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Study of Casting Defects by Varying Molding Sand Properties &Temperature

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Abstract:*In this paper casting defects was studies due sand properties like permeability, grain size, moisture content and molten metal pouring temperature. Pure Aluminium metal has taken to study defects like porosity, shrinkage, and blow holes.In order to minimize these defects, process parameters were studied like Sand – Grain Fineness Number of sand, permeability, Pouring Temperature.Sieve shaker, Permeability meter, Muller machine, Scanning Electron Microscope was used to study the surface defects. Since permeability of sand is function of the degree of ramming, so it is very important to prepare the specimen according to standard conditions. A laboratory sand rammer was used along with a specimen tube to get standard ramming conditions. For this purpose three samples of aluminium product was casted from sand of different grain size. It has seen that casting defects like Blow holes was more when with Grain Fineness Number(GFN) was high &Permeability Number was low. If pouring temperature is much more than melting temperature of Aluminiumit creates more porosity but if pouring temperature is too nearby melting temperature then another defect like cold shut will occurs. Permeability of molding sand depends on number of factors like shape & size of sand grains, moisture content, amount of binder present and packing.Analysis is done using visually and with help of Optical imaging by LEICA DMLM & Using SEM by JEOL (JSM-6390LV).*
Keywords: *GFN, Permeability ,Shrinkage defects*

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I. Introduction

Sand casting is one of the oldest and basic manufacturing processes.It provides option of forming modest as well as intricate shapes with extensivechoice of materials. Many parts and components are made by casting, including pistons, toys, engine blocks, turbine blades etc.

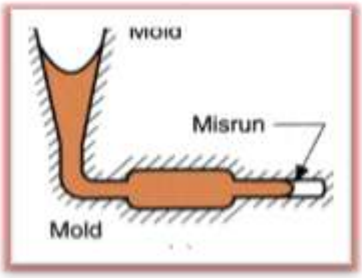
Any carelessnessin the molding process cause defects in castings which may be eliminated with proper molding practice. Some major defects which likely to occur in sand castings are: Gas defects, Shrinkage cavity defects, Molding material defects & pouring metal defects which in turn creates blow holes, Porosity, Metal penetration, Cold shut or miss-run & Hot tears etc.

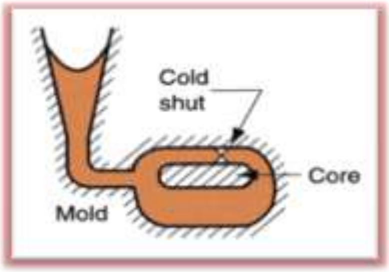
To achieve the aim of this study, effect ofvarying pouring temperature and permeability of sand, GFN of sand, moisture content & clay variation on the pure aluminium mouldwasstudied. For this I prepared a mixture of sand, clay & moisture with the help of Sand Muller machine. Again I found permeability of mixture. Then I prepared a mold cavity by selecting v-block shape single piece pattern for casting. Patterns in casting are used to form cavitywhere molten metal is going to poured. Patterns must be larger than required mold (i) to compensate shrinkage during cooling and solidification, and (ii) to offersufficient metal for machining operation(s).

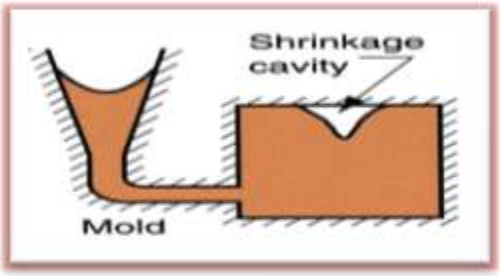
With the help of crucible I melted pure Aluminium metal for casting. For each casting I varied temperature of pouring. Finally studied the defects occurred by varying the different parameters with the help of optical imager, Scanning Electron Microscope and visually also.


