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Effect of Grain Fineness of Moulding Sand on the Properties of Metal Casting

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ABSTRACT

Most of the foundry shops in Bangladesh do not control the grain fineness of moulding sands and for this reason, the quality of the casting does not improve. In order to give conclusive recommendations for the foundries producing various castings, a project of this type has been undertaken. To this end, sands with varying grain fineness number have been collected from different foundry shops and various laboratory tests have been performed in the Department. Results of the experiments show that sands with fine, medium and coarse grains produce the best combination of physical and mechanical properties for castings with Aluminium, Brass and Cast iron respectively.

INTRODUCTION

Sand is one of the principal moulding materials used in the foundry shop to produce casting, irrespective of whether the cast metal is ferrous or non-ferrous. The grain fineness of the moulding sand has tremendous effect on the permeability and compressive strength of the moulding aggregate, and as such, it affects the properties of the casting. Therefore, selection of appropriate grain fineness of the moulding sand to produce good casting is imperative.

Bangladesh foundries usually do not control the grain fineness of the moulding sands and for this reason, quality of the casting does not improve. In order to give them conclusive recommendations, a project of this type has been initiated in the Department. To this end, sands with varying grain fineness number have been collected from different foundry shops and various laboratory tests have been carried out.

EXPERIMENTAL DETAILS

(a) Collection of Moulding Sands: In order to carry out experiments in the present study, different grades of moulding sand from Adamjee Jute Mills, Bangladesh Machine Tools Factory, Gulzar Metal Industry and BUET Central Foundry Shop, were collected. Bentonite, the best quality bonding clay was collected from Adamjee Jute Mills (which had been imported from Japan).

(b) Performance of Different Tests: After collecting the moulding sands from different sources, these were washed, cleaned and dried. The determination of A.F.S. grains fineness number of different sands were then measured by Tylors Sieve Shaker and were found to be about 60, 90, 120 and 150. The determination of moisture content, estimation of clay content and grain shape configuration were also performed in the laboratory using standard test procedure.

Four separate moulding aggregate were prepared with the sands having different grain fineness number. Each aggregate consisted of natural sand, 12% bonding clay (imported bentonite), 1.5% coal dust to which 5-6% water was added. Then A.F.S. standard test specimens were prepared with these aggregate and moulding properties for different aggregate were determined.

(c) Melting and Casting: Commercially pure Aluminium, Brass (80% cu, 20% Zn) and cast iron were melted in a natural gas fired pit furnace using graphite crucible. Aluminium was super heated to about 725°C and poured at 700-710°C[Haque et al (1985)]. Brass was super heated to about 1100°C and poured at 1080-1090°C [Haque et al (1989)]. Cast iron was super heated to about 1350°C and poured

at 1300°C. The temperature was measured with the help of degital thermometer which gave a direct reading of ± 2°C accuracy.

Molten metals and alloys were poured in all the moulds prepared with sands of different fineness number. After few minutes, the moulds were broken and each casting was individually marked for identification.

(d) Determination of Tensile Properties: Tensile testing of different castings were performed with a 24 kg Hydraulic tensile testing machine fitted with a screw type operating cylinder using 15 kN scale. The standard 0.25 inch (6.25mm) diameter round test specimen was used for tensile testing. The U.T.S. in Newtons/mm^2 and percentage elongation were obtained and the results were averaged from two determinations.

RESULTS AND DISCUSSIONS

The results of the various tests such as determination of moisture content, clay content, grain shape, A.F.S. fineness number of the sand, moulding properties of the sand aggregate are summarised and shown in different tables below:

It can be seen from table-1 that the percentage moisture content and clay content of the sands of different origin are within the range available in the literature [Heine et al (1976)]. The grain shapes of the sands are of subangular variety but the percentage should have slightly higher. Since good moulding properties are obtained with subangular grains [Annual Handbook of ASTM Standards (1979)], therefore the properties obtained with these sands should be at least comparable. It can be seen from table-2 that the green compressive strength of the moulding sand increases with increasing grain fineness number but the permeability decreases.

The surface appearance and tensile properties of aluminium, brass and cast iron castings made with the sand aggregate containing sands of different fineness number are shown in Table 3, 4 and 5 respectively.

