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Reclamation of Sodium Silicate Sand Moulding

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ABSTRACT
Sodium silicate has been widely used in the foundry as a binder to make sand moulds and cores. However, the collapsibility of the sodium silicate bonded sand is normally low for sand reclamation. In this study, the effect of composition alteration of sodium silicate mixing with water as the binder for sand molding to improve the collapsibility of the cast iron casting sand was investigated. The sand specimens were prepared using 4 to 6 weight % of binder. The strength of the sand specimens and their collapsibility were examined. The size and shape of the sand grains produced from the reclamation were also studied. It is observed that sand moulds made with 6 weight % binder with 4:1 (sodium silicate to water) ratio has the sufficient compression strength to hold the sand particles together and a low retained compressive strength that increases the collapsibility of the sand mould.

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INTRODUCTION

Sand casting starts with melting metal into liquid and then pours in a mould. Silica sand is the most essential raw material. Silica sand used by foundries is desired for its thermal resistance and availability. One ton of cast iron casting could produce up to one ton of foundry waste (EPA, 1981). The increased costs of acquiring new foundry sands, disposal cost and also the environmental impact have made sand reclamation a practical solution attractive to the foundries.

Various sand reclamation methods have been studied to recycle the foundry sand. Most of the reclamations were carried out on moulding sands bonded by bentonite (Zanetti, M.C., S. Fiore, 2003) and alkaline phenolic resin system (Andrade, R.M., 2005). Ruffino (2006) studied the recovery of sand and potassium fluoborate from magnesium casting operation. Fluidisation processes have been investigated by Cruz (2009) and Geldart (2010), the reclamation process applied attrition process using fluidised bed that requires high energy and equipment cost.

Sodium silicate bonded sand is believed to have the greatest potential to achieve green casting production since it is almost odour free and less health hazard to the users. However, it gives poor break down characteristic and difficulty in residual sand reclamation. One of the possible ways to solve this problem is to reduce the amount of binder in the moulding sand (Fan, Z., 2004).

In this project, a study on the reclamation of sodium silicate sand moulding process was carried out. The properties of sand specimens made with various percentage of binder with different amount of water were compared. Cast iron was poured into the sand moulds with the proposed binder ratios to evaluate the effects on the compressive strength and collapsibility.

Experimental Procedure:

For test specimen preparation, 2 kg of moulding sand mixed with 80 g, 100 g and 120 g of binder (sodium silicate and water) were prepared, which is equivalent to 4 %, 5 %, and 6 % of the weight of moulding sand respectively, with sodium silicate to water ratio set to 1:1, 2:1, 3:1 and 4:1. Controlled sample was prepared with 10 % sodium silicate without mixing with water. 170 g of the moulding sand was rammed into split core boxes for compression, tensile and shear specimens. CO_2 gas with a pressure of 15 Pa was then pumped into the core box for 2 minutes. A universal strength machine (Versatile, India) was used to measure the strength of the test specimens. Sand siever machine (Versatile, India) was used to compare the grains fineness number (GFN) of the new and reclaimed sand.

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Sand moulds were prepared with 4 to 6 % binder, with sodium silicate to water ratio set to 4:1. Cast iron heated using induction furnace (Inductotherm, Australia) was poured into the cavities and the sand moulds were left to cool for a day. The condition of the sand moulds was observed.

RESULT AND DISCUSSION

Effects of binder-water ratio on the strength and collapsibility of the sand mould:

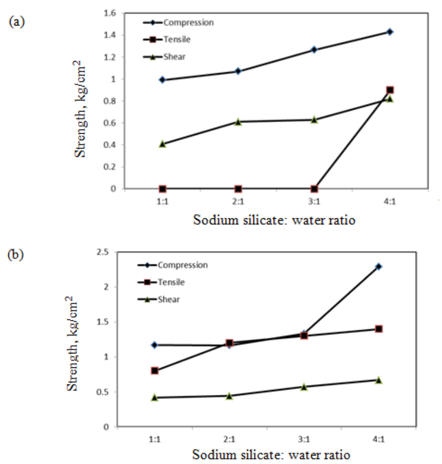
The compression, tensile and shear strength of the control specimens made with 10 % sodium silicate were found to be 7.78 kg/cm^2, 4.40 kg/cm^2, 1.76 kg/cm^2, respectively.

For the sand specimens made with 4 to 6 % of binder, the effect of altering the sodium silicate-water ratio to 1:1, 2:1, 3:1 and 4:1 on the strength of sand specimens is shown in Figure 1. Reducing the amount of sodium silicate has reduced the strength. The highest compressive strength of 3.41 kg/cm^2 was recorded in the sand specimen made of 6 weight% binder with 4:1 sodium silicate-water ratio, which is lower than the 7.78 kg/cm^2 observed in control sample. According to Ohdar (2003), the collapsibility of the sand mould can be estimated in terms of retained compressive strength of moulding sands. The lower the retained compressive strength, the better is the collapsibility. 4 to 6 % binder with 4:1 sodium silicate to water ratio was therefore used to prepare sand moulds to evaluate their rigidity as well as collapsibility.

