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≫研究論文≪

Recycling of CO_2-Silicate Bonded Sand

Hyuk-Moo Kwon and Seoung-Won Lee

Dept. of Metallurgical Eng. Chungnam National University,

Abstract

Once-used CO_2-silicate bonded sand from domestic foundry is mostly discarded in a reclaimed land because of its bad collapsibility and reproduction properties. So this causes serious environmental problem.

We can get 82% recovery of silica from used sand by scrubbing reclamation process in this research. When we repeat the reclamation- recycling of the foundry sand, artificial silica sand is broken down below 2-cycles, but natural silica sand does not destroyed when used repeatedly more than 10-cycles and have a good property of recycling with little change of its size.

1. Introduction

The CO_2 process in foundries expands due to the cheap molding equipment cost and strong bonding power of over 10kg/㎠. Moreover, when pouring of molten iron, it does not generate flammable gases but just reduces a little water of crystallization. This is so profitable for production of large scale casting products because of less gas generation.

The mechanism of bonding is the reaction products of sodium carbonate containing water of crystallization and silicate in gel state from the reaction of sol state water glass and CO_2 gas. But this silicate gel worsen the properties of expansion absorbing and collapsibility When we use the recycled sand, sodium carbonate increased around the sand particle causes the casting defects. The treatments of removing this complex layer of sodium carbonate and gel state silicate to reclaim the once-used sand are required

Many studies on reclamation of CO_2-silicate bonded sand have been conducted[1-10], but their technical data depend on the quality of raw silica sand and water glass. Studies on the reclamation of CO_2-silicate bonded sand in domestic have not been reported yet So in this research, we set up a pilot plant for reclamation of the CO_2-silicate bonded sand, and investigate the effects of scrubbing frequency of the used sand on surface cleanness when we recycle 80% or more of silica as a molding sand, and also the repeated recycling effects on the silica sand quality.

2. Experimental procedure

2.1 Raw material and Additive

We used artificial and natural silica sand respectively as a raw material and their sieve grading are in Table 1. 3.2 mol ratio of water glass is used as a additive, and added 4wt% in vacuum replacement hardning(VRH) process and 6wt% in traditional CO_2 process. Dexile as a disintegrator added 1wt% in molding sand

Table 1. Sieve grading of raw sands (wt%)

Sieve size (mesh)	20	30	40	50	70	100	140	200	270	Pan	AFS NO
Artificial sand 1	0.1	1.4	14.1	19.5	19.5	20.5	14.7	5.9	2.4	1.9	69.9
Artificial sand 2	33.3	0.2	66.3	0.6	0.2	0.1	0.03	0.01	0.0	0.07	23.7
Natural sand	2.0	13.2	37.6	27.5	12.5	5.9	1.2	0.1	0.1	0	37.0

2.2 Used Sand Reclamation

Fig.1 shows the layout of the discarded CO_2-silicate bonded sand reclamation equipments for this research and it consists of sand crusher, scrubbing reclaimer, dust collector, neutralization tank, filtration tank, dryer and classifier The sandlifter carries the processing silica sand from the lower part of one facility to the upper part of the next facility. Input materials in this apparatus are discarded CO_2-silicate bonded sand coming into the sand crusher, dilute acid and water into the neutralization tank Output materials are first reclaimed silica from the scrubbing reclaimer, second reclaimed silica from the classifier, neutralized water, air and dust.

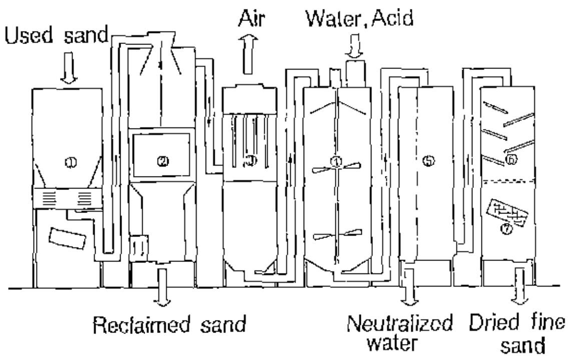

Fig 1. Arrangement of the reclamation equipments for used sodium silicate bonded sand.
① Vibration crusher ② Sand reclamer
③ Dust collector ④ Neutralization tank
⑤ Filter ⑥ Dryer ⑦ Classifier

