Scientific Journal Impact Factor (SJIF): 3.518
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

EVALUATING THE PROPERTIES OF MOLDING SAND BY VARYING BENTONITE COMPOSITION

M.Srinivasa Rao
Associate Professor. Department of Mechanical Engineering, Sri Indu College of Engineering & Technology R.R.Dist,Telangana,India

Abstract- Good casting can't be made without good molds it is, therefore, important to prepare a good mold and test it before hand. The testing is done on the standard specimens prepared by the molding sand. Testing here is to determine the measurable characteristics i.e. properties namely strength, hardness, permeability etc, Strength and hardness always go together so either of them would describe both. There are various factors that affect the properties of molding sand but additives play a very important role. Research by lohm et al in 2006 confirms that factors affecting properties has individual as well as joint or combined influence on them. It was revealed that various sand systems in use in the metal casting industry have been investigated in the past and such investigations were mostly carried out by classical methods of single factor experiments involving a large number of trials, yet the interaction between two variables have not been clearly understood but effort has been made to ascertain the affect of interaction among variable factors in conjunction with the affect on how the property differs and this would be the impact of individual addition on sand properties for specific or standard process of casting. In this paper the procedure in order to obtain the affect of Bentonite content is given by initiating the process with the most commonly used additives in usual compositions, determining the individual affect by excluding each of the other sand additives, determining the properties without any special additives, Determining the properties with a single sand additive , by these steps the individual effect of special additives with specific composition is obtained , Now Bentonite content is varied and its affect on properties is analysed**.** The experimentation for the last stage is conducted on the molding sand with suitable composition of other additives that give adequate properties and that is economical to the user. This data synthesised can be used for casting various components by analysing results from them in a specified format and by following statistical procedure specific composition of the molding sand can be determined.
Keywords: Grain fineness number, Permeability number, Bentonite

I. INTRODUCTION

Casting is one of the most commonly used manufacturing processes. It may be defined as metal object obtained by allowing molten metal to solidify in a mould. The shape of the object being determined by the shape of mold cavity, Hence the mould determines the casting. Therefore, good casting can't be made without good molds. Due to the importance of the mould, casting process and castings are often described by the materials and methods employed in molding and hence molding refers to the method of making a mould and the materials used. Of all the molding processes, sand molding is the oldest and a major production of castings in a sand mould. Therefore, the materials used in the sand mould plays an important role to decide the fate of casting. Keeping this in view it is necessary to test the mould before it is used for casting. The testing of mould sands performed on the standard specimens made from it.The important properties that determine the mould are permeability, strength, hardness, refractoriness etc., Strength and hardness are always said to go together and refractoriness is the inheriting properties of silicon oxides is sand. Therefore, it is important to test permeability and hardness for the molding sand.These are various factors that influence these properties. These factors show both individual and combined effect on the properties of molding sands, but both of them can't be separated. Therefore, efforts are made to enhance the individual effect of Bentonite besides that of Moisture, Linseed oil, Red-oxide, Graphite, Dextrin, Wood flour.

II. LITERATURE

Sand casting:

Sand casting, also known as sand molded casting, is a metal casting process characterise by using sand as the mould material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The term "sand casting" can also refer to a casting produced via the sand casting process. Sand castings are produced in specialised factories called foundries. Over 70% of all metal castings are produced via a sand casting process.

Classification of molding processes:

Molding processes can be classified in a number of ways. Broadly they are classified either on the basis of the method used or on the basis of the mould material used.

Sand molding: Molding processes where a sand aggregate is used to make the mould produce by far the largest quantity of castings. Whatever the metal poured into sand moulds, the product may be called a Sand casting.

Green sand moulding: Among the sand-casting processes, molding is most often done with green sand. Green molding sand may be defined as a plastic mixture of sand grains, clay, water, and other materials which can be used for molding and casting processes. The sand is called "green" because of the moisture present and is thus distinguished from dry sand. The basic steps in green-sand molding are as follows:

Dry-sand Moulds: Dry-sand moulds are actually made with molding sand in the green condition. The sand mixture is modified somewhat to give good strength and other properties after the mould is dried. Dry-sand molding may be done the same way as green-sand molding on smaller sizes of castings.

Usually, the mold cavity surface is coated or sprayed with a mixture which, upon drying, imparts greater hardness or refractoriness to the mould. The entire mould is then dried in an oven at 300 to 650 F or by circulating heated air through the mould. The time-consuming drying operation is one inherent disadvantage of the dry-sand mould.

