

EXPERIMENTAL RESEARCH ON CREATING FUNCTIONAL MODELS BY POWDER METALLURGY IN THE AUSTENITIC STAINLESS STEEL – ALUMINA SYSTEM

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ABSTRACT: This paper sets out to present experimental research done on a mixture of powders of austenitic stainless steel AISI 316 L and alumina, out of which bush type pieces (valve seats for automobiles) were created by powder aggregation. The dimensions were: exterior diameter: 34mm, interior diameter: 21mm and height: 11mm. In the specially designed cast for this experiment, 2 sets of 9 samples each were created from mixtures of stainless steel, 10, 20 and 30% Al₂O₃ and 0.5% Zinc stearate. Two values were chosen for pressing forces: 400 kN and 200 kN. After pressing, the mass variation of the samples sintered at 1200° C for 1 h was analyzed, and the microstructural aspect. It was noted that the samples containing 20% Al₂O₃ had the least mass variation and present the most uniform structure, both by particle size and by homogeneity.

KEY WORDS: powder metallurgy, stainless steel, alumina, sintered, experimental

1. INTRODUCTION

Powder metallurgy offers the possibility of creating new products and materials, with different characteristics necessary in advanced technologies, because of certain technical and economic advantages.

The technological process of manufacturing sintered products, fundamentally different from classical technologies, mostly because of high productivity, is composed of the following main operations: creating the metal powders, forming of the semi-finished product and sintering them, supplementary processing and final control. Most of these operations are easy to mechanize, automatize and robotize.

Mainly, in manufacturing by powder aggregation, the starting point is a mixture of metallic powders (sometimes also metalloids) which are homogenized in the prescribed proportions and pressed into molds to obtain semi-finished products which are then sintered.

The sintering, an essential operation in powder aggregation processing technologies, consist of thermic treatment done at the melting temperature of the most easily fusible component in the powder mixture.

The main technological properties of the metallic powders are: filling and flowing capacity, filling volume, filling density, porosity, fluidity, pressing capacity, edge resistance and capacity for sintering. Forming products out of powders is mainly achieved by pressing into molds.

2. MATERIALS USED FOR EXPERIMENTS

A mixture of powders based on austenitic stainless steel AISI 316 L, Al₂O₃ in proportions of 10%, 20% and 30% and 0.5% zinc stearate was used for experimental research.

Zinc stearate has a binder role in the process of molding the powder mixture and volatilizes at sintering temperature, so it does not affect the final composition of the samples.

The chemical composition (% mass) of the 316 L steel powder is presented in Table

Table 1. Chemical composition (% mass) of austenitic stainless steel 316L powder

Element	C	Cr	Ni	Mo	Mn	Si	S	Fe
Quantity [%]	0,024	16,78	13,48	2,0	0,11	0,77	0,11	rest

The granulation of the used powder (particles with irregular shape, non-spherical) had the following values: < 40 μm – 60%; 40-63 μm – 18%; 63-80 μm – 12%; 80-100 μm – 10%.

3. TECHNOLOGICAL OPERATIONS FOR PROCESSING

Bush samples (valve seats for automobiles) were proposed for experimenting. The dimensions of the samples are: exterior diameter of 34 mm, interior diameter of 21 mm and height of 11 mm. They are presented in Figure 1.



Figure 1. Research samples

The technological operations for processing these functional models were:

- dosing the components of the powder mixture (316 L steel, 10, 20 and 30% Al₂O₃);
- homogenizing the powder mixture and adding 0.5% zinc stearate;
- filling the mold with powder mixture;
- assembling the mobile parts of the mold;
- pressing the powders in the mold, at pressing forces of 400 kN and, respectively, 200 kN (Figure

2). For this operation, a pressing mold with two column guidance was designed, with modular elements for a variety of types and dimensions of the samples);

- sintering the samples in H₂ atmosphere, at a temperature of 1200° C for 1 hour and cooling in still air;
- austenitization of the samples at 1100° C for 1 hour.



Figure 2. Components of pressing mold

4. RESULTS OF EXPERIMENTAL RESEARCH

Two sets of 9 samples each were used for experimenting. The first set of samples was pressed at 400 kN and the second one at 200 kN. The nine pieces of a set are numbered A1; A2 and A3, each with 3 samples (10, 20 and 30% Al₂O₃).

The composition, dimensions and weight of the samples after sintering are presented in Table 2 and Table 3.

The samples with a higher alumina content are lighter because of a constant filling volume in the mold; the alumina having a lower specific weight than stainless steel.

The mass of the mixed samples before processing was: 47.5g (10% Al₂O₃); 39.365g (20% Al₂O₃) and 38.24g (30% Al₂O₃). The volume percentage was respected and the mass percentage resulted from maintaining a relatively constant filling volume.