A. Optical Imager **B.** Scanning Electron Microscope

Different types of defects are looks like:-







II. Literature Review

From the existing and recent literature citations it is found that now a days lot of methods are available to analyze the defects and have received considerable attention from researchers in the past. Various researches and their finding are available for the improvement of casting defects. John Campbell & Richard A. Harding [1] studied the reasons & origin of major solidification defects in casting. Rahul Bhedasgaonkar&UdayDabade [2] studied the casting defects occurring in green sand molding process by design of experiments like Taguchi method and tried to reduce shrinkage in casting.P. Shailesh [3] studied the defects in centrifugal casting by Taguchi's method and came to point that when pouring temperature was reduced and increased the speed of die, mechanical properties improved. Dr. M. Arasu [4] studied that casting defects are the reason of poor maintenance of machines and less of precise knowledge by the shop floor workers. Rajesh Rajkolhe [5] studied that reason of sand inclusion and slag inclusion defects and came to the point that main reason of inclusion defects associated with CO blow holes and slag particles.Achamyeleh A. Kassie[6] has studied the major steel casting defects like gas defects & shrinkage defects. For this purpose he conducted 9 experiments using Taguchi's DOE by changing the sand binders and de-oxidant amount.KusampudiNavyanth[7] has studied the casting defects in Aluminum alloy using techniques like historical analysis, cause effect diagram and by X-ray inspection. He studied that the shrinkage defects are due to lack feedability during solidification of casting and hydrogen present in the metal is the reason of porosity in aluminum alloy casting.

III. Experimental Work

3.1:Determinationof Grain Fineness Number (GFN):

The percentage of Grain sizes is determined by sieving the dried clay-free sand. Sifting time was 15 minutes and the test sieves used was 1.40-mm, 1.00-mm, 0.63-mm, 0.32-mm, 0.20-mm, 0.10-mm and 0.06-mm. I have taken 50-gm of representative sample through 7 sieves indicated as above, starting with coarse sieve. Weighted out the sand retained on each sieve and the pan material individually and put down as percent of the dried unwashed sand.

Calculation for GFN:

Sand -1:

Sl. No.	Sieve sizes (in mm)	Multiplying Factor(M.F)	weight retained (in gm)	% of weight Retained (I.F)	M.F×I.F
01	1.40	12	0	0	0
02	1.00	14	0	0	0
03	0.63	20	2.83	5.66	113.2
04	0.32	30	20.10	40.20	1206
05	0.20	50	16.57	33.14	1657
06	0.10	70	9.04	18.08	1265.6
07	0.06	140	1.41	2.82	394.8
		TOTAL	49.95	99.90	4636.6

GFN=(M.F×I.F) ÷ 100, So, GFN=(4636.6) ÷ 100=**46.37**

Sand-2:

Sl. No.	Sieve sizes (in mm)	Multiplying Factor(M.F)	weight retained (in gm)	% of weight Retained (I.F)	M.F×I.F
01	1.40	12	0	0	0
02	1.00	14	0	0	0
03	0.63	20	2.59	5.18	103.6
04	0.32	30	13.89	27.78	834
05	0.20	50	23.85	47.70	2385
06	0.10	70	7.12	14.24	996.8
07	0.06	140	2.39	4.78	669.2
		TOTAL	49.84	99.68	4984.6

➢ **GFN**=(4984.6) ÷ 100= **49.85**

Sand-3:

Sl. No.	Sieve sizes (in mm)	Multiplying Factor(M.F)	weight retained (in gm)	% of weight Retained (I.F)	M.F×I.F
01	1.40	12	0	0	0
02	1.00	14	0	0	0
03	0.63	20	0	0	0
04	0.32	30	10.90	21.80	654
05	0.20	50	20.45	40.92	2046
06	0.10	70	12.32	24.64	1724.8
07	0.06	140	6.31	12.62	1766.8
		TOTAL	49.98	99.98	6191.6