Advantages: Dry-sand moulds are generally stronger than green sand moulds and therefore can withstand much additional handling. Better dimension control than if they were molded in green sand. The improved quality of the sand mixture due to the removal of moisture can result in a much smoother finish on the castings than if made in green sand moulds. Where moulds are properly washed and sprayed with refractory coatings, the casting finish is further improved.

Disadvantages: This type of molding is much more expensive than green sand molding and is not a high production process. Correct baking (drying) times are essential.

Skin-dried Moulds: The effect of a dry-sand mould may be partially obtained by drying the mould surface to some depth, 1/4 to 1 in. Skin drying may be performed by torches or electrical heating elements directed at the mould surface. Skin-dried moulds must be poured shortly after drying so that moisture from the undried sand will not penetrate the dried skin.

Steps involved in making a sand mold:

1. Initially, a suitable size of moulding box for creating suitable wall thickness is selected for a two piece pattern. Sufficient care should also be taken in such that sense that the molding box must adjust mould cavity, riser and the gating system (sprue, runner, and gates etc.).
2. Next, place the drag portion of the pattern with the parting surface down on the bottom (ram up) board
3. The facing sand is then sprinkled carefully all around the pattern so that the pattern does not stick with molding sand during withdrawn of the pattern.

4. The drag is then filled with loose prepared molding sand and ramming of the molding sand is done uniformly in the molding box around the pattern. Fill the molding sand once again and then perform ramming. Repeat the process three four times.
5. The excess amount of sand is then removed using strike-off bar to bring molding sand at the same level of the molding flask height to completes the drag.
6. The drag is then rolled over and the parting-sand is sprinkled over on the top of the drag.
7. Now the cope pattern is placed on the drag pattern and alignment is done using dowel pins.
8. Then cope(flask) is placed over the rammed drag and the parting sand is sprinkled all around the cope pattern.
9. Sprue and riser pins are placed in vertical position at suitable locations using the support of molding sand. It will help to form suitably sized cavities for pouring molten metal etc.
10. Fill the cope with molding sand and ram uniformly.
11. Strike off the excess sand from the top of the cope.
12. Remove sprue and riser pins and create vent holes in the cope with a vent wire.
13. Sprinkle parting sand over the top of the cope surface and roll over the cope on the bottom board.
14. Rap and remove both the cope and drag patterns and make the mould suitable if needed and dressing is applied
15. The gate is then cut connecting the lower base of sprue basin with a runner and then the mould cavity.
16. Bake the mould in the case of a dry sand mould.
17. Set the cores in the mould, if needed and close the mould by inverting cope over drag.
18. The cope is then clamped with drag and the mould is ready for pouring.

III. METHODOLOGY

AFS-standard cylindrical test specimen:

Test Specimen: Cylindrical test specimen of 50.8 (plus or minus0.03 mm) height and 50.8 mm diameter (or of 50 –plus or minus 0.3 mm height and 50 mm diameter) shall be used as the strength of a moulding sand depends greatly on its degree of ramming, the conditions of moulding the standard sample must be carefully controlled. Reproducible ramming conditions can be obtained with the standard sand rammer and specimen –tube accessories .The ramming device must be securely mounted .The sand is placed in the specimen tube and rammed by impact with three blows of a 14-16 weight.

Fig: Sand rammer

The cam is actuated by a user by rotating the handle, causing a cam to lift the weight and let it fall freely on the frame attached to the ram head. This produces a standard compacting action to a pre-measured amount of sand.Variety of standard specimen for Green Sand and Silicate based (CO_2) sand are prepared using a sand rammer along with accessories

Specimen	**Type of Sand**
Compression	Green Sand and Silicate based

(Cylindrical)	sand
Tensile Specimen	Silicate based sand
Transverse Specimen	Silicate based sand

