

APPLICATION OF FLOATEX/SPIRAL CIRCUIT IN PROCESSING SILICA SAND

Partha Venkatraman¹, Weng S. Kow¹, Jim Sadowski¹ and Alex Anthraper²

Outokumpu Technology, Inc. Carpc Division¹
1310-1 Tradeport Drive
Jacksonville
Florida 32218

e-mail: partha.venkatraman@outokumpu.com
Ph.: (904) 353-3681 ext. 137
Fax: (904) 353-8705

Chevalier Silicates²
Anthraper Gardens
Cherthala
Kerala 688 524
INDIA

Presented at the SME Annual Meeting Salt Lake City, Utah – February 28-March 1, 2000
SME Preprint No. 00-162

ABSTRACT

Spirals have been the most widely used unit operation for upgrading silica sand. However, in the recent past there has been a considerable interest in using the Floatex Density Separator in combination with spiral concentrators to produce a high-grade silica sand product with minimal loss in recovery. The main features of this processing scheme are a) Floatex preclassifies and preconcentrates spiral feed, b) preclassified feed improves spiral performance and c) a superior product is obtained with minimal loss in recovery at a lower capital cost. This paper will present results obtained from a Floatex/Spiral test work on a 'difficult to process' silica sand. The major contaminants in this deposit are coarser size (+70 mesh) sillimanite and ilmenite particles.

INTRODUCTION

Although, silica sand occurs in abundance in varying degrees of purity, only a small percentage is suitable for glassmaking and other high-grade industrial applications, including foundry, ceramics, chemicals, fillers and the construction industry. In general, mineral processing is an essential step in upgrading the raw sand to meet industrial specifications.

Gravity concentration using spirals has been the preferred process for the production of high-grade glass sand. Spirals are low cost and easy-to-operate unit operations that have no moving parts (Sivamohan and Forssberg 1985). These advantages are sometimes offset by a spiral's inability to achieve the desired final product grade in a simple and efficient circuit.

Outokumpu Technology, Inc. Carpc Division has conducted extensive test work on various sand deposits. Test results indicate that the Floatex Density Separator, a hindered-bed classifier, in conjunction with spiral, a flowing film separator, provides an efficient and cost-effective processing scheme (McKnight, 1996). In this circuit, Floatex was found to be highly effective in removing coarser sized silica and heavy minerals. More importantly, the narrow size distribution combined with the concentration of heavy minerals in the finer size fraction makes the Floatex overflow an ideal spiral feed. The preclassified and preconcentrated feed improved the efficiency of the spiral to remove finer sized heavy minerals.

This paper presents the benefits of a Floatex/Spiral circuit for the separation of sillimanite and ilmenite in a silica sand feed material. Also shown is the overall versatility of this processing scheme for the production of high purity glass sand and different co-products.

DESCRIPTION OF THE EQUIPMENT

Floatex Density Separator

The Floatex Density Separator is a hindered-bed classifier that consists of an upper square tank and a lower conical section (Figure 1). The Floatex can be divided into three main zones,

- the upper zone (zone A) above the feed inlet,
- the intermediate zone (zone B) between the feed inlet, and teeter water addition point, and
- the lower section (zone C) below the teeter water addition point.

Feed slurry is introduced to the Floatex tangentially through a centralized feedwell that extends to approximately one third of the length of the main tank. Fluidizing (teeter water) is introduced over the entire cross-sectional area at the base of the teeter chamber through evenly spaced water distribution pipes. As the feed enters the main separation zone it expands into a teetered or fluidized bed as a result of the rising current of water. The teeter water flow rate is dependent upon a) feed particle size distribution, b) density and c) the desired cut-point for the separation. The separation takes place in zone B and the separated lighter/finer particles and the coarser/heavier particles leave the separator through zone A and zone C respectively. This separator is equipped with a pressure sensor mounted in zone B above the teeter water pipes and an underflow discharge control valve. The pressure, sensed by a level sensor, is transmitted to the underflow control valve using a specific-gravity set-point controller. The instrumentation helps in maintaining a constant height of the teeter bed and a steady discharge of the underflow.

Humphreys Glass Sand Spiral - Model LC-3700

The Humphreys Spiral is a flowing film separator generally comprised of a feed box, 7-spiral turns and a product collection box. The feed slurry is introduced on the top turn of the spiral surface. As the slurry flows downward, the coarser and less dense minerals present in the feed migrate radially outward from the central column, while the heavier and smaller minerals stay closer to the central column. As the slurry flows down, the spiral the segregation of heavier from the lighter minerals become more pronounced. The segregated materials are collected from the bottom turn of the spiral using splitters that channel the product, middlings and gangue into different ports. In this test work, a 6-way product box was used to minimize the operators' variability; and also to evaluate more exit streams.

