International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 2, 2020
ISSN: 1475-7192

Analysis of silica sand distribution and Grain Fineness Number (GFN) for Casting Process

Udin Komarudin[1], Ida Farida[2], Heru Santoso[3]

ABSTRACT---*Silica sand is one type of sand that is sought after by industries, especially industries engaged in metal casting, because this sand can be used as a molding material. Besides being easily formed, silica sand can achieve maximum hardness after being mixed with chemicals namely resins and catalysts. To achieve the maximum strength of the sand mold curing time is required. This curing time provides the time / opportunity for the resin and catalyst to react so that the mold reaches its maximum strength. This study aims to determine the distribution of sand and the value of GFN (Grain Fineness Number), to determine the suitability of sand with the physical requirements of sand for casting iron. Testing of sand distribution is carried out on new, reclaimed and mixed Silica sand using the Sieve Analysis Test Type PSA (GP) (Laboratory Siever). The test was carried out within 15 minutes with vibration 8. Analysis results showed that the most recent sand distribution was in the 0.5 mm sieve, namely 29.61 g or 59.22%, with GFN = 27.8. The most reclamation sand distribution is in the 0.355 mm sieve, which is 15.65 gr or 31.3% with GFN = 43.53. And the most mixed sand distribution was at 0.355 mm sieve, which was 15.68 gr or 31.36% with GFN = 39.6. Sand that meets the physical requirements for the cast iron casting process is reclaimed Silica sand.*

Keyword---*Silica, siever, GFN.*

I. INTRODUCTION

Metal casting is one of the manufacturing production techniques. Casting technology is increasingly showing its development in accordance with the needs of the metal industry itself. The casting process is still used today to obtain castings in accordance with consumer demand. In the system and the casting process can not be separated from the mold, this mold affects the metal in terms of surface roughness and metal shape. The mold that is commonly used until now is sand mold. Some sand molds and soil molds contain binding agents such as resins, catalysts, bentonite, and other binding agents.

In the sand casting metal casting technique there are many advantages. Sand molds can be used repeatedly so they can save on production costs. Besides that, sand mold is easy to be formed so that it can ease the production process and can save production time. The types of sand used for casting casting techniques, namely silica sand, zircon sand, olivine sand and so forth

[1]*Department of Mechanical Engineering, Widyatama University, Bandung, Indonesia*
komarudin.mt@widyatama.ac.id
[2]*Department of Mechanical Engineering, Widyatama University, Bandung, Indonesia*
ida.farida@widyatama.ac.id
[3]*Department of Mechanical Engineering, Widyatama University, Bandung, Indonesia*
heru.santoso@widyatama.ac.id

One important factor in the casting process is the GFN Grain Finess Number distribution. In casting as much as possible should produce a smooth and precise surface so that when done with the machine later can be faster. The higher the GFN number, the finer the sand and the relatively low air permeability.

In general, sand does not consist of grains of the same size. To get this result, the casting mold must have the same grain sizes. If the grain size is not uniform, it will result in a less precise size, and the adhesion power between the grains of sand will be less strong if the grain size is not the same. So to know the distribution of sand grains that have different grain sizes, it is necessary to do a sieve analysis of the sand to be used.

II. BASIC THEORY

Metal casting is one of the manufacturing production techniques. Casting technology is increasingly showing its development in accordance with the needs of the metal industry.

1) Silica Sand

One of the sand that is often used is Silica Sand. Silica sand is sand that is often used in every metal casting industry, because besides being easily obtained, this sand has properties that are suitable for the metal casting process. Silica sand is obtained by destroying silica stones and then filtered to get the desired granules. Silica sand is found in nature such as on beaches, rivers and mountains. This silica sand is often used by cast metal alloys in copper, aluminum, iron and cast steel. Silica sand has properties, including:

a. Melting point 1700 ^{o}C.
b. Colour white.Gray
c. Specific gravity 2.65 kg / dm^3.
d. Crystallographic changes during the heating process:
   - At 573 ^{o}C, changes in $\alpha > \beta$ quartz with expansion of 1.5% - 2%.
   - At 870 oC, β quartz> α Tridymite (shrinkage occurs).
   - At 1470 oC, α Tridymite> α Kristobalit which is hard.
e. This sand is reactive to certain alloys such as metals that have Manganese (Mn) alloys.
f. Silica sand has a PH <7 and is easy to react with liquid metals, especially steel to form compounds that are attached to the casting surface so that the casting surface becomes rough. This reaction in the term casting is called sinter and the compound formed from the sintered process is called hard fayalite.

