MME **345**, Lecture **A:06**

Moulding and Casting Methods

4. Testing and control of moulding sand

Ref:

[1] Heine, Loper & Rosenthal, Principles of Metal Casting, McGraw-Hill, 1976
[2] Beeley, Foundry Technology, Butterworth-Heinemann, 2001

Topics to discuss today …

1. Introduction
2. Sand testing techniques
3. Control of moulding sand aggregate

1. Introduction

- The quality of a foundry's green sand has a definite impact on the quality of the castings.
- Periodic tests are necessary to determine the essential qualities of foundry sand as properties changes during use.
- Test may be either chemical or mechanical in nature.
- Various tests are designed and standardised to determine the properties of moulding sand

- To have uniform properties, control in sand properties is necessary.
- Even though control is done, sand properties will change from time to time.
- To have good control of the sand properties, control values in properties are to be determined and to be tested periodically.

2. Sand testing techniques

- The need for systematic evaluation of the working qualities of moulding materials under foundry conditions has led to the development of a wide range of tests.
- Sand testing falls into two categories:
  1. **checking consistency of sand by determining its basic chemical and physical characteristics**
  2. **measuring the bulk properties of an aggregate by evaluating physical and chemical properties of a sand mix.**
- The bulk properties of an aggregate are sensitive to small variations in mixing conditions and specimen preparation
- Rigid standardisation is needed at all stages.
  Even under these conditions results usually show considerable scatter.

- Some of the most important tests routinely performed in foundry:

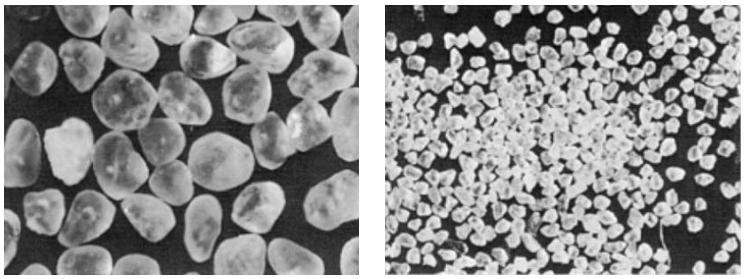
Consistency tests

1. AFS sieve analysis and GFN
2. Moisture content
3. AFS clay content and Methylene blue test
4. Loss on ignition
5. Compactibility

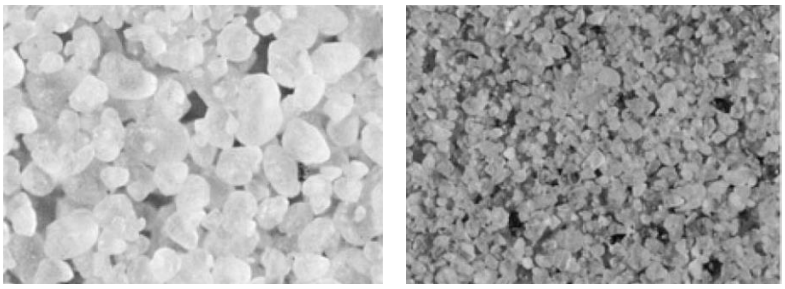
Bulk / mould property tests

1. Mould hardness
2. Green and dry compression strengths
3. Permeability
4. Flowability
5. Collapsibility
6. Shatter index
7. Surface stability index

Test	Significance
AFS sieve analysis and GFN	• The size, size distribution, and shape of the sand grains are important in controlling the quality of the mould. • Course grained sand → metal penetration, poor surface finish; fine grained sand → better surface finish, low permeability, higher binder content • Very different sand mixes with different properties still may average out to the same GFN (Table 1). • The **grain size and shape** contributes to the amount of sand surface area. • high surface area (e.g., angular grains) → high bond requirement; as opposed to round grains (low bond requirement) → difficulties in automation (as it requires high-strength mould). • The **grain size and size distribution** controls the permeability of the mould. • Sand grains of equal size (i.e. low size distribution) → highest permeability. • If the porosity of the mould is too great, metal may penetrate the sand grains and cause rough surface.Therefore, it is necessary to balance the base sand distribution.



two sizes of rounded sand grains. x35



sizes of pores in faces of moulds made from coarse sand and from fine sand. x35

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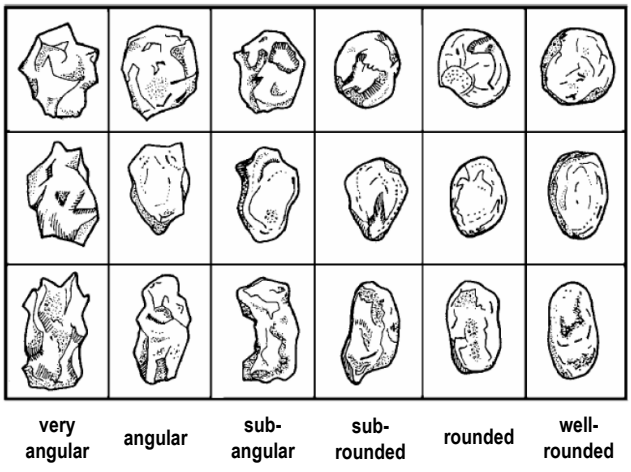