Figure 1. A schematic diagram of the Floatex Density Separator.

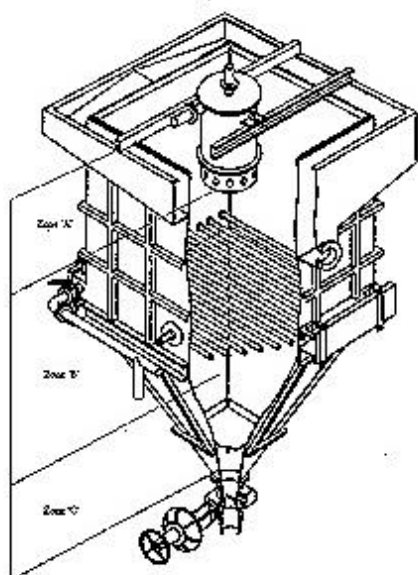
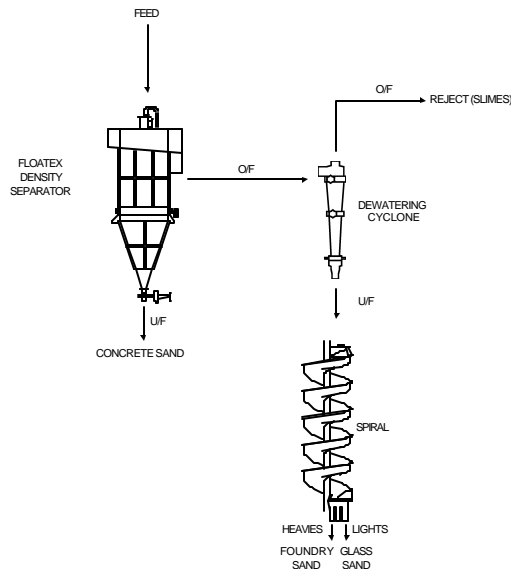


Figure 2. A schematic diagram illustrating the Floatex/Spiral circuit.



EXPERIMENTAL

Sample

A representative sample of 20 kg was obtained from 500 kg of as-received sample. Characterization tests of the feed included:

- screen analysis and size-by-size chemical analysis (Tables I), and
- sink-float analysis of the feed followed by mineralogical analysis on the sink fraction to determine the amount and distribution of heavy minerals (Table II).

Floatex/Spiral Test Work

A simplified Floatex/Spiral circuit is shown in Figure 2. The as-received material was slurried and fed to the Floatex Density Separator in order to segregate the sillimanite particles greater than 50 mesh into the underflow. The Floatex overflow was fed to a dewatering cyclone to increase the solids content and to remove -140 mesh slimes. The thickened cyclone underflow was fed to a Humphreys LC-3700 spiral fitted with a special 6-way product box.

Timed samples of the feed and products from both the Floatex and spiral were collected, dried and weighed. Size and size-wise chemical analyses, sink-float analyses and mineralogical analyses were conducted on representative samples obtained from the feed and exiting streams.

Table I. Size analysis and size-by-size chemical analysis of the feed.

Size		Wt. (%)	SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	TiO ₂ (%)	(CaO+MgO) (%)	(Na ₂ O+ K ₂ O) (%)
mesh	microns							
+30	+595	11.0	99.2	0.285	0.037	0.055	0.057	0.232
30 x 40	420	20.3	99.7	0.080	0.028	0.044	0.015	0.014
40 x 50	297	27.6	99.7	0.127	0.026	0.044	0.017	0.010
50 x 70	210	27.8	99.1	0.537	0.054	0.143	0.029	0.014
70 x 100	149	8.5	92.9	3.016	0.764	2.540	0.035	0.039
100 x 140	105	1.4	92.4	3.101	0.869	3.264	0.080	0.080
-140	-105	3.4	80.1	3.121	1.211	3.223	0.111	0.173

Table II. Size-by-size mineralogical analysis of the feed.

Size		Heavies (ppm)		
mesh	microns	Sillimanite	Ilmenite	Others
+30	+595	9	9	32
30 x 50	297	329	81	30
50 x 70	210	2,853	535	178
-70	-210	11,496	13,408	3,117

Table III. Specifications for silica sand used in flint and colored glass.

