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The Effect of Burning Temperature on the Pozzolanic Activity of Rice-husk Ash

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Introduction

Since the end of 1970s many investigations on the production of Rice-husk ash (RHA) with high activity and the possible application of RHA in concrete have been made (1,2). RHA, being similar to silica fume in SiO_2 content, contains 90-95% SiO_2 and 1-5% carbon residue, but the silica in it can be amorphous or crysta-lline in form according to the burning conditions under which it is burned. It has been observed that the pozzolanic activity of RHA is mainly depended on the amount of amorphous silica in it and at high temperatures the amorphous silica will be transformed to SiO_2 crystals. Here the effect of burning temperatures and heating time on the silica form and pozzolanic activity of RHA is presented.

Raw Materials and Experimental

Raw material

The RHA used in this experiment was obtained by burning rice husk in a batch furnace. XRD pattern shows the most silica in it is in amorphous form. Its chemical composition and N_2 adsorption specific surface (unground) are shown in Table 1.

Table 1 Chemical composition(%) and N_2 specific surface of the RHA used in the experiment

Loss	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	C	Total	Surface area
2.93	91.90	0.25	0.41	0.38	0.21	0.05	2.78	0.01	0.36	0.16	0.41	99.85	36.6 (m^2/g)

Evaluation of the pozzolanic activity of RHA

Luxan et al. proposed a method for rapid evaluation of the pozzolanic activity of natural products by electrical conductivity measurement (3). According to this method if the variation is lower than 0.4 mS/cm the tested material can be considered as non-pozzolanic one, while the variation is greater than 1.2 mS/cm the material will have very good pozzolanicity. We found this method is also available to estimate the pozzolanic activity of RHA quickly. The larger the variation in conductivity, the more active the RHA. On another hand it was observed that the pozzolanic activity of RHA is also closely related to its specific surface, the RHA with high activity is certain to have a big specific surface(4).

Experimental

The RHA which was burnt in the batch furnace was heated again at 490℃, 600℃, 700℃, 800℃, 900℃, 940℃, 960℃, 980℃, 1000℃ and 1100℃ in an electric furnace for 1hr, respectively, then they were quenched to room temperature. In another parallel experiment the RHA was heated at 490℃, 600℃ and 1000℃ for 2hr and 4hr so as to conduct an investigation into the effect of heating time on the pozzolanic activity of RHA. After ground in a ball mill for 1hr X-ray diffraction, measurement of specific surface and conductivity of all the ground RHA were carried out. Fig. 1 and Fig. 2 are their XRD patterns (CuK $_{\alpha 1}$, 20mA, 40KV, scanning at 4.000 deg./min). Fig. 3, Fig.4 and Fig. 5 show the influence of heating temperature and heating time on the variation in conductivity and N_2 specific surface of the RHA.

Discussion and Results

From Fig. 1 and Fig.3 it can be known that below 600℃ the RHA is mainly consisted of amorphous SiO_2 (d=4.040Å, JCPDS Card 29-0085), and has a high specific surface and high variation in conductivity as well. Above 600℃ SiO_2 crystals appear and their diffraction intensity is continually increased as heating temperature rises, which shows the amorphous silica in the RHA is gradually changed to crystalline SiO_2. Therefore its N_2 specific surface and the variation in conductivity is reduced, especially there is a big reduction in the variation in conductivity between 600℃ and 900℃. In the RHA heated at 700℃ there is only a little of β-quartz and β-tridymite. After 900℃ β-quartz disappears, at the same time α-tridymite and α-cristobalite are formed in the RHA. With further increment of temperature all the amorphous silica in the RHA have been gradually transformed to crystalline silica – a mixture of α-tridymite, β-tridymite and α-cristobalite, hence the RHA will not have any pozzolanic activity(3,4).

At the same temperature heating time does not have a great influence on the crystal form SiO_2 in RHA (Fig. 2), but at 600℃ the specific surface and variation in conductivity of RHA is varied with heating time (Fig. 4 and Fig. 5). During the first two hours the specific surface and variation in conductivity of RHA are increased with heating time, then they are decreased with further heating. This may be due to the decrease of the residual carbon in RHA and the variation of the crystallinity of SiO_2 in RHA with heating time at the temperature.