The object for producing the standard cylindrical specimen is to have the specimen become 2 inches high (plus or minus 1/32 inch) with three rammings of the machine. After the specimen has been prepared inside the specimen tube, the specimen can be used for various standard sand tests such as the permeability test, the green sand compression test, the shear test, or other standard foundry tests.The sand rammer machine can be used to measure the compactability of prepared sand by filling the specimen tube with prepared sand so that it is level with the top of the tube. The tube is then placed under the ram head in the shallow cup and rammed three times. Compact ability in percentage is then calculated from the resultant height of the sand inside the specimen tube.The proper height of specimen is most simply achieved by weighing the sand to be put into the specimen tube. If oversize ,the weight can be reduced in increment until a proper weight to produce a 2.0-in. sample height is obtained .The sample weight necessary to produce a 2.0-in sample height after three rams, usually 145 to 175g,is actually a valuable piece of information .Specimen weight in grams ,multiplied by 0.603, gives the bulk density of the sand in pounds per cubic foot .The bulk density of the specimen may be increased or decreased by changing the number of rams and weight of sand in the 2.0 –in. diameter *2.0-in high specimen .The standard procedure ,however ,is to use three rams.
A rammer is mounted on a base block on a solid foundation, which provides vibration damping to ensure consistent ramming.

Testing procedure of Permeability test:

Permeability is defined as that physical property of the molded mass of sand mixture which allows gas to pass through it and is indexed by permeability number. It is numerically equal to the volume of air in milliliters per minute that will pass through the sand under the standard condition of pressure.

Determination of Green Permeability - The green permeability of foundry molding sand is the permeability of a molded mass of sand in its moist or tempered condition. In other words, it is the permeability of a naturally or synthetically-bonded foundry molding sand mixture which (a) has been mixed and tempered experimentally in the laboratory or (b) has been mixed and tempered for use in the foundry

Fig 5.2: permeability-meter

Test Specimen – Cylindrical test specimen of 50.8 (plus or minus0.03 mm) height and 50.8 mm diameter (or of 50 –plus or minus 0.3 mm height and 50 mm diameter) shall be used

Procedure: Find out the time required for exactly 2000 ml of air to pass through the specimen. After the pressure has become steady, read the pressure on the pressure indicator and record in gf/ cm^2. The base permeability number (P) of the sand is given by the following formula:

P= (V*H)/(p*A*T)

Where v = volume of air in ml passed through the specimen =2000 cm^3
h = height of the test specimen =5.08 cm,p = pressure of the air in g/ cm^2,
a = cross-sectional area of the test specimen =20.268 cm^2 , t = time in minutes.

Volume 03, Issue 10, [October– 2016] ISSN (Online):2349–9745; ISSN (Print):2393-8161

Test three specimens individually. The base permeability shall be the average of three tests. If the test result of one of the test specimens varies more than 10 percent from the average of three, this result shall be discarded and another specimen tested.

Hardness Test procedure

Bring the unloaded plunger of the tester in contact with the mould surface. Apply the load to the plunger and read the hardness number, on the graduated dial of the testing apparatus.

Fig : Mold hardness tester

The mold hardness test is similar to the Brinell hardness test used on metal castings, where a ball or point is pushed into the mold surface to measure 'pushback' resistance. A handheld mold hardness tester is used to show the penetration of the ball or point—the softer the mold, the greater the penetration.

A type B scale tester is used for softer molds (up to 90 mold hardness reading), like those typical of squeezers and hand ramming. The tester uses a larger diameter ball (about 0.5 in.) under a spring load of approximately 980g. For testing denser molds, such as those produced on automatic molding equipment, the C scale hardness tester can provide more sensitive results. The cone-shaped penetrator (about 0.375-in.) is smaller and the spring load higher(about 1,500g). These two instruments can be used only on flat sections of the mold, and each leaves a slight dimple on the casting if used on a mold cavity surface. Electronic versions of these tools also are commonly used.

Moisture content test Procedure: Weigh accurately about 100 g of a sample of sand in a tarred covered porcelain dish. Dry it in a uniformly heated oven between 105 degrees and 1l0 degree C for about one hour. Cool to room temperature and weigh. Repeat the process of drying and cooling till constant weight is attained.

Fig 5.4: Muffle furnace

Calculate the percentage moisture by the following formula:

Moisture, percent = (A/B)*100

Where **A** = loss of weight of the sand sample in grams on heating, and

B = weight in g of the sand sample taken.

