SIEVE AREA CALCULATION IN THE PROCESSING OF MARAWILA SILICA SAND FOR THE GLASS INDUSTRY IN SRI LANKA (A CASE STUDY)

by

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Introduction

The glass industry in Sri Lanka makes use of Marawila sand as the main raw material. The sand is mined, processed and finally sieved to a specified size. The processing involves washing, gravity separation of heavy minerals and finally dry sieving. The sieve surface area determines the overall efficiency of sieving. This paper highlights the sieve area calculation using the semi empirical approach.

1. Raw material (sand) Beneficiation

The most important steps in the processing of Marawila sand for the glass industry are the following :

a) The removal of organic and other impurities.
b) The reduction or complete elimination of transitional metal ions (Iron and Titanium) present as Ilmenite and Rutile and the rare earth metal ions (Cerium and Thorium) present as Monazite.
c) The grading of sand to a specified size distribution.

2. Flow sheet of Sand Beneficiation

The main impurities in the Marawila sand are organic matter, heavy minerals and rare earths, the amounts varying from place to place. The first step in the beneficiation is the removal of organic matter using a rotary trommel (Fig. 1) where the cylindrical rotary mesh removes the oversize material. The undersize, comprising the particles of size less than 2 mm. is fed on to a Wilfley Table where the heavy sand fraction comprising Ilmenite, Rutile and Monazite are separated out. The sand so processed has a size distribution shown in Fig. 2. Also note the shapes of the particles (Figure 3).

3. Tunnel kiln drying

The sand from the Wilfley table is dried to almost zero moisture content by feeding it onto a rotary tunnel dryer where manual feeding is employed.

4. The importance of particle size

In glass manufacture it is important that the sand particles conform to a particular size distribution. If they are small, they will be carried away by the hot blast via the exhaust fans. When they are of large size the sand dissolution in the furnace takes a long time making it difficult for the glass to form. Therefore it is imperative that the sand conforms to an accepted size distribution. The usual practice is to take the upper limit as 25 mesh B.S. and the lower limit as 100 mesh B.S.

5. Sieving

For the sieving, only one vibratory sieve is sufficient i.e. 25 mesh B.S. It is not necessary to use 100 mesh B.S. as the sand passing through this mesh is almost negligible.

6. The mechanism of sieving

The passage of sand particles passing through a screen surface is a probability function, and by referring to Fig. 4a, we see that, the probability of passage p through the screen aperature is given by the expression (1).

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$$p = \left[\frac{a - d}{a}\right]^2$$

for wires of very small section compared to the opening,

where,
a = distance between two consecutive wires in the screen.
and
d = particle diameter.

For the wires of substantial diameter (Fig. 4b) the probability p is given by

$$p = \left[\frac{a - d}{a + d}\right]^2$$

When we consider the normal incidence with reflection of the wires Bouncing off is considered. It can be shown mathematically, that

$$p = \left[\frac{(a + b) - (b + d) \cos \alpha}{a + b}\right]^2$$

In the case of oblique incidence, the above expression takes a much more complicated form. The theoretical approach is difficult to apply in sieve area calculations. However what is commonly adopted in practicle is the semi-empirical approach.

7. Sieve area determination

In order to determine the size of the screen the following information is required:

a) Sieve analysis of the feed material. This is obtained by sieving the sand through standard screens and then plotting the data on a semi-log paper as shown in Figure 2.

b) The density of the material.

c) Whether the screening is done wet or dry.
d) The shape of screen opening, square, round or rectangular.

e) The moisture content of the sand.

8. Semiempirical Approach

To determine the size of a screen, the following empirical formula is used:

Area (Sq ft) of the Screen surface (2):

$$= \frac{(TF - Oversize)}{(A \times B \times C \times D \times E \times F)}$$

Where
TF = Total feed to screen in TPH
Oversize = Amount of feed material in TPH, the size of which is larger than the required sieve opening.

And the factors A,B,C,D,E and F are obtained from tables 1, 2 & 3.

9. Observations

A standard size glass factory as in Sri Lanka makes use of sand feed rate equal to 6 tons per hour.

The % of sand above 25 mesh B.S. from Figure 2 is = 16. Therefore oversize of sand in T.P.H. based on the fact that the feed rate on to the screen surface is 6 TPH

= 6 x 16/100 TPH
= 0.96 TPH

From Tables 1, 2, 3

A = 0.26 approx. Table 1 (between 20 and 28 mesh)
B = 1.03 Table 2
C = 1.00 for 95% efficiency in sieving Table 2
D = 0.7 Table 3
E = 1.0 Table 3
F = 1.0 for a single deck screen. Table 3.