Screen Specification				Chemical Specification			Sillimanite Specification		
Mesh	microns	India	US		India	US	Mesh	India	US
+20	841	Nil	Nil	SiO ₂	>99.5%	>99.5%	+30	Nil	Nil
+30	595	<5%	<2%	Al ₂ O ₃	<0.3%	<0.30%	+50	As low as possible	60 ppm or less
+40	420	<20%	<20%	Fe ₂ O ₃	<0.05%	<0.03%			
-140	105	<5%	<5%	TiO ₂	<0.03%	<0.03%			
				ZrO ₂	<0.01%	<0.01%			
				CaO+MgO	<0.05%	<0.05%			
				Na ₂ O+K ₂ O	<0.1%	<0.10%			

RESULTS AND DISCUSSION

Sample Characterization

High silica content (98.4% SiO₂), narrow size distribution and lower amount of clay combined with the low levels of TiO₂, Al₂O₃ and Fe₂O₃ makes this material a suitable sand for glassmaking (Tables I through III).

However, the sink-float and mineralogical analyses on the sink fraction reveal the presence of a substantial amount of sillimanite, a refractory heavy mineral, as well as ilmenite. Sillimanite, a harder mineral, is concentrated in the coarser size fraction (30x140 mesh) while, ilmenite, a heavier mineral, is concentrated in the finer size fractions (70x200 mesh). Therefore, in spite of a good chemistry and size distribution, the presence of sillimanite, which is a potential source of stones in the glass, and ilmenite, which discolors the glass, makes the processing of this sand essential and challenging.

Performance Evaluation of the Floatex/Spiral Circuit

In general, the main contaminants in a glass sand deposit are ilmenite, rutile, chromite, zircon and clay minerals, and are normally concentrated in the finer size fractions (-70 mesh). A typical glass sand processing scheme comprises of a classification step using screens to control the top size and cyclone to remove slimes followed by a concentration step using multiple stages of spirals to separate fine heavy minerals from the glass sand product.

However, the increase in demand combined with depletion of good reserves has made it necessary to process silica sand that contains larger amounts of sillimanite in the +70 mesh fraction. The conventional processing scheme using multiple stages of spirals is very efficient in separating fine heavies (-70 mesh) from coarse lights, but unfortunately, they are not well suited to remove coarse sillimanite.

To assist glass sand suppliers, an extensive research program was conducted on similar sillimanite and ilmenite-rich deposits at Outokumpu Technology, Inc. Carpc Division. This research work culminated in the development of a combined Floatex/Spiral circuit that is capable of producing a desired product at a higher yield. In a hindered settling device like Floatex, it is possible to produce an overflow in which the top size of the lighter silica particles is up to 30 mesh, while restricting the top size of the associated heavier sillimanite and ilmenite particles to 50 mesh. This closely sized Floatex overflow is then treated on a flowing film separator like Humphreys spirals, to remove the finer heavy minerals.

The size distribution and chemistry of the product is given in Table IV and Figure 3. The results clearly indicate that the glass sand obtained from the combined Floatex/Spiral circuit far exceeds the customer's specification. The amount of +30 mesh is only 2.2% by weight, while the weight of -140 mesh fraction (slimes) is a mere 0.2%. Similarly, the chemical analysis shows that the SiO₂ content in the product is as high as 99.6% and the values of TiO₂, Al₂O₃ and Fe₂O₃ are well below the product specification.

Table IV. Floatex/Spiral circuit product weight distribution and chemical assay.

Product Name	Stream Name	Wt. (%)	SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	TiO ₂ (%)	(CaO+MgO) (%)	(Na ₂ O+K ₂ O) (%)
Feed	Floatex feed	100.0	98.4	0.637	0.143	0.439	0.030	0.043
Glass Sand	Spiral lights	65.4	99.6	0.222	0.025	0.030	0.015	0.016
Foundry Sand	Spiral heavies	9.6	97.9	1.430	0.110	0.465	0.017	0.018
Concrete Sand	Floatex u/f	25.0	95.7	1.188	0.548	2.296	0.023	0.090

Figure 3. Size distribution of the feed and glass sand product.

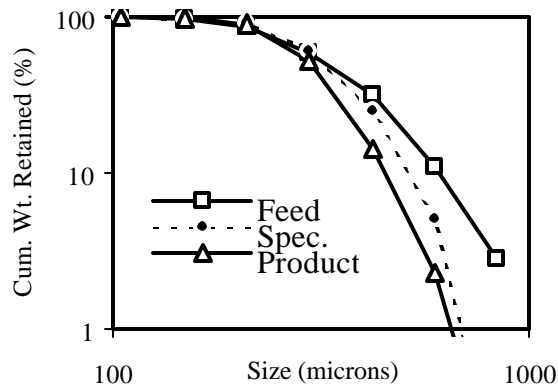


Figure 4. Comparison of the sillimanite content in the feed and glass sand product.