classification of grain shape

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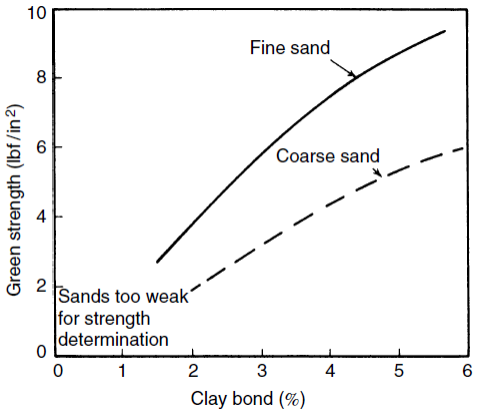
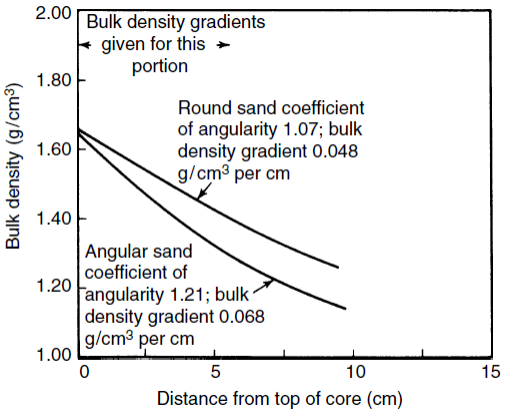


- For a fixed clay-water content, fine sand yields better strength
- To obtain a fixed strength, coarse sand requires more binder content.

Effect of grain size on strength of clay bonded sand



- angular sand yields steeper density gradients between centre and surface or core (due to lower flowability)

Effect of grain shape on bulk density of oil bonded sand

Table 1. Example of a Sieve Analysis

U.S. Sieve Number	Sand A	Sand B
20	0.0	0.0
30	1.0	0.0
40	24.0	1.0
50	22.0	24.0
70	16.0	41.0
100	17.0	24.0
140	14.0	7.0
200	4.0	2.0
270	1.7	0.0
Pan	0.3	1.0
Total	100.0	100.0
AFS Grain Fineness Number	60.0	60.0

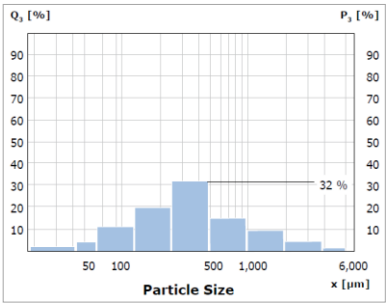
- 5-mesh sand
- wider distribution

- 3-mesh sand
- narrow distribution

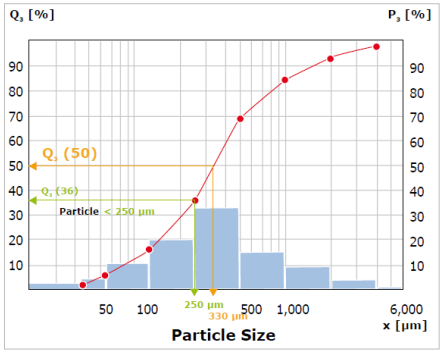
Sieve Analysis Results

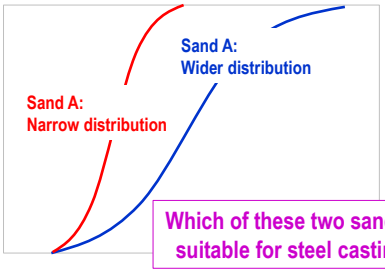
Sample volume: 150 grams = 100 %
Parameters: time = 4 minutes, amplitude = 1.3 mm

Sieve [µm]	Net Weight [g]	Weight after sieving	Differ-ence [g]	Per-centage [%]
Bottom	501	505.5	4.5	3
45	253	259	6	4
63	268	283	15	10
140	298	328	30	20
250	325	373	48	32
500	362	384.5	22.5	15
1,000	386	401	15	10
2,000	406	412	6	4
4,000	425	428	3	2
			= 150 g	= 100 %



Histogram





Cumulative distribution curve

Test	Significance
Moisture content	• Affects every property of green sand (except GFN of base sand) • Excess water produces an oxidizing atmosphere in the mould, excess gas evolution, lower permeability, high dry and hot strength, low mold hardness and poor flowability • Two factors that affect the moisture requirement are: [1] the type and amount of clay, and [2] the type and amount of additives in the sand mix.
AFS clay content and methylene blue test	• AFS clay may contain active clay, dead clay, silt, seacoal, cellulose, cereal, ash, fines and all materials that float in water. • Only the active clay gives active bonding capacity to the system • So dead clay and fines should be removed and active clay and new additives should be added periodically. • MB clay test determines the amount of active clay present in a clay sample.

