Influence of mechanical activation of steel powder on its properties

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Abstract. It has been studied properties of stainless steel based powders after mechanical activation using planetary ball milling technique. It have been shown that after one minute mechanical activation porosity of sintered steel is less than 5%, which is less than the porosity of the sintered steel powder without mechanical activation. The sample without activation has austenite state, which changes after activation toaustenite and ferrite mixtures. X-ray analysis confirmed that the mechanical activation leads to a change in the phase state of the samples: the samples without activation of the FCC structure (γ-Fe), after activation - FCC (γ-Fe) and BCC (α-Fe). The hardness increases at increasing activation time from 800 MPa for the sample without mechanical activation to 1250 MPa for the sample with the activation time of 10 minutes.

1. Introduction

Mechanical activation is a way to accelerate the physical and chemical processes and is becoming more widely used due to action on materials a mechanical stresses **[1-4]**. Planetary milling is a high-energy activation process and may improve an initial state of powder mixtures before its using for preparing samples. Therefore one can needs to investigate the influences of such high-energy treatment on properties of powders and sintering body **[5-11]**.

The aim of this work is to investigate the influence of mechanical activation of stainless steel powder on the properties of sintered samples produced using injection moulding technology.

2. Materials and methods

Samples were prepared using powder metallurgy technology by mixing the initial powders with mechanical activation for 1, 5 and 10 minutes. The chemical compositions of samples are shown in Table 1.

Determination of samples porosity was carried out using “Analyzer of fragments microstructure for solid bodies SIAMS 700TM”. The average size of pores was determined by randomly secants. Analysis of phase composition was carried out by X-ray with CoKα radiation.

Metallographic analysis was performed on“Labomet-I” metallographic microscope with system visualizationimage. Microhardness was measured with an indenter (diamond quadrangular pyramid) at a load of 50 g.

Table 1.-The chemical composition of the material

C, %	Cr, %	Ni, %	W, %	Fe, %
0,03	17	12	2	Base

3. Results and Discussion

Porosity

All samples have a residual porosity after sintering.Metallographic examination of the polished sample surface allowsevaluating the presence of pores, their number, shape, size and size distribution.On the polished surface one can see areas with a high concentration of pore and comparable size of the area where almost there are no pores.The pores are usually irregular shapes and different sizes. The results of theporosity size distributions are shownon the Figure 1.The distribution of pores in the sintered samples is uni-modal.

Size distributions are shown that the majority pore (up to 90%) for all samples have a size not more 10 micrometers. Samples with mechanical activation with 5 and 10 minutes have a larger pores size up to 70 micrometers.

It can be seen that the lower porosity (Figure 1) and a smaller average pore size (figure 1b) has sample after mechanical activationduring 1 min and the highest porosity values had samples with mechanical activation for 5 and 10 minutes.