The total area of the mesh is,

$$= \frac{(6.00 - 0.96)}{(0.26 \times 1.03 \times 1.0 \times 0.7 \times 1.0 \times 1.0)}$$

= 28 sq.ft. approx.

10. Blinding of Screen aperture

When designing vibratory screens, it must be noted that allowance must be made for the sieve area covered by the mounting frame. The area calculated above should therefore be the effective area for the sieving and should not include the blinding area.

The vibratory mechanism is rather costly, and hence it is very often fitted with two screens coupled to the same vibrator. In such cases the sand fed on to the screens must be equally divided by a suitable ducting or a conveyor.

11. Conclusions

The correct sieve surface area is a must for carrying out efficient sieving. The lower sieve surface area gives inefficient sieving, whereas higher surface area consumes more power and the floor space. Therefore, the correct size must be determined by the semi empirical approach as given here. The calculations used in this paper can be extended to sieving of any mineral, provided the parameters A, B, C, D, E and F are known.

12. Acknowledgement

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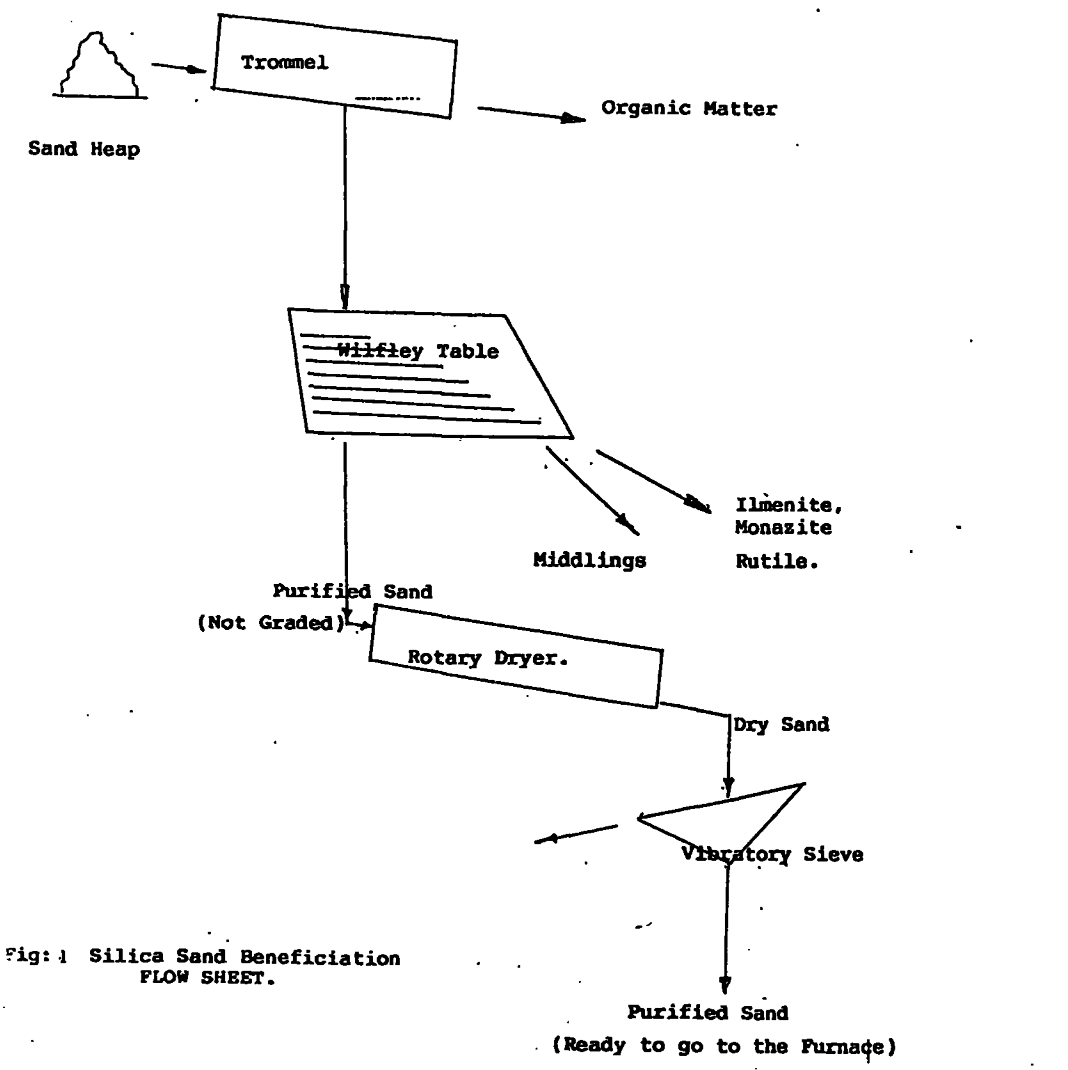

Fig: 1 Silica Sand Beneficiation FLOW SHEET.

