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Evaluation of Ceramic sand produced by Ultrahigh temperature melting process

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Abstract
The recently ceramic sand is produced by our ultrahigh temperature melting process through advances in the melting technology for the ceramics and it is possible to produce the ceramic sand with the high refractoriness and dense particle. Against such a background, the characteristic of the ceramic sand produced by the ultrahigh temperature melting was evaluated by the particle compressive strength measurement and the burning resistant sand test in this study, which burning resistant sand test comes from that the mold wash is required for the molten metal in the cast steel due to the low refractoriness of the existing ceramic sand. As the result of this study, it was found that the ceramic sand produced by the ultrahigh temperature melting process had a few times of the particle strength as compared with the existing ceramic sand which showed the capable resistance for the stress in the casting line. For the sand burning, it was showed that the sand burning was encouraged by the low melting substance in the ceramic sand and the basic ceramic sand was effective to improve the burning sand.

Keywords: *ceramic sand, ultrahigh temperature melting, particle compressive strength, burning resistant sand*

1. Introduction

The usage of the ceramic sand as the environmentally-friendly foundry sand is increasing yearly because the factory waste and the casting defect rate can be reduced by it. For the action to prevent the casting defect by the ceramic sand, the reason to use it in the casting line comes from the low expansion for the deformation or the crack, the high refractoriness for the sand burning, the low usage of the binder with the good grain shape for the blow hole. In 2005, in order to estimate the amount of the factory waste, the authors investigated that the compressive strength of the particles in the casting sand was measured by the micro strength tester and the estimation was determined quantity in contrast with the stress of the particles in the casting sand damaged in the casting line. Against such a background, the characteristic of the ceramic sand produced by the ultrahigh temperature melting was evaluated by the particle compressive strength measurement and the burning resistant sand test in this study.

2. Experimental Procedure

2.1 Test Pieces

The ceramic sand as test pieces were prepared by the ultrahigh temperature melting process, in which ceramic materials are melted under plasma heat in atmosphere and the melted ceramic is gas atomized to form ceramic sands. The chemical composition of the ceramic sands was adjusted using four types of raw material including of SiO_2, Al_2O_3, MgO, and ZrO_2. As comparison samples, several types of marketed ceramic sand were provided with melting method using sintering heat or arc heat or LPG-O_2 flame heat.

2.2 Measurement

The obtained ceramic sands were evaluated by measuring the sand particle strength, sand burning resistant test for the melt cast steel and other characteristics as foundry sands.

3. Experimental Results

The sand particle strength and features of ceramic sands are presented in Table 1 with the purpose of comparing ceramic sand characteristics between ultrahigh temperature melting by plasma heat and existing melting methods by sintering heat or arc heat or LPG-O_2 flame heat. By evaluating the sand particle strength, it was found that the particle strength of the ceramic sand produced by the ultrahigh temperature melting process was a few multiples of that of the existing ceramic sand. As the chemical composition of the ceramic sand has been adjusted to the existing ones, the melting temperature of the plasma heat is considered to have caused an increase in strength.

Table 1. Sand particle strength and features of ceramic sands.

Sample#	Sand particle strength, MPa	Aspect ratio, -	Ceramic sand type
Test-1	2,627	0.944	Mullite
Exsiting-1	1,170	0.851	
Test-2	2,653	0.946	Corundum
Exsting-2	1,163	0.881	
Test-3	2,347	0.964	Corundum-Zirconia
Existing-3	1,466	0.845	
Test-4	3,193	0.957	Corundum
Exisitng-4	2,175	0.941	
Test-5	899	0.958	Periclase
Existing-5	222	0.940	

The cross sections of ceramic sands are shown in Fig. 1 to illustrate the reason behind the increase in strength; the images are of one of the comparison examples listed in Table 1. A comparison of the cross sections shows that the air bubble of melting by plasma heat (Test-1 to 5) is less than that from the existing melting ones (Existing-1 to 5). Additionally, there is an improvement in the aspect ratio defined as shortest diameter / longest diameter, as seen in Table 1; hence, it is expected that the higher temperature of plasma heat reduces the viscosity of the melting ceramic material and contributes to the reduction in the air bubble size and improves the aspect ratio during gas atomizing.

