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Tin influence on diamond-metal matrix hot pressed tools for stone cutting*

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The article presents the influence of a small (up to 12% wt.) amount of tin in metal matrix composition of the sintered tools for construction materials cutting. The degree of compacts densification, hardness and phase composition turnover (if occured) have been taken into account. The results have been compared for the pairs of the segments those have almost the same chemical composition - the difference was tin presence. The compacts containing tin have higher hardness and better densification in comparison to those without. (3 references).

1. INTRODUCTION

February 15th, 1953 the team of Swedish scientists has succesfully synthesised diamond crystals after 24 unsuccesful attempts [1]. Since that day every year the number of synthetic diamonds applied in tools industry increases [2]. Diamond-metal matrix tools for stone-work and civil engineering are usually being produced by mixing the diamond grit together with the appropriate metal(s)/alloys powders and then hot pressed. Such achieved segments are brazed or welded onto a steel pipe (core drill) or disc (sawblade). Depending on workpiece material (its hardness and abrasivity) the metal matrix contains the metals or alloys as follows: cobalt, cobalt and tin, cobalt and bronze, tungsten carbide etc [3]

2. MATERIALS & EXPERIMENTAL PROCEDURE

The aim of the experiment was to make out the influence of small (up to 12 % wt.) tin addition into the composition of hot pressed diamond-metal matrix tools for stone processing. 4 pairs of the materials have been prepared. Each pair had similar chemical composition, they differed in tin addition. The proportion of the other elements were constant. The amount of diamond in a sawblade segment is expressed according to a scale in which 100 concentration is equivalent to 4,4 carat/cm^3 (25% vol.). The other numbers are proportional. The chemical compositionas well as process parameters and segment height are shown in the table 1.

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Table. 1.
Hot pressed segments' composition & parameters

sample number	time [s]	temp. [°C]	press. [MPa]	segment height [mm]	matrix composition [% wt.]	diamond conc.
1(2nd time)	60	850	25.3	8.90	Ni 59; Cu 35; Fe 6	15
1a(2nd time)	180	850	25.3	7.96	Ni 55; Cu 33; Sn 6,5 ; Fe 5,5	15
2	120	700	42.8	8.22	Cu 61; Co 20; Fe 19	15
2a	120	700	42.8	7.43	Cu 55; Co 18; Fe 17, Sn 10	15
3	120	700	42.8	8.04	Co 100	15
3a	120	700	42.8	7.79	Co 89; Sn 11	15
4(2nd time)	60	850	25.3	11.12	Fe 77; FeCr 23	27
4a(2nd time)	60	850	25.3	8.76	Fe 68; FeCr 20; Sn 12	15

The powders' mixtures have been hot-pressed in graphite moulds of the Sintris furnace, computer operated. The process parameters are: temperature 700°C, pressure 42,8 MPa, time 120 s. Such conditions were appriopriate only for samples nr 2, 2a, 3 and 3a. The others segments were not strong enough so that a man could break them in his hands. The operation has been repeated for them in a higher temperature. Afterwards the segments' heights have been measured so that the densification could be estimated.

3. X-RAY DIFFRACTION

The X-Ray phase analyze has been conducted with use of the computer operated diffractometer XRD 3003 Rich. Seifert&Co. working in T-T system. The scan range was 25º-160º, step 0.1º, anode material Co, voltage 40 kV, current 30 mA. The DHN_PDS database software package (containing over 70,000 records) has been very helpful in analyzing the phase compositon of the compacts basing on the diffractograms. The results are shown in fig. 1 and table 2.

Table 2.
Phase composition of the hot pressed segments

sample nr	phases (crystalographic system)
1	Cu (fcc), Ni (fcc), Cu+Ni (fcc)
1a	Cu+Ni (fcc)
2	Cu (fcc), Fe-α (bcc), Co-α (hcp), Co-β (fcc)
2a	Cu (fcc), Fe-α (bcc), Co-α (hcp), Co-β (fcc)
3	Co-α (hcp), Co-β (fcc)
3a	Co-α (hcp), Co-β (fcc), Γ' (Co_3Sn_2; NiAs-type)
4	Fe-α (bcc)
4a	Fe-α (bcc)

