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1. The importance of suitable moulding sand to a Foundry cannot be over-emphasised. The gradations and composition of sand contribute to a large extent to the success of the castings, in particular when the item cast is to be of a high standard having excellent finish at both outer and inner surfaces. To O.F.M. which is essentially a Steel Casting Factory, the problem has had been two-fold, firstly the location of a suitable nearer source of silica sand to avoid transportation difficulties which often cause breakdown in supplies, and secondly the establishing of a source of sufficient quantity having a suitable and consistent grading so as to adopt it on a permanent basis. This article does not claim to present any extensive research work or any original finding, but simply tries to put forth this problem with all its implications and the effects made to overcome it.

2. This Factory had a major disadvantage in its being far away from any developed sources of suitable Silica Sand for Steel Castings. From 1944 till 1946, an extensive exploration was made by us in collaboration with the Directorate of Supply and the Archaeological Department. During this period particulars of sources known to most of the Founderers in India were obtained with a view to find suitable as also nearer sources of supply, with no satisfactory results. Samples were also collected and analysed from and round about Delhi area but none of the sources yielded sand of any appreciable quality or quantity. The chief constituent of Foundry Sands is quartz (silica). Other minerals present are usually compounds of silica with alumina and complex minerals containing lime, Magnesia, oxides of iron and alkaline earths in varying proportions. Those sands containing more or less natural bonding clay comprise the natural moulding sands, whilst the clay-free sand usually termed sharp silica sands, are the basis of synthetic moulding sands and oil sands used in the foundry for moulding and core making. In June last year, again some search was made and a quarry located near Delhi cantt. Samples were obtained and analysed and the sand was found to be of the following gradation and composition :

gradation—

Over 30 mesh	18%
72 mesh	0·45%
100 mesh	29%
200 mesh	8%

composition—

Loss on ignition	0·10%
SiO_2	95·20%
Al_2O_3	3·5%
Fe_2O_3	0·2%
MgO	Trace
Other Alkalies	0·2%
CaO	0·8%
	100·00%

3. The gradation and composition of this sand was quite satisfactory but the grains were of a round type with the result that the grain strength was low and permeability very high. This sand could not be used for making cores for the casting of Trench Mortar Bombs. However, this sand was mixed with our old sand in the following composition. Satisfactory results were obtained in the making of steel moulds for general castings of medium size which are in use at this Factory.

composition—

New Sand	44·5
Old Sand	44·5
Bentonite	5·0
Water	6·0

The result was :

Moisture	6·5%
Green permeability	180
Green compression strength	7·1 lbs. per sq. inch.
Dry permeability	230
Dry compression strength	90 lbs. per sq. inch.

Core-making sand must possess :—

1. Excellent green strength ;
2. High dry and baked strength ;
3. Satisfactory permeability ;
4. Resistance to high temperature ; and
5. Thermal shocks and ability to form a good skin and satisfactory collapsability.

We use oil bond sand for making cores and this sand was very unsuitable for this purpose, the green strength being very low and the permeability high due to round grains. A mixture was made with following composition :—

Sand	100 grams.
Dextrine	4%
Linseed Oil	2·5%

Results are :—

Moisture	0·6%
Green permeability	650
Green compression	1·3 lbs. per sq. inch.
Dry permeability	700
Dry compression strength	850 lbs. per sq. inch.

Bombs cast with this had a very rough inside surface due to the above defects. The only satisfactory source on which we have been

depending so far is Jubbulpore. At present we are using sand supplied by a Jubbulpore firm, with an average gradation as follows, but there is a wide variation in supply from time to time :—

Over 30 mesh	12 to 20%
72 mesh	35 to 40%
100 mesh	20 to 30%
Through 100	18 to 25%

4. Sand at present received contains a high percentage of dust and it has been used by dedusting it upto 10 per cent. approximately. The following composition was used :—

Sand	96%
Dextrine	2%
Linseed Oil	2%

Results were :

Moisture	1·5%
Green permeability vary between	200±50
Green compression strength	3·0±·5
Dry permeability	300±50
Dry compression strength	200±50 lbs. per sq. inch.

