Chapter Three

BASIC CHARACTERISTICS

The basic requirements of foundry sands are availability at low cost and ability to take the shape of the pattern easily by ramming, jolting, slinging, etc. They should also retain the shape of the pattern when the latter is withdrawn. In most of the cases, moulding sands meet these requirements, but in certain cases, aiding by rods, springs, nails, grids, etc. may be necessary. Ability to withstand the weight and flow of metal is also an important requirement of these sands and in more than 50 per cent cases, moulding sand is capable of retaining the weight while in others it may need aiding by drying of the mould, by use of springs or by holding the mould in flasks or jackets to stand the weight and flow of metal. The sand should also be permeable to gas and air, i.e. it should allow easy escape of the gas generated in the mould when molten metal is poured. Steam is produced in most cases. A cubic centimetre of water roughly releases 1500 ml. of steam at 100°C. and double that at 373°C.

Though moulding sands fulfil these conditions in most cases, still in the case of some sands, additional aids like feeders, venting, embedding of the mould or core with coke or cinder to help the gases to escape are required. To prevent fusion of the sand grains to the casting when molten metal is poured, the sand should be refractory ; the degree of refractoriness required in foundry sands naturally depends upon the type of metal cast. In the case of light alloys and non-ferrous alloys, the metal can be poured directly into the mould whereas with steel and other high melting alloys refractory facing materials may be necessary to prevent sand from burning on to the castings. The sand should have the minimum of thermal expansion as it is difficult to control it especially in the case of silica sands ; if not controlled it may give rise to scabbing and other surface defects. Durability is also an important factor. A sand which gives more weight of castings per unit weight of sand than another is more economical to use.

While the chemical composition of a sand gives an idea of the impurities like lime, magnesia, alkalies, etc. present, and hence the refractoriness of the sand, the primary factors which determine the working properties of a sand are related to the size, shape, distribution and surface characteristics of the sand grains and the mineralogical composition of the sand grade and clay bond, present in the natural form or in admixture in synthetic sand mixtures. Hence, a full appreciation of the influence of various factors on the properties of sands is necessary for preparing the sand mixture to suit the job on hand.

Grain Size Distribution

The size of sand grains and their distribution are of fundamental importance in controlling the properties of sand mixtures which ultimately influence the surface finish of the casting produced. Finer the sand grains, smoother is the finish within certain limits, although fine grained sands require greater percentage of bond addition due to increased surface area. Optimum size grading is, therefore, important to ensure satisfactory results and generally foundrymen prefer the use of a sand of the smallest grain size that gives the required permeability.

The average size of the sand grains computed on the basis of the percentage distribution of sand grains by the A.F.S. method gives the grain fineness number of the sand. However, this number is in no way an index of the distribution of the sand grains. Sands having the same grain fineness number need not be of the same grade. A sample of sand with higher proportion of the coarse fraction which is considered undesirable for good surface finish, and another one having too high a proportion of fines which lowers the permeability, can have the same fineness number as another sand which has neither a preponderance of coarse particles nor of fines. Hence, a more reliable method for assessing the suitability of a sand sample from the point of view of size distribution is to plot percentage values (by weight of sand) retained on sieves of different mesh sizes as cumulative grading curves. The nature of the cumulative grading curve is independent of the type of standard sieves used. Thus, both the British Standards Institution and United States sieves (Taylor sieves) give similar type of curves, provided sufficient number of sieves are used in each case. Sands with well defined grading with cumulative percentage of 70 per cent and above retained by three or four adjacent sieves are considered satisfactory from the point of view of grain fineness.

Grain Shape

The shape of the sand grains also influences the moulding characteristics of a sand. The shape varies from round to angular. Whereas in some sands, almost all the grains are of one type, in others, grains of varying shapes are present. From the point of view of grain shape, foundry sands are classified into four types: angular, sub-angular, round and compound. Round grains have least contact with one another in a rammed mixture and therefore, produce moulds which may lack the strength of those made from sands having sub-angular grains. Further, moulding sands composed of angular grains need higher amounts of binder and moisture. Compound grains also need higher amounts of binder and moisture. Compound grains composed of mixtures of angular, sub-angular and round grains are least desirable in sand mixtures because of their tendency to disintegrate at high temperatures.