2) Sand Mold

In making sand molds, physical requirements must be determined from various sizes and types of metals. The following table 1. physical requirements of sand and metal types that have become provisions for sand mold testing.

.

Table 1: Physical requirements Sand and metal grains

Metal	**Size**	**GFN**	**Permea bility**	**Clay (%)**
Steel	Big & Medium, Small	35-50 50-70	100- 200	10- 16

			above 100	12-16
Cast Iron	Big, Medium, Small	40-70 70-100 100-140	50-150 50-80 20-50	15-20 12-18 12-18
Copper Alloy	Big, Medium, Small	90-100 100-120 below 140	25-50 20-40 15-30	15-20 12-18 12-18
Alumunium	Big, Medium/Small	100 – 120 below 140	20-40 10-25	15-20 10-20

3) Sand Distribution Testing

The sand distribution testing aims to find out or get the percentage of sand size distribution. The sand used to make the mold is expected to have a size that is suitable for the type of metal castings. To express the size of the size of the grains of sand is indicated by the GFN (Grain Fineness Number) is a measure of the smoothness of the average grain of sand. The higher the GFN number, the finer the sand and the relatively low air permeability.

In general, sand does not consist of grains of the same size. To find out the distribution of sand grains that have different grain sizes, it is necessary to do a Sieve Analysis.

Fig. 1: Sand Distribution Machine

The fineness number is calculated using the formula:

$$GFN = \frac{\Sigma(W_n \text{ x } S_n)}{\Sigma W_n} \quad \text{................(1)}$$

where:

GFN = Fineness number

Wn = Total weight of sand after sifting (gr)

Sn = Multiplier Factor

III. METHODOLOGY

The methodology used in the sand distribution analysis is as follows:

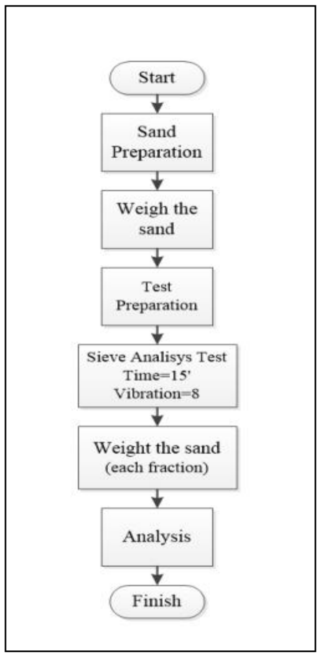


Fig. 2: Flow chart Sand Distribution Testing

1) Sand Preparation

Prepare the sand to be tested :

- New Silica sand,
- Reclamation sand, and
- Mixed sand (20% new + 80 % reclamation)

2) Measurement of sand weight

Measure the weight of sand, each 50 gr

Fig. 3: Measurement of sand weight

3) Test preparation

Prepare the Sieve Analysis Test sand distribution test equipment, type PSA (GP), as follows:

- Prepare a clean sieve arrangement.
- Arrange the sieve in the order of the sieve hole. Sequence sieve position :

No.	Size
1 (Top)	1,4
2	1
3	0,71
4	0,5
5	0,355
6	0,25
7	0,18
8	0,125
9	0,09
10	0,063
	PAN

- Put sand in the top sieve.

- Place the sieve arrangement on the test machine.

4) Testing Process

   After the siever installed, set the engine in Vibration 5 and 15 minutes. Wait for the engine to stop

5) Measure the weight of the sand (test results), for each sieve.

