CHAPTER 3 MATERIAL CHARACTERISATION

3.1 Introduction

The purpose of the material characterisation experiments was to identify the main properties of the material that would affect the values of parameters in the simulation model.

3.2 Description of physical properties

3.2.1 General description of the sample

The material that was available for the experimental work was a quartz waste rock ore of a generally irregular flaky shape (flat and elongated) which after being smoothed in the mill became more ellipsoidal. This shape poses some problems for DEM where spheres are the easiest shape for simulation. The three different size fractions in the two plates below show that the particle shape is similar at different sizes.

Figure 3-1 Sample of raw material on the left of the ruler and sample that has been tumbled in the mill for about 30 minutes on the right

Figure 3-2 Large media rocks (-126 +106mm) that have spent over 90 min in the mill and a fine fraction (-16 +13.2mm) that has been in the mill for about 20 minutes.

3.2.2 Measurement of specific gravity

The specific gravity determined from the ground powder of the sample by a technician at the Council for Mineral Technology (Mintek) laboratory was 2.745.

3.2.3 Surface properties

From the wear rate experiments discussed later, it appears there were three distinct types of this material, which for the purpose of these studies would be considered slow, medium and fast wearing material. The faster wearing particles appeared light and grainy while the harder material was smooth and dark. Since most experiments involved handling particles en-masse the understanding of the overall behaviour of the entire sample was however more important.

3.3 Characterisation of size distribution

3.3.1 Particle Sizing Procedure

The particles were classified according to size using a standard nest of 20cm-diameter laboratory sieves. For the larger particles, half-meter-diameter JK screens were used or single wire frames with suitable apertures for the very largest lumps. The $\sqrt[4]{\ }$ size interval was used for size classification at all times. For convenience sake, whenever a single size figure is quoted in the rest of the document, it should always be assumed that the upper screen size is implied and the lower screen can be calculated by dividing the quoted figure by $2^{1/4}$.

3.3.2 Determining mass distribution on the screen fractions

The particles that were retained on the screens after test sieving were weighed individually to see if they had a characteristic mass distribution. The results for the screen fraction sizes ranging from 9.5 mm to 45mm are shown in Appendix A.

3.3.3 Results of analysis of mass distribution on screen fractions

3.3.3.1 Mean mass of fraction

From the observed size fractions of particles ranging from 9.5mm to 45mm, it was found that each screen fraction retained a similar mass distribution of particles. It was thus easy to predict the mean mass (X_m) of any fraction using the equation below.

$$X_m = \pi \frac{(d_l d_u)^{3/2}}{6} \rho \psi \tag{3.1}$$

where d_l and d_u are the respective lower and upper screen sizes, ρ is the density and ψ is a shape factor which in this case was 1.31 i.e. 1.31X heavier than a sphere of equivalent screen diameter (Prasher 1987). The experimental means for the results given in Appendix A is given in Table 3.1.

Table 3-1Means obtained from screen fractions compared with means predicted by Equation 3.1

Screen Fraction (mm)	Experimental Mean (g)	Predicted Mean (g)
-11.2 + 9.5	2.10	2.03
-13.2 +11.2	3.17	3.33
-16.0 +13.2	5.58	5.68
-19.0 +16.0	9.65	9.82
-37.5 +31.5	78.90	75.19
-45.0 +37.5	154.70	128.38
-75.0 +63.0	648.18	601.5

The prediction is compared with the experimental means in the graph below.