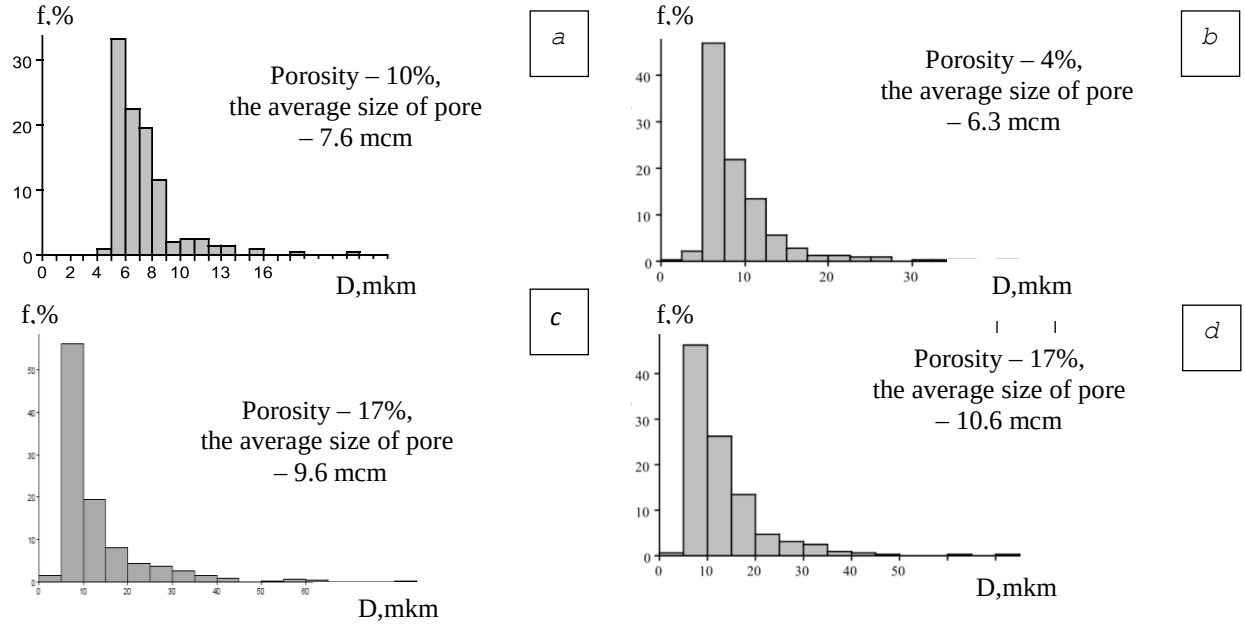

Figure 1 - Distribution of pore size for a sample a) in initial state without mechanical activation; after mechanical activation 1 (b), 5 (c) and 10 minutes (d)

Microstructure and Phase Composition

Metallographic studies after etching (Figure 2) are shown that sample without mechanical activation has an austenitic structure with a large number of twinsdue to adding of nickel to steel, which expands the range of γ-phase.

For samples after mechanical activation one can observe two areas first the ferrite – dark areas and second austenite - light areas. This also was confirmed by x-ray analysis.

X-ray analysis showed that the sample in initial state (Figure 3a) has a FCC structurewith lattice parameter 0.359561 nm. After mechanical activation (Figure 3b) were found two phases of the FCC structure(lattice parameters 0.36055, 0.3598, 0,35632nmfor 1, 5 and 10 min respectively) and BCC

lattice (0,28844, 0,28961, 0,28983 35632nmfor 1, 5 and 10 min respectively respectively). These lattice parameters slightly differ from pure γ-Fe (0,356 nm) and α-Fe (0,286 nm).

