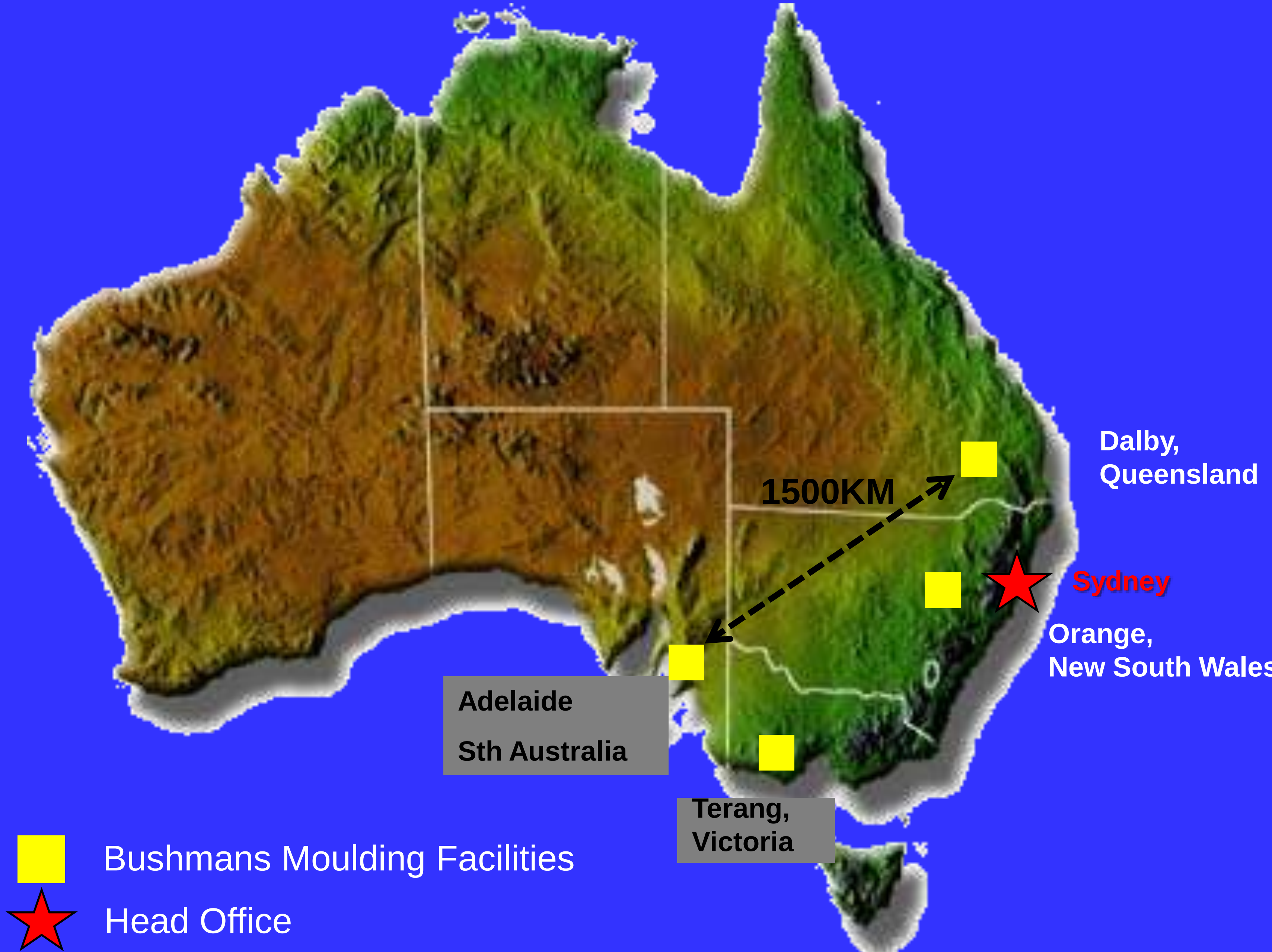
Bushmans

Quality Control at the Rotomoulder

Ian Hansen
Bushmans Group Pty Ltd, Australia
Nordic ARM Conference, Horsens, Denmark, February 2011

Bushmans locations around Australia



Quality Control at the Rotomoulder

In this presentation we will review four simple quality evaluations that the rotational moulder is capable of undertaking. You can find out when powders vary from their normal characteristics.

