Steel Slags - A Boon For Foundry Industry

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Abstract- *This paper describes the effects of Steel Slag in Nishiyama process. Fe-si is replaced with steel slag which is a waste material from the steel making industry. Molding sand is prepared using NISHIYAMA process .Molding sand properties were analyzed by taking Steel Slag in different percentages and in different Granule Sizes. Finally suitable percentage of steel slag have been obtained.*

Keywords- Moulding sand properties like Compression Strength, Compactibility, Collapsibility Hardness, Permeability, Shear Strength and Temperature effect.

I. INTRODUCTION

1.1 Introduction to foundry:

A foundry is an industrial facility that produces metal castings. Metals are thrown into shapes by dissolving them into a fluid, liquid metal is filled in molds. The pattern is made out of wax, wood, plastic, or metal. The molds are built by a few distinct procedures subordinate upon the kind of foundry, metal to be poured, amount of parts to be created, size of the casting, and complexity of the casting. And these are filled with molding sand.. Pouring can be accomplished with gravity, or it might be helped with a vacuum or pressurized gas.

The solidified metal segment is then expelled from its mold. Where the mold is sand based, this should be possible by shaking or tumbling. This liberates the throwing from the sand. The mold hole needs to hold its shape until the point that the metal has set also, the throwing is evacuated. This sounds simple to fulfill, however relying upon the decision of metal, estimate and amount of the throwing certain qualities are requested of the shape.

At the point when granular obstinate materials, for example, silica, olivine, chromite or zircon sands, are utilized, the form must be:

Sufficiently strong to maintain the heaviness of the liquid metal.

Permeable, to allow any gasses framed inside the shape or form depression to escape into the environment.

Resistant to the erosive activity of liquid metal amid pouring and the high warmth of the metal until the throwing is strong.

Sufficiently collapsible to allow the metal to contract without undue restriction amid hardening.

Able to neatly strip far from the throwing after the throwing has adequately cooled.

Economical, since a lot of refractory material are utilized.

1.2 NISHIYAMA PROCESS:

The method is based on the principal that if sodium silicate and powdered ferro-silicon are mixed in a weight ratio of 2.25:1, foaming action takes place and the temperature rises simultaneously, reaching a boiling condition at about 90 degree celsius.

The reactions taking place are:

$$Na_2O\ .nSiO_2 + H_2O_2 \longrightarrow NaOH + nSiO$$
$$mSi + 2NaOH + H_2 \longrightarrow Na_2O\ .mSiO_2 + 2H_2$$

1.3 STEEL SLAG:

This is mostly used for land filling and like a layer on the molten liquid in furnace. This slag is a result from steelmaking forms in which the parts of pig iron and steel-scrap are altered so as to create steel that is so exceptionally esteemed for magnificent strength and workability. Steelmaking slag comprises of converter slag that is obtained by converter and electric arc furnace slag that is produced amid the electric arc furnace steelmaking process that utilizes steel-scrap as the raw material.

II. OBJECTIVES OF THE PAPER

1) To study the molding sand properties.
2) To find the suitable percentage of steel slag.
3) To find the suitable granule size of steel slag.

Molding sand properities studied in this paper are:

- Hardness
- Compactibility
- Permeability
- Compression Strength
- Shear Strength
- Collapsibility

III. METHODOLOGY

3.1 Materials and Machines

Silica Sand, Sodium Silicate , Steel Slag, Sand hardness tester, Compactibility scale, Universal sand strength machine, etc..

3.2 Molding Sand Preparation

1000 gms of sand was taken and experiment was carried as follows:

940gms of silica sand was taken in a tray and then 20gms of steel slag was added and mixed by hand for 30 times later 40 gms of sodium silicate(specific gravity: 1.5) was added to the mixture which was in the tray and again mixed by hand for 45 times.

Similarly molding sand was prepared using 4% and 6% Steel slag having different granular sizes.(-40+70, -70+120, -120

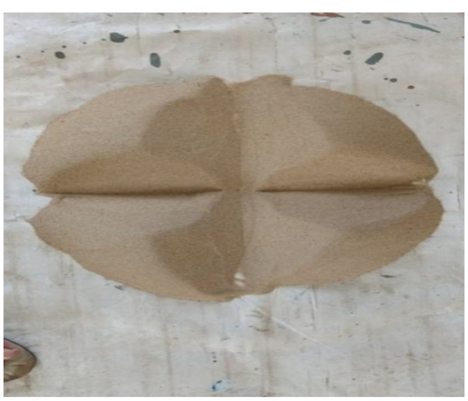

Fig 1 Silica Sand

Fig 2 Steel Slag

Fig 3 Sodium Silicate

Standard Samples

Standard sand samples of 2 X 2 ± 1/32 inches were prepared as per the AFS standards by using sand rammer with the above mentioned compositions.