➢ **GFN=(M.F×I.F) ÷ 100**So, GFN of sand-3= (6191.6) ÷ 100= **61.92**

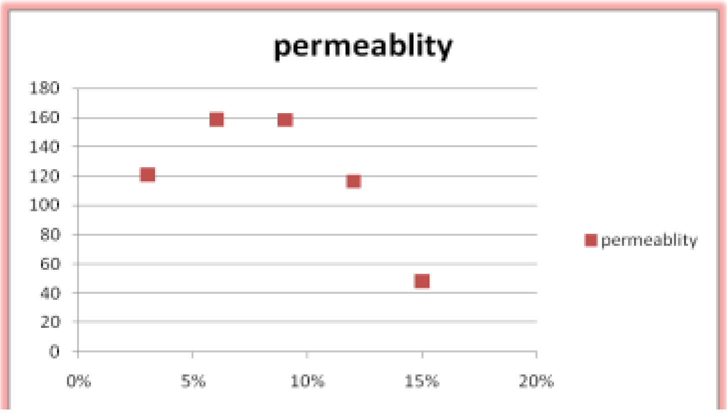
3.2: Study of clay and moisture variation and effect on Permeability:

(A) Variation of moisture keeping clay fixed:

Sample weight=200-gm, Clay fixed= 6% (12-gm)
Variation of moisture = 3%(6-gm), 6%(12-gm),
9%(18-gm), 12%(24-gm) and 15%(30-gm)

I have made five samples by adding different % of silica sand, clay & moisture after that found Permeability number with the help of Permeability meter. All time noted the time for passing through the cylindrical sample prepared.

Sl.No.	Weightofsand (in gm)	Moisture	Clay (fixed)	Time (minutes)	Pressure (gm./cm^2)	Permeability number
01	182	3%	6%	0.941	44	121.071
02	176	6%	6%	0.875	36	159.137
03	170	9%	6%	0.877	36	158.774
04	164	12%	6%	0.957	45	116.401
05	158	15%	6%	1.737	60	48.098



X-axis= % of moisture
Y-axis= permeability

(B) Variation of Clay keeping moisture fixed:
Sample weight= 200-gm; Moisture fixed= 6% (12-gm)
Variation of clay= 3%(6-gm), 6%(12-gm), 9%(18-gm), 12%(24-gm) and 15%(30-gm)

Sl. No.	Weight of sand (in gm)	Clay	Moisture (fixed)	Time (minutes)	Pressure (gm./cm^2)	Permeability number
01	182	3%	6%	0..901	36	154.545
02	176	6%	6%	0.867	38	152.153
03	170	9%	6%	0.8858	37	152.949
04	164	12%	6%	0.8885	38	149.058
05	158	15%	6%	0.878	38	150.247

3.3: Specimen Preparation:
Cylindrical test specimen of 50.8$\pm$0.3-mm height and 50.8-mm diameter was used. The weighted amount of sand was filled in the specimen tube, and a weight of 6.35 to 7.25 kg was allowed to fall on the sand in the tube three times from a height of 50.8+0.125-mm. By this process I get specimen for permeability test.

Prepared Specimen

3.4: Determination of Permeability of molding sand:

Permeability meter was used for this purpose. The air (2000cc volume) detained in the bell jar was forced to pass through the specimen. Recorded the pressure reading in the manometer& the time in passing 2000cc of air through the sand.Permeability number was calculated by formula given below;

Permeability (P) = (V×H) ÷ (p ×A×T)

Where V=volume of air passed=2000cm^3
H=height of specimen= 5.08-cm
p=air pressure, gm./cm^2 , A=cross sectional area of sand specimen=20.298 cm^2 , T=time in minutes for the complete air to pass through
Putting all above standard values in expression, we get;

P= (5012.828) ÷ (p×T)

For,
Molding Sand 1: P=116.16(at pressure= 48; Time=.899-min)
Molding Sand 2: P=98.65 (at pressure= 54; Time=0.941-min)
Molding Sand 3: P=79.94(at pressure=57;Time=1.101-min)

3.5: Molding sand composition and preparation:

The representative foundry sand is a mixture of fresh and reprocessed sand, which contains 90-91% silica (SiO2),3-4% water, and 7-8% clay.So, I have taken mould sand mixture of 5- kg.According to composition:

Sand taken in each mixture: 90% of 5-kg =4.5-kg; Water taken in each mixture: 3% of 5-kg=0.15-kg.
Clay (bentonite) in each mix:7% of 5-kg=0.35-kg

Preparation of mixture: It is most important for the preparation of sand is a thorough mingling of its various elements. This is crucial to confirm uniform scatteringof elements throughout the sand.
During the mixing process, sand wassmashed up and clay was uniformly shrouded around the sand grains and moisture washomogeneouslycirculated. It was done with help of sand Muller machine.