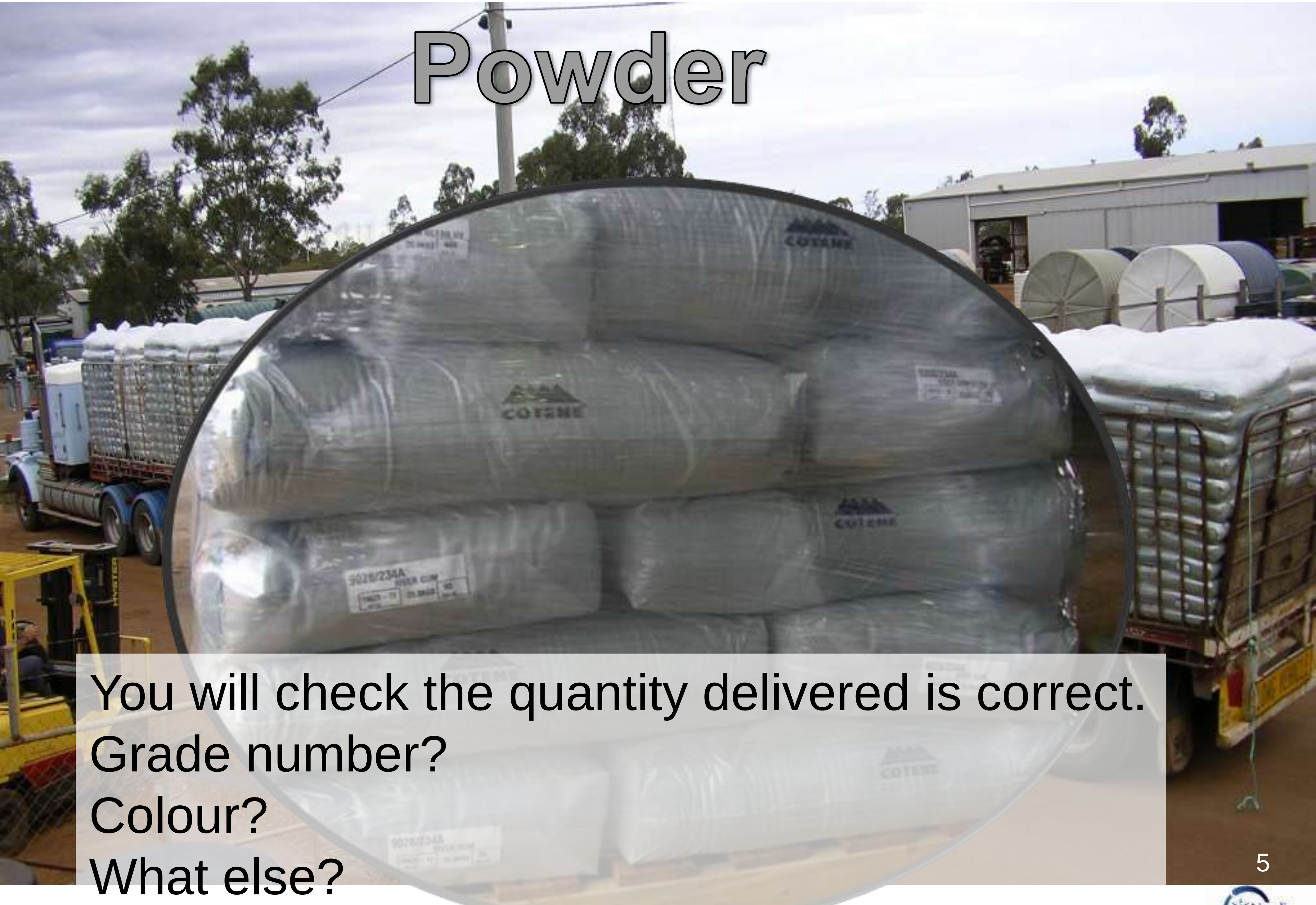
Even though abnormal powder can still be moulded, adjustments in your moulding process are normally required to ensure you still produce good quality parts.