3. Results

3.1 Ignition Loss

The effects of scrubbing cycles on LOI of the reclaimed sand are shown in Fig. 2. Before scrubbing, LOI of used sand in VRH process (4% water glass added) is 0.55% and that in CO_2 process(6% water glass added) is 0.69% As the number of scrubbing cycle is increased, the LOI is decreased. When it treated 4 times, LOI in the VRH process is 0.25% , just as the same value of the new sand, but that in the CO_2 process is 0.31% Moreover, it treated 6-10 times, the LOI value decreased more. LOI in the CO_2 process can be lowered to the new sand level after over 7 times treated

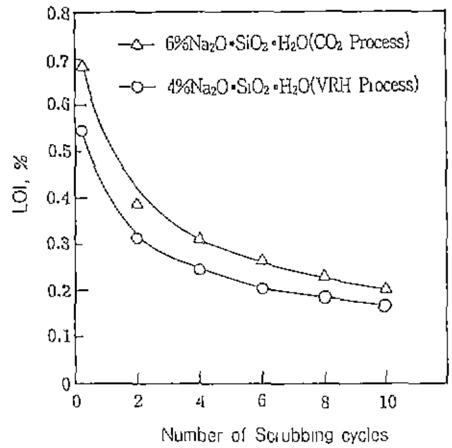

Fig 2. The change of ignition loss with respect to the number of scrubbing cycles.

3.2 Residual Base

Fig.3 shows the relationship between the amount of consumed acid and the number of scrubbing cycles. The total amount of basic components are sum of residual water glass which does not react with CO_2 gas during the mold making, and NaOH existed in water glass and sodium carbonate formed by the reaction with CO_2 gas. It shows that the amount of consumed acid(0.1 N HCl) is 94-111ml before scrubbing, 44-50ml after 6 cycles of scrubbing and 30-37 ml after 10 cycles of scrubbing. As the number of scrubbing cycle increases, the residual base materials decrease.

While, chemical analysis was done on each sample, and convert sodium salts in the residual basic components into Na2O The results are shown in Fig 4 that the residual Na 2O decreases linearly as the number of scrubbing cycle up to 5 cycles, and after that the decreasing rate becomes slow to 10 cycles

From the results of acid consumed in Fig 3 and residual contents of Na2O in Fig 4, we can conclude that the economic number of scrubbing cycle is around 6.

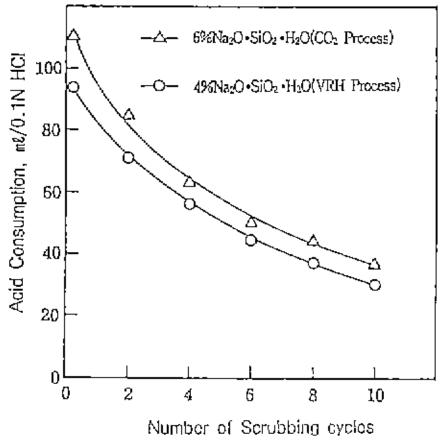

Fig 3. The change of acid consumption amounts with respect to the number of scrubbing cycles.

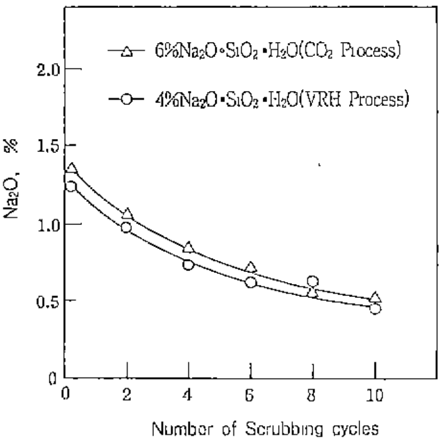

Fig 4. The change of Na_2O contents with respect to the number of scrubbing cycles

3.3. Surface condition of sand particles

Photo 1 to photo 4. are the micrographs of the sand particles after scrubbing obtained by SEM. Photo 1. shows the surface condition of artificial silica sand as subangular type at 35 magnification in (A), and fine silica dust adhered on the artificial silica at 1000 magnifications in (B). On the contrary, Photo 2 and 3 show the surface conditions before scrubbing and after 10 cycles of scrubbing of the sodium silicate bonded used sand added 6% water glass respectively

The shape of particle is improved to be round by scrubbing for surface cleaning, this is so for reclaimed sand than for new fresh sand. Photo 2(B) ,the surface of the used sand at 1000 magnifications, shows the precipitates of acicular type of $Na_2CO_3.H_2O$ grown, but in photo 3(B) which is the surface of 10 cycles of scrubbing, those are nearly cleaned off. But compare to photo 1(B), we cannot say that those are completely cleaned off

To investigate quantitatively the $Na_2CO_3.H_2O$, Na dot mapping was done. The results are in photo 4. in which, Na dots in (B) are notably decreased compare to (A), but still remained a minute quantity.