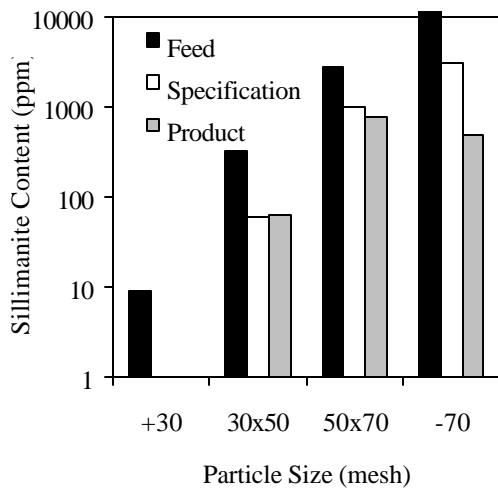
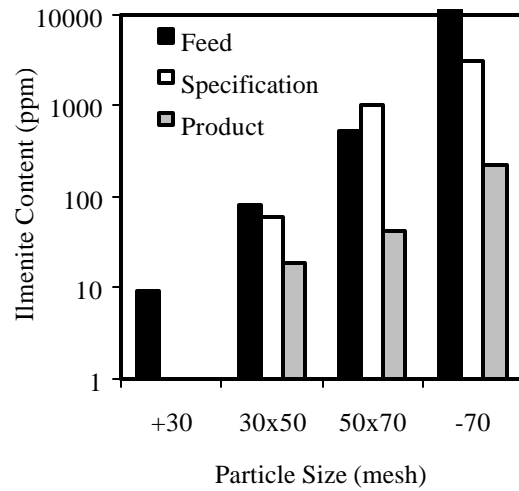


Figure 5. Comparison of the ilmenite content in the feed and glass sand product.



The mineralogical analysis clearly shows a significant reduction in the sillimanite and ilmenite content in the product (Figures 4 and 5). They have been reduced from 14,687 ppm to 1,325 ppm and from 14,033 ppm to 291 ppm respectively. Most importantly, the final glass sand product was free of +30 mesh sillimanite and ilmenite particles.

In this test work, the spiral was fitted with a 6-way product box. Samples from each exit stream were analyzed to better understand the size and distribution of the sillimanite and ilmenite in the product. It is interesting to note that this combined Floatex/Spiral circuit is capable of producing a superior glass sand product meeting the US specification for flint sand at a ~51% weight yield.

Product Mix

In India, where there is a considerable demand for good and consistent quality glass sand and foundry sand, it is important to have a processing scheme that has the flexibility to produce different types of product. Results presented in Table IV reveal that this processing scheme is highly robust and flexible. It is capable of producing a high quality glass sand along with a good concrete and foundry sand as well. The foundry sand obtained from this test work had a size distribution of AFS 60 with Acid Demand Value of 2.1, pH of 7.3 and permeability of 120.

CONCLUSIONS

1. The gravity concentration circuit developed by Outokumpu Technology Inc., Carpc Division using both Humphreys Spirals and a Floatex Density Separator is capable of producing a high-purity glass sand from a 'difficult to process' sand.
2. Floatex was highly efficient in removing most of the coarse silica (+30 mesh) along with sillimanite and ilmenite particles larger than 40 mesh.
3. Floatex overflow with its narrow size distribution was found to be an ideal feed for the downstream spiral concentrators. Spiral was very effective in removing finer heavy minerals, namely, ilmenite, zircon and leucoxene to produce a high purity glass sand.
4. This combined circuit produced a desired glass sand product at a 65.4% weight yield. Most importantly, the final glass sand product was free of +30 mesh sillimanite or ilmenite particles.
5. This simple and robust circuit is also capable of producing varying amounts of foundry sand and concrete sand as co-products.

REFERENCES

- Sivamohan, R., and Forsberg, E., 1985, "Principles of spiral concentration," International Journal of Mineral Processing, Vol. 15, pp. 157-171
- McKnight, K., Stouffer, N., Domenico, J., and Mankosa, M.J., 1996, "Recovery of zircon and other economic minerals from wet gravity tailings using the Floatex Density Separator," SME Annual Meeting, Phoenix, Arizona.