PERMEABILITY TEST PRESSURES AND CORRESPONDING VALUES AS OBTAINED WITH STANDARD ORIFICES

Table : Permeability test pressures and corresponding values as obtained with standard orifices

Pressure grams per	PERMEABILITY		Pressure grams per	PERMEABILITY	
	Small	Large		Small	Large

sq. cm.	Orifice 0.5 mm	Orifice 1.5 mm	sq. cm	Orifice 0.5 mm	Orifice 1.5 mm
0.1	….	….		14.3	134
0.2	….	….		13.8	128
0.3	….	….		13.4	126
0.4	….	2450		13.0	122
0.5	….	2000		12.6	119
0.6	….	1620		12.2	115
0.7	….	1350		11.8	112
0.8	….	1200		11.4	108
0.9	….	1060		11.0	105
1.0	….	950		10.7	102
1.1	….	850		10.3	99
1.2	….	780		10.0	96
1.3	….	710		9.7	93
1.4	….	650		9.4	90
1.5	….	610		9.0	88
1.6	….	550		8.8	85
1.7	….	525		8.5	82
1.8	….	492		8.2	80
1.9	….	467		7.9	77
2.0	49	440		7.7	75
2.1	47	417		7.5	73
2.2	44	398		7.2	70
2.3	42	376		7.0	67
2.4	40	358		6.7	65
2.5	38	341		6.5	63
2.6	36	326		6.3	61
2.7	34	313		6.0	58
2.8	33	300		5.8	56
2.9	31	287		5.6	54
3.0	30	275		5.3	52
3.1	29	264		5.1	50
3.2	28	253		4.9	48
	27				46
	25.8				44
	24.2				42
	23.4				40

	22.7				38
	21.8				36
	21.0				….
	20.0				….
	19.5				….
	19.0				….
	18.4				….
	17.8				….
	17.3				….
	16.7				….
	16.2				….
	15.7				….
	15.2		1		….
	14.7				….

Procedure to determine affect of moisture:

In order to initiate the sand is prepared with 1% -wood Flour,0.5%-Red oxide,0.5%-Dextrin,4% - Bentonite,5%-Moisture

Experimentation: Sequence of steps:

1. The sand is added with additives and is mulled for a specific duration.
2. The standard specimen is prepared by ramming it for three times.
3. It is then tested for permeability number on permeability metre.
4. The specimen is now removed from the sleeve and is tested for hardness using sand mold hardness tester.

ANALYSIS OF SAND, Collection of sand sample:

The Krishna river bank sand brought it for the purpose of construction of a new building is being used for experimentation. The sand is collected at fifteen different areas from various heaps. This sand is then thoroughly mixed and the further process is carried out.

Filtering sand: The sand collected is poured onto the sand filter in order to remove the foreign particles such as weeds, stones,etc,

Determination of Clay content: Clay influences strength, permeability and other molding properties. It is responsible for bonding sand particles together.

Procedure:

1. Small quantity of prepared molding sand was dried
2. Separate 50 grams of dry molding sand and transfer wash bottle.
3. Add 475cc of distilled water + 25cc of a 3% NaOH.
4. Agitate this mixture about 10 minutes with the help of sand stirrer.
5. Fill the wash bottle with water up to the marker.
6. After the sand etc., has settled for about 10 minutes, Siphon out the water from the wash bottle.
7. Dry the settled sand.
8. The clay content can be determined from the difference in weights of the initial and final sand samples.

Percentage of clay content = (W1-W2)/(W1) * 100

Where, W1-Weight of the sand before drying,
W2-Weight of the sand after drying

Sample	Weight of sand befo drying(w1)	Weight of sand aft drying(w2)	Clay content(w w2)/(w2)*100

Sand	100	93.9	6.1

The amount of natural clay content identified in sand sample is 6.1%

Determination of Grain fineness number:

Sieve Analysis: The test of determining the AFS grain fineness number is performed on a dried sand sample from which all clay substances have been removed. A set of standard testing sieves is used to screen the sand. These sieves are stacked in sequence with the coarsest sieve at the top and placed in a sieve shaker. About 100 g sand is placed at the top sieve and, after 15 minutes of vibration, the weight of the sand retained in each sieve is obtained. The AFS grain fineness number of the sand tested can then be determined by taking the percentage of sand retained on each screen, multiplying each by a multiplier (which is simply the next available sieve old mesh number greater than the one being weighed out), adding the total, and then dividing by the total percentage of sand retained on the sieves. Typical calculation of the AFS fineness number, which includes the multiplier factor, is given in table

Table : Determination of grain fineness number

AFS sieve no	Amount of sample attained sieve(gm)	Multiplier factor	Product
12	0.4	5	2
20	0.3	12	3.6
30	0.5	20	10
40	3.4	30	102
50	9.7	40	388
70	37.6	50	1880
100	34.6	70	2422
140	8.5	100	850
200	0.7	140	98
270	0.69	200	120
Pan	0.4	300	120
Total	96.7	-	5995.6

