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EXPERIMENTAL SIMULATION OF PARTICULATE DISPERSION IN SAND-WATER SLURRY SYSTEM IN MECHANICALLY AGITATED METALLURGICAL VESSEL

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Simulation by dispersion of sand particles in water in an impeller stirred vessel has been carried out with a view to establish parameters for effective dispersion of dispersoids in Mg-Metal Matrix Composites by liquid metallurgy route. The effect of z-distance (height of the impeller from the base of the vessel) and rotational speed on the degree of dispersion has been studied and the results are reported in this paper.

INTRODUCTION

The study of particulate dispersion in the slurry system has gained significance in recent times with the development of technology for the production of a new series of metal-matrix composites for advanced engineering applications. This work, in particular, is undertaken with a view to optimising the conditions of dispersion for the production of Mg-SiC composites. Although there are many routes such as powder metallurgy, infiltration etc. the liquid metallurgy route is simple and economical in this regard. However, dispersion of particulates uniformly throughout the liquid metal prior to casting to shape is a problem as it depends on several parameters such as difference in densities of the particulate and the medium, pulp density and the design of the mechanism for dispersion. It is being realised that the last one plays an important role and with a suitable design a uniform dispersion can be achieved irrespective of the particulate and the liquid in chemically non-reacting system.

EXPERIMENTAL

In this paper a transparent sand-water slurry model was fabricated with an impeller stirring arrangement as shown in Fig.1. The dimensional details of the experimental set up are given in Table I. Since a transparent liquid with the same density and viscosity as that of molten Mg is not available, water has been chosen as a medium of dispersion for the present study. The dispersoid chosen is high purity silica sand of size distribution in the range 100-25 μm. Water has a viscosity of 0.894 Cp at 25°C comparable to Mg (0.15Cp at 651°C) and density 1 g/cc comparable to Mg (1.59 g/cc at 651°C). A single stage 3-blade impeller is rotated with varying electrical power input driven through a 1/30 hp motor connected to a step down transformer. The diameters of the vessel and impeller were 55 mm and 30mm and the water level was 145mm which were kept constant at 145mm in the present studies but the height of the impeller from the bottom of the vessel was varied from 320 to 40mm. 200g of pure silica sand of particle size 100 to 250μm was introduced into 120-22mm^3 of water to make up the slurry for the present work. The power input was also varied from 12 to 18 W. The studies were conducted for different weight fractions of sand. The degree of dispersion was studied under the above conditions by collecting samples from different levels for predetermined times and weighing the samples collected after drying. Their pulp densities were also determined. Water drawn out at predetermined times was transferred back to the vessel after decanting the sand portion to maintain the constant level. An attempt was made to understand the nature of dispersion with depleting amounts of the particulates. The results of dispersion of sand particulates are discussed on the basis of the observation of pulp density profile in the impeller stirred vessel and the particle size distribution in the collected samples.

Table I Details of setup used in the present investigation

Diameter of vessel	55mm
Diameter of blade	30mm
Height of liquid	145mm
z-distance	30, 40mm
Rotation speed	300-800 rpm
Energy input	1.8W
Location of outlets from base, mm	140 (top), 100 (middle), 5 (bottom)

RESULTS AND DISCUSSION

Pulp density profile in the impeller stirred vessel

Pulp density (g/cc) collected regular intervals under the conditions listed in Table II and for a typical case is plotted in Fig. 2. The pulp density is defined as the weight of sand particles in unit volume of water. High, medium and low pulp densities are defined as 0.4, 0.2 and 0.1 fraction of sand particles in the slurry in the scope of the present work. It can be noticed that at a z-distance of 30mm the pulp density of samples from the top of the vessel remains always higher than the middle sample and the bottom sample shows closer pulp density to that of the middle layer. However, when the pulp density reaches about 0.1 an uniformity of distribution of particles is observed. When the z-distance is increased to 40mm a better dispersion density is observed at less than 0.1 pulp density showing the influence of the z-distance on particle size distribution in different zones.

Table II Details of experimental conditions

Sand Wt. (g)	Volt	Amp	Ht(mm)	zt(mm)	Observations
200	90	0.19	145	30	$TP_d >> MP_d > BP_d$
200	80	0.17	145	40	$TP_d < MP_d < BP_d$
200	80	0.19	145	40	$TP_d > BP_d > MP_d$

In Fig.3 are plotted the weight of sand particles collected for top, middle and bottom zones of the impeller stirred vessel at a z-distance of 30 and 40mm respectively. This figure also contains the profiles of weight of sand in different zones at increased z-distance from 30 to 40mm. A better mixing is indicated with z-distance of 30mm at 13W energy input. Increasing the energy input to 17W, particles are preferentially lifted to the top zone but the homogeneity exists only in the middle and bottom zones of the vessel.