6) Analysis

   The results of the measurement of the weight of each sieve, grain fineness analysis (GFN) was performed using equation (1).

IV. TEST RESULT

Sand distribution testing is done by using sieve analysis test equipment. The tested sand is a sample of new silica sand, reclaimed silica sand and mixed silica sand with a sample size of 50 gr each. Sand is put in the top filter with a vibration strength of scale 8 and sifting time of 15 minutes. After the sifting process then weigh the weight of sand in each sieve. The silica sand distribution test data of the test results are as follows:

1) Test Result (New Silica Sand)

Sieve Size (mm)	**Empirical Weight (gr)**
1,4	0
1	0,02
0,71	0,97
0,5	29,61
0,355	12,13
0,25	4,38
0,18	1,34
0,125	0,51
0,09	0,05
0,063	0
PAN	0
Σ	49,1

2) Test Result (Reclamation Silica Sand)

Sieve Size (mm)	**Empirical Weight (gr)**
1,4	0
1	0,03

0,71	0,56
0,5	8,72
0,355	15,65
0,25	12,65
0,18	7,65
0,125	3,91
0,09	0,5
0,063	0,06
PAN	0
Σ	49,73

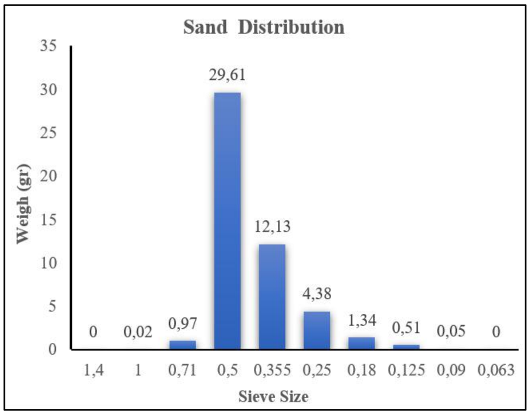
3) Test Result (Mixing Silica Sand, 20% new+ 80 % reclamation)

Sieve Size (mm)	**Empirical Weight (gr)**
1,4	0
1	0,01
0,71	0,84
0,5	13,32
0,355	15,68
0,25	10,51
0,18	5,93
0,125	3,06
0,09	0,35
0,063	0,09
PAN	0
Jumlah	49,79

V. ANALYSIS

Test results from each sand obtained uneven sand distribution. This will determine the value of the GFN.

1) Distribution of Silica Sand (New)



Graph 1. Distribution of New Silica sand

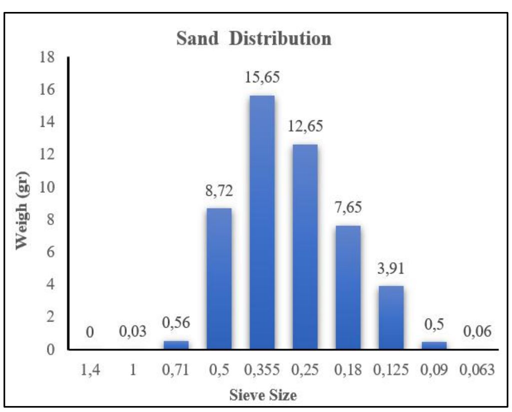
In Graph 1, it shows that the most sand distribution is in the 0.5 mm sieve, which is 29.61 g or 59.22% of the total test sample. Using equation (1), we get:

Cor.	Sieve Size	Wn	Wn.Sn
10	1,4	0	
16	1	0,02	0,2
22	0,71	0,97	15,52
30	0,5	29,61	651,42
44	0,355	12,13	363,9
60	0,25	4,38	192,72
100	0,18	1,34	80,4
150	0,125	0,51	51
200	0,09	0,05	7,5
250	0,063	0	0
	PAN	0	0
	Σ	49,01	1362,66

$$\mathrm{GFN} = \frac{\Sigma(\mathrm{W_n \; x \; S_n})}{\Sigma \, \mathrm{W_n}} = \frac{1362{,}66}{49{,}01} = 27{,}8$$

These results do not meet the requirements of the cast iron foundry GFN sand.