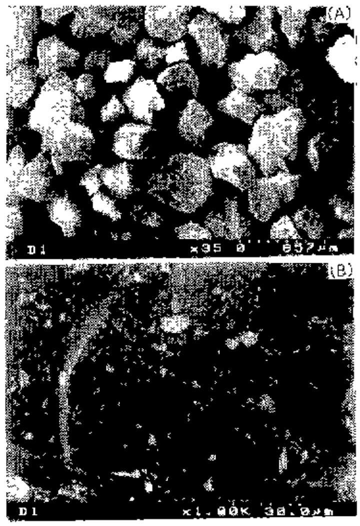

Photo 1. SEM micrograph of new sand (A.×35, B ×1,000)

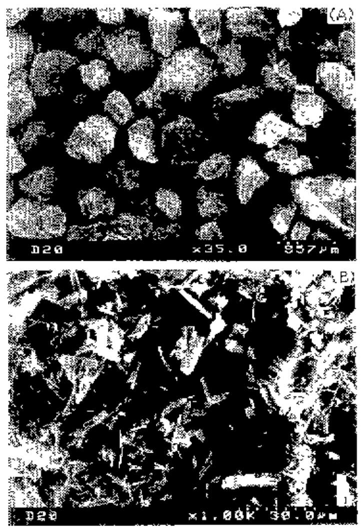

Photo 2. SEM micrograph of 6% sodium silicate bonded sand (A ×35, B ×1,000)

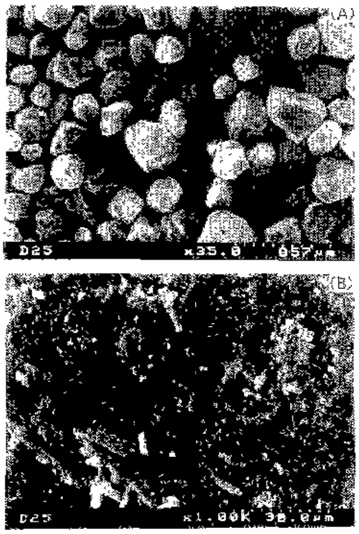

Photo 3. SEM micrograph of reclaimed sand scrubbed 10 cycle. (A:×35, B:×1,000)

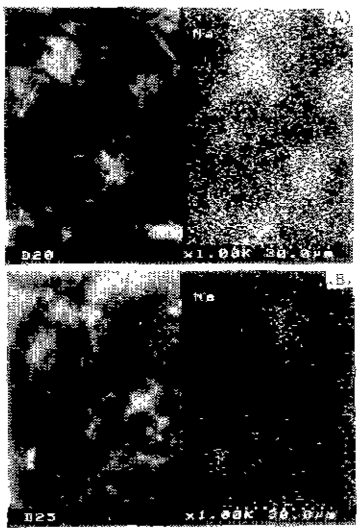

Photo 4. Na dot map of 6% sodium silicate bonded sand (A:used sand B:reclaimed sand)

3.4 Effect of Silica Sand Quality on Reclamation

Fig.5 shows the particle size variations of new and reclaimed artificial sand. The new artificial sand is made of 2 screen sand, which is mixed up with the ratio of 1 2 of 20 mesh and 40 mesh silica sand crushed and screened from silica rocks having 96.5% SiO_2 purity.

The particles of artificial sand are screened having residual crack inside, and they are crushed when scrubbing. So the particles of reclaimed sand are to be finer than the raw sand particles. This means that the used artificial sand can not be used as a raw material for the 'reclamation-recycling' of the used sand. On the contrary, Fig.6 shows the size distributions of the new and the 6 times reclaimed natural silica sand from Australia. The new natural sand having 99% Silica purity is made of 3 screen sand that is mixed up with 40, 50 and 70 mesh sand, total amount of 89%. The particle size distributions of the 6 cycles scrubbing this natural used sand show a little bit fine but nearly same distribution of 3 screen sand. The grain fineness number(GFN) of the new natural sand is 38.4 mesh and that of the used one is 43.7 mesh.

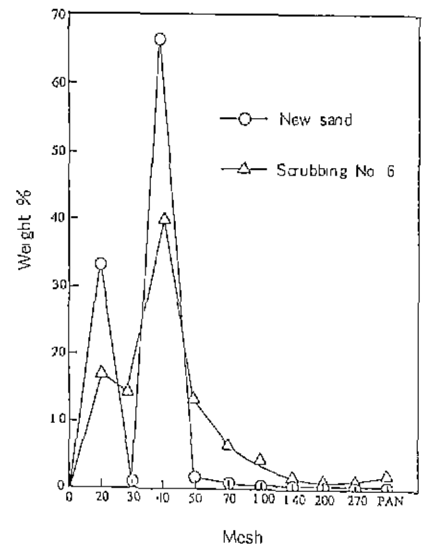

Fig 5. Grain size distribution of artificial sand after reclamation.

