mkm	Al_2O_3, %	$ZnCl_2$, %	P, t/sm^2	Heating cooking process					
					temperature, ^{0}S				time, minutes	environment
1	10	3,5	3	3	560	580	610	620	60	High vacuum 1,33·10^{-4} Pa
2	30				560	580	610	620		
3	50				560	580	610	620		
4	70				560	580	610	620		

We determined the mechanical properties of the material samples obtained on the basis of aluminum powder in the order of experimental research. The raw material used dAl - the limit of compressive strength, relative elongation, impact viscosity and hardness of the samples depending on the particle size is shown graphically in Figure 3.

According to the experimental results obtained, the bending strength of the samples varied depending on the particle size of the raw powder dAl - and the heating temperature of the heating. The powder used in the preparation of the sample dAl - a decrease in particle size and an increase in the heating temperature from 560 0S to 610 0S had a positive effect on the bending strength of the samples (Fig. 3, a, 1, 2, 3). However, an increase in temperature from 610 0S to 620 0S resulted in a decrease in strength (3, a - Fig. 4). Test results on the samples show that the mechanical properties of the samples are fully

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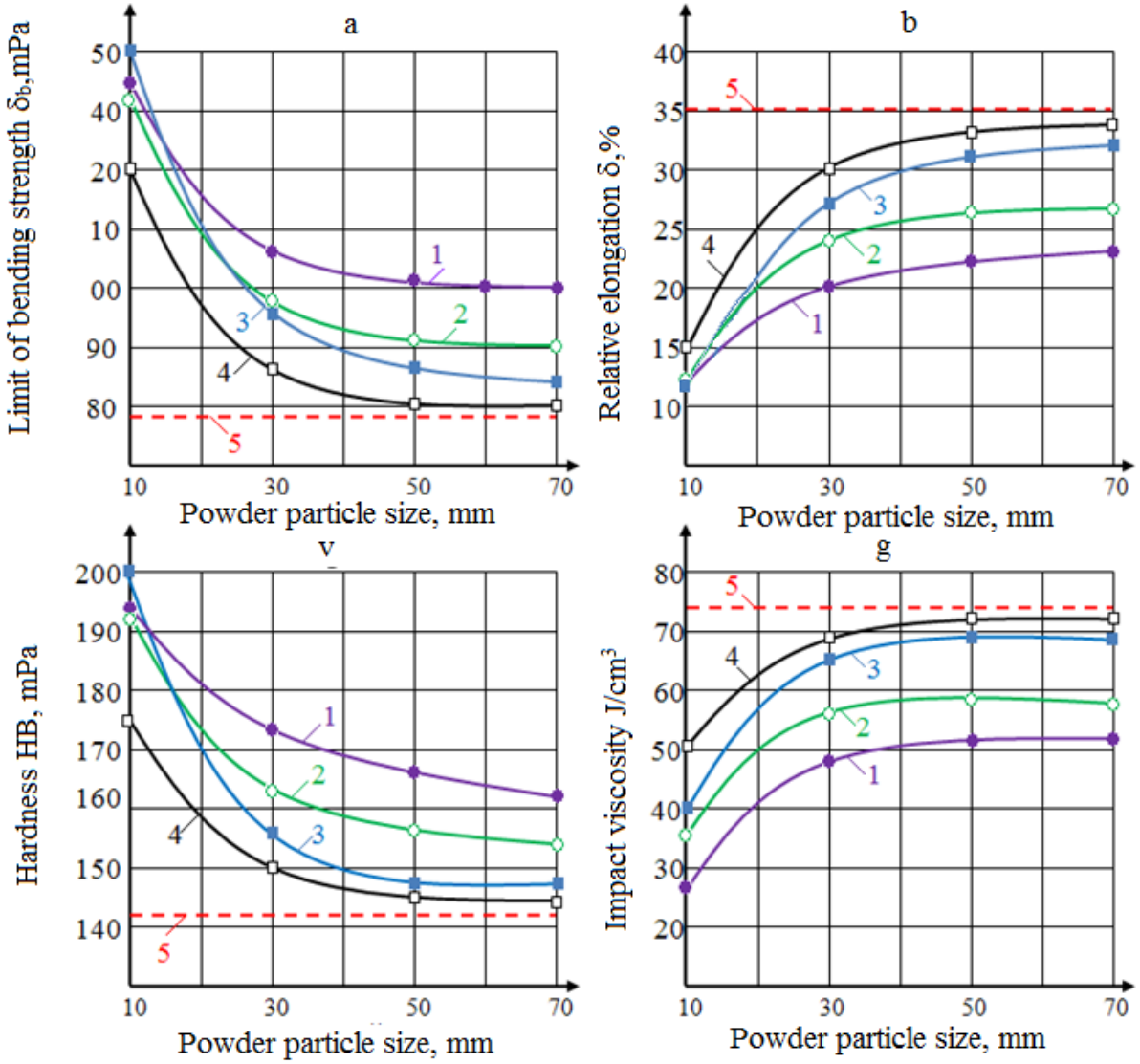
consistent with the theory of strength and plasticity of metals and alloys.

In our opinion, the decrease in the strength of the samples as a result of raising the heating temperature of samples made of powder with a particle size of 10 microns dAl to 620 0S was due to the enlargement of the powder with a particle size of 10 microns. The larger the particle size of the raw powder dAl - particle, the greater the effect of temperature on the particle size.



a-is the limit of bending strength; b-is the relative elongation; v - hardness;

g - impact viscosity (1 - 560 0S; 2 - 580 0S; 3 - 610 0S; 4 - 620 0S).

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Figure 3. Raw material powder dAl - change in particle size and mechanical properties of samples by heating cooking temperature.

CONCLUSION

As a result of the analysis, we came to the following conclusions: in order to achieve high mechanical properties, it is necessary to choose aluminum powder with a particle size of 10 μm or less as a raw material, with a heating temperature of 610 0S and holding time at this temperature for 60 minutes. Increasing the firing temperature of aluminum powder-based samples by vacuum to 620 0S leads to an increase in the bending strength of the powder and a decrease in the bending strength of the sample from 150 mPa to 120 mPa, but an increase in plasticity properties.

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