Test	Significance
Los on ignition (LOI)	• The quantity of gas-forming material in the sand will affect casting properties. • High LOI may produce gas defects such as pinholes and blows. • In steel castings, high LOI can lead to carbon pickup on the casting surface.
Mould hardness	• Proper mold hardness will give castings a better finish, more accurate dimensions and reduced penetration, drops and swells. • Excessive hardness can cause cracks, scabs, blows, pinholes and penetration.

Test	Significance
Green compressive strength	• The degree of mulling, sand-to-metal ratio, clay content, compactibility range and type of additives have a significant effect on green compression. • As the amount of bentonite is the most influencing factor, the control value should be maintained for the bentonite content. In case the green strength of the moulding sand is low, the type of bentonite and mixer used should be checked. • The compression reading should be read at comparable compactibility ranges. Moulding sand at higher or lower compactibility will produce varying green strengths. • Green compression in conjunction with moisture can be used to determine the available bond.

Test	Significance
Dry compressive strength	• When sand exhibits high dry compression, a greater number of large, hard lumps are present at shakeout and more sand carryout will take place. • An increase in moisture, the type and amount of clay and the rammed mould density will affect the dry strength. • An excessive amount of moisture-absorbing materials will decrease the dry strength.
Permeability	• The grain size, shape and distribution of the foundry sand, the type and quantity of bonding materials, the density to which the sand is rammed and the percentage of moisture used for tempering the sand are important factors in regulating the degree of permeability. • In case of used sand, fines and dead clay affects the permeability. • An increase in permeability usually indicates a more open structure in the rammed sand, and if the increase continues, it will lead to penetration-type defects and rough castings. • A decrease in permeability indicates tighter packing and could lead to blows and pinholes.

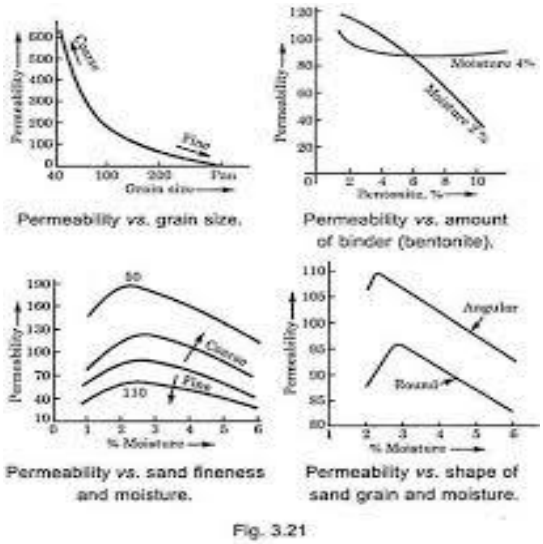


Fig. 3.21

Test	Significance
Surface stability index	• Surface stability index is affected by: [1] filling-up condition of the moulding sand, [2] amount of moisture, [3] kind and amount of binder (bentonite, starch, etc.), and [4] type of mixer and mixing time used. • The main factors are the amount of moisture and the starch and, therefore, should be controlled.
Flowability	• The flowability of green sand is affected by: [1] amount of moisture, and [2] amount and kind of binder. • The flowability of green sand will improve by reducing the amount of water, bentonite and starch in the sand. In this case, longer mixing time is necessary.

3. Control of moulding sand aggregate

1. Moisture Content
2. Permeability
3. Green Compressive Strength (GCS)
4. Green Surface Stability Index
5. Flowability
6. Clay Content
7. Loss on Ignition

control properties and standard control values

Properties	Steel	Cast Iron	Copper	Aluminium Alloy
Clay content	8	10	12	14
Moisture content	3.2	3.2	4.0	4.0
Permeability	200	150	20	20
GCS, kg/cm^2	0.8	1.0	0.6	0.5
Green surface stability index	92	88	86	85
Flowability	72	75	75	75
Loss on ignition	3	4	5	6

- **These values will change depending on [1] the type, size, shape, etc. of the casting, and [2] the foundry technique and equipment being used.**
- **Allowances and/or adjustments therefore must be made accordingly.**
- **If actual value does not tally with the value as desired or required, the problem as those shown on the following table might arise.**

control property and resulting problems

Property	Too Low	Too High
Moisture	Low green strength, Bad surface stability, Edge friability	Reduced permeability, Low green strength, Reduced sand flowability, Low mould hardness, Blow holes (pin holes), Swollen castings
Permeability	Blow holes (pin holes), Misruns, Hard castings, Difficult pattern draw	Rough surface, Metal penetration
Strength	Bad surface stability, Friable mould, Sand inclusion, Mould erosion, Scabbing, Poor pattern strip	Bad flowability, Under compaction, Rough casting surface
Surface Stability Index	Edge friability, Sand inclusions, Mould erosion, Scabbing	
Flowability	Soft mould, Sand inclusions, Swollen castings, Bad surface stability mould	
Clay Content (Active Clay)	Low strength, Bad surface stability, Friable mould, Sand inclusions, Erosion defect, Scabbings	Reduced permeability, Knock-out problems, Increase of moisture content, Cracked castings
Loss on ignition	Poor surface finish, Scabbing	Blow or pin-holes

Next Class

MME **345**, Lecture **A:07**

General Methods of Moulding Casting

5. Sand-based special casting methods 1