1.8 Pattern Colours

Actually, there is no universal standard for representation of various types of surfaces by different colours. This varies with different countries and sometimes with different manufacturers also. Patterns are provided with certain colours and shade for following reasons:

1. To identify quickly the main pattern body and different pattern parts.
2. To indicate the type of the metal to be cast.
3. To identify loose pieces, core prints, etc.
4. To visualise machined surfaces, etc.

An American colour scheme for pattern and core boxes is as follows:

1. Cast surfaces to be machined-Red.
2. Surfaces to be left unmachined – Black.
3. Core print seats – Yellow.
4. Loose piece and seatings – Red strips on yellow base.
5. Parting surfaces – Clear or no colour
6. Supports or stop-offs –Black strips on yellow base.
7. Core prints for machined castings – Yellow strips on black background.

1.9 Mould Materials

Mould material is the one out of which a mould is made. Mould material should be such that, the cavity of the mould retains its shape till the metal has solidified. Casting can be made in permanent mould (made of ferrous metals and alloys) or temporary refractory moulds (made of refractory sands and resins). Moulds can also be made up of wax, carbon, plaster of paris, ceramics, etc. permanent moulds are used for low melting point materials and they are also costly. Hence, most of casting are produced by using refractory mould materials mainly refractory sands.

The choice of a particular mould material depends on the following factors:

1. Cost of the material
2. Quality of casting required
3. Number of casting required
4. Shape and size of the casting
5. Accuracy of the casting
6. Material to be cast, etc.

1.9.1 Moulding Sand

Sand is the most widely used mould material for casting ferrous and non ferrous metals from few grams to few tons. The main reason for this is that, the sand fulfills service requirements at reasonably lower cost than the other materials. When the sand is properly mixed with other elements, it constitutes one of the best materials for the mould. The sources of moulding sands are river beds, lakes, sea and deserts.

1.9.2 Types of Moulding Sand

All types of sands used in the foundry can be grouped as:

1. Natural sand 2. Synthetic sand 3. Special sands

1. Natural sand

Natural sand can be used directly for making moulds as soon as it is received from its source. It contains binding materials (5 to 20% clay) and needs only water (5 to 8%) to mix before making the mould. It can maintain moisture content for a long time and also contain considerable amount of organic matter. This type of sand permits easy patching and finishing of moulds. Natural sands are less refractory than synthetic sands and also less costly. Hence, natural sands are used for cast iron and non ferrous casting.

2. Synthetic sand

Synthetic sand consists of natural sand with or without clay, moisture and binder like bentonite. Hence, this sand is a formulated sand. These types of sand are used for steel and other ferrous and non-ferrous alloy casting.

Synthetic sand has following advantages as compared to natural sand:

- It requires less proportion of binder.
- Higher refractoriness and permeability.
- Properties can be easily controlled.
- Refractory grain size is more uniform
- It is more suitable in mass production and mechanized foundries
- It requires less storage space.

3. Special sands

The special sand includes green sand, loam sand, core sand, parting sand, facing sand and backing sand.

a) Green sand

It is the sand which is in condition and contains 5% of water and 15 to 30% of clay. Moulds and cores both can be made up of green sand. Green sand moulds are poured in the green condition (not dried). It is preferred for producing simple, small and medium sized casting.

b) Loam sand

It contains more amount of clay as compared to other sands i.e. upto 50% loam sand dries hard. Its ingredients are fine sand, finely ground refractories, clay, graphite and fibrous reinforcement. It is used for heavy and large parts.

c) Core sand

Core sand is different from moulding sand as it has very low clay content and their grain size is large to increase the permeability. It is silica sand mixed with core oil which is composed of linseed oil, resign, light mineral oil and other binding materials. Core sand is a suitable sand mixture, also used for making cores.

d) Parting sand

It consists of dried silica sand, sea sand or burnt sand. It is used to keep the green sand from sticking to the pattern and also to allow the sand on the parting surface of the cope and drag to separate without clinging. Its parting compounds may be dry or liquid. Dry parting substances are charcoal, ground bone and limestone, ground nutshells, etc. whereas liquid substances are petroleum jelly mixed with oil, paraffin and stearic acid.

