Densification Technology of Al_2O_3/Fe Metallic Ceramic Materials Prepared via Powder Metallurgy Method

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Keywords: Metallic ceramic materials, Densification, Al_2O_3, Fe, Powder Metallurgy Method.

Abstract. Metallic ceramic materials while maintaining the excellent properties of ceramic materials, but also have the advantages of a metal material, is an important new engineering materials. Iron-based composite applications broad, but not high abrasion resistance, wear-resistant engineering parts for such restrictions, in order to improve the wear resistance of the iron-based composite materials and lower production costs, Al_2O_3/Fe metallic ceramic materials were prepared by powder metallurgy method in this paper, the effect of preparation technology on the properties of Al_2O_3/Fe metallic ceramic materials can be investigated, which includes all the molding and sintering process parameters. Through the results and analysis, the density of the best organized, namely 4.38g/cm^3, prepared with 25wt% of Al_2O_3 powder, 75wt% of Fe powder, the molding pressure of 30MPa, holding time pressure of 10min, atmospheric sintering at 1000℃ parameters.

Introduction

Metal matrix composites is hard ceramic reinforced composite body to ductile metal or alloy matrix, the plastic and high strength and high modulus and toughness ceramic metal effective combination, therefore, it has high shear and compression strength and high temperature service capability [1-3].

Al_2O_3 has high hardness, wear resistance, chemical stability advantages, especially those with good performance at high temperatures, Al_2O_3 particles because of its low price, the most widely used in industrial production [4-5]. Iron having excellent mechanical properties of high ductility, good toughness, by adding alloying elements and thermal treatment to change the microstructure and mechanical properties, in order to adapt to different working conditions, while iron rich material resources, lower cost [6-7]. Particulate reinforced iron matrix composites with high strength, abrasion resistance and heat resistance properties, have broad application prospects, attracted more and more attention researchers [8-10].

Powder metallurgy process is simple and can take full advantage of the performance of a variety of materials[11-12]. In this paper, the use of powder metallurgy of Al_2O_3 particles reinforced Fe metallic ceramic materials study Al_2O_3/Fe metallic ceramic materials preparation technology to provide reference for the preparation of high-performance Al_2O_3/Fe metallic ceramic materials.

Experimental Materials and Methods

Raw materials used in the experiments were produced by a company in Tianjin and Shanghai Fe powder factory production analytically pure Al_2O_3 powder having an average particle size was 35μm and 10 μm. 25% of Al_2O_3 powder and 75% Fe powder were mixed in the blender, mixer speed of 100r/min, mixing time of 2h, mixing with agate beads as milling media. The powder mix was charged into Φ10mm×10mm mold dry pressing and packing. The sample after forming into the ZT-50-22-type vacuum sintering furnace using different sintering densification process. The surface

of the sintered samples were polished specimen spare. TESCAN VEGA type Ⅱ using scanning electron microscopic structure of the sample, using the HV-1000 Webster hardness tester test sample surface hardness.

Results and discussion

Table 1 Effect of sintering temperature on the density of Al_2O_3/Fe metallic ceramic materials

Sample No	Molding pressure	sintering temperature	Holding pressure time	Holding temperature time	density
1#	30MPa	1000℃	15min	1h	4.38g/cm^3
2#	30MPa	1100℃	15min	1h	4.16g/cm^3
3#	30MPa	1300℃	15min	1h	4.06g/cm^3

As shown in Table 1, when molding the same, and the sintering temperature are different, have some impact on body density. Comparison with samples 1 and samples 2, samples 1 density of 4.38g/cm^3 slightly higher than samples 2 of 4.06g/cm^3, but the difference between the two is not very clear, mainly due to the main component of the sample is Fe, Fe melting point of 1535℃, the sintering atmosphere and the sintering temperature is generally used as a base of the melting point of 0.7Tm-0.8Tm, 1000℃, 1100℃ belong to this temperature range, and therefore both density less.

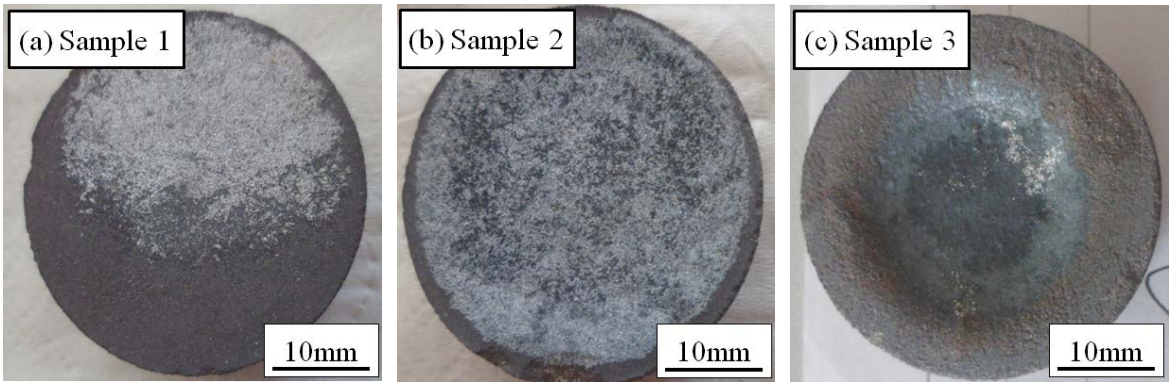

Fig.1 The effect of sintering temperature on the surface of Al_2O_3/Fe metallic ceramic materials

As shown in Fig.1, Fig.1-c with respect to Fig.1-a, b, the bottom contraction is serious, the burnt phenomenon is obvious. The so-called over-burning refers to the sintering temperature is too high and lead to the final properties of the sample decreased, the main phenomenon of deformation, reducing the strength and density of the serious and the like. Moreover, the apparent from their sectional, 130℃ firing sample density was significantly lower than 1000℃ and 1100℃ firing from cross-sectional view of samples 3 shows that the presence of a lot of holes in their structure, but also a significant iron agglomeration. Thus, from the above analysis shows that, when a sample of about 1000℃ sintering atmosphere, the highest density, the green body density is best.