Grain fineness number = weight of the product/weight of sand = 5995.6/96.7 = 62 The grain fineness number for sand sample is 6

IV. RESULTS & DISCUSSIONS

S.N	Composition	Co
1	bentonite(3%);woodflour(0.2%);redoxide(0.5%);dextrin(0.7%);graphite(0.2%);moisture(5	Sb
2	bentonite(4%);woodflour(0.2%);redoxide(0.5%);dextrin(0.7%);graphite(0.2%);moisture(5	Sb
3	bentonite(5%);woodflour(0.2%);redoxide(0.5%);dextrin(0.7%);graphite(0.2%);moisture(5	Sb
4	bentonite(6%);woodflour(0.2%);redoxide(0.5%);dextrin(0.7%);graphite(0.2%);moisture(5	Sb
5	bentonite(7%);woodflour(0.2%);redoxide(0.5%);dextrin(0.7%);graphite(0.2%);moisture(5	Sb

Where Pressure = P ,Time = T,Permeability =Per,Hardness = H

Moulding Sand (Sb1):

S.No	P	T	Per	H
3 minutes of mulling:				

1	2.3	93	376	46
2	2.3	84	376	51
3	2.1	90	417	52
4 minutes of mulling:				
1	2.2	84	398	55
2	2.4	83	358	52
3	2.8	85	300	52
5 minutes of mulling:				
1	3.1	85	264	55
2	2.3	80	370	60
3	2.9	83	287	61

Moulding Sand (Sb_2):

S.No	P	T	Per	H
3 minutes of mulling:				
1	2.4	84	358	59
2	2.4	82	358	65
3	2.3	83	376	63
4 minutes of mulling:				
1	2.4	82	358	62
2	3	80	275	63
3	2.8	78	300	61
5 minutes of mulling:				
1	2.6	76	326	64
2	2.7	75	313	65
3	2.7	77	313	64

Moulding Sand (Sb_3):

S.No	P	T	Per	H
3 minutes of mulling:				
1	2.6	77	326	70
2	2.8	77	300	69
3	2.8	77	300	70
4 minutes of mulling:				
1	2.7	76	313	72
2	2.5	78	341	73
3	2.5	78	341	70
5 minutes of mulling:				
1	2.5	79	341	74
2	2.9	78	387	72
3	2.5	78	341	70

Moulding Sand (Sb_4):

S.No	P	T	Per	H
3 minutes of mulling:				
1	2.9	75	387	75
2	2.9	75	287	75
3	2.3	75	376	75
4 minutes of mulling:				
1	2.2	77	398	76
2	2.5	75	341	73
3	2.4	77	358	74
5 minutes of mulling:				
1	2.4	73	358	78
2	2.4	74	358	76
3	2.4	75	358	79

Moulding Sand (Sb_5):

S.No	P	T	Per	H
3 minutes of mulling:				
1	2.8	85	300	79
2	2	84	440	78
3	2	76	440	76
4 minutes of mulling:				
1	2.8	76	300	77
2	2.5	78	341	77
3	2.3	76	376	76
5 minutes of mulling:				
1	2.3	75	376	78
2	2.3	76	376	76
3	2.2	74	398	81

Average values of Moulding Sand (Sb1):

Mulling time	Pressure	Time	Pressure x Time	Calculated permeability	Permeability from table	Hardness

Volume 03, Issue 10, [October– 2016] ISSN (Online):2349–9745; ISSN (Print):2393-8161

3	2.26	89	201.1	249.21	389.6	49.6
4	2.46	84	206.6	242.6	352	53
5	2.83	82.6	233.7	214.4	307	58.6

Average values of Moulding Sand (Sb_2):

Mulling time	Pressure	Time	Pressure x Time	Calculated permeability	Permeabilit from table	Hardness
3	2.36	83	195.8	256	364	63
4	2.73	80	218.4	229.5	311	62
5	2.66	76	202.16	248	317.3	64.3

Average values of Moulding Sand (Sb_3):

Mulling time	Pressure	Time	Pressure x Time	Calculated permeability	Permeabilit from table	Hardness
3	2.73	77	201.21	238.46	308.6	69.6
4	2.56	77.3	197.8	253.3	322.3	71.6
5	2.63	78.3	205.9	243.2	323	72