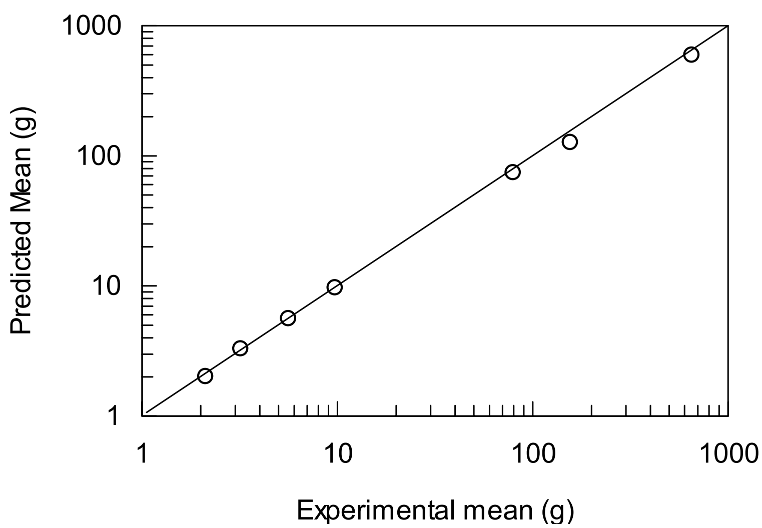

Figure 3-3 Predicted Mean Mass of fractions compared with the measured

3.3.3.2 Characteristics of the mass distribution

To compare the characteristic mass distributions, the cumulative size distributions of all the different size fractions are plotted below using a normalised scale and fitted with Rosin-Ramler equation.

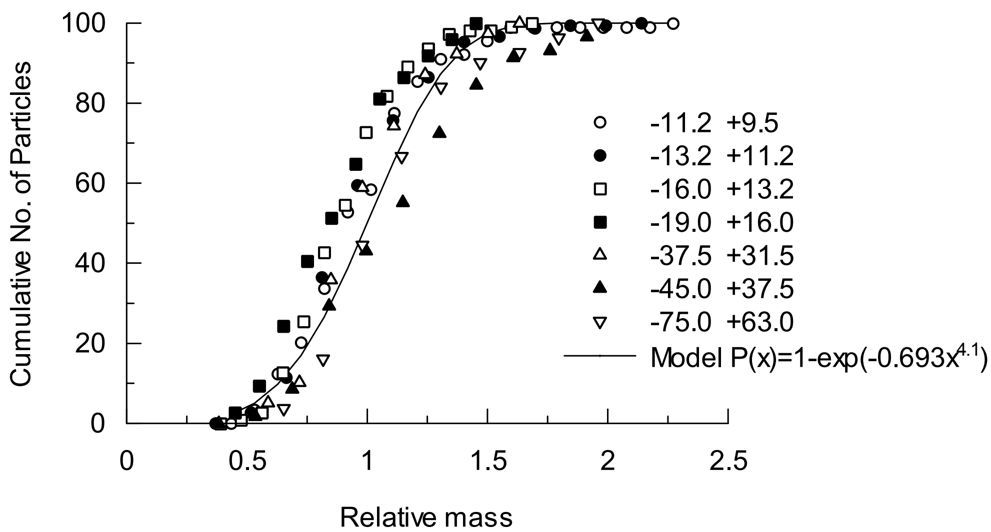

Figure 3-4 Mass distribution of particles between $\sqrt[4]{\;}$ successive screen sizes plotted on a normalised scale

In spite of the data scatter seen above it is seen that cumulative mass distribution of particles between two adjacent screens is well described by the Rosin-Ramler equation below.

$$F(x) = 1 - e^{-0.693x^{4.1}} \tag{3.2}$$

where F(x) is the fraction mass comprising particles between the immediate lower screen and particles of mass x.

For the purpose of assigning the DEM spectral energy levels resulting from the simulation to each particle more accurately, there was need to discretise the size fractions in to a further 20 sub-fractions. The fraction mass of particles in any sub-class can be found by taking the difference between calculated upper and lower limits of the cumulative mass distribution curve. This can be converted to number by dividing with the relative midpoint mass and multiplying by the total mass of the screen fraction. A specific application of this equation is encountered in Chapter 7.

3.4 Conclusion

The general ellipsoidal characteristic shape of the particles is a disadvantage to the simulator which at its current status can only simulate spheres. The characteristic size distribution as seen in Figure 3.4 allows use of a general equation to predict the size distribution for any screen fraction, provided the $2^{1/4}$ series is used.