Some Physical Properties of Regeneration Cemented Carbide Using Recycling WC Fine Powder by Tin Impregnation Method

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Abstract

Development of recycling method at cemented carbide scraps was researched. Some properties of recycled cemented carbides were investigated. Recycled WC fine powder suffered the surface oxidation. Therefore it was necessary to be done by reduction treatment at 1073K-3.6ks under hydrogen atmosphere. When sintering condition at 1673K-3.6ks was treated under vacuum condition, it gained the deflective strength of about 90%, and gained hardness and sintering density about same value compared with commercial alloys. As a result, it was able to recycle only by 7 processes.

Keywords : Recycling process, Cemented carbides, Tin impregnation method, Surface oxidation, Deflective strength

1. Introduction

Cemented carbides materials were utilized mainly by die mold and cutting tool. But, these materials were spoiled after use. These physical properties show an excellent value and very expensive material because of use of rare metals (W and Co). The purpose of research was proposed a new recycling technique of these alloys. Tin impregnation method[1,2] of a new recycling system characterized a very low cost and makes an omit-energy. This method can separate WC and Co element completely, and can recover WC fine powder and Co-Sn compounds. Finally, we developed to recover WC fine powder compared by commercial powder level (1~3μm). On the other hand, by the addition of Co element, this recycled WC fine powder was able to get recycled cemented carbides perfectly. In this experiment, recycling WC fine powder was done to mix commercial Co and graphite, compress molding and sintering process. Obtained recycling cemented carbides mechanical properties were compared by commercial alloys. And after, we tried to develop the recycled cemented carbides and to make clear a few problems.

2. Experimental and Results

Fig.1 shows SEM photograph and EPMA analysis of Sn impregnation specimen treated 1323k-7.2ks condition. Cobalt element was almost substituted to tin, as a result, tin show to impregnate all specimens' area. Cobalt element were transformed the γ' phase, and precipitated in the molten pool. WC-Co alloy were substituted WC-Sn alloy because of penetrate the surplus of tin liquid, WC-Sn alloy were able to brittle remarkably.

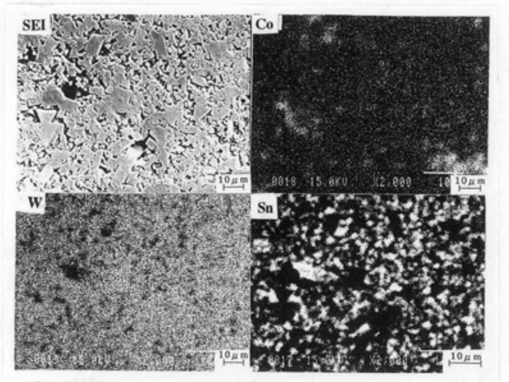

Fig. 1. SEM photographs and EPMA analysis of Sn impregnated specimen.

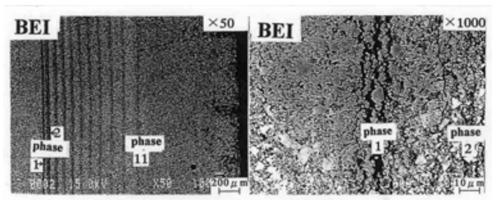

Fig. 2. SEM photographs of Sn impregnated specimen.

Fig.2 shows SEM photograph of representative tin impregnation specimen treated 1373K-5.4ks condition.

Table 1 indicates the quantitative analysis results by EPMA. Considered by each concentration of phase 1, 2 and phase 11, γ' phase (Co_3Sn_2) exists in site of phase 1 and 2, and site of phase 11 exists γ' phase and $CoSn_2$ too. Phase 11 zone observed to exist many pore. That is to say, Cobalt and tin elements in cemented carbides were reacted easily and were separated by WC particles.

Table 1. Atomic percentages of Sn and Co elements on three phases.