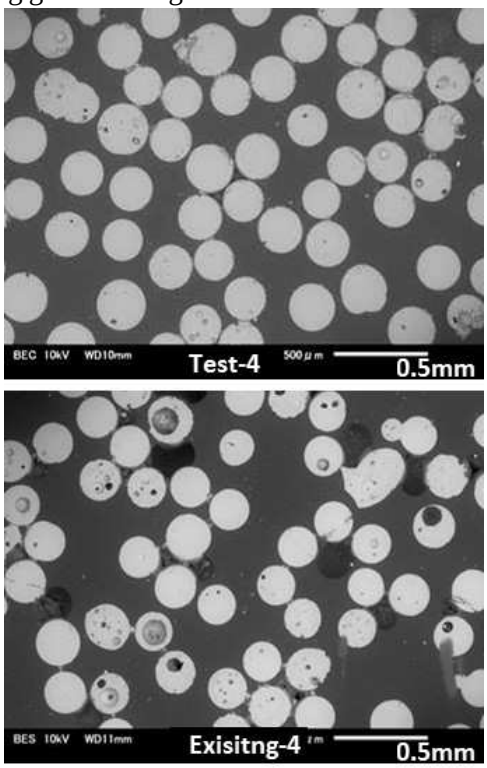

Fig. 1 Cross section of ceramic sands (Compositional image in BES mode)

The basic oxide of MgO in periclase is known to have burning resistance because the weakly-basic oxide of ferrous oxide or stainless steel is unreactive with MgO. On the other hand, it is difficult to melt the ceramic raw material containing a large amount of MgO because of its high refractoriness. However, as it is possible to melt raw material with more basic oxide using the plasma heat of the ultrahigh temperature melting process, the burning resistance was tested by reaction with melt stainless steel. The scanning electron micrograph of the burning resistance test with the stainless steel is shown in Fig.2; the images are of one of the comparison examples presented in Table 1. As seen in these images, there was little chemical burning in the ceramic sands with a ceramic sand type of periclase including MgO although there was chemical burning in other ceramic sand types such as mullite, corundum, and zirconia.

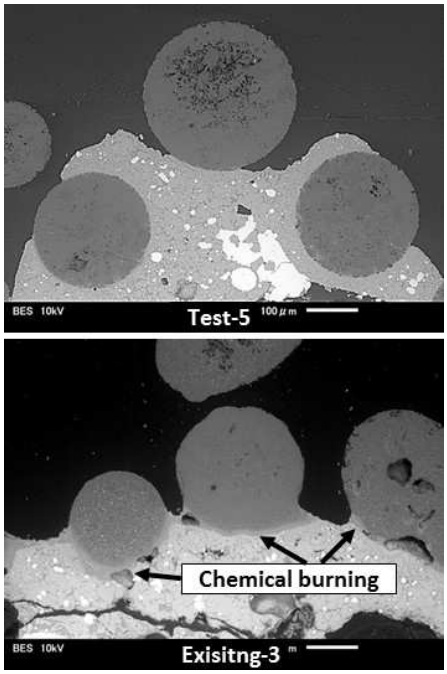

Fig. 2 Scanning electron micrograph of the burning resistance test with stainless steel (Compositional image in BES mode)

4. Conclusion

It was found that the particle strength of the ceramic sand produced by the ultrahigh temperature melting process was a few multiples of that of the existing ceramic sand, which implies capable resistance under stress in a casting line. It was also shown that sand burning was encouraged by the low melting substance in the ceramic sand and the basic ceramic sand was effective in improving the characteristics of burning sand.