Sand Muller Machine

3.6: Preparation of mold and final product by sand:

I used single piece v-shaped wood patter for making cavity. Same pattern is used for casting all main three aluminium mold.
1:- I have taken molding flask .Filled that with molding sand prepared before with one by one according to GFN of sand.
2:- There I put pattern of v-block in drag part.Sand was rammed by rammer properly.
3:-Then I put parting sand ,so that cope sand not stick with drag part .When I filled sand in cope part sets riser and runner.
4:-.Put cope and drag one over another properly aligned. After that separated cope and drag part.
5:-Then prepared in gate with help of small square shape and removed pattern slowly.
6:-let it dry for 24 hours.
7:-Next day melted crap of Aluminium in crucible. (for each casting maintained different temperature for melting aluminium in crucible.)
8:-Molten metal was poured gently into a mold cavity formed by the pattern.
9:- Let it solidify for 15 minutes. The casted v-block was removed by breaking the mold.
10:-Finally the extra metal from the sprue and risers was cut from the rough casting.

(A) (B) (C) (D)

A: Final product; **B**: Mould box after V-block shape pattern removal;
C: Parting sand;**D**: Filled cavity assured by looking riser filled.



EF **G**

E:Scrap of aluminium for melting**F**: Heated metal in crucible **G**: Final Product with Riser and Sprue

IV. Investigation Of Defects Occurred:-

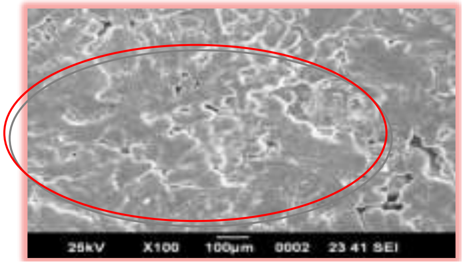
Final Product Obtained by Casting are:-



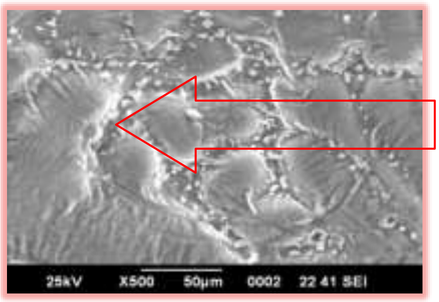
By sand 1 By sand 2 By sand 3

Sand 1:(permeability=116.6; Pouring temp. of Molten aluminium=800^0c)
(Porosity=more, surface finish =Better)
Sand 2: (permeability=98.65; Pouring temp. of Molten aluminium=750^0c)
(Porosity=less than "A", surface finish =less Better than "A")
Sand 3:(permeability=79.94 ; Pouring temp. Of Molten aluminium=680^0c)
(Porosity=less than "A&B", surface finish =Shrinkage occurred)

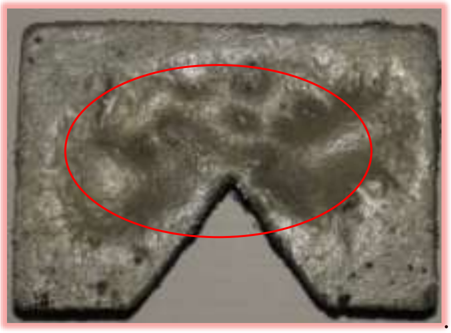
Defects and Reasons:



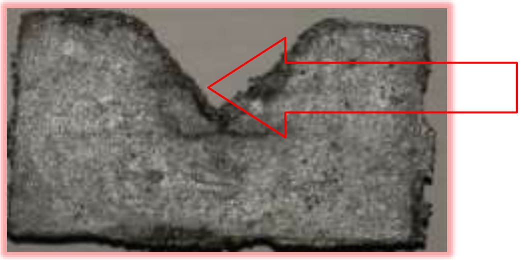
Porosity:-This was due to presence of hydrogen in molten metal. When the pouring temperature was higher i.e800^0C the gas pick up capacity increased. So porosity was more