Fig 4 Sand Rammer

Fig 5 Standard Samples

3.3 Tests Conducted

1. SIEVE ANALYSIS:

The sieves are arranged in the order of decreasing mesh size. The set of sieves are placed in the Rotap sieve shaker. The sieves are mechanically vibrated for a fixed period of 20 minutes. The weight of sediment retained on sieve is measured and converted into a percentage of the total sediment sample. This method is quick and sufficiently accurate for most purposes.

Fig 6 Sieve Shaker

2 .HARDNESS:

Hardness of the samples were tested using the mould hardness tester.

Fig 6 Hardness Tester

3. COMPRESSION STRENGTH:

Compression strength generally refers to the stress required to rupture the sand specimen under compressive loading. The sand specimen is taken out of the specimen tube and then allowed it to dry for 6 hours later it is kept on the strength testing machine and the force required to cause the compression failure is determined.

4 .SHEAR STRENGTH:

With a sand sample similar to the above test, a different adapter is fitted in the universal machine so that the loading now be made for the shearing of the sand sample. The stress required to shear the specimen along the axis is then represented as the green shear strength.

Fig 7 Universal Sand Strength Machine

5. COMPACTIBILITY

The sand after mulling was initially tested for its compactibility using compactibility scale. This test measures the percentage decrease in height from the original constant level of loose sand under the influence of fixed compacting force. The test directly simulates the behavior of system sands used on molding machines. High compactibility would indicate voids on the vertical faces of the mould. Low compactibility would render the sand/slag friable and subject to the cuts and washes.

Fig 8 Compactibility Scale

6. PERMEABILITY:

Permeability is defined as that physical property of the molded mass of sand mixture which allows gas to pass through it. It is numerically equal to the volume of air in milliliters that will pass per minute under a pressure of 1 gf/ems through a specimen of 1 ems in cross-sectional area and 1 cm high.


Fig 9 Permeability Tester

7.COLLAPSIBILITY:

Collapsibility is the ability of the sand to be easily stripped off the casting after it as solidified. Sands with poor collapsibility will adhere strongly to the casting. During casting, metals contract a lot during cooling or with long freezing temperature ranges. Sand with poor collapsibility will cause cracking and hot tears in the casting. Special additives are used to improve collapsibility.


Fig 10 Muffle Furnace

8. HEAT TREATMENT:

The prepared samples are placed in the hot air oven at different temperatures.(50^{O},100^{O},150^{O}) centigrade for a period of 30,30,15 minutes. Tests like hardness, compression, shear, collapsibility, are conducted for the samples.


Fig 11 Hot Air Oven

IV. RESULTS AND DISCUSSION

4.1 SIEVE ANALYSIS:

Table 1 Sieve analysis data noted after sieving 20 minutes

S .No Mesh	Mesh No	Weight retained (W)	Cumulative Weight	Mul. Factor (M.F)	W*M.F
1	20	12	12	12	144
2	30	51	63	20	1020
3	40	79	142	30	2370
4	70	40	182	40	1600
5	120	8	190	70	560
6	150	4	194	120	480
7	Pan	2	196	150	300

Total weight retained $\sum W = 196g$

Summation of product of weight retained and Multiplication factor $\sum(W*M.F) = 6474$