After the powder in a mold under pressure, the volume will be greatly reduced, which is due to the pressing process, the powder not only displacement occurred, and when the pressure reaches a certain degree of deformation will occur. In the pressing process, the variation of body density includes three stages: (I) applying pressure, the particles start to move, pore filling body between the arch and the occurrence of damage, so that the packing density is maximized. The implications of this body is the volume decreases rapidly, density increases rapidly. (II) after the first stage of the green body pressure, density reaches a certain value. In this case, the powder appears certain compression resistance, when the pressure continues to increase body density change is not very obvious, the

reason is because although the scope of the powder particles larger displacement is reduced, and the occurrence of a small particle only modification, did not produce a large amount of deformation. (III) With the further increase of pressure, more than the yield limit (critical stress value), the powder particles began to produce a large amount of powder material cracking and deformation, resulting in the displacement and deformation of simultaneous action of the particles, so that the blank density continues to increase. Due to the current limited use of my school experimental equipment, the maximum pressure of the graduation project can adopt only 30MPa. As shown in Tab.2, with increasing pressure, the density tends to decrease, which does not match the curve of the relationship between pressure and density of the molding pressure, the main reason for this phenomenon is the dwell time is short, the specimen not a lot to eliminate stress, so that when the pressing force is removed, the internal stress relaxation occurs, a direct result of the expansion of powder size, porosity increased, thereby reducing the density. Therefore, when the holding time enough, you should take a greater molding pressure. In summary, the combination of rate shaping and limiting conditions of laboratory equipment pressing process, the pressure of 30MPa, dwell time of 10 minutes when the best results.

Table 2 Effect of molding pressure on the density of Al_2O_3/Fe metallic ceramic materials

Sample No	Molding pressure	sintering temperature	Holding pressure time	Holding temperature time	density
$4^{\#}$	20MPa	1100℃	5min	1h	3.84g/cm^3
$5^{\#}$	25MPa	1100℃	5min	1h	3.76g/cm^3
$6^{\#}$	30MPa	1100℃	5min	1h	3.66g/cm^3

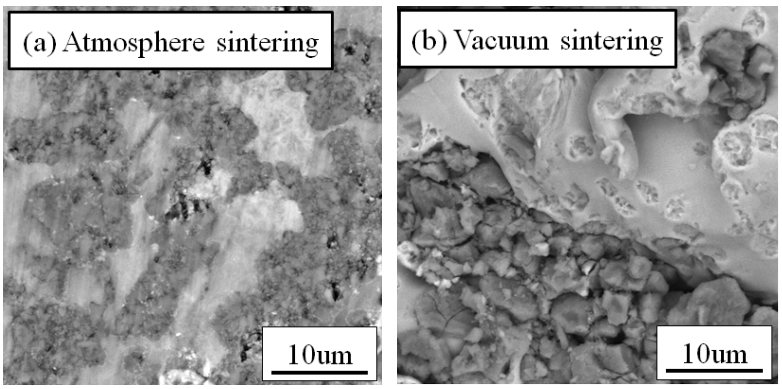

Fig.2 The effect of sintering method on the microstructure of Al_2O_3/Fe metallic ceramic materials

From Fig.2, in the same 1100℃ sintering, sintering under atmospheric density significantly higher than the vacuum sintering density. As shown above (a), the white of Al_2O_3, black as Fe, Al_2O_3 particles are encased in molten Fe and Al_2O_3 particles with the surrounding surface were in contact to form a dense structure. Fe also melted and pore filling body between the body so that the gap is reduced, but also increased the density of the green body. The way the powder particles Figure (b) on the majority of the contact point contact and line contact, Fe and no obvious signs of melting,; and the sintering vacuum sintering after there will be a small amount of powder out phenomenon, its strength poor, can easily use the saw blade sawing. On the contrary, with the sample after sintering atmosphere blade sawing difficult, there is no phenomenon of powder out. From the Fig.2, in the case of atmospheric sintering, the interface between the two phases combined with better, more uniform distribution between phase to phase, which makes the mechanical performance of the cermet may be better.

Summary

In this paper, Al_2O_3/Fe metallic ceramic materials were prepared by powder metallurgy method in this paper, the effect of preparation technology on the properties of Al_2O_3/Fe metallic ceramic materials can be investigated, which includes all the molding and sintering process parameters. Through the results and analysis, the density of the best organized, namely 4.38g/cm^3, prepared with 25wt% of Al_2O_3 powder, 75wt% of Fe powder, the molding pressure of 30MPa, holding time pressure of 10min, atmospheric sintering at 1000℃ parameters.

Acknowledgements

The authors are thankful for the Science and Technology Landing Plan of Education Department of Jiangxi province (KJLD12096), the Key Subjects Construction Program for the Materials Processing Engineering of Jiangxi Province during the 12th Five-Year Plan Period, the Science and Technology Foundation of Jiujiang University (2015LGYB12) and the Foundation for Creative Research Groups of Jiujiang University.

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