e) Facing sand

It is fresh and specially prepared moulding sand which covers the pattern all around it, thus forms the face of the mould cavity. It comes in direct contact with the molten metal being poured; hence it should possess much improved properties than other sands. Its use reduces the mould material cost. Various facing materials are plum bags, graphite, talc, molasses, etc.

f) Backing sand

It is the sand which backs up the facing sand and does not come in direct contact with the pattern. This sand has black colour and hence, sometimes called as black sand. It should be cleaned off the foreign matter like fins, nails, etc. before use. It is the floor sand which can be used again and again.

1.9.3 Characteristics of Moulding Sand

Moulding sand is used to produce sound castings. Hence, it should possess following desirable properties:

1. Flowability or plasticity

It is the ability of the moulding sand to get compacted to a uniform density. It assists moulding sand to flow and pack all-around the pattern and take up the desired shape. It increases with the amount of clay and water.

2. Green strength

It is the strength of the sand in the green or moist condition. A mould which has adequate green strength will retain its shape and does not distort or collapse, even after the pattern has been removed from the moulding box. It helps in making and handling the moulds. If the mould is hardened in contact with the pattern surface with adequate green strength, then high degree of dimensional accuracy and stability can be obtained.

3. Dry strength

It is the strength of the moulding sand in the dry state. A sand must have sufficient dry strength to withstand erosion of the mould walls and enlargement of mould cavity during the flow of molten metal. It is related to grain size, binder and water content.

4. Permeability or porosity

Molten metal always contain some amount of dissolved gases which are evolved when the metal solidifies. Also, when the molten metal comes in contact with moist sand, it generates steam or water vapour. If these gases and water vapour generated by moulding sand do not find opportunity to escape completely through the mould, then they will form gas holes and pores in the castings. Hence, the sand must be porous to allow the gases and steam generated within the moulds to be removed freely. This property of sand is known as permeability or porosity.

5. Refractoriness

It is the ability of moulding sand to withstand high temperatures without fusion, cracking and buckling, hence facilitating a clean casting. The amount of this property depends upon the metal which is to be cast. If sand lacks this property, then it slags on the surface of the mould and smooth casting surface can be obtained.

6. Adhesiveness

It is the property of moulding sand because of which it is capable of adhering to the surface of other materials. Also, with this property gaggers are able to hold bulky sand projections of the mould. Due to this property, the heavy sand mass is successfully held in a moulding flask and manipulated as required, without any risk of its falling down.

7. Cohesiveness

It is the property of the sand due to which sand particles stick together. This property helps in withdrawing the pattern from the mould without damaging the mould surfaces and edges. Due to cohesiveness, the mould faces get adequate strength to withstand the pressure of the flowing molten metal and do not get washed under this pressure. This property is similar to the green strength. It depends upon the grain size, clay and moisture content.

8. Thermal stability

To avoid breaking, buckling and flaking off of mould surface at higher temperatures, sand possess dimensional thermal stability. If not, the casting may have defects like cuts and washes.

9. Collapsibility

It is the property due to which the sand mould automatically collapses after freezing of the casting, to allow the free contraction of the metal. If this property of the sand is absent, then the casting will result in tears and cracks.

1.9.4 Constituents of Moulding Sand

The main constituents of Moulding are

1. Sand 2. Binder 3. Additives 4.Water

1. Sand

The sand which form the major portion of the moulding essentially a silica grain. It is river sand which is used with or without washing. The shape of the grains may be round, sub angular, angular or very angular. The shape and size of the grains have more void space between the grains which increase permeability, whereas a fine grain lowers the permeability. Silica sand, with rounded grains, gives much better compatibility as compared to angular grains, because sand with rounded grains has the greatest degree of close packing of particle.

