Characteristics of Pre-alloyed Powders for Diamond Tools

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Abstract

In this paper, the fundamental attributes, phase composition of three pre-alloyed powders for diamond tools by water atomization were investigated. The density, hardness, bend strength and bending modulus of their hot pressing samples were examined. The results showed that the three pre-alloyed powders have excellent low temperature sintering characteristics. The physical and mechanical properties of the samples were found to be nearly the same as those of fine cobalt powders.

Keywords : diamond tools, pre-alloyed powders, sintering characteristics

1. Introduction

According to previous researches, diamond tools matrix has five major characteristics, wearing resistance, high dia-mond retention, low temperature sintering, good technologyand economic efficiency. Cobalt matrix has very positive characteristics but is expensive. In recent years, some pre-alloyed powders have been developed to replace the cobalt powders [1,2]. In this paper, the characteristics of the three pre-alloyed powder developed were investigated.

2. Fundamental attributes

Pre-alloyed powders for diamond tools are generally prepared by chemical co-precipitation reduction and water atomization. The pre-alloyed powders (symbol 04,05 and 06) in this paper are prepared by water atomization with 50MPa. The chemical composition and fundamental attributes are shown in Table 1, and the fundamental attributes of A, B, C pre-alloyed powders of a foreign com-pany and fine cobalt powder are presented for comparison.

TABLE 1. Fundamental attributes.

Symbol	Chemical composition (%)	True density (g/cm^3)	Oxygen content (wt%)	Scott density (g/cm^3)	Particle diameter D50(μm)
04	Fe65Cu20Ni7Sn8	8.03	0.38	3.4	17.8
05	Fe65Cu25Co10	8.15	0.29	2.9	18.3
06	Fe15Cu 75Co10	8.72	0.24	2.6	15.3
A	Cu－Co	8.48	1.07	1.1～1.6	4.95
B	Cu－Co	8.75	1.04	1.0～1.5	4.45
C	Fe－Co	8.05	0.39	2.16	13.97
Co	Co100	8.9	0.28	0.9	~1.5

Table1 shows that attributes of 04, 05 and 06 are equivalent to C powder. Compared with A, B and Co powders, they have low oxygen content, larger particle size and higher loose density.

The particle size distributions of 04, 05, 06 powders and C powder take on normal distribution.The particle size distributions of A and B take on multimodal distribution.

The morphology of 04, 05, 06 and C powder are irregular (04 and C powder in Fig.1). Furthermore, the morphology of A and B powder is like a sponge (A powder in Fig. 1).

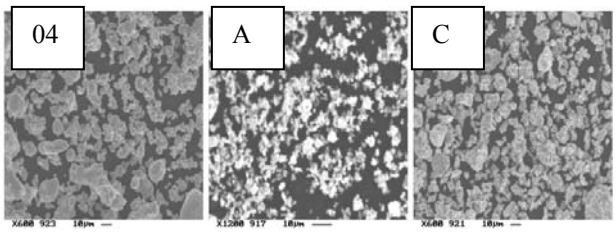

Fig. 1. SEM morphology of 04, A and C powders.

3. Phase composition

The XRD analysis shows that the 04 powder consist of two phases. The basic phase is α-Fe solid solution, and the second phase is Cu-Sn phase, which belongs to the electron compound of Cu31Sn8 whose electron concentration is 21/13. The basic phase of 05 powder is α-Fe solid solution, and the second phase is Cu phase. There is a small amount of Co_3Fe_7 phase. For 06 powder, the principle phase is the Cu phase, and the second phase is α-Fe solid solution. There is a small amount of Co_3Fe_7 phase as well.

4. Sintering density, hardness, bend strength and bending modulus

The sintered density (D) and hardness (HRB) of 04, 05 and 06 powders with the hot pressing temperatures (T) are shown in Fig. 2.

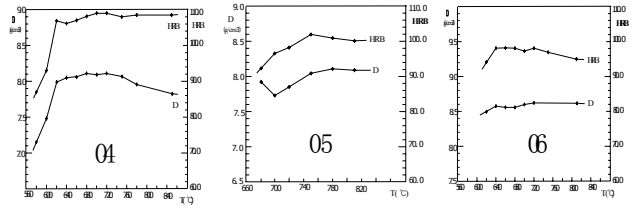

Fig. 2. Sintering density(D) and hardness(HRB).