Grain Fineness Number(GFN) $= \sum(M.F*W)/\sum W$

GFN $= 6474/196 \approx 33$

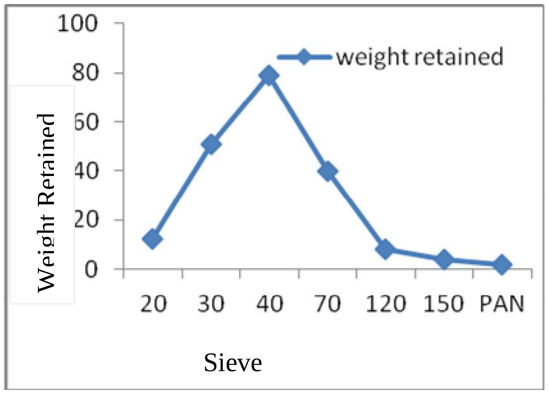

Fig 12(a) Mesh size vs Weight retained

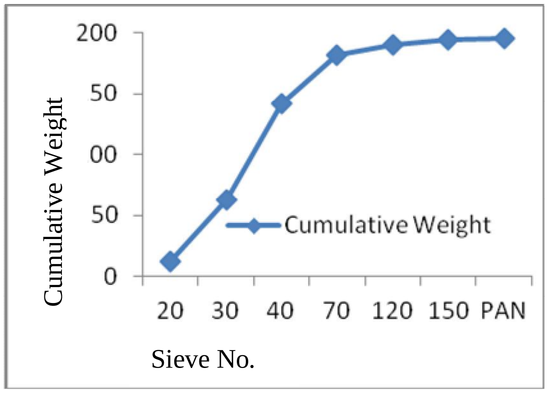

Fig 12(b) Cumulative curve (mesh size vs cumulative weight retained)

For a particular sand to have uniformity with respect to grain size, the basic thumb rule is that 60-80% of the sand must pass through three to four consecutive sieves. From the above graphical observations, it is observed that 84 % of the sand passes through the 30, 40 and 70 mesh sieves. So this implies that the sand is suitable for foundry purposes.

4.2 SAMPLES PLACED AT AMBIENT TEMPERATURE

A.HARDNESS

(1)Variation in hardness among (2,4,6) percentages of steel slag having -40+70 granular size.

The hardness values of 2,4 &6 percentages of steel slag of size -40+70 with 4% sodium silicate are tabulated and plotted in graphs shown below.

Table 2 Hardness Values of Steel Slag (-40+70)

Time in hours	2% steel slag		4% steel slag		6% steel slag	
	Top	Bottom	Top	Bottom	Top	Bottom
1	36	24	25	14	32	21
2	72	45	62	32	62	41
3	75	45	70	39	77	50
4	81	54	77	52	80	52
5	82	71	80	64	83	64
6	86	73	83	70	84	70

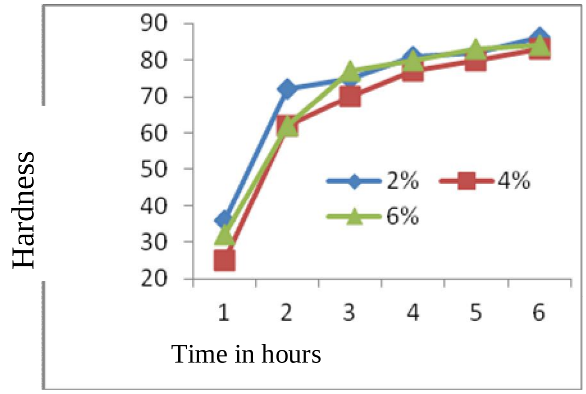

Fig 13 Time Vs Hardness

(2)Variation in hardness among (2, 4, 6) percentages of steel slag with -70+120 granular size.

The hardness values of 2,4 &6 percentages of steel slag of size -70+120 with 4% sodium silicate are tabulated and plotted in graphs shown below.

Table 3 Hardness Values of Steel Slag (-70+120)

Time in hours	2% steel slag		4% steel slag		6% steel slag	
	Top	Bottom	Top	Bottom	Top	Bottom
1	32	15	44	25	48	29
2	51	28	67	37	71	48
3	79	37	81	50	81	55
4	83	50	85	65	83	55
5	86	60	86	66	83	59
6	86	73	86	67	85	76

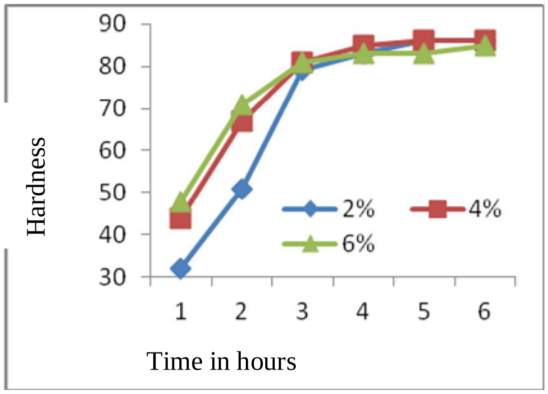

Fig 14 Time Vs Hardness

(3) Variation in hardness among (2, 4, 6) percentages of steel slag having -120 granular size.