1. Particle Flow Distribution,
2. Dry Flow,
3. Bulk Density,
4. Visual Analysis.

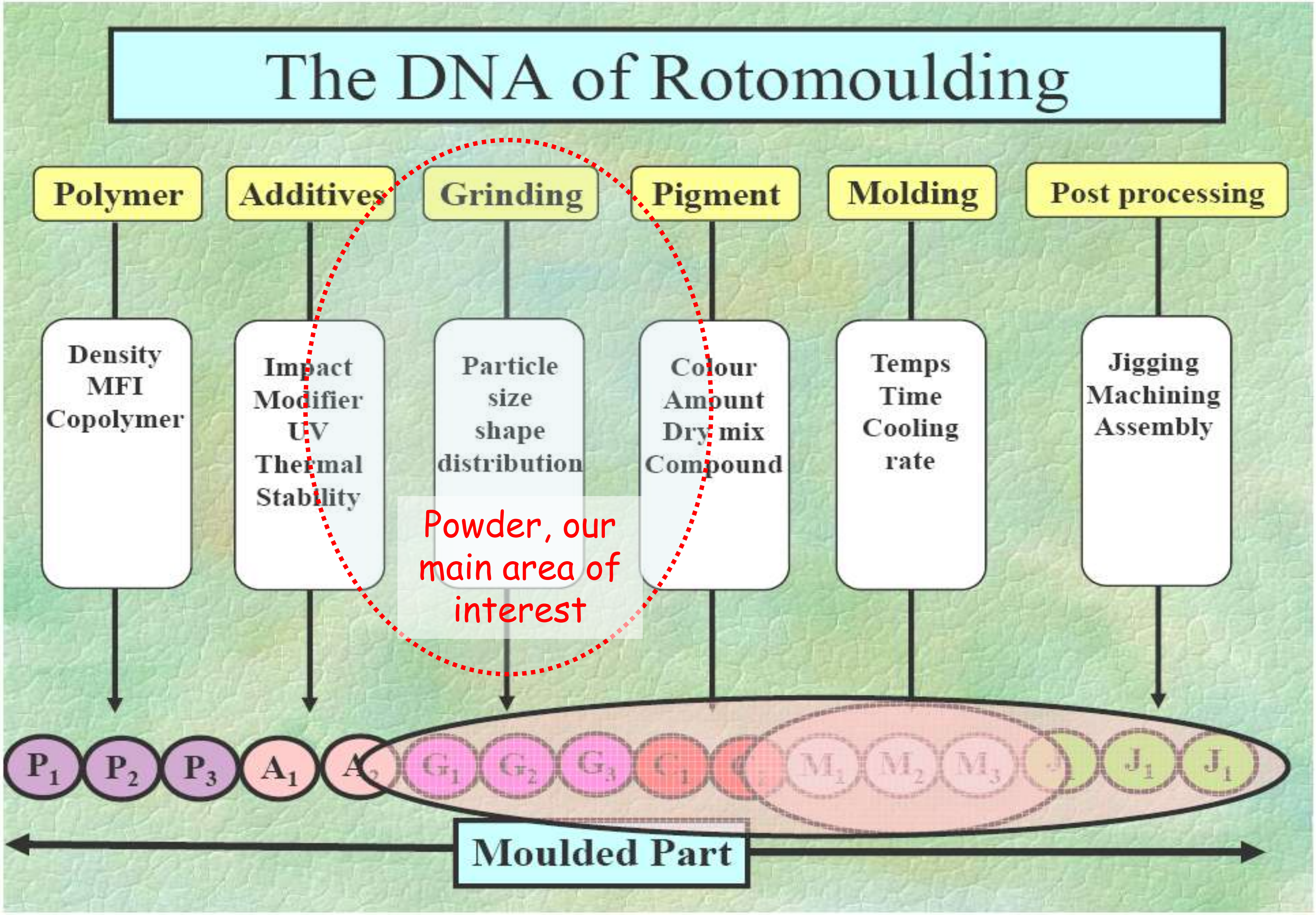
Simple and regular testing will keep people within your factory and your suppliers factory looking out for and solving minor problems before they become major problems.