Figure 2 shows the condition of the sand moulds prepared with 4 to 6 % of binders with 4:1 sodium silicate to water ratio. In Figure 2 (a), the sand mould made with 4 % binder collapsed after cast iron was poured into it. This indicates that the binder used did not provide enough strength to hold the sand particles together and maintain the mould in shape. Figure 2 (b) shows the sand mould prepared with 5 % binder was able to hold the mold in shape after pouring process, but there were few cracks observed on the sides of the mold. The sand mould made with 6 % binder shown in Figure 2 (c) was found to be in good condition after pouring process. This shows that the binder used has provided enough strength to hold the sand mould.

Most foundry sands fall within grain fineness number (GFN) ranging from 50 to 60 and average grain size of 220 µm to 250 µm (Brown 1999). Figure 3 shows the sand size distribution of new and reclaimed sand. Largest amount of sand was found in the GFN 50 mesh for both new and reclaimed sand, which are equivalent to 24.5 % and 35.5 % of total sand weight, respectively. The size distribution of the sands affects the quality of the castings. Coarse grained sands allow metal penetration into moulds and cores giving poor surface finish to the castings. Fine grained sands yield better surface finish but need higher binder content and the low permeability may cause gas defects in castings. The grains should therefore be distributed between GFN 20 mesh to GFN 100 mesh For the new sand, there was 9 % of GFN 16 mesh (1.19 mm) sands and 2.5 % of dust that is finer than GFN 100 mesh (0.149 mm). For the reclaimed sand, there was only 1% of GFN 16 mesh sands and 0.5 % of dust that is finer than GFN 100 mesh. The unwanted sand has been minimised to only 1.5 % in the reclaimed sand instead of 11.5% in the new sand. Higher percentage of acceptable size of sand grains obtained from reclaimed sand was due to during the reclamation process, coarse sands were removed during vibration stage and dust was sucked out during classification stage.

Figure 4 (a) and (b) shows the shape of new and reclaimed sand particles. The circles show there are a lot of angular shape sands found in new sand compared to rounded reclaimed sand. This could be due to sands scrubbing with each other and hit against the wall during reclamation process causes the sharp corners of sand to become rounded. Rounded grains can give good flowability and higher packing density at lower binder additions compared to angular sands (Brown 1999). Therefore reclaimed sand can reduce the amount of binder used in the moulding process and hence improve the collapsibility of the sand mould.



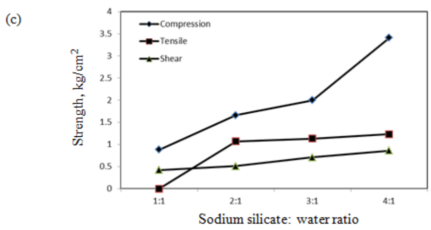


Fig. 1: Compressive, tensile, and shear strength for sand made of (a) 4 % of binder, (b) 5 % of binder, and (c) 6 % of binder (sodium silicate and water).

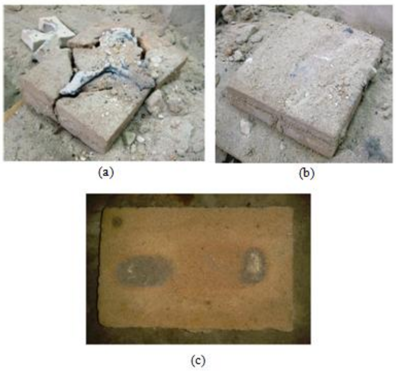


Fig. 2: The conditions of the sand moulds made of (a) 4 %, (b) 5 %, (c) 6 % binder (4:1 sodium silicate to water ratio) after pouring of cast iron.

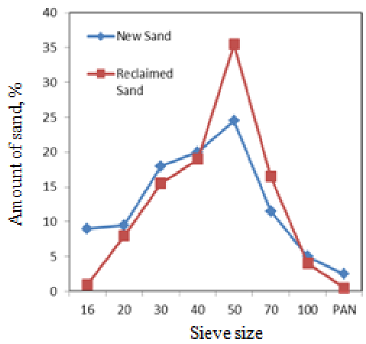


Fig. 3: Sand size distribution of new sand and reclaimed sand.

Fig. 4: The shape of sand particles (a) new sand, (b) reclaimed sand.

Conclusion

Different amount of binder with varying sodium silicate to water ratio were observed for the effects on the strength and the collapsibility of the sand mold. The optimum amount of binder is found to be 6 % with 4:1 sodium silicate to water ratio. This combination provided enough silica gel to hold the sand particles together, and at the same time improve the collapsibility of the sand mold and hence improved reclamation process.

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