Conclusion

1. The burning temperature has a great influence on the pozzolanic activity of RHA. At temperatures higher than 600℃ the amorphous SiO_2 in it will be transformed to crystalline silica – a mixture of α-tridymite, β-tridymite and α-cristobalite, coherently the pozzolanic activity of RHA is decreased.
2. At 490℃ and 600℃ heating time does not have a great influence on the crystal form of the SiO_2 in RHA, but it has an effect on the pozzolanic activity and specific surface of RHA.

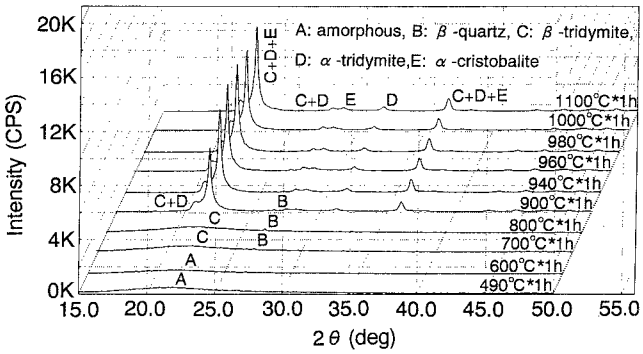

Fig. 1 XRD patterns of the RHA heated at different temp. for 1hr.

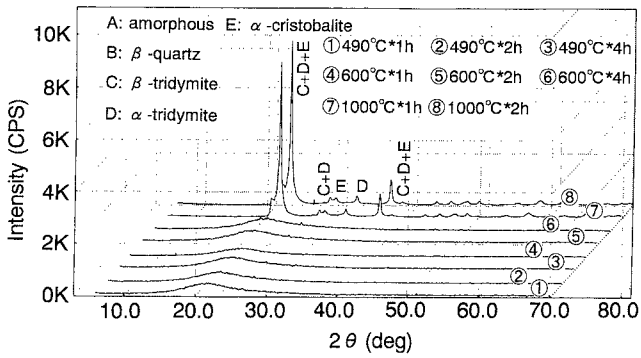

Fig. 2 XRD patterns of the RHA heated at different temp. for different time

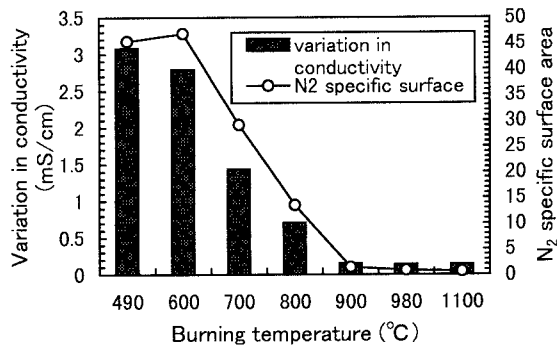

Fig. 3 Variation in conductivity and specific surface of RHA vs burning temperature

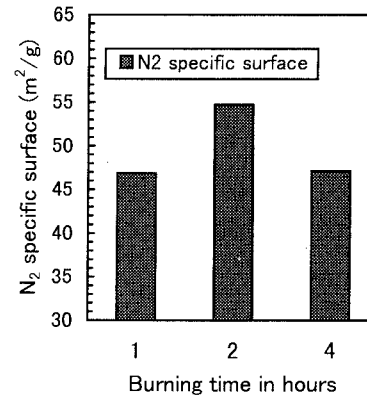

Fig. 4 N_2 specific surface of RHA vs heating time at 600℃,

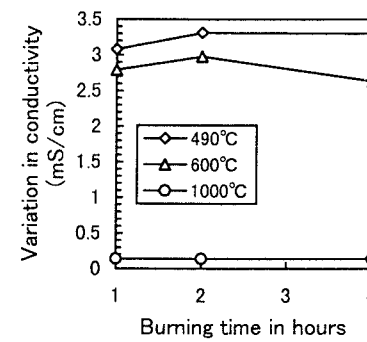

Fig. 5 Relation between the variation in conductivity of RHA and heating time at different temp.

References

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