Phase		1	2	11
at%	Sn	39.3	37	27
	Co	59.2	24	11.4
		Co_3Sn_2(γ'phase)	Co_3Sn_2(γ'phase)	Sn rich phase and many pores

Table 2 shows to compare of chemical composition and some properties between commercial alloy (DA50) and recycled WC-Co alloy. By chemical composition, retained tin analyzed 0.05 ~ 0.07 mass% on recycled cemented carbides. Sintered density and hardness were almost same of commercial alloy. On the other hand, deflective strength of recycled cemented carbides was obtained 2700 ~ 2820 MPa values. Commercial alloy data was obtained 3038 ~ 3136 MPa values. This value was gained about 90%. The lower tendency of deflective strength caused by retained tin. But, recycled cemented carbides shows to clear easily JIS standard value.

Table 2. Comparison of chemical composition and some properties between commercial alloy and recycled WC-Co alloy.

SAMPLE	Chemical Composition (mass%)				Density (g/cm^3)	Deflective Strength (MPa)	Hardness (HRA)
	W	Co	C	Sn			
DA50	81.67	13.00	5.33	–	14.20	3038～3136	87.6
Recycled WC-Co	80.73	13.54 ～ 13.87	5.27	0.05 ～ 0.07	14.04	2700～2820	87.8～88.6

Fig.3 shows the flow chart of recycling process on disposal alloys. In this experiment, tin drops and cobalt in cemented carbides reacted tin bath 1323K-7.2ks condition. After Sn impregnation treatment of cobalt element, reacted Co-Sn compounds and WC particles were crushed by physical method. Stirring-cleaning method after crushing process was done 18 vol% HCl solutions. Tin and tin compounds resolved HCl solution easily. WC particle obtained by these treatments was screened till under 45μm. Over 45μm particles repeated to crushing and stirring. We got 60% recovery ratio of WC particles.

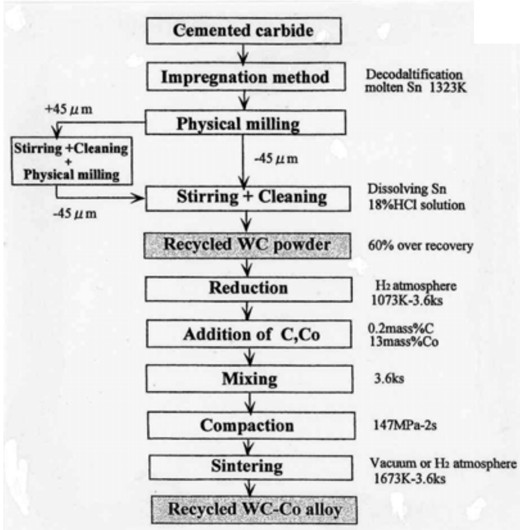

Fig. 3. Flow chart of recycling process on disposal cemented carbides.

3. Summary

Development of recycling method at cemented carbide scraps was researched. First, brittle alloy was obtained by tin impregnation method and then WC fine powder was procured after the physical crushing. Thereafter, the sample followed by the processes of reduction treatment, molding and sintering works. Some properties of recycled cemented carbides were investigated. The results summarized as follows; Recycled WC fine powder suffered the surface oxidation. Therefore it was necessary to be done by reduction treatment at 1073K-3.6ks under hydrogen atmosphere. When sintering condition at 1673K-3.6ks was treated under vacuum condition, it gained the deflective strength of about 90%, and gained hardness and sintering density about same value compared with commercial alloys. As a result, it was able to recycle only by 7 processes, that is to say, tin impregnation, physical milling, stirring HCl cleaning, reduction, mixing, molding and sintering works.

4. References

1. M Nakamura, M Tagusari :"Recycling Technique of WC Fine Powder Contained in Cemented Carbides by Tin Impregnation Method", J.Jpn. Soc. Powder Powder Metallurgy, 52(2005) 317-321
2. M Nakamura: "Re-powdering Technique of Used Cemented Carbides Parts by Tin Impregnation Method", Jpn. Patent 2000-072430.
3. K Yoshida: "Cemented Carbides Tools", Nikkan Kogyo Press, (1982) 20-22.
4. Japan Powder Metallurgy Association: "Sintering Mechanical Parts -Planning and manufacturing-", Gijutsushoin, (1985)333.