The hardness values of 2,4 &6 percentages of steel slag having granular size -120 with 4% sodium silicate are tabulated and plotted in graphs are shown below.

Table 4 Hardness Values of Steel Slag (-120)

Time in hours	2% steel slag		4% steel slag		6% steel slag	
	Top	Bottom	Top	Bottom	Top	Bottom
1	48	35	72	50	50	32
2	72	49	84	62	74	53
3	81	56	85	69	77	56
4	83	61	85	76	83	70
5	83	66	85	80	86	71
6	83	80	86	85	87	75

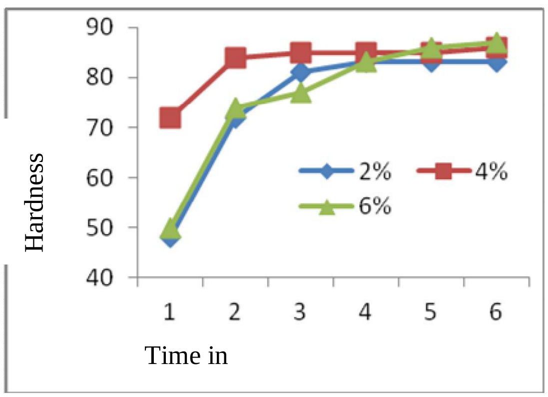

Fig 15 Time Vs Hardness

B. PERMEABILITY AND COMPACTABILITY

The permeability of the preferred combination i.e., 4% steel slag and 4% sodium silicate is **525** and the compactibility for this combination is **44**.

C. SHEAR STRENGTH

The shear strength values for the composition of various percentages of steel slag of different granaule sizes mixed with 4% sodium silicate.

Table 5 Shear Strength Values of Steel Slag

	2% steel slag	4% steel slag	6% steel slag
-40 +70	271	244	260
-70 +120	188	255	209
-120	281	389	160

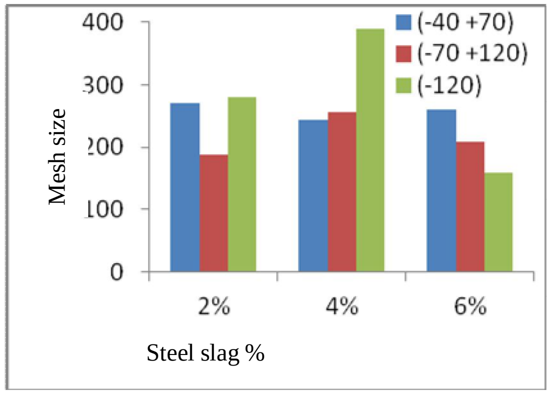

Fig 16 Steel Slag Percentage vs Mesh Size

C. COMPRESSION STRENGTH

The compression strength values for the composition of various percentages of steel slag of different granule sizes mixed with 4% sodium silicate.

Table 6 Steel Slag Compression Strength Values

	2% steel slag	4% steel slag	6% steel slag
-40 +70	702	532	622
-70 +120	593	617	627
-120	659	1037	524

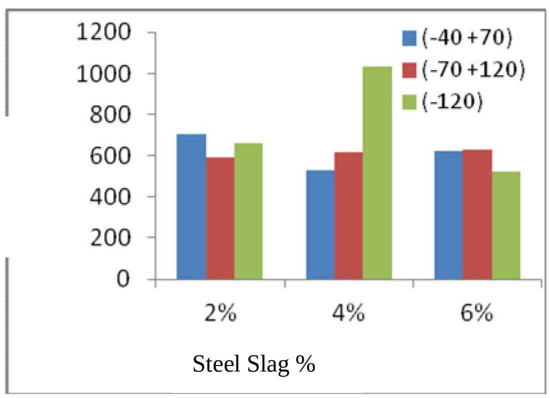

Fig 17 Steel Slag Percentage vs Mesh Size'

D. COLLAPSIBILITY

Collapsibility values for 4% steel slag with 4% sodium silicate is **1561**.

4.3 TEMPERATURE EFFECT ON STEEL SLAG

The temperatures maintained for the preferred combination that is 4% steel slag having -70 +120 granular size and 4% sodium silicate are 50°C, 100°C and 150°C for a period of 30,30,15 minutes and tests are conducted.

A. HARDNESS temperatures have been noted

The hardness values are plotted in the below table and graphs are drawn successively.