In another set of experiments, 5 sets of known quantity of sand slurry was collected from top, middle and bottom parts of the vessel at regular intervals, water was put back into the system and the sand dried at 120°C and weighed. A sieve analysis was carried out and the results are plotted in Fig.4 for various conditions of the vessel. After the experiments were over the remaining sand particles were filtered and thoroughly dried, weighed and sieve analysis carried out and plotted in Fig. 4. It can be seen that a normal particle distribution is always observed irrespective of the pulp density in the vessel. The maximum fraction was in the size range 100-250 μm. This only indicates that the stirrer parameters do not influence the particle size distribution in the sample collected or the remainder left over in the vessel. Another point of interest is that coarser particles have a tendency to remain on the top when the pulp density is high but the particles of size 100-150 μm tend to remain in the middle portion of the vessel. Particles of less than 100 μm size are uniformly dispersed. This has been observed even for lower pulp densities in the vessel.

Similar observations have been made for a z-distance of 30mm also (Fig.4) under identical vessel conditions. It was observed that the input energy, particle size and pulp density play important roles in establishing conditions to achieve nearly uniform dispersion of particulates. The extent of dispersion has also been visually observed where stratification of different size particulates at different levels is considered to indicate the level of mixing.

CONCLUSIONS

Particle size distribution in different layers in the impeller stirred vessel is not influenced by the z-distance. There is a tendency for the coarser particle to remain dispersed preferentially on the top layer and the medium size particle to remain in the middle portion. The fine particles get uniformly dispersed in the medium. Pulp density is nearly uniform with the increase in the z-distance from 30 to 40mm.

REFERENCES

1. McCabe W.L. and Smith J.C., Unit operations of Chemical Engineering,McGraw Hill Kushaku, (1962), 792.
2. Brown, G.G. Unit Operations, John Wiley & Sons, N.Y. (1950), 503.
3. Holland, F.A. and Chapman, F.S., Liquid Mixing and Processing in Stirred Tanks, Reinhold Pub., London, (1966)
4. Azbel, D.S. and Cheremisinoff, Fluid Mechanics and Unit Operations, Ann Arbon Series, Butterworth Gr., (1983), 675
5. Drew, T.B., Hooes Jr,.W. and Vermenlen, T., Advances in Chemical Engineering, **3**, (1962), 120
6. Gildyal, B.P. and Tripathy, R.P., Soil Physics, Wiley Eastern Ltd., (1987)