Permeability

Very few of the moulding sands used in the foundry are obtained from one source. Generally, mixtures of two or more sands are used. Thus, natural moulding sands are always blended with sands appreciably free from clay grade matter to secure the desired permeability. Even in synthetic sand practice, core sands always get mixed up with the system sand. In these cases, it is important to bear in mind the effect of addition of sands of different grain sizes as the permeability is adversely affected by the addition of sand grains of critical grain size. If sand grains of diameter equal to two-fifth of the diameter of the grains of the base sand are added to the base sand, permeability will not be affected. In blending sands, attention should, therefore, be paid to the permeability of the base sand also and not to its strength alone.

Strength

The strength of a moulding sand depends greatly on the surface area of the sand grains available for bonding. Fine grained sands present more surface area than coarse sands and can develop higher strength but more clay is required for bonding the sands.

Considerations of the surface area of the sand grains show that in case the percentage of clay added to a sand is sufficient to cover all the sand grains, the area of contact is the same irrespective of the sizes of the grains. However, if the percentage of clay added is fixed, sands of coarser grains will exhibit greater strength than the finer grained sands due to increase in the surface area of the sand grains, as in the latter case, the bond may be insufficient to cover the sand surface completely. However, if the amount of clay bond added is increased beyond that required to cover the smaller grains, sands of smaller grains by virtue of greater surface area will give more strength. In the case of core sands bonded with oil, the percentage addition of oil is always on the lower side and hence coarser sands give a definitely marked increase in strength as compared to sands of finer grain size. Even in this case, if the quantity of oil added is increased beyond the limit required for the increased surface area of the smaller grains, sands of smaller grain sizes will exhibit higher strength than coarser ones.

Angular sands give better strength in compression as compared to sands having rounded grains. The latter sands, however, give higher strength under tension and also possess higher permeability if they are of uniform sizes as compared to angular sands. Round grains are preferred to angular grains on the basis of permeability and consistency of strength. It should, however, be borne in mind that round grains of uniform sizes can give expansion troubles.

On the basis of experiments on British foundry sands, Davies concluded that the average strength of angular sands is much lower than that of the round grained sands. This is mostly due to difference in grain shape and partly due to variation in bulk density gradients*. If equal amount of bonding clay is

* By bulk density is meant the ratio of a known weight of sand to the volume occupied by it.

added to two samples of sand graded to be similar on the basis of their specific surfaces, the angular sand will still have much lower strength than the rounded sand. The depressing effect of grain shape may be minimized in several ways such as widening the grading, reducing the density gradient by a suitable choice of bond, so as to improve both strength and bulk density gradient.

Refractoriness

The size distribution and purity of sand grains also influence their refractoriness. Fine grains get fused more easily than coarser ones. Where maximum refractoriness is required, as in steel moulding, coarse, high purity silica sands with the optimum degree of fineness required for surface finish are used with advantage.

Surface Texture

Surface texture is also important as grains of rough texture show increased strength for the same percentage of bond addition without impairing permeability. In natural moulding sands, most of the sands contain iron oxide which imparts roughness to them. In the case of synthetic sands, during repeated use, the grains get roughened and, therefore, give better strength as compared to new system sands.

Keeping in view the above requirements, various tests on foundry sands and bonding clays were carried out. The results of these tests will enable one to process sand mixtures and correlate the defects encountered in the castings due to sand and to maintain a particular set of properties in a foundry sand mixture which will eventually help to produce good castings. By no means can it be guaranteed that sand control and sand testing will eliminate defects in castings as the other variables involved in producing successful castings, namely condition of the metal, its composition, design of the casting, etc. play a significant part.

REFERENCES

1. DAVIES, W.—*Foundry Sand Control* (United Steel Co., Sheffield), 1950.
2. MARECK, CLARENCE, T.—*Fundamentals in the Production and Design of Castings* (John Wiley & Sons, New York), 1950.