Table 7 Hardness Values of Steel Slag

Time in hours	50◦C		100◦C	
	Top	Bottom	Top	Bottom
0.5	72	59	90	89
1	87	67	95	95
1.5	92	78	95	95
2	94	84	95	95
2.5	94	90	95	95
3	95	90	96	96

Time in minutes	150◦C	
	Top	Bottom
15	94	94
30	95	95
45	95	95
60	95	95
75	95	95
90	95	95

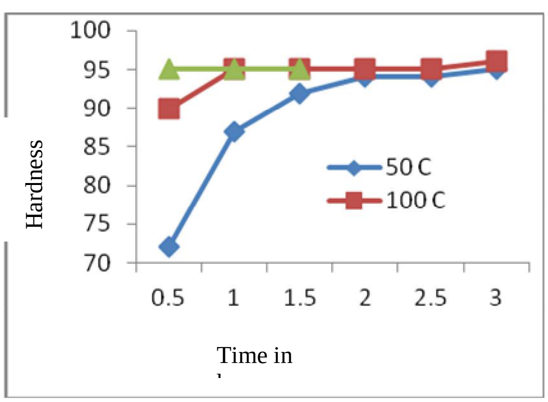

Fig 18 Time vs Hardness

The preferred temperature to place the sample is 100°C for a period of 30 minutes.

B. SHEAR STRENGTH

Shear Strength values at 50°C, 100°C and 150°C for a period of 30,30,15 minutes are as follows.

Table 8 Shear Strength Values of Steel Slag

Temperature in ◦C	Shear value
50	863
100	1037
150	1850

The hardness values for the samples at different

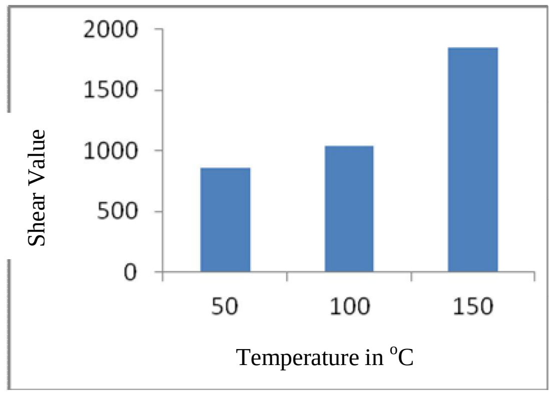

Fig 19 Temperature vs Shear

C. COMPRESSION STRENGTH

Compression Strength values at 50°C, 100°C and 150°C for a period of 30,30,15 minutes are as follows.

Table 9 Compression Strength Values of Steel Slag

Temperature in ◦C	Compression value
50	1958
100	3673
150	3974

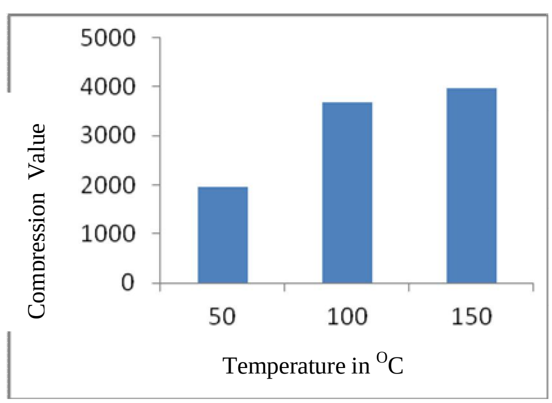

Fig 20 Temperature vs Compression

D. COLLAPSIBILITY

Collapsibility values for 4% steel slag and 4% sodium silicate at different temperatures is as follows.

Table 10 Collapsibility Values of Steel Slag

Temperature in °C	Collapsibility value
50	1587
100	1514
150	938

V. CONCLUSION

Ferro Silicon using as a hardner in NISHIYAMA process is very costly. Steel Slag which is a waste product from steel making industry is obtaining in tons

- Among different granular sizes of steel slag that is -40+70, -70+120, and -120 , 4% steel slag of granular size -70+120 with 4% sodium silicate is preferred to prepare the molding sand because of the capability to obtain maximum hardness.
- When heat treatment is done for the Samples with 4% Steel Slag of granule size -70+ 120 mixed with 4% Sodium Silicate, temperature of 100°c for a period of 30 minutes is preferred to make the mould.
- For samples when heat treated at 150°c hardness obtaining is beyond our requirement Mould should have the property to expand when it is filled with hot metal , so temperature of 150°c it is not preferred for molding sand preparation.

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