2. Binder

Moulding sand binders are refractory as compared to moulding sand. Binders produce cohesion between the moulding sand grains in the green or dry condition. They give strength to the moulding sand so that it can retain its shape as mould cavity. If the amount of binder increases, permeability of moulding sand decreases. The most commonly used binders are as follows:

- Organic binders
- Inorganic binders

Organic binders are mostly used for making. The common binders in this group are

a) Linseed oil b) Dextrin
c) Molasses d) Pitch

Commonly used inorganic binders are clay, sodium silicate and Portland cement. Clay binder which is most widely used have following types

a) Bentonite b) Fire clay c) Limonite d) Ball clay e) Kaolonite

Out of these clay binders, bentonite most commonly used.

3. Additives

The basic constituents of moulding sand mixture are sand, binder and water. Materials other than the basic ingredients are also added to the moulding sand mixtures in small quantities for the following purposes

- To enhance the existing properties.
- To develop certain other properties like resistances to sand expansion defects, etc.

The most commonly used additives are as follows:

a) Coal dust

It is mostly used in the sand for the grey iron casting. It reacts chemically with the oxygen present in the sand pores and thus, produces a reducing atmosphere at the mould metal interface and prevents oxidation of the metal. It reduces cohesiveness and strength of the sand.

b) Sea coal

It is a finely ground soft coal and is widely used in sands for grey iron castings. It restricts the movement of the mould wall and improves surface finish. It reduces hot strength and permeability of the mould and requires more amount of water in the sand.

c) Cornflour or cereals

It promotes wall movement of the mould by being volatized by heat and reduces expansion defects. It improves the strength, toughness and collapsibility and reduces permeability and flowability of the sand. Its proportion in the sand varies from 0.25 to 2.0%.

d) Silica flour

It increases hot strength and decreases metal penetration into the mould. It reduces expansion defects and improves surface finish. It may be added upto 35%.

e) Wood flour

It promotes wall movement of the mould. It reduces expansion defects; increases collapsibility; improves surface finish and thermal stability of the mould. It may be added from 0.5 to 2.0%.

f) Pitch

It increases hot strength and surface finish on ferrous casting. It is added upto 2.0%; if higher proportion is added it reduces the green strength.

g) Fuel oil

It is added to reduce the requirement of the free water in the sand.

h) Dextrin and molashes

Its addition increases the dry strength of the mould. It is almost similar to cornflour.

4. Water

The amount of clay added to the moulding sand will not give the required strength and bond, until a suitable quantity of water is mixed with it. The amount of water may vary from 1.5 to 8.0%. Water added to the sand mixture partly gets absorbed by clay and partly remains free, which is called as free water. The free water acts as a lubricant and affects following properties:

- It increases plasticity.
- It improves mould ability.
- It reduces the strength of the sand mixture.

For given amount of clay and its types, there is an optimum requirement of the water. If the amount of water is less, it does not develop proper strength and plasticity, whereas if water content is more, then it results in excessive plasticity and dry strength.

1.10 Sand Preparation and Conditioning

The best selected sand and binders will not produce good casting, until they are properly and efficiently mixed and prepared. Sand preparation means mixing the moulding sand ingredients such as sand, binder, moisture and other additives. Mixing can be done manually or by using mechanical mixers. An operation in addition with sand preparation is called as sand tempering, which is a process by which adequate amount of moisture is added to the moulding sand to make it workable. Sand conditioning consists or preparing of the moulding sand, so that it becomes suitable for moulding purposes.

Functions of sand preparation and conditioning

The functions of sand preparation are as follows:

To develop optimum properties in the moulding sand.

To obtain even distribution of sand grains throughout to bond.

To add suitable amount of water to activate clay binder.

To deliver sand at the suitable temperature.

To remove impurities from the moulding sand.

Steps involved in preparation of sand

Remove all the impurities and underirable matters such as nails, fins, hard sand lumps, etc.

With the help of mechanical mixer i.e. Muller, start the mixing of sand ingredients in dry state.

Temper the moulding sand ingredients and continue mixing or mulling action till there is a uniform distribution of the ingredients.

Then the sand is treated by an Aeration Process which separates sand grains into individual particles.

Aerated sand is easy to handle and use and provides better moulding results.