Most of the test equipment is inexpensive and will go a long way to enable you to be sure raw material is consistent and fit for purpose.

Powder



You will check the quantity delivered is correct.
Grade number?
Colour?
What else?



Source : Prof Roy Crawford

MATERIAL TESTING

The rotational moulding process is such that there are a large number of variables that can make a significant impact on the quality of the end product.

Moulders generally want a powder that will easily flow into all areas of their moulds and melt into a bubble free state with the minimum of heating time.

Whether you purchase powder or make you own, the grinding process is one of the DNA variables that are difficult to control.

The powder is produced by grinding polymer, and is typically produced on a batch basis, so variations between batches of powder can be expected.

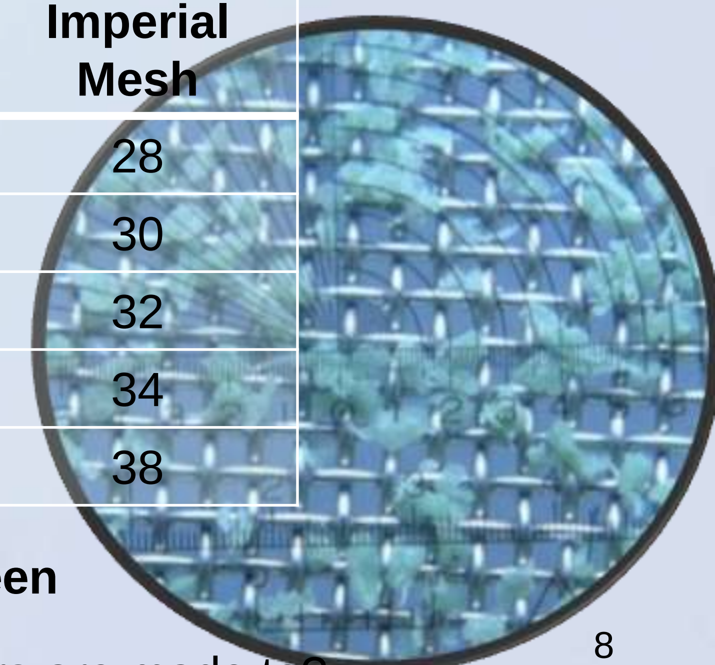
The job of the powder manufacturer is to minimise these variables.

MATERIAL SPECIFICATIONS

The moulder and the powder supplier must first agree on the powder specification.
It also needs to be defined in writing, so that you can measure compliance.

Some powder suppliers will use 30mesh screens, others 32mesh, or 34mesh or anything else that suits their manufacturing requirements.
In Australia, bolting cloth is used for the mesh screens used to sift the powder.

Approx Aperture microns	Wire Diameter mm	Open Area %	Imperial Mesh
710	0.200	61	28
680	0.200	65	30
630	0.165	63	32
580	0.165	61	34
500	0.165	57	38



Mesh Screen

Do you really know what specification your powders are made to?

EVALUATION 1 - PARTICLE SIZE DISTRIBUTION

Powder has been characterised into three groups:

Sieve Size	Fine %	Average %	Coarse %
600 um	0	0	3
500 um	0	3	15
425 um	1	15	20
300 um	15	25	22
212 um	27	22	20
150 um	32	20	15
Pan (fines)	25	15	5

(Source : R.J.Crawford – Rotational Moulding of Plastics, 2nd Edition).

