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The properties of innovative sintered structural parts manufactured of elemental powders of iron, molybdenum and boron

J. Karwan-Baczewska[a], M. Rosso[b]

[a] AGH-University of Science and Technology in Cracow, Faculty of Non-Ferrous Metals, al. Mickiewicza 30, 30-059 Cracow, Poland

[b] Politecnico di Torino, Dipartimento di Scienza Materiali e Ingegneria Chimica, Duca Degli Abruzzi Torino, Italy

Abstract: Sintered iron-molybdenum alloys and steels are innovative materials that are expansively applied in the motor car industry. The research project involves the production of structural details with use of conventional powder metallurgy; elemental powders of iron, molybdenum, and boron are mixed together, compacted, and sintered. Furthermore, it is planned to manufacture some modified sintered alloys of molybdenum and steels, they will be modified by boron additions amounting to 0,2%, 0,4 %, and 0,6 %. The planned experiments will involve structural investigations and the mechanical properties of Fe-Mo-B samples. Also studied is how the addition of molybdenum and boron impacts the structure and properties of the alloys investigated.

Keywords: Molybdenum, Boron, Liquid phase sintering

1. INTRODUCTION

Molybdenum is one of the elements, usually applied in conventional cast steels and also a component of sintered alloys and steels manufactured on the base of partially alloyed powders. Molybdenum improves the tensile strength and wear resistance of sintered alloys, and increases their hardenability, therefore P/M structural parts of iron-molybdenum are treated using various thermochemical treatment procedures [1]. Moreover, the addition of boron in iron-molybdenum alloys activates the sintering process and increases the alloys density. Recently, the structure and properties of sintered Astaloy and Distaloy powder-based and boron-modified materials have been investigated [2, 3]. It was stated that with the increasing boron contents, the mechanical properties were improved. In the paper innovative structural parts base on iron-molybdenum powders modified by boron were manufactured. Influence of molybdenum and boron contents on the structure and properties of new sintered structural parts were analysed.

2. EXPERIMENTAL AND PROCEDURE

In the experiments iron, molybdenum and boron powders were used. The P/M iron-molybdenum alloys, modified by 0,2 wt %, 0,4 wt % and 0,6 wt % of boron, were manufactured by mixing the iron, molybdenum, and boron elemental powders, then, by compacting (600 MPa) and sintering them at t = 1473 K for 60 minutes, in hydrogen atmosphere. First part of sintered specimens were cylindrical and the second part were prepared for mechanical testing. The molybdenum contents in sintered alloys amounted from 1,5 wt % to 5,0 wt %. The density and hardness and mechanical properties of boron-modified alloys were analyzed, and structural investigations of them were carried out.

3. RESULTS AND DISCUSSION

The completed experiments evidenced that if 0,4 wt % and 0,6 wt % boron amounts were added to sintered alloys made of iron powder containing 1,5 wt % and 2,0 wt % Mo, their relative density essentially increased. In sinters containing 3 – 5 wt % Mo, the addition of boron reduces the samples' relative density level. The highest density values were found in sinters containing 1,5 wt % Mo (Fig. 1a).