Aeration is achieved by power operating riddles, screening, beating the sand or by passing the sand stream over toothed belt.

To avoid difficulites in mould making, sand is cooled below 37ºC.

Working of Muller

A continuous mixing or mulling action is very much required for mixing sand, binder and moisture thoroughly.

It is carried out by using hand shovels or mechanical mixers i.e. Muller.

Hand mulling is suitable for natural sand but not for synthetic sand.

A muller kneads, shears, slices through and stirs the sand with the help of revolving wheels or rollers.

During the process two wheels along with two plows roll and rotate in a circular path about the horizontal axis.

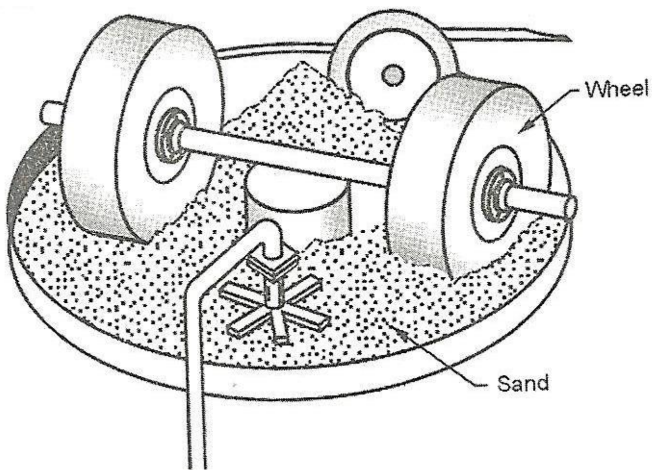

Figure 1.14 Moulding sand muller

Wheels either rest on the sand or remain about 5 mm to 10 mm above the base of the rotating pan.

The wheels may move with the stationary held pan or the wheels may be mounted rigidly with the rotating pan. Refer Figure1.14.

Plows stir the sand and bring it under the wheels, whereas wheels mix the sand with a squeezing action.

After mixing of the sand, it may be taken out from a drop door, which is provided at the bottom of the muller.

1.11 Sand Testing

Production of sound casting mainly depends upon uniform and good quality of moulding sand. Hence, the moulding sand is expected to have many good properties. These properties depend on the shape and size of sand grains and the amount and distribution of the other constituents added to the sand. In order to control these factors effectively, a number of tests are performed in foundary laboratories, which indicates the moulding sand performance and helps the foundrymen in controlling the moulding sand properties. Some of the common tests which are performed in the foundry laboratories are as follows:

1. Moisture content test
2. Clay content test
3. Permeability test
4. Grain fineness test
5. Mould hardness test
6. Refractoriness test
7. Compression strength test

Sample preparation

The tests are conducted on a sample of standard sand. The samples are prepared by ramming sand in a specimen ram tube on sand rammer. The shape of the sand samples varies as per the nature of the test. Various sand samples used in testing are:

- Cylindrical green sand sample, for testing compressive and shear strength and permeability.
- Dry sand core specimen for bending test and tensile strength test.

1.11.1 Moisture Content Test

Moisture is one of the most important factors which control the properties of moulding sand.

Low moisture in the moulding sand does not develop strength properties and high moisture decreases permeability and adds to other problems associated with moulding operations.

The moisture content test is carried out by using separate moisture determining apparatus.

It consists of a cost iron base, an infrared heating bulb fitted in a shade and a drying pan with handle. Refer Figure 1.15.

Procedure

20 to 40 grams of prepared sand sample is placed in the pan.

The pan is slided and fitted under the shade and the bulb is switched on.

It is heated by an infrared heater bulb for 2 to 3 minutes.

The moisture in the moulding sand is thus evaporated.

The switch is put off; pan removed and sample is reweighted.

The percentage of moisture can be calculated from the difference in weights of the original moist and the consequently dried sample of the sand.

It is then expressed as a percentage of the total weight of the sand sample.