Fig.7 shows the relationship between the GFN and the number of 'reclamation-recycling' of the natural and the artificial sodium silicate bonded sand after 6 times scrubbing and mixed with 17% new sand. In case of artificial sand, the GFN changes abruptly from 23.8 mesh to 49 mesh after 2 cycles of 'reclamation-recycling', and to 59 mesh after 4 cycles. This is due to that the sand particles destroyed severely in the reclamation process. Compare to this, the GFN of the new natural sand is 38.4 mesh and changes in the range of 42 to 46 mesh up to 10 cycles of 'reclamation and recycling'. This means that there is no fracture of the silica sand during reclamation process.

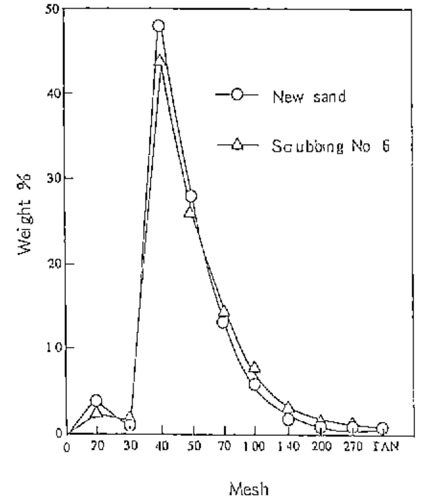

Fig 6. Grain size distribution of natural sand after reclamation

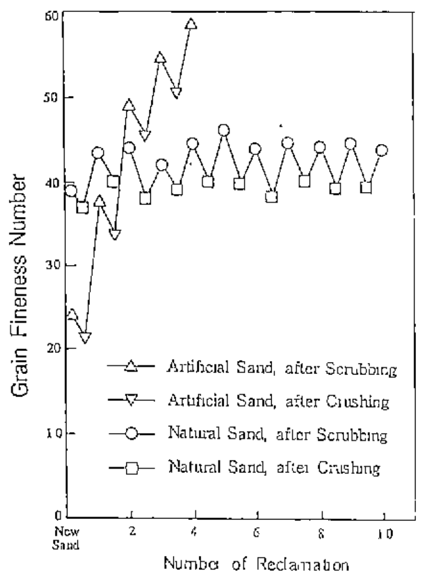

Fig 7. The change of grain finess number depending on the number of reclamation

It can be concluded from the results of Fig.5, 7 that the artificial silica sand made from crushing of silica rocks can be used as the sodium silicate bonded sand, but it's useless as a raw material for reclamation process, because of fracture of the particle, and the natural sand from Australia having above 99% purity of SiO_2 can be reused 82% or more of reclaimed sand It's because the particle size variation is little during the 'reclamation-recycling' process.

4. Conclusions

(1) The most economic scrubbing cycles are 6 times and the recovery of the reclaimed sand is 82% of the silica in the used sand from the results of the investigation of the effects of scrubbing cycles on the ignition loss, residual base, surface condition of the sand reclaimed in the scrubbing type reclaimer.

(2) According to the cyclic reclamation and recycling experiments with second reclaimed sand mixed 82% of reclaimed sand being treated 6 cycles of scrubbing and 18% of new one, the artificial silica sand was fractured and can not be reused again as molding sand, but the natural silica sand can be reused more 10 times repeatedly by 'reclamation and recycling' process without much variations of average particle size, that is, without much fracture of the sand particle.

Acknowledgements

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5. References

1 H G.F.Kuns mann Trans AFS Vol.78, p37 (1970)
2 H S Leidel:Trans. AFS Vol.85, p429 (1977)
3 R R Stanbridge, R.Willian:Trans. AFS Vol 89, p77 (1981)
4. J. H. Morgan:Castings(AUS), Vol.28, p36 (1982)
5 M Skubon·Foundry Trade J (GBR) Vol.152, p25 (1982)
6. C C Sharp.Foundry Trade J (GBR) Vol.152, p18 (1982)
7 K.Shahan·Moden Casting, p12, Jun (1982)
8. G J Bolton:Trans. AFS Vol 91, p95 (1983)
9 N Tsutsumi, K Sun Rep. of Casting Reasearch Lab, Waseda Univ. No. Vol 36, p1 (1985)
10 K Shahan.Moden Casting, p118, Apr. (1987)