MICROSTRUCTURE AND PROPERTIES OF POWDER STEELS SINTERED

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Abstract:*The results of the analysis concern with the influence of high rate heating and high rate cooling on microstructure formation and strength properties achieved at an electric-contact sintering of two types of alloyed powder steels. The results confirmed the favorable effect of electric-contact sintering on the microstructure formation and final properties of this type of sintered steels.*

Keywords: strengh properties, powder steel, sintered steel.

1. INTRODUCTION

Starting from the behavior of sintered steel steels in mechanical tests against woody composites is totally different [3], it is acceptable to replace the metals with wood elements because the rupture is immediately noticeable. If is known that the phase transitions, taking place at heat treatment, are one of the main factors determining the microstructure and properties of steels. Maitensite transition is particularly actual in the steels produced by the powder technology, whereas this process has not been adequately explored yet. Beside the chemical composition, the final microstructure of sintered steels depends on the heating and cooling rates during sintering process. In the case of higher cooling rate, the formation of martensite, as a microstructure component, and the micros-trains arising in it, play a decisive role. Small amount of martensite is formed even at the convenţional sintering in a furnace with low cooling rate. In this case, its effect on the properties is insignificant. Quite another picture is observed when new elec-trophysical technologies of sintering, e.g. electric-contact sintering with a high-rate heating and high-rate cooling, are used [1]. The authors have already shown, that at electric-contact sintering of one-component powder systems considerably densi-fication caused by electric current passing through the pressed specimens occurs [2, 4]. The substance of activated electric-contact sintering is the local temperature increase resulting from concentration of electric current flux in partide contacts and the subsequent release of Joul heat [2]. According to the work [4], the temperature increase by 107 K is possible in the partide contact regions and a local development of liquid phase can occur. The use of this method of sintering allows to avoid the chief drawback of convenţional furnace sintering, i.e. the formation of large pores and their negative influence on the mechanical properties of sintered metallic materials. However, all this investigations have been made on plain Fe, Ni, Cr. To the present time, the understanding of the electric-contact sintering influence on phase transitions and properties of the multicomponent powder systems is insufficient.

2. MATERIAL AND METHODE

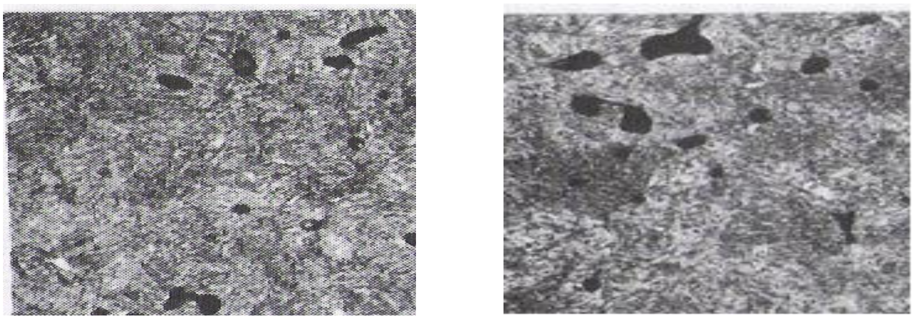
The presented poster deals with the study of martensite formation during the electric-contact sintering and with its influence on mi were in-vestigated crostructure and properties of alloyed powder steels. Two types of prealloyed powder steels :

- Astaloy A (0.09%C, 0.010%S, 0.04%Cr, 0.21%Mn, 0.50%Mo, 1.02%Ni, 0.20%O_2);
- Astaloy C (0.11%C, 0.023%S, 0.23%Cr, 0.45%Mn, 0.33%Mo, 0.36%Ni, 0.25%O_2).

The partide size composition of both powders was less than 0.16 mm with the 10 wt% portion of the fraction below 0.04 mm. The 0.45 wt% of natural graphite was added to the both powder steels types. The powders were dry mixed in a Turbula mixer. The specimens with the dimensions of 10 x 5 x 55 mm^3 were pressed under the pressures of 400, 600 and 800 MPa. The electric-contact sintering took place at temperatures of 1370, 1470 and 1577 K for 1.5, 15 and 30 minutes in a specially created experimental equipment allowing the sintering by direct trans-mission of electric current. The heating rate was 120 K/min and cooling rate was 250 K/min. To comparison the microstructure and properties formation, the convenţional sintering in furnace at the temperatures of 1370, 1470 and 1577 K for 30 minutes, was also carried out. The heating rate was 16 K/min and the cooling rate was 15 K/min. In the both cases, the sintering took place in a dry hydrogen atmosphere.