Table 1: Miosture content , Clay content and Grain shapes of sands of different origin

A.F.S. Fineness No.	Moisture content (%)	Clay content (%)	Grain Shapes			
			Sub angular (%)	Angular (%)	Round (%)	Compounded (%)
F.No. 60	1.30	1.60	70.0	5.0	10	15
F.No. 90	1.40	1.70	67.5	7.5	12	13
F.No.120	1.35	1.80	66.0	8.0	13	13
F.No.150	1.30	2.10	68.0	8.0	14	10

Table 2: Moulding Properties of Sand Aggregate

Test sample, made with various fineness No.	Green compressive strength (psi)	Permeability
Fineness No. 60	3.20	50
Fineness No. 90	4.64	41
Fineness No. 120	5.30	33
Fineness No. 150	6.10	25

Table 3: Surface appearance and tensile properties of aluminium, as-cast condition

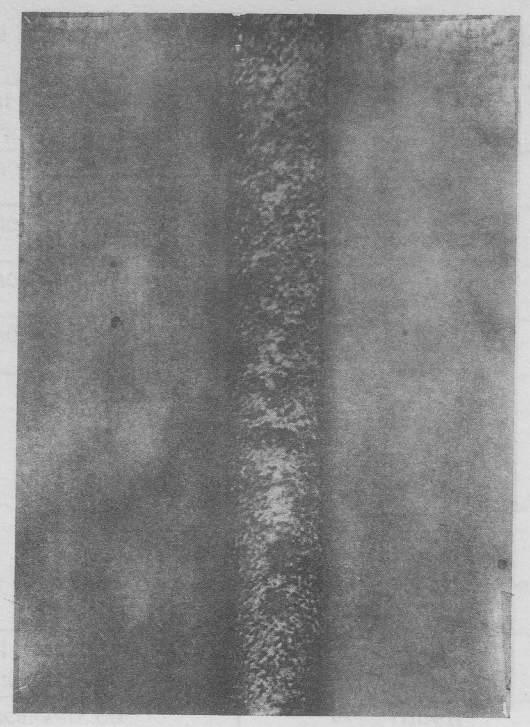
Test bars made with various fineness No.	Surface appearance	UTS (psi)	Elongation (%)
Fineness No. 60	Vey rough	4875	12.7
Fineness No. 90	Moderately rough	5700	16.1
Fineness No. 120	Moderately smooth	6925	22.0
Fineness No. 150	Smooth	7900	27.0

Table 4: Surface appearance and tensile properties of brass, as-cast condition

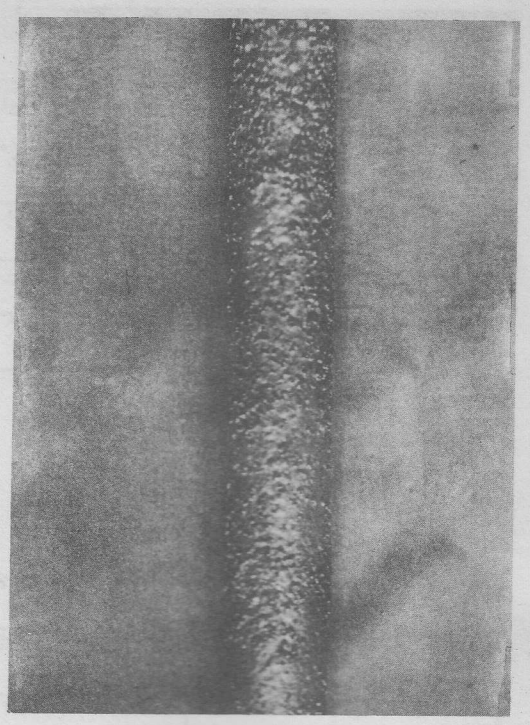
Test bars made with various fineness No.	Surface appearance	UTS (psi)	Elongation (%)
Fineness No. 60	Very rough	18500	1.5
Fineness No. 90	Moderately rough	23800	22.8
Fineness No. 120	Moderately smooth	25000	26.0
Fineness No. 150	Very smooth	28800	30.0

Table 5: Surface appearance and tensile properties of cast iron, as-cast condition

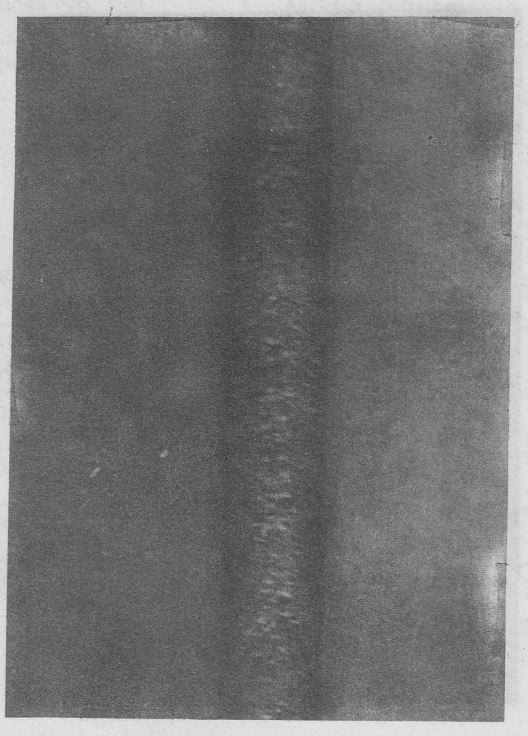
Test bars made with various fineness No.	Surface appearance	UTS (psi)	Elongation (%)
Fineness No. 60	Not smooth	31000	1.5
Fineness No. 90	Not smooth	20000	1.0
Fineness No. 120	Moderately smooth	15000	nil
Fineness No. 150	Smooth	12000	Nil