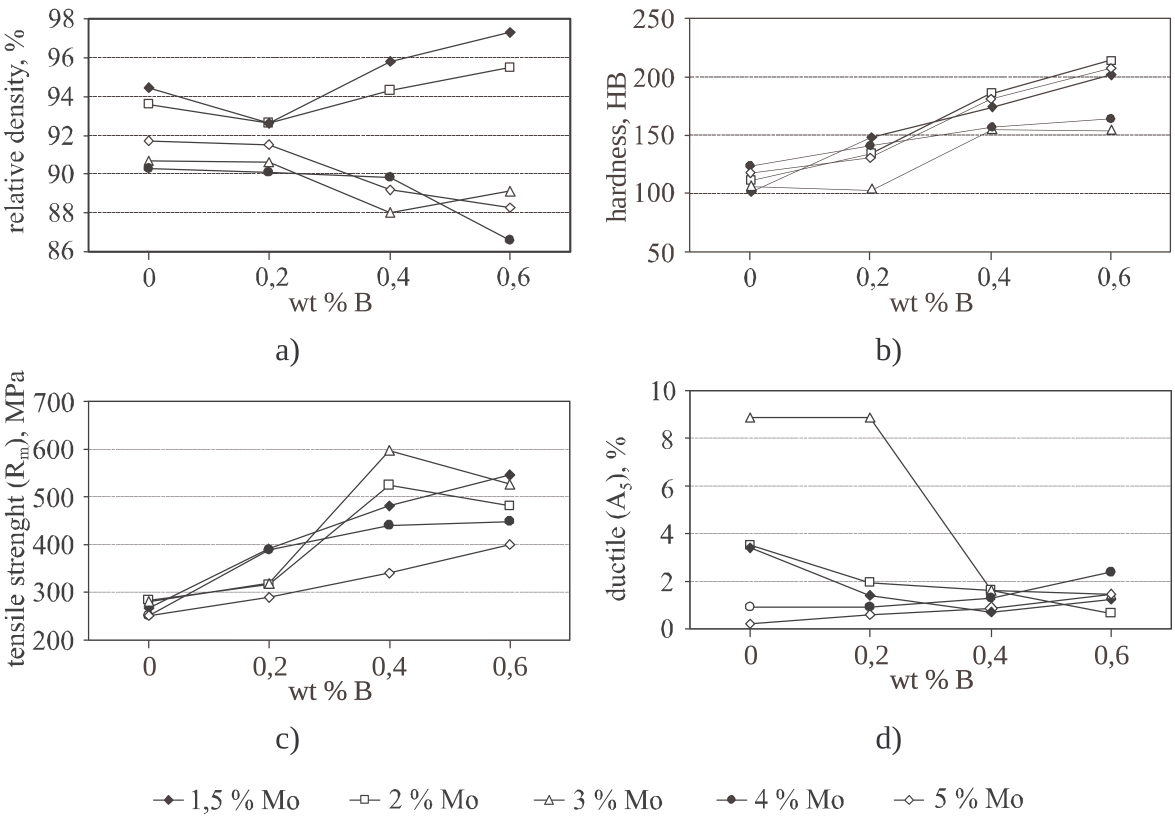

Figure 1. Effect of boron on the mechanical properties of P/M iron – molybdenum alloys
a) relative density, b) hardness, c) tensile strength, d) elongation

The highest relative density amounting to 97 % was shown in samples having the following chemical composition: Fe-1,5 wt % Mo-0,6 wt % B, whereas the lowest relative density of about 87 % was characteristic for the sinters: Fe-4.0 wt % Mo-0.6 wt % B.

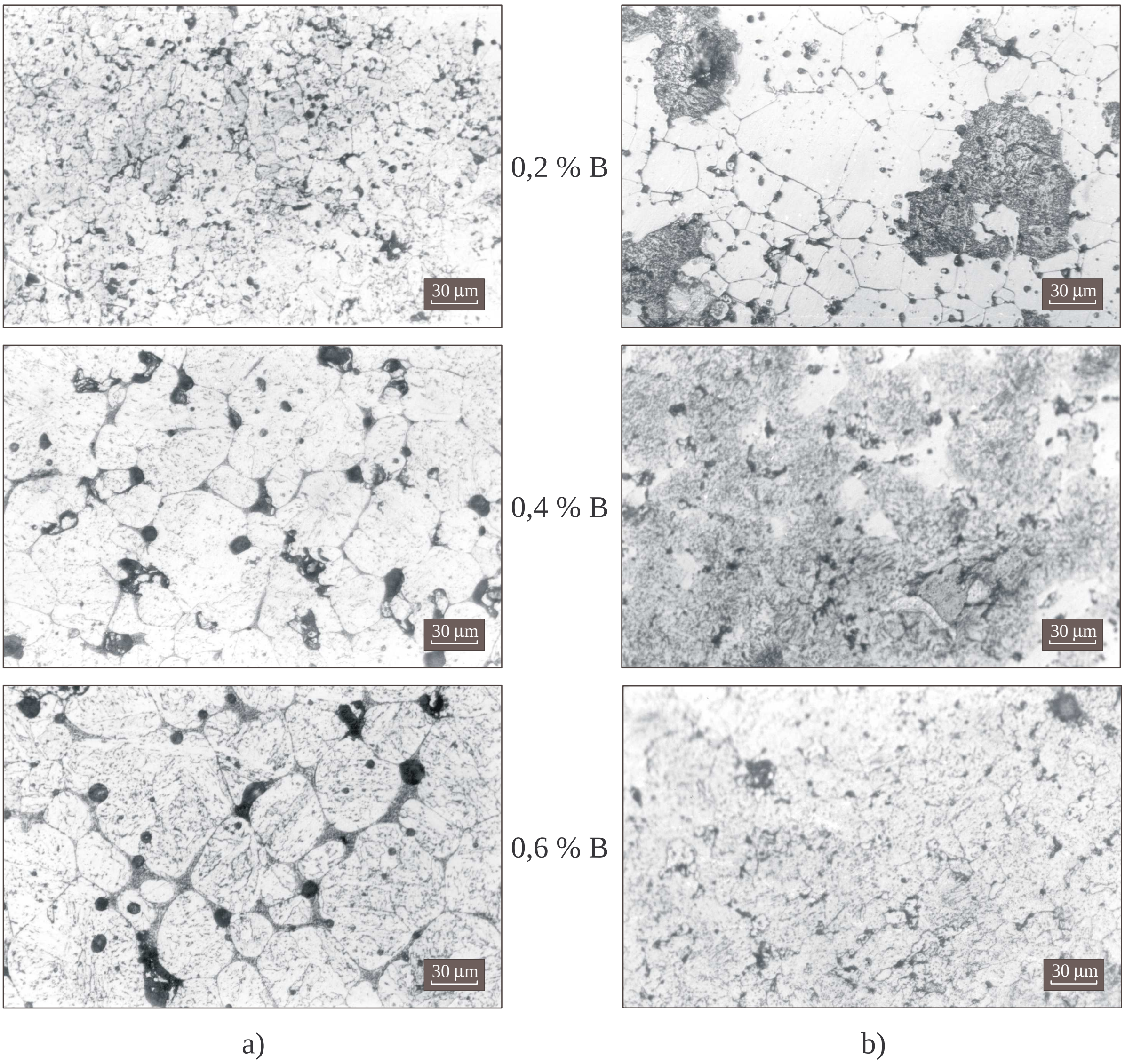

Figure 2. Microstructures of P/M iron – molybdenum alloys with boron a) 1,5 wt % Mo, b) 5 wt % Mo