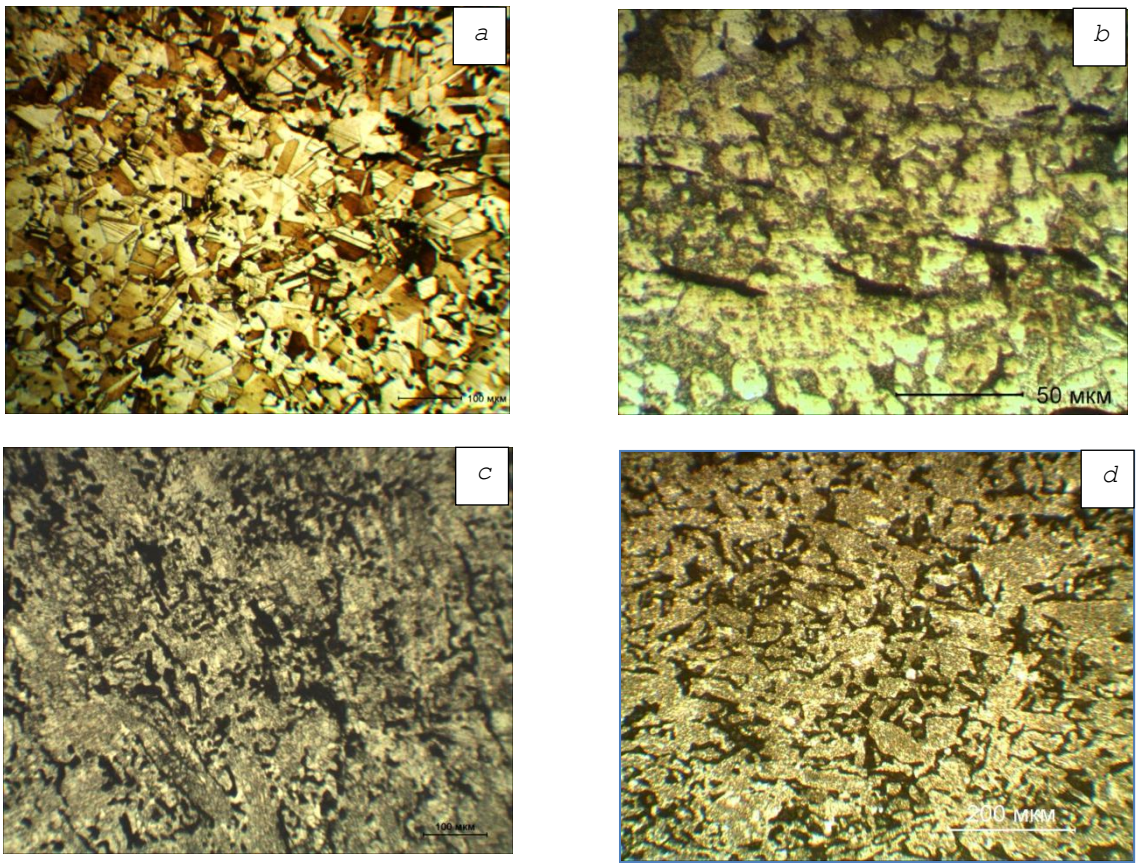

Figure 2 - The microstructure of samples etched surface: a) initial state and for mechanical activation 1 (b), 5 (c) and 10 minutes (d)

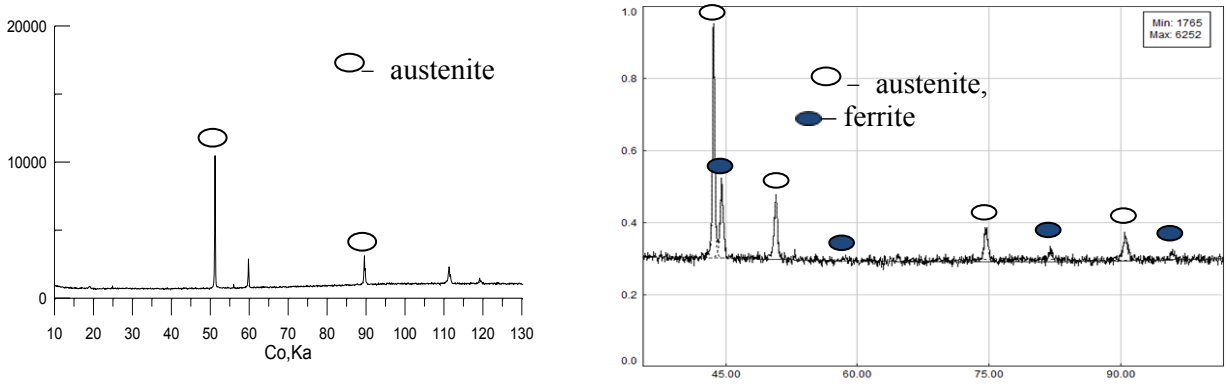

Figure 3 - Diffraction patterns on the surface of samples: a) without mechanical activation; b) a mechanical activation for 10 minutes

Microhardness

During an increasing the activation time hardness increases from 800 MPa(Table 2) in initial state and its increasing up to 1250 MPa for the sample with the activation of 10 minutes, which corresponds to the hardness of stainless steel. Despite the porosity, hardness corresponds to the hardness of the cast material.

Table 2. Microhardness value for samples with different activation time

Sample	**Microhardness**, MPa
without activation	815±11
1 min	794±50
5 min	1196±100
10 min	1265±120

4. Conclusion

After one minute mechanical activation porosity sintered steel is less than 5%, which is less than the porosity of the sintered steel powder without mechanical activation.

The sample without activation has austenite state, which changes after activation toaustenite and ferrite mixtures. X-ray analysis confirmed that the mechanical activation leads to a change in the phase state of the samples: the samples without activation of the FCC structure (γ-Fe), after activation - FCC (γ-Fe) and BCC (α-Fe).

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