Coarse Sieve, Largest particles

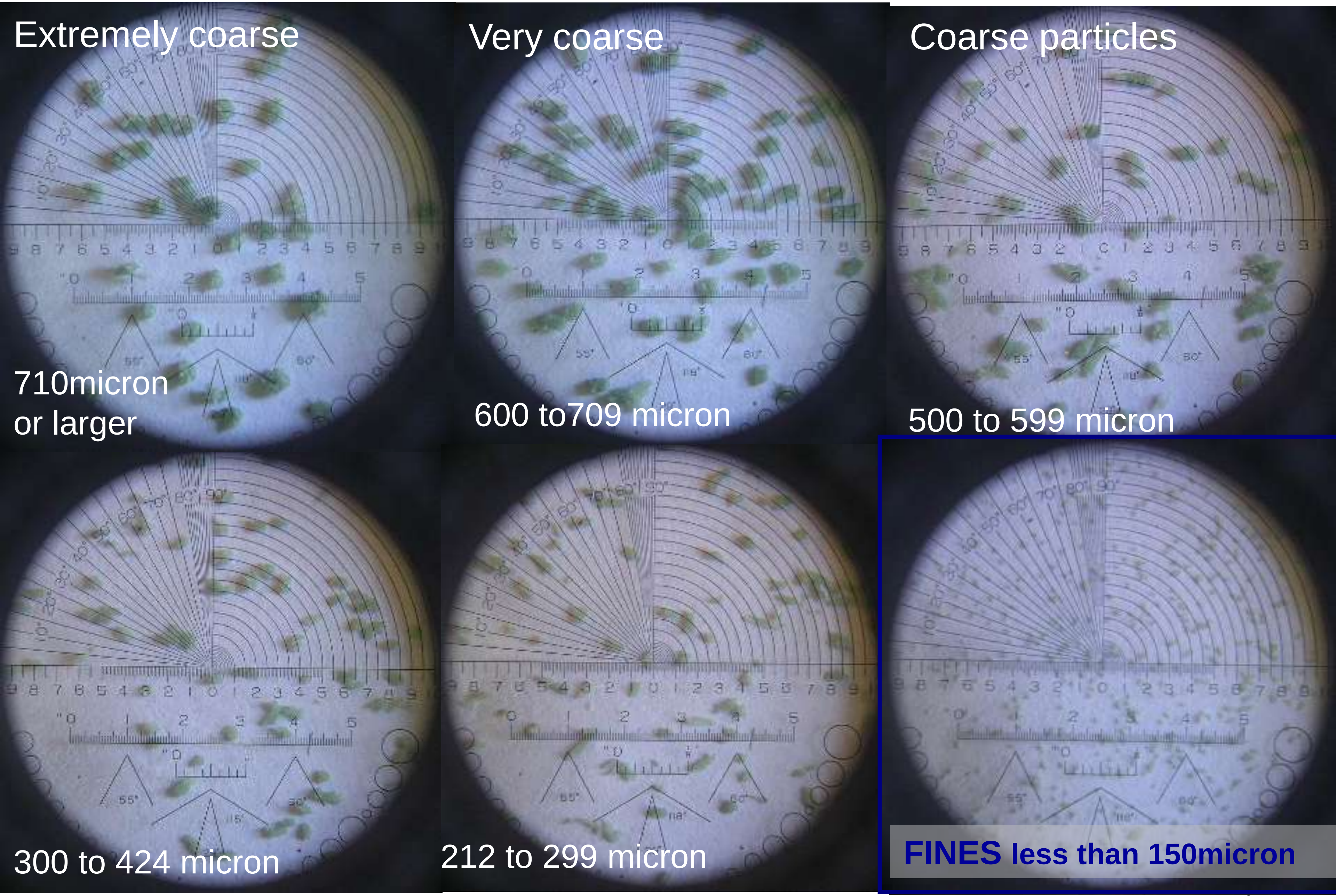
Fine Sieve Smallest particles

Finely ground powders tend to be more susceptible to thermal deterioration due to their greater surface area to volume ratio. Finer powders don't flow as well and fluidize more rapidly so heating cycles can be extended.

Coarse powders tend to require extended heating cycles and often an irregular, matt outer surface with pin holes is produced.

A good particle size distribution reduces voids, air bubbles and minimises porosity.

While both Prof Crawford and Paul Nugent have tried to characterise particle size distribution the commercial manufacturers are yet to agree on what is good or bad , nor even what is fine and coarse.