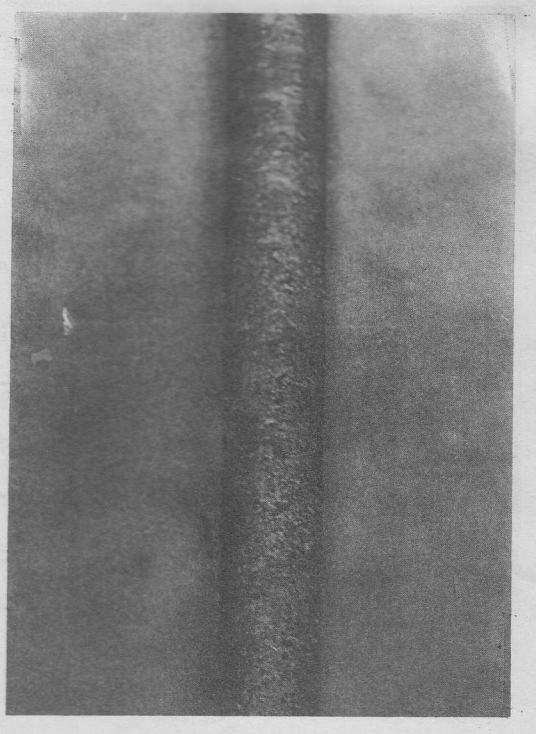
a. Cast in Sand fineness No. 60



b. Cast in Sand fineness No. 90

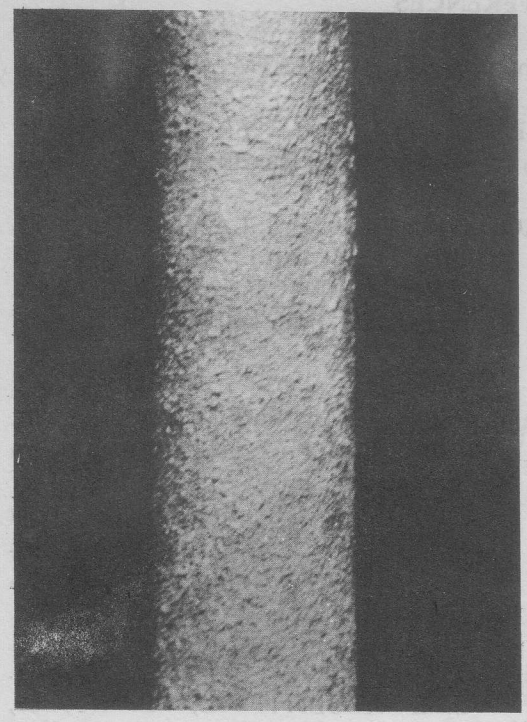


c. Cast in Sand fineness No. 120

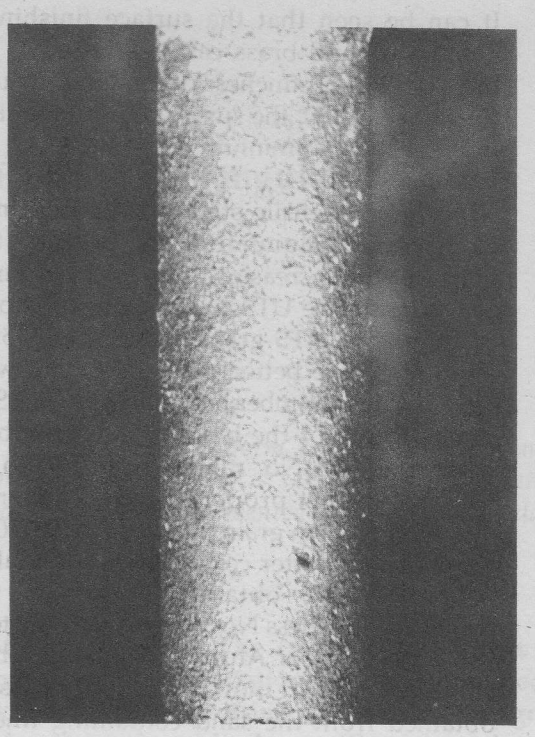


d. Cast in Sand fineness No. 150

Fig. 2: Shows the surface appearance of brass castings.