The sintering density of 04 powders approaches the true density starting from 620 ℃, whose value fluctuates at the range of 8.0 ~ 8.1 g/cm^3 until 750℃. The HRB fluctuates at the range of 106-109. The sintering density of 05 powders approaches the true density starting from 750 ℃, whose value fluctuates at the range of 8.0 ~ 8.15 g/cm^3 until 810℃. The HRB is at the range of 101-102.The sintering density of 06 powders is in the range of 8.55 ~ 8.65 g/cm^3 from 640℃ to 810℃. The HRB is constant within the range of 97-98. The three powders show excellent low-temperature sintering characteristic, and this is attributed to the Cu-Sn electron compound and Cu phase in the powders.

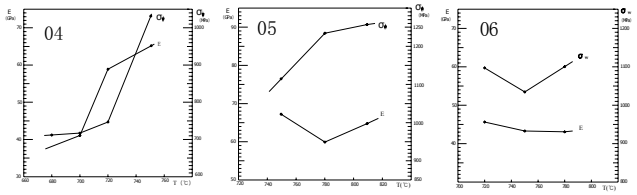

Fig. 3. Bending strength(σ_w) and bending modulus (E).

The bend strength(σ_w) and bending modulus(E) of 04、05 and 06 powders at densification sintering temperature are shown in Fig. 3.

The figure show that the bend strength and bending modulus of 04 powders increase greatly from 720℃ to 750℃. At 750℃, the bend strength reaches1030MPa while bending modulus reaches 65GPa. But at 620-720℃, 04 powder is not well sintered, thus the bend strength and bending modulus are low. From 750℃ to 810℃,the bend strength and bending modulus of 05 powder are1120 ~ 1270MPa and 60 ~ 67GPa, respectively. From 720 ℃ to 780℃, the bend strength and bending modulus of 06 powder are1120 ~ 1270MPa and 60 ~ 67GPa, respectively. The low bending modulus of 06 powders maybe related to the fact that major phase of 06 powders is Cu phase.

Some of the physical and mechanical properties of 04, 05,06, A, B, C and ultra-fine cobalt powder are listed in the Table 2.

From Table 2, we can see that the physical and mechanical properties of 04, 05 and 06 powders are similar to those of A, B and C powders. Their properties are almost same asthat of fine pure cobalt powder.

5. Summary

In this paper, the characteristics of 04, 05 and 06 pre-alloyed powders were investigated and based on the results. We could make the following conclusions.

(1) The three pre-alloyed powders with average sizebetween 15~18μm and containing 0.24~0.38wt% oxygen,have irregular morphology. Compared with foreign pre-alloyed powders the three pre-alloyed were found to have lower oxygen content but larger particle size. Besides the major phase, these powders have a second phase with lower melting point.

(2) The three pre-alloyed powders have excellent lowtemperature sintering characteristics. Their physical andmechanical properties match well with cobalt powder.

6. References

1. M.del villar, P.Muro and J.M. sanchez: *Consolidation of diamond tools using Cu-Co-Fe based alloys as metallic binders* [J]. Powder metallurgy, 2001,1 (44), 81 ~ 90
2. IE Clark, BJ Kamphuis: *Cobalite HDR—a new pre-alloyed matrix powder for diamond construction tools* [J]. Industrial diamond review, 2002, 3, 177

TABLE 2. Physical and mechanical properties

Symbol	Hot pressing temperature (℃)	Sintering density (g/cm)^3	Relative density (%)	Hardness HRB	Bend strength (MPa)	Bending modulus (GPa)
04	700 ~ 750	8.0 ~ 8.1	98 ~ 100	106 ~ 109	~ 1030	60 ~ 65
05	750 ~ 810	8.0 ~ 8.15	98 ~ 99	101 ~ 102	1120 ~ 1270	60 ~ 67
06	660 ~ 720	8.55 ~ 8.65	98 ~ 99	97 ~ 98	1040 ~ 1100	43 ~ 46
A	700 ~ 750	8.36 ~ 8.40	98 ~ 99	106 ~ 108	–	–
B	700 ~ 750	8.57 ~ 8.66	98 ~ 99	102 ~ 104	–	–
C	720 ~ 780	7.95 ~ 8.00	97 ~ 99	98 ~ 102	–	–
Co	780 ~ 850	8.72 ~ 8.90	98 ~ 100	102 ~ 105	1200	70