The cores prepared from this sand have given results which were not very satisfactory. There was a certain number of bombs which had a very hard and rough inside, the percentage was roughly 25. During February more experiments were carried out to alter this gradation and at present a mixture with the following gradation is being used :

Over 25 mesh	16—18%
60 mesh	45—52%
100 mesh	20—30%
Through 100 mesh	6—8%

Composition :—

Sand	96%
Dextrine	2%
Linseed oil	2%

Results :

Green permeability	250±50
Moisture	1·5%
Green compression	3·5±·3
Dry permeability	350±50
Dry compression	300±50 lbs. per sq. inch.

Bombs cast with the above sand showed considerable improvement over those previously manufactured and also the number of blow holes were considerably reduced. Experiments are still on hand to try more gradations.

5. These too frequent variations in the gradations and composition of silica sand have often presented certain difficulties, especially when we cast Mortar Bombs which require a high standard of finish. Briefly I will deal with the various types of defects and the causes contributing to them. In certain cases defects arise from different factors and attempts to rectify one defect tend to increase the other type of defects. So a broad compromise has to be found.

1st Defect: Roughness of the Inner surface.

Some experiments were conducted and it was found that roughness in surface varies with the grain of sand. The bigger the grain sand, the rougher the side surface. Another factor was pouring temperature. The higher the temperature the rougher was the inside.

At present by restricting the temperature and proper gradation of sand and hard ramming we are able to get bombs with fairly smooth insides.

2nd Defect: Tail Blow holes.

This defect is caused by the escape of gas from the top of the core inside the chill and the gas generated by the core should either escape from top or through the core. There is an obstruction to gas escaping on the top as the feed link of metal is from the same side. In order to avoid this the dry permeability of the core has to be increased, so that the gas thus made could easily escape from the core. After many experiments we are now able to reduce these defects.

3rd Defect: Scabs.

The metal strikes directly with the core and there is a possibility of washing away some of the sand at the striking points causing scabs. This defect has been overcome by making the baked strength of the core high and hard ramming.

Rejections due to blow holes.

This was due to inclusion of sand in the metal. This has been reduced by increasing the dry strength of the core and sand runners.

4th Defect: Cracks.

Longitudinal cracks near the band are another cause of heavy rejections. The thickness of the wall section in this area is about 1½ times the average thickness of the wall of the bomb and the metal solidifies last in this region and thereby steel tears are developed due to the influence of contractional stresses. In order to decrease this we will have to reduce the strength of the core, but to do this will be to increase the defects No. 3 and 4. The other factor responsible for cracks is the high pouring temperature and high carbon composition of the steel. Effects are in hand to control the composition of steel and to reduce the pouring temperature but this too cannot be reduced beyond a certain limit as the casting is fairly within wall and the time for pouring about 15 minutes.

Lap marks or coal shuts.

These are due to low pouring temperature and generally occur in the bombs cast at the end of the heat. Remedy is high temperature which again increases defect No. 4.

5. A majority of the above defects will be cured if an ideal synthetic sand for the casting of mortar bombs could be found preferably near Delhi. The first step in this direction is to determine the more suitable gradations. After this is established, the formation of a synthetic sand by submitting the natural sand to suitable selective treatment will be required. This can be achieved by the help of sand grading plant. The process would be to wash the sand with a view to remove clay matter and dust particles, to dry it with the help of Rotary Drier, then to sieve it to required size by electrically help of Rotary Drier, then to sieve it to required size by mechanically vibrated screens, and finally to mix it in required proportions.

Sand selected and synthesised by such a process with careful control of moisture and standard mixing conditions, lead to a reduction in the quantity of scrap castings produced and a greater overall efficiency in operation.

Preliminary experimental work in this direction is in hand at Ordnance Factory, Muradnagar and once the requisite machinery is obtained and installed the problem is expected to be solved to a large extent.