Average values Moulding Sand (Sb_4) :

Mulling time	Pressure	Time	Pressure x Time	Calculated permeability	Permeabilit from table	Hardness
3	2.7	75	202.5	247.5	316.6	75
4	2.33	76.3	177.7	282	365.6	74.3
5	2.4	74	177.6	282.25	358	77.6

Average values Moulding Sand (Sb_5):

Mulling time	Pressure	Time	Pressure x Time	Calculated permeability	Permeabilit from table	Hardness
3	2.23	81.6	182	275.47	393.3	77.6
4	2.53	76.6	193.79	258.66	339	76.6
5	2.26	75	169.5	295.74	383.3	78.3

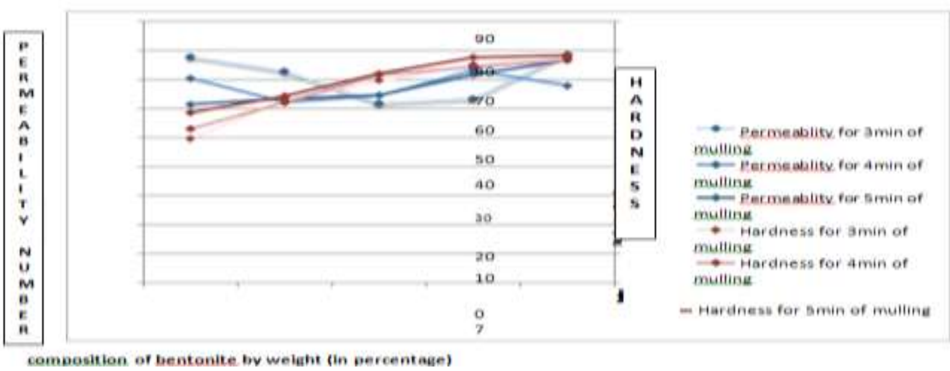

Fig: Plot of properties vs. bentonite composition

V. CONCLUSION & FUTURE SCOPE

It is very difficult to achieve certain marks of result whereas efforts have been made to use the available products that are commercially viable in the market. It has come to the conclusion that a special sand possessing high refractoriness, high angularity, and other required properties should be used. Our effort shows that due to the change in modification of contaminants of molding sand, available sand in our location and its surroundings can be used successfully for small, intricate castings like slush casting, non-ferrous metal casting etc,

It can be observed that 3 minutes of mulling time gives adequate hardness and permeability.

INDIVIDUAL AFFECT OF BENTONITE

From 34 sets of molding sands, a total of 306 specimens have been tested and the sand with specific composition have been identified with the known effect of additives other than in interest on properties. Based on this set of molding sand 45 specimens have been tested for the affect of Bentonite. The individual affect of bentonite can be attributed to binding the smaller grains together forming grains of mediocore size that decreases the permeability and increases hardness but with further addition permeability increases due to increased grain cluster.There is a huge scope to advance in the identification of combined effect of additives but is all the matter of time and very expensive advanced technology in the field of sand testing and advanced statistical facilities.

In addition to the work done, there lies a future possibility for the preparation of mold with the synthesised composition and test the casting obtained which can be attributed to the effect of additives both individual and combined excluding the effect of pattern design.

REFERENCES

[1] Principles of metal casting by Richard W Heine, Carl R Loper, Philip C Rosenthal
[2] Dynamic properties of immersed sand at the beach, Virginia by Department of Army, Corps of Engineers.
[3] Indian standard specification for determining the permeability of foundry sands.
[4] Analysis and prediction of green permeability values in sand moulds using multiple linear regression model by A. P. Ihom1, J. N. Ogbodo, A. M. Allen, E. I. Nwonye and C. Ilochionwu from African journal of engineering research.
[5] http://www.wiloludjournal.com
[6] Sand and clay, their analysis and physical properties by Augustine C. Passamore
[7] Indian standards, methods of physical tests for molding sands.
[8] Indian standards, the specification for standard silica sand for raw material testing in foundries.
[9] https://archive.org/index.php
[10] http://shodhganga.inflibnet.ac.in/
[11] International Journal of Engineering Innovation & Research Volume 4, Issue 2, ISSN: 2277 – 5668
[12] Sand, sand additives, sand properties, and sand reclamation by Prof. Dr. Altan Turkeli MSE-432 Foundry Technology.