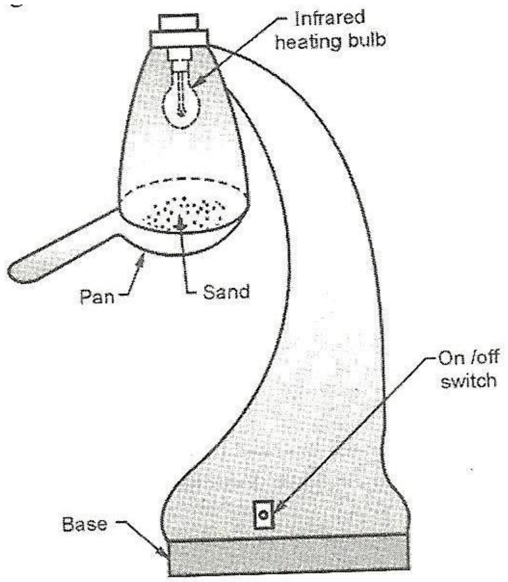

Figure 1.15 Moisture Determining Apparatus

1.11.2 Clay Content Test

For testing purposes the clay in the moulding sand is defined as particles which fail to settle one inch per minute when suspended in water.

These are generally less than 20 microns.

The apparatus used for the purpose is called as mud or clay content tester.

It consists of a cast iron base, stirring shaft with paddles driven by an electric motor and an adjustable support for the glass beaker.

Procedure

Take a sample of 50 grams of dry sand which is dried at 105ºC for an hour.

Place a sample in a wash bottle and add 475 ml of distilled water and 2.5 to 3% of NaoH.

Stir the contents for 5 minutes using stirrer.

Fill the wash bottle with water upto the mark indicated on it (generally 6 inches).

After the sand, etc. has settled for about 10 minutes, siphon out the water from the wash bottle, which leaves a minimum depth of water i.e. one inch in the bottom of the wash bottle.

Add more water to the sand thus left in the was bottle and stir the constituents again till the sand settles down.

Repeat the above step until the water over the settled sand is clean, which assures that the whole amount of clay has been removed from the sand.

The bottle is placed in an oven and after the sand is dried out, a sample is weighed.

The percentage of the clay is determined by the difference in the initial and the final weights of the sample.

1.11.3 Permeability Test

Permeability is that property of moulding sand which permits the escape of water vapour (steam) and other gases generated in the mould during hot metal pouring.

- Permeability depends on the following factors:
- Grain shape and size
- Grain distribution
- Binder and its contents
- Water amount in the moulding sand
- Degree of ramming

Before permeability test, a standard sized sand specimen is rammed by a specimen rammer. For measuring the permeability of sand, a permeability tester is used which consists of following parts (Refer Figure1.16)

- An inverted bell jar, which floats in a water seal and it can permit 2000 c.c. of air to flow.
- Specimen tube for holding the sand specimen.
- A monometer for measuring air pressure.

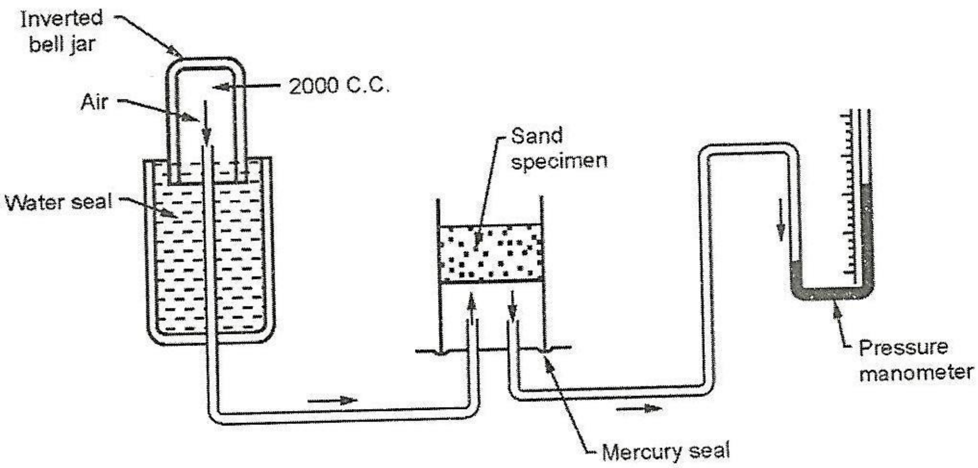

Figure 1.16 Permeability Tester

Procedure

2000 c.c. of air is held is an inverted bell jar and forced to pass through the sand specimen.