In the present project, hardness measurements were performed, as well as assessment of mechanical properties: tensile strength (R_m) and elongation (A_5) of boron-modified, sintered molybdenum alloys. It was stated that molybdenum did not show any greater impact on the hardness of materials studied. However, boron influenced the hardness of sinters (Fig. 1b).

Along with the increase in the boron content in the samples tested, a raise in the hardness value was observed. Interesting relations were noted whilst studying mechanical properties of Fe-Mo-B sinters. In Fe-1,5 wt % Mo-B, Fe-4,0 wt % Mo-B and Fe-5,0 wt % Mo-B sinters, the tensile strength (R_m) value raises as the amount of boron contained increases, whereas in alloys:Fe-2,0 wt % Mo-B and Fe-3,0 wt % Mo-B, the tensile strength goes up as high as the 0,4 wt % boron content, and from this level, it goes down (Fig. 1c).The elongation of the Fe-(1,5-3,0) wt % Mo-B sinters investigated decreases with the increase in the boron amount but the elongation of Fe-(4,0-5,0) wt % Mo-B samples increases with the increase in the boron amount in the tested alloys. (Fig. 1d).Molybdenum crucially increases ductility of sinters. This statement is proved by the achieved elongation of about 8.9 % in such alloys as: Fe-3,0 wt % Mo and Fe-3,0 wt % Mo-0,2wt % B (Fig. 1d). Microstructures of the sinters investigated are shown in Fig.2. Molybdenum alloys without boron additions reveal ferrite-like structures. In molybdenum alloys with boron added, deposits of fine borides of $FeMo_2B_2$ type are visible at the background of the ferrite-like matrix; the amount of borides increases along with the raise in the boron levels in samples [4] (Fig. 2a). The borides that deposit in the alloys' matrices enhance their hardness. At the same time, at the grains boundaries, a non-homogenous eutectics is visible, and its amount grows along with the growth in the boron content in samples: Fe-1,5 wt %Mo-(0,4 and 0,6) wt % B. It was stated that with the increasing of boron contents in samples a significant growth grains and spheroidization of pores were observed.

4. CONCLUSIONS

1. The structure and mechanical properties of sintered molybdenum alloys depend on the molybdenum and boron levels, as well as on phenomena occurring whilst sintering process.
2. Sintering processes with investigated materials proceed under the participation of liquid eutectics that is produced as a result of the eutectic reaction between iron and a complex of borides.
3. Boron diffuses into molybdenum causing liquid eutectics to be separated at the grains boundaries; the amount of this liquid eutectics is reduced parallel to the growth in the molybdenum and boron amounts in tested samples; furthermore, more borides are produced inside grains.
4. When 0,4 wt % and 0,6 wt % boron amounts are added to sintered Fe-1,5 % Mo-B, then, the relative density, hardness, and tensile strength of this alloy is effectively higher.
5. With higher molybdenum contents, i.e. in such sinters as Fe-(2,0-5,0) wt % Mo-B the growth in the boron content is accompanied by the reduction in the relative density, but hardness and tensile strength of these alloys are effectively higher.
6. The best elongation was obtained for Fe-Mo-B containing 1,5-3 wt % Mo and 0,2wt % B, especially for Fe-3,0 wt % Mo-0,2 wt % B.

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REFERENCES

1. L. A. Dobrzański, "Metaloznawstwo z podstawami nauki o materiałach", WNT,W-wa, 2002.
2. J. Karwan-Baczewska, "Influence of Boron on the Structure and Mechanical Properties of Sintered and Ion-Nitrided Distaloy Alloys", International Journal of Materials and Product Technology, Vol.15, pp. 193-204, 2000.
3. J. Karwan-Baczewska, M.Rosso, "Effect of boron on the Microstructure and the Mechanical Properties of P/M Sintered and Nitrided Alloyed Steels", Powder Metallurgy, Vol. 44, No 3 pp. 221-226.
4. A. Szewczyk, T. Pieczonka, A. Molinari, J. Kazior, "Rola fazy ciekłej podczas spiekania układu Fe-Mo-B", II Ogólnopolska Konferencja Naukowa – Problemy Jakości stymulatorem rozwoju technologii bezodpadowych, Kraków 16-18 września 1999, Materiały Konferencyjne, Vol. II, Metalurgia Proszków - Jakość pp. 41-49, 1999.