2) Distribution of Silica Sand (Reclamation)



Graph 2. Distribution of Reclamation Silica sand

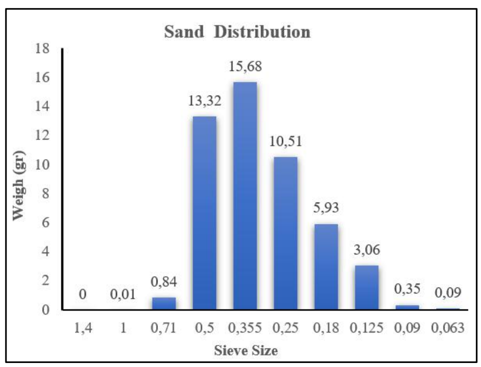
In Graph 2, it shows that the most sand distribution is in the 0.355 mm sieve, which is 15.65 gr or 31.3% of the total test sample. Using equation (1), we get:

Cor.	Sieve Size	Wn	Wn.Sn
10	1,4	0	
16	1	0,03	0,3
22	0,71	0,56	8,96
30	0,5	8,72	191,84
44	0,355	15,65	469,5
60	0,25	12,65	556,6
100	0,18	7,65	459
150	0,125	3,91	391
200	0,09	0,5	75
250	0,063	0,06	12
	PAN	0	0
	Σ	49,73	2164,2

$$\mathrm{GFN} = \frac{\Sigma(\,W_n \times S_n)}{\Sigma\, W_n} = \frac{2164{,}2}{49{,}73} = 43{,}52$$

These results meet the requirements of the cast iron foundry GFN sand.

3) Distribution of Silica Sand (Mix)



Graph 3. Distribution of Mixed Silica sand

In Figure 3, it shows that the most sand distribution is in the 0.355 mm sieve, which is 15.68 gr or 31.36% of the total test sample. Using equation (1), we get:

Cor.	Sieve Size	Wn	Wn.Sn
10	1,4	0	
16	1	0,01	0,1
22	0,71	0,84	13,44
30	0,5	13,32	293,04
44	0,355	15,68	470,4
60	0,25	10,51	462,44
100	0,18	5,93	355,8
150	0,125	3,06	306
200	0,09	0,35	52,5
250	0,063	0,09	18
	PAN	0	0
	Σ	49,79	1971,72

$$GFN = \frac{\Sigma(\ W_n \times S_n)}{\Sigma\ W_n} = \frac{1971,72}{49,79} = 39,6$$

These results do not meet the requirements of the cast iron foundry GFN sand.

VI. CONCLUSION

Sand distribution that meets the physical requirements for metal casting (size big: GFN 40 – 70) is Reclamation sand with GFN value 43,52. Where sand distribution is in the 0.355 mm sieve, which is 15.65 gr or 31.3%

RFERENCES

[1] American Foundry Society, Mold and Core Test Handbook, 3rd edn. (AFS, Illinois, 2001)
[2] Surdia, Tata, dan Chijiwa, K. (2000). Teknik Pengecoran Logam.Jakarta : PT Pradnya Paramita
[3] Campbell, John, "Complete Casting Handbook Metal Casting Processes, Metallurgy, Techniques and Design", Elsevier Ltd, 2011.
[4] Jabarullah, N.H. (2019) Production of olefins from syngas over Al2O3 supported Ni and Cu nano-catalysts, *Petroleum Science and Technology*, 37 (4), 382 – 385.
[5] Prialaksana, Didik, "Proses Pembuatan Cetakan Pasir", https://cepiar. wordpress. com/2007/12/10/proses-pembuatan-cetakan-pasir/, accessed on june 05.
[6] R, Trisnasaputra, "Pengaruh pemakaian pasir baru dan reklamasi dengan variasi waterglass terhadap kualitas cetakan pasir CO2 dan Produk Cor", Bandung. Universitas Jendral Achmad Yani, 2017.