A situation comes when the air entering in the specimen is equal to the air escaped through the specimen.

It gives a stabilised pressure reading on the manometer and it can be read on the provided scale.

At the same time, the time required for the 2000 c.c. of air to pass through the specimen of sand is recorded by using stop watch.

Finally, calculate the permeability by using following relation:

Permeability Number = ——

Where, V = Volume of air passing through the specimen in c.c.

(standard values is 2000 c.c.)

h = Height of the specimen (standard value is 5.08 cm)

a = Areas of the specimen in cm^2 (standard value is $20.268 cm^2$)

P = Air pressure is gm/cm2

t = Time taken by 2000 c.c. of air to pass through the sand specimen in minutes.

Permeability number = ———— ——

1.11.4 Grain Fineness Test

This test determines the grain size, distribution and grain fineness.

It is performed on the dried sample for which all clay substances have been removed.

The grain size of moulding sand provides a significant effect on it permeability.

The apparatus required for determining grain fineness number is show in Figure 1.17.

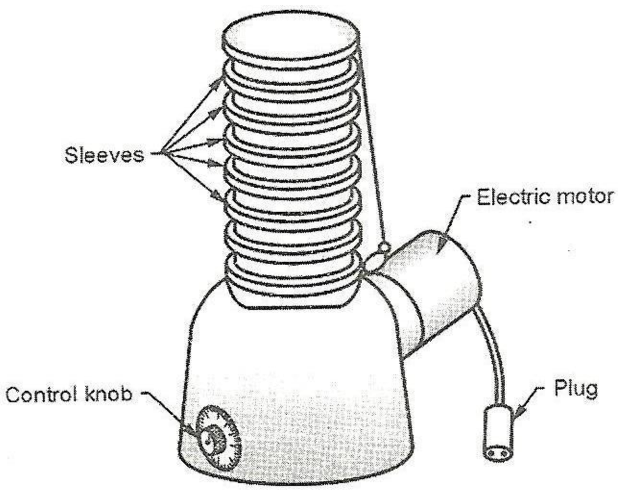

Figure 1.17 Grain Fineness Tester

It consists of a number of standard sleeves mounted one above the other on a power driven shaken.

There are eleven standard sleeves mounted one above the other and a pan is placed under the bottom – most sieve.

The coarsest sleeve is placed at the top and finest sieve at the bottom.

The rest being placed below one another in order of fineness from top to bottom.

The whole unit is shaken by an electric motor.

The sample of dry sand, which is free of clay, is placed in upper-most sleeve and sand is vibrated for definite period of time.

The amount of sand retained on each sleeve is weighed and percentage distribution of grains is found.

To obtain the American Foundry Association (AFA) fineness number, the weight of sand on each sleeve and pan is multiplied by a factor shown against each sleeve and pan as show in the table1.2.

The grain fineness number is obtained by adding all the resulting products and diving the total by percentage of sand grains retained.

AFA grain fineness number

= ——————————————

Table 1.2 AFA Fineness Calculations

Mesh	6	12	20	30	40	50	70	100	140	200	270	Pan	Total
% retained	0	0	0	2.0	2.5	3.0	6.0	20.0	32.0	12.0	9.0	4.0	90.5
Multiplier	3	5	10	20	30	40	50	70	100	140	200	300	
Product	0	0	0	40.0	75.0	120.0	300.0	1400.0	3200.0	1680.0	1800.0	1200.0	9815.0

Grain fineness number = ——

1.11.5 Compression Strength Test

The compression strength testing apparatus for sand is shown in Figure1.18.

It consists of hand wheel which is rotated to build up the hydraulic (oil) pressure on the specimen.