Fig:2- CUMULATIVE % PASSING THROUGH Vs. PARTICLE SIZE (SEMILOG PLOT)

SAMPLE : GLASS SAND
WASHED & DRIED

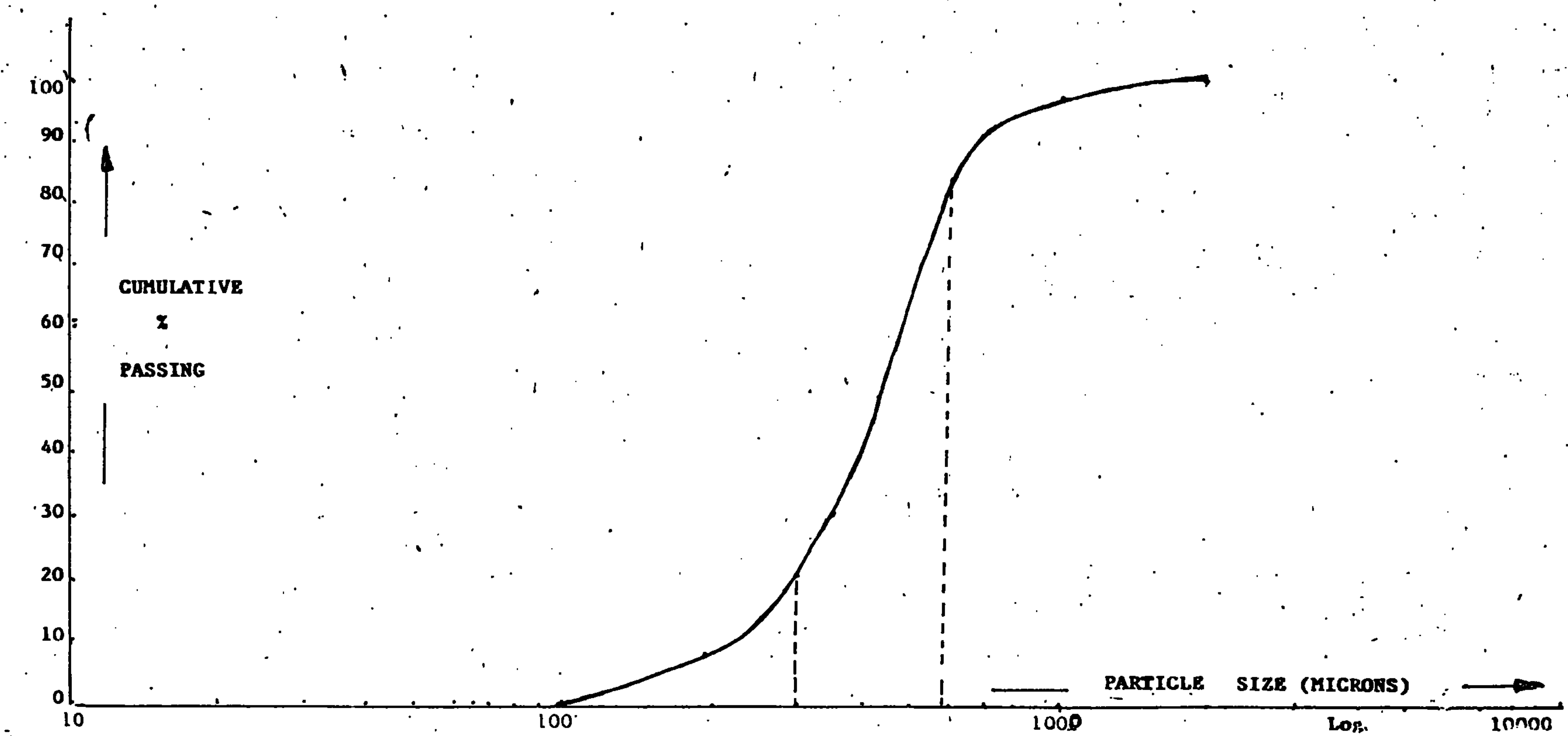

Fig. 3 - Processed Glass sand particles

Note : Particles are angular and highly irregular.

Bar = 1 mm.