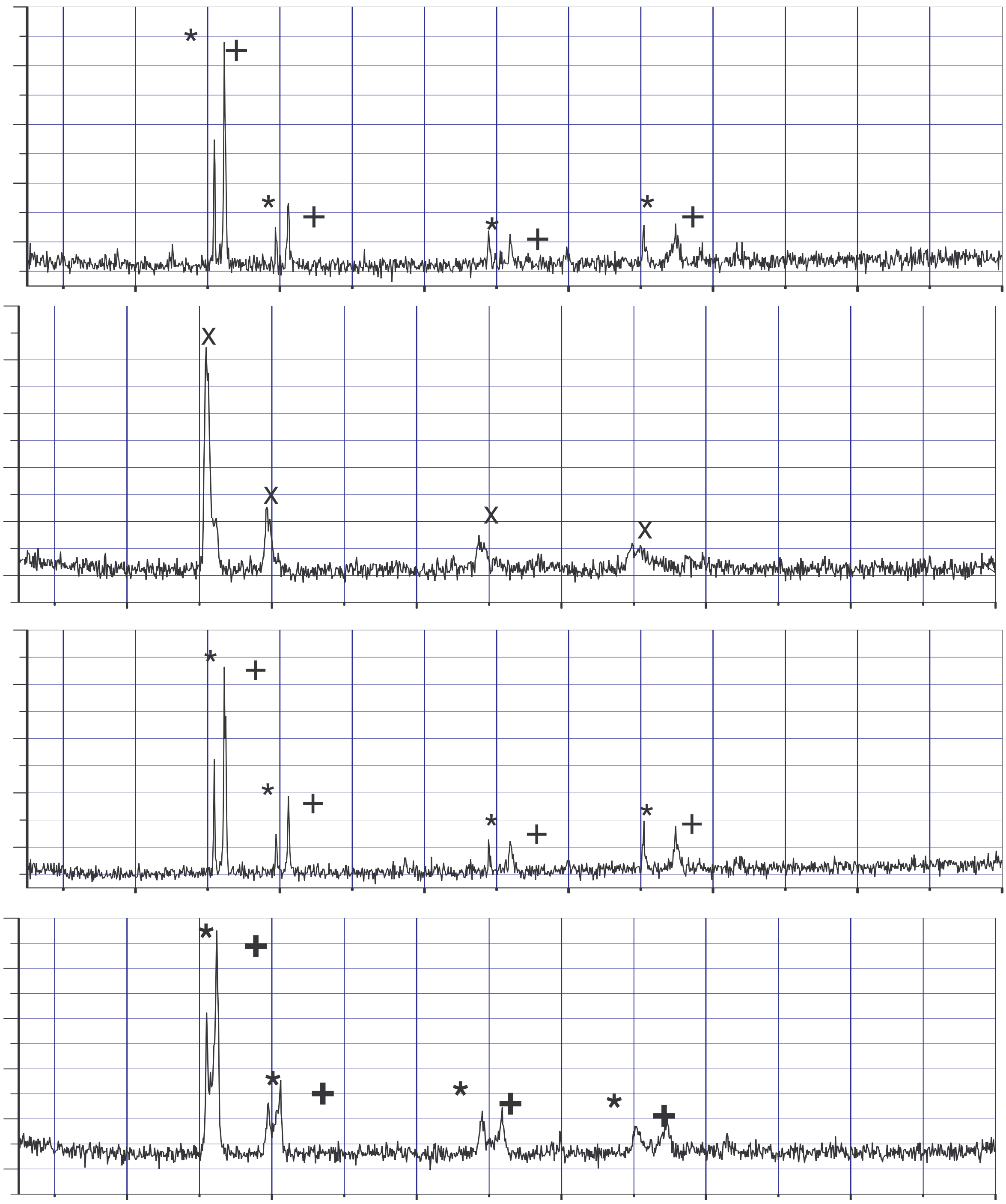

Fig. 1. Respectively from the top X-Ray diffraction patterns: powder nr 1a, hot pressed compact nr 1a, powder nr 1, hot pressed compact nr 1; symbol * corresponds to Cu, + to Ni and x to (Cu+Ni).

The peaks above show that Ni and Cu have tendency to form a solid solution because their peaks seem to join. Sn addition influence this effect increasing this tendency.

4. HARDNESS

Hardness is a very important feature of the tool that determins its working behaviour. For such materials usually Rockwell method is being applied (scale B or C). The measurments for this work have been made according to polish standard PN-91/H-04355. The results are shown in the table 3. For comparison the results have been recalculated to Vickers hardness according to polish standard PN-93/H-04357.

Table 3.
Rockwell hardness tests' results.

sample number	Rockwell hardness	Vickers hardness
1	56 HRB	100
1a	89 HRB	187
2	74 HRB	136
2a	76 HRB	147
3	69 HRB	125
3a	95 HRB	220
4	not measured	unknown
4a	75 HRB	140

5. CONCLUSIONS

a) powders mixtures as nr 1, 1a, 4, 4a are not able to be sintered in temperature 700° C and pressure of 42.8 MPa,
b) the segments differ in densification degree, those containing tin are better densified,
c) Co and Sn create phase Γ' (Co_3Sn_2) in such conditions,
d) after hot pressing the increase of the Co-β phase has been observed,
e) Sn in samples 2 and 2a creates with Cu an α solid solution and eutectoid α+δ,
f) 11 % wt. of Sn to Co increases hardness of about 35 %,
g) in case of nr 2, 10 % wt. of Sn increases hardness only a little (2a),
h) for 1 and 4 can be observed a big increase of hardness,
i) Sn intensifies the solid solution occurence of Cu and Ni,
j) Sn solves in Fe-α.

REFERENCES

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