a. Cast in Sand fineness No. 60



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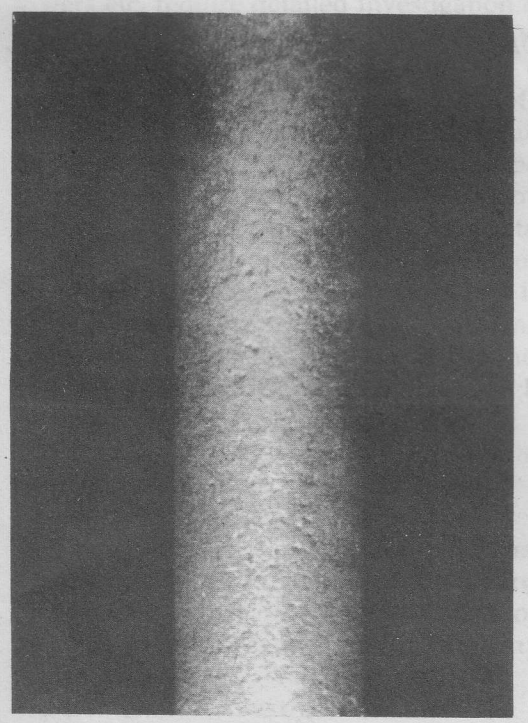
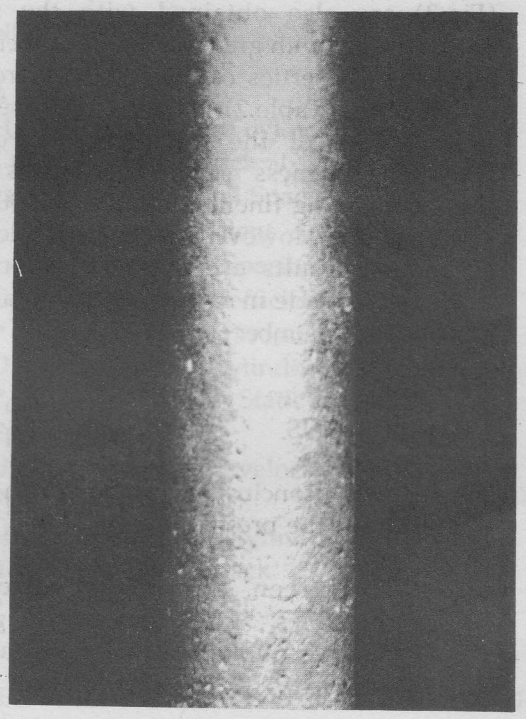


c. Cast in Sand fineness No. 120



d. Cast in Sand fineness No. 150

Fig. 3: Shows the surface appearance of cast iron castings.

It can be seen that the surface finishing of aluminium and brass castings improve with increasing grain fineness of the sand. By using fineness No. 150, the surface finishing of brass is better than aluminium (Figs. 1 & 2).

The ultimate tensile strength and percentage elongation of aluminium and brass castings increase with increasing grain fineness number of the sand. The UTS and % elongation of the casting using AFS grain fineness No. 150 for aluminium are better than the others which have fineness number below 150. The UTS and % elongation of the brass castings are better when the AFS No. ranges from 120 to 150, whereas these properties are higher for aluminium when grain fineness No. is 150. For brass casting better combination of moulding properties are obtained from the sand containing fineness No. ranges from 120 to 150 [Roast (1953)]. For Aluminium castings, better combination of moulding properties are obtained from the sand containing fineness number above 150 [Burns (1989)].

The smooth casting surface of cast iron bars (Fig.3) are also obtained with the sand moulds made with grain fineness number 150. Here the properties of the test bars are not satisfactory (Table.2). This is because the permeability of the moulding aggregate containing fineness number 150 is less than those containing fineness number 60, 90 and 120. (Table 2) However, the comparable and acceptable results are obtained when the castings are made in sand moulds containing grain fineness number 60.

CONCLUSIONS

The following conclusions can be drawn from the results of the present investigation:

1. The green compressive strength increases with increasing grain fineness number but the permeability decreases.

2. The surface finishing and the tensile properties of aluminium, brass and cast iron test bars cast in sand moulds having grain fineness number 150, 120-150 and 60 respectively show better properties than those cast in sand moulds containing other fineness numbers.

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