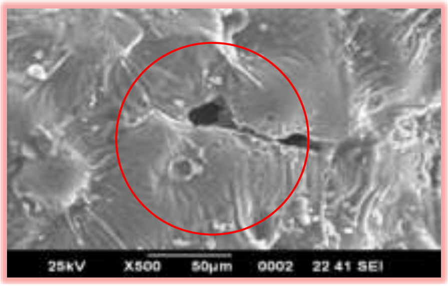
Hot Tear:- Due to uneven temperature distribution or due to sudden cooling at higher temperature the rapture occurred in casting called hot tear defect.



Shrinkage in Casting:- Occurred while temperature of pouring lowered than 700^0c.As the molten metal solidify soon and not feed to cavity in full amount during the solidification.



Metal Flow Out:-Defect due toMold Miss-alignment molten metal flown out. It can be removed by cutting or by machining operations.



<u>Blow Holes:</u>- Due to improper venting or due to moisture present inside the casting , the steam form due to molten metal heat & blows out. It was seen more with low permeability sand casting.

<u>Cold- Shut</u> :-Occurred when pouring temperature was below 680^0c.Also it may be reason of improper gating system or small size of riser, as molten metal is not compensated before solidification.

V. Conclusion

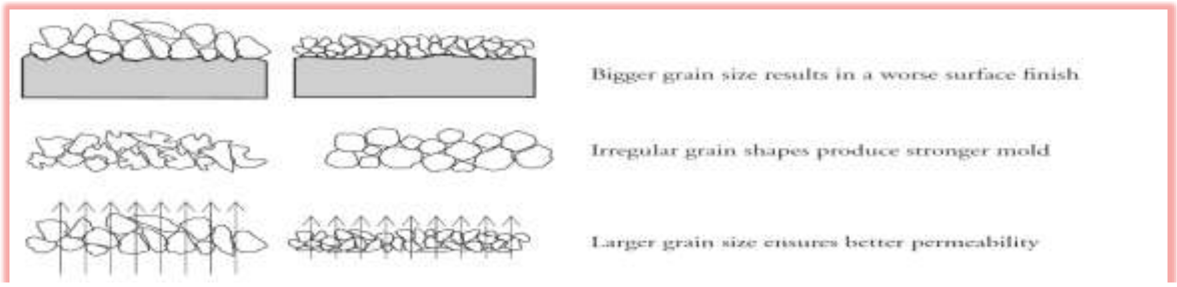
Permeability of molding sand be influenced by on numerousreasons like shape of sand & size of grains, fineness of grains and moisture gratified, amount of binder present. Coarse grained sands are more permeable than finer ones.Casting defects like Blow holes has seen more with casting with higher GFN value & low Permeability Number. As there is less space between the sand and additives, this reduces the escaping capability of gas. So, the parts from which they coming out create blow holes and porosity. More will be the size of grain, more will be the permeability but surface will be rough and strength of product will be less.

The melting temperature of pure Aluminium metal is 660^0C. As the pouring temperature of melted Aluminium varied from 750^0 C to680^0 C shrinkage in mold was more. Temperature selection is more important as more temperature creates more porosity but less temperature creates defects like cold shut& miss-run. In which metal solidify before reaching to full cavity.

Shrinkage also may be reason of more moisture in the moldingsand, cast metal & Casting Dimension. Shrinkage was also occurred in casting when there was insufficient metal to properly feed the casting to counteract the solidification.

Casting defects like hot tear was the reason of un-even temperature distribution. Some part becomes hot and some colder. So crack occurred across grain boundaries during solidification from the melt or shortly after solidification while casting is quite hot.For preventing the casting from cold-shut or Miss-run, a metal cast to be heated somewhat above its melting point to ensure that it possesses sufficient fluidity to completely fill the mold before it starts solidify. But more superheating also cause porosity defects.

Venting of sand with vent wire near pattern helps to escape gases generated in mold cavity thus reduces porosity and blow holes.



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