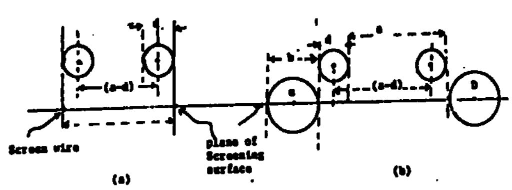

Fig: 4 Passage of Sand particles through the screen wire

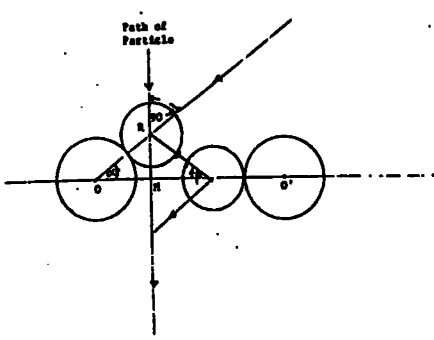

Fig: 4c Normal incidence of Sand particle with reflection on the wire

Table 1

CAPACITY OF VIBRATING SCREENS

FACTOR "A" Capacity in Tons Per Hour Passing Through 1 sq. ft of Screen Cloth Based on 95% Efficiency

Size of Clear Square Opening	.0116"	.0164"	.0232"	.0328"	.046"	.065"	.093"	.125"	.131"	.185"	¼"	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1¼"	1½"	2"	2½"	3"	4"	5"
Mesh Size	48	35	28	20	14	10	8	7	6	4														
Sand	.144	.183	.226	.282	.36	.45	.57	.69	.73	.90	....	....	....	....	....	...	...	...	...	...	...	...	...	...
Stone Dust	.120	.152	.188	.235	.30	.375	.475	.56	.595	.75	....	....	....	....	....	...	...	...	...	....	..	...	...	...
Coal Dust	.091	.115	.142	.178	.226	.284	.36	.43	.45	.57	....	....	...	....	....	...	...	...	...	....	..	...	...	...
Gravel	....	....	....	....	....	...	....	...	...	...	1.08	1.40	1.68	1.94	2.16	2.36	2.56	2.90	3.20	3.70	4.05	4.40	4.65	4.90
Crushed Stone	....	....	....	...	....	...	....	...	...	...	.88	1.19	1.40	1.60	1.80	1.96	2.12	2.40	2.68	3.10	3.38	3.60	3.86	4.07
Coal	....	....	....	...	....	...	...	...	...	...	.68	.88	1.04	1.21	1.36	1.48	1.60	1.83	2.00	2.31	2.53	2.69	2.91	3.06

Table 2

FACTOR "B"

To Determine or estimate percentage of oversize in feed to screen use proper factor as given below. For example, if screen has 1" openings and 60% of feed to screen will go through 1" openings, there is 40% of oversize and factor .95 would apply. Other percentages accordingly.

Amount of Oversize	Factor "B"	Amount of Oversize	Factor "B"
10%	1.05	85%	.64
20%	1.01	90%	.55
30%	.98	92%	.50
40%	.95	94%	.44
50%	.90	96%	.35
60%	.86	98%	.20
70%	.80	100%	.00
80%	.70		

Factor "C"

Desired Efficiency	60%	70%	75%	80%	85%	90%	92%	94%	96%	98%
FACTOR "C"	2.10	1.70	1.55	1.40	1.25	1.10	1.05	1.00	.95	.90

Factor "C" Slight inaccuracies are seldom objectionable in screening aggregate and perfect separation (100% efficiency) is not consistent with economy. For finished products, 98% efficiency is the extreme practicable limit and 95% is usually satisfactory. 60% to 75% efficiency is usually acceptable for scalping purposes.

Table 3

Factor "D"

Amount of Feed less than ½ the Size of Opening	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
FACTOR "D"	.55	.70	.80	1.00	1.20	1.40	1.80	2.20	3.00	.....

FACTOR "D" Consider this factor carefully where sand or fine rock is present in feed. For example if screen has ½" square openings and a large percentage of the feed is ¼" or less in size such as sand or dust, determine percentage and use proper factor given in the table

Factor "E" **Wet Screening**

Size Opening (Mesh or Inches)	20	14	10	8	1/8"	6	4	1/4"	5/16"	3/8"	1/2"	3/4"	1" or more
FACTOR "E"	1.10	1.50	2.00	2.25	2.50	2.50	2.50	2.25	2.00	1.50	1.30	1.20	1.10

Wet screening below 20 mesh not recommended.
FACTOR "E" If material is dry, use factor 1.00. If there is water in material or if water is sprayed on screen, use proper factor given opposite. Wet screening means the use of about 5 to 10 G.P.M. of water per cubic yard of material per hour or for 50 cu. yards / hour of material use 250-500 G.P.M. OF WATER, etc.

Factor "F"

Deck	Top	Second	Thired
FACTOR "F"	1.00	.60	.75

FACTOR "F" For single deck screen, use factor 1.00, for a multiple deck screen, to to use proper factor for each deck.