Table 2. Pressing force: 400 kN

Components		A1	A2	A3
10% Al ₂ O ₃ 0,5% Zn stearate	Int. Diam. (∅)	21	21	21
	Ext. Diam. (∅)	34,18	34,18	34,18
	Height (mm)	10,37	10,31	10,34
	Weight (g)	39,438	39,155	39,302
20% Al ₂ O ₃ 0,5% Zn stearate	Int. Diam. (∅)	21	21	21
	Ext. Diam. (∅)	34,20	34,20	34,20
	Height (mm)	11,22	11,16	11,17
	Weight (g)	40,802	40,741	40,752
30% Al ₂ O ₃ 0,5% Zn stearate	Int. Diam. (∅)	21,03	21,04	21,03
	Ext. Diam. (∅)	34,24	34,24	34,24
	Height (mm)	11,48	11,43	11,41
	Weight (g)	38,133	38,108	37,853

Table 3. Pressing force: 200 kN

Componenți de adaos		A1	A2	A3
10% Al ₂ O ₃ 0,5% Zn stearate	Int. Diam. (∅)	21,01	21,01	21,01
	Ext. Diam. (∅)	34,15	34,15	34,15
	Height (mm)	10,94	11,03	11,79
	Weight (g)	38,868	39,433	40,472
20% Al ₂ O ₃ 0,5% Zn stearate	Int. Diam. (∅)	21,03	21,01	21,01
	Ext. Diam. (∅)	34,16	34,16	34,16
	Height (mm)	11,73	11,77	11,79
	Weight (g)	40,535	40,514	40,472
30% Al ₂ O ₃ 0,5% Zn stearate	Int. Diam. (∅)	21,03	21,04	21,04
	Ext. Diam. (∅)	34,19	34,19	34,18
	Height (mm)	12,07	12,01	12,00
	Weight (g)	39,391	37,990	38,149

Figures 3 and 4 present the mass variation of samples obtained with various alumina contents and pressed at 400 kN and 200 kN.

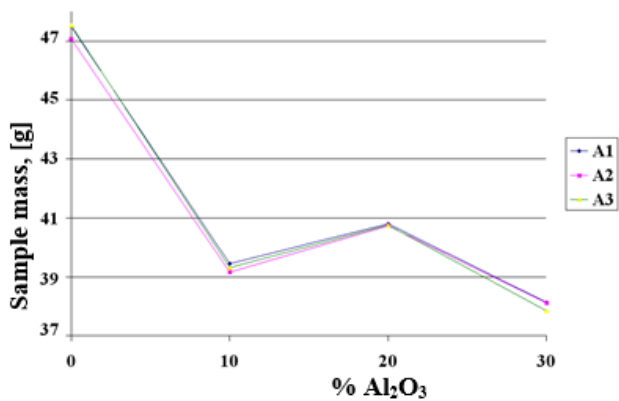


Figure 3. Mass variation according to alumina content [400kN]

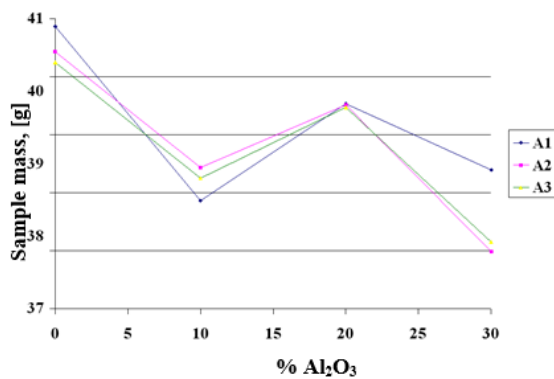


Figure 4. Mass variation according to alumina content [200kN]

We notice that in all analyzed samples, the mass has an accentuated tendency for reduction until a 10% Al₂O₃ addition, as a result of the low density of alumina.

The samples with a 20% Al₂O₃ addition have slightly larger masses, a phenomena which is explainable by smaller alumina particles occupying the spaces between the larger stainless steel particles, so an increase in the compactness as a result of lower porosity.

For samples with 30% Al₂O₃, the mass has a decreasing tendency, because of the increased amount of alumina with low density and the absence of pores in which the surplus of small particles can go to.

The samples were then analyzed for their microstructure and we determined that the supplementary austenitization treatment (1100°C/1h) accentuates only in a small proportion the austenitic characteristics of particles, without modifying the values of some mechanical characteristics (hardness, corrosion resistance).

5. CONCLUSIONS

- Functional models, created in 2 sets of 9 samples each, are bush type parts and present a uniform pressing degree and have a relatively homogenous

structure for both values of the pressing force used: 400 kN and 200 kN.

- The dosage of the powder mixture was done gravimetrically, but we recommend volumetric dosage for mass production.
- The dimensions and mass variations of the samples have low values, specific to the process of manufacturing by pressing the powder mixture into molds.
- The design of a new mold was necessary, to insure guidance on two columns and to provide modular elements in order to be able to manufacture a variety of types and dimensions of parts manufactured by powder metallurgy.
- Experimental research was continued with the metallographic study of the samples, determination of hardness (HB and HV 0.1), corrosion tests in acid solution environments and abrasive wear.

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