Particles Separated by sieve

PARTICLE SIZE DISTRIBUTION – TEST METHOD

The particle size distribution is tested in accordance with ASTM test method D1921
(copies of the standard are available from your local standards organisation)

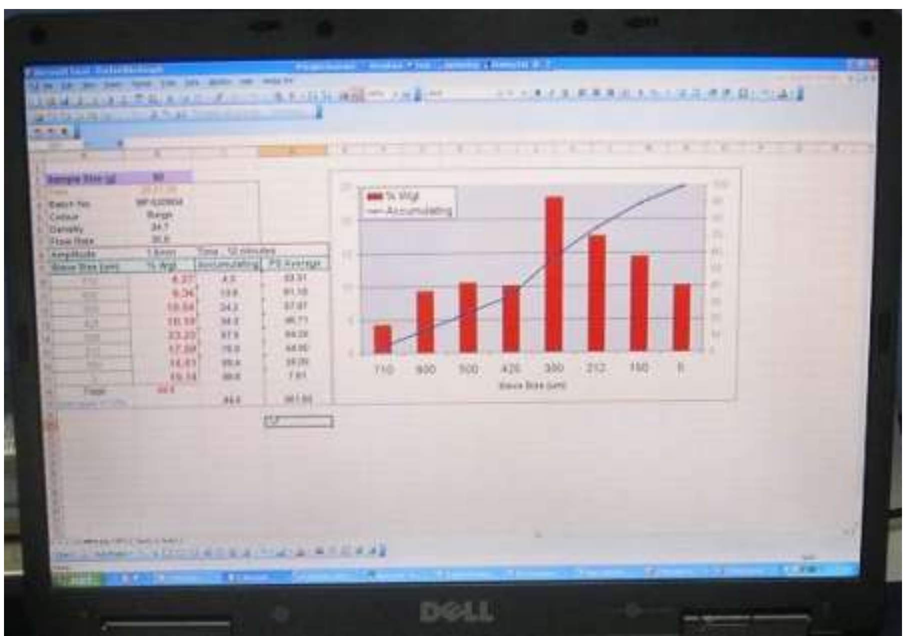
PROCEDURE

1. Nest the sieves together in order of diminishing opening with the coarsest sieve on top and the pan on the bottom
2. Weigh the sieves and record their mass as their tare weight, respectively
3. Weigh 50gram sample of the powder and transfer it to the top of the stack and record the sample weight. (Balance must have accuracy of reading to nearest 0.1g)
4. Place the stack of sieves in the mechanical sieve shaker. Start the shaker and run for ten minutes
5. After shaking, carefully separate the stack of sieves. Beginning at the top with each sieve with powder. Determine the net weight of powder remaining in each sieve by subtracting the sieve tare weight from the total weight of sieve plus powder. If the cumulative total actual weight is less then 98%, carefully check the weights and operation and repeat work if necessary.
6. Record the net weight of material for each sieve (nearest 1g) and calculate the percentage powder in each sieve by dividing the net weight by the total sample weight * 100.
7. Record the percentage powder in each sieve.

Note : Test sample weight is typically 50grams (Test method A) or may sometimes be 100grams (Test method B)

The table below indicates the recorded particle size distribution data:
Supplier ………………………..
Product code ………………..… Batch no ……..……………Powder sample total weight : 50g

Sieve size	Tare weight	Total weight	Net weight	Percentage powder
710 um	….g	….g	0g	0/50*100=0%
600 um	….g	….g	0g	0/50*100=0%
500 um	….g	….g	1g	1/50*100=2%
425 um	….g	….g	7g	7/50*100=14%
300 um	….g	….g	24g	24/50*100=48%
212 um	….g	….g	11g	11/50*100=22%
150 um	….g	….g	5g	5/50*100=10%
Pan	….g	….g	2g	2/50*100=4%



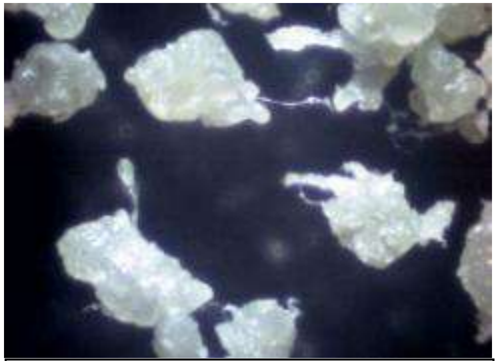
EVALUATION 2 – POWDER DRY FLOW

Dry flow is the measure of how a powder will tumble and flow in the mould during the rotational moulding process. The dry flow affects the heat transfer in the powder pool and how the powder distributes itself over the mould surface and into narrow recesses.