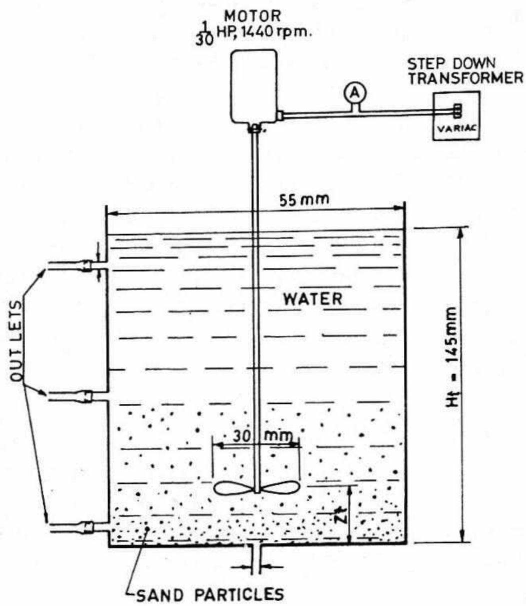

FIG. 1: EXPERIMENTAL SET-UP

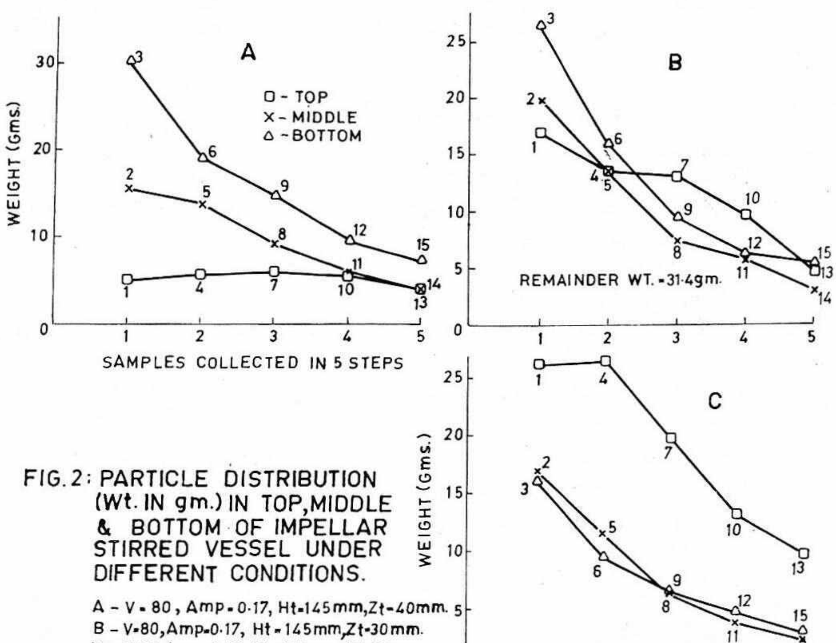

FIG. 2: PARTICLE DISTRIBUTION (Wt. IN gm.) IN TOP, MIDDLE & BOTTOM OF IMPELLAR STIRRED VESSEL UNDER DIFFERENT CONDITIONS.

A – V = 80, Amp = 0·17, Ht = 145mm, Zt = 40mm.
B – V = 80, Amp = 0·17, Ht = 145mm, Zt = 30mm.
C – V = 90, Amp = 0·19, Ht = 145mm, Zt = 30mm.
SLURRY MADE UP OF 200gm. SAND.

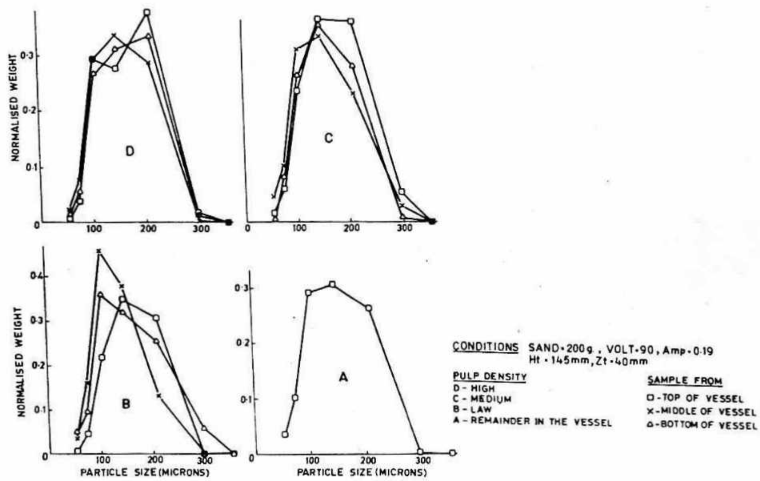

FIG. 3: PARTICLE SIZE DISTRIBUTION IN SLURRY SAMPLES FROM AGITATED VESSEL.

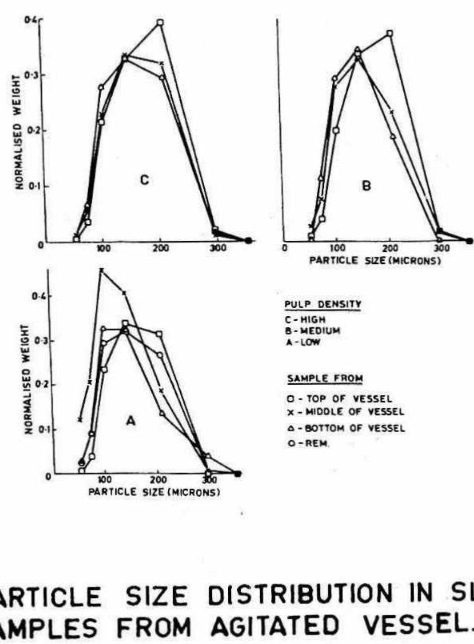

FIG. 4: PARTICLE SIZE DISTRIBUTION IN SLURRY SAMPLES FROM AGITATED VESSEL.

CONDITIONS: SAND-200g, VOLT-90, Amp-0.19
Ht = 145mm, Zt = 30mm.