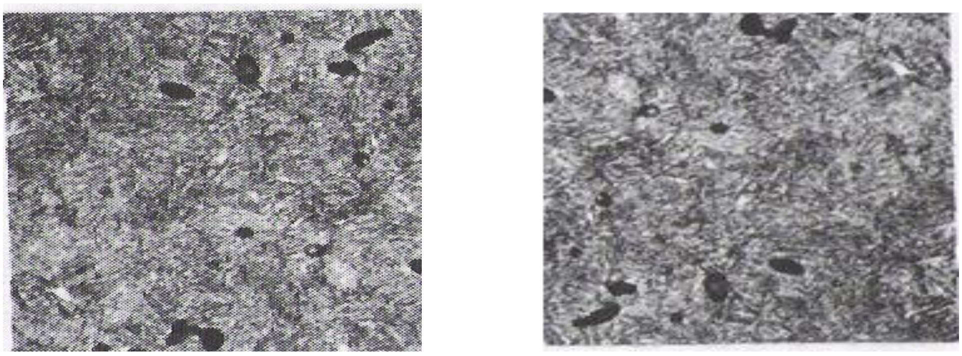
The activity of sintering processes is reflected in the quality of partide con-nections formed during the sintering; the quality of connections can be evaluated by means of suitable strength characteristics, e.g. by values of fracture strength R_{FR} and bending strength R_{po}.

The typical microstructure of electric-contact and convenţional sintered materials Astaloy A and Astaloy C with 0.35% of graphite addition is in figs.1 a,b and 2 a,b.



a). b).

Fig.1. Microstructure of Astaloy A+ 0,25% C



a). b).

Fig.1. Microstructure of Astaloy C+ 0,25%

3. RESULTS AND DISCUTION

The measurment of both, the fracture strength R_{FR} and the bending strength R_{po} of materials sintered at various conditions was carried out, tab. 1.
The results have shown, that at the electric-contact sintering of alloyed powder materials as well as at sintering of plain powder materials, the activated sintering processes are taking place.

Table 1. The values of R_{FR} and R_{po} of electric-contact (EC) and convenţional (C) sintered Astaloy A and C

Powder	Density [g/cm3]		R_{FR} [MPa]		R_{PO} [MPa]	
	EC	C	EC	C	EC	C
Astaloy A						
+0.0	6.80	6.75	323	200	207	600
+0.35	6.90	7.13	305	178	187	1050
+0.45	7.02	7.08	315	280	280	1220
Astaloy C						
+0.0	6.9	6.90	225	125	445	505
+0.35	7.1	7.10	202	298	880	680
+0.45	7.03	7.07	270	325	1050	810

The main portion of compact densification takes place during the high-rate heating up to sintering temperatnre and the changes of compact density after high-rate heating did not influenced by the sintering time.
At the same sintering temperature, the densification of electric-contact sintered compacts for 1 minute is the same as the densification achieved by convenţional sintering for 30 minutes. Also, the graphite addition has small infiuence on density changes of the compacts sintered by both methods of sintering. The detailed results will be presented in the poster.

4. CONCLUSIONS

The microstructure analyses and microfractography have shown that due to the concentration of electric current in partide contacts and due to the following diffusion processes activation, the pores with rounded features and massive partide connections are formed at the electric-contact sintering. The microstructure of investigated materials after electric-contact sintering differs from the one formed by convenţional sintering. As a result of high cooling rate, the microstructure after electric-contact sintering is ferritic-bainitic-martensite one, while martensite component prevails. The electric-contact sintering conditions lead to the lower homogeneity of carbon distribution, which is predominantly concentrated in the partide connections zones. Then, the martensite microstructure components are localized mainly in the surroundings of porcs/or partide connections.

The analysis of strength properties of sintered specimens based on the powder Astaloy A with 0.35% of graphite addition showed that in the dependeiice on pressing and sintering paranieters, the bending strength R_{po} increases by 250-300 MPa, fracture strength R_{FR} by 100-120 MPa, and hardness by 30 HV 10 after electric-contact sintering in comparison with the convenţional sintering. In the case of specimens prepared form Astaloy C the increase of R_{po} values is by 200-250 MPa, R_{FR} by 50-90 MPa and hardness by 50 HV 10. This fact can be explained by martensite formation con-nected with more suitable morphology of pores and partide connections formation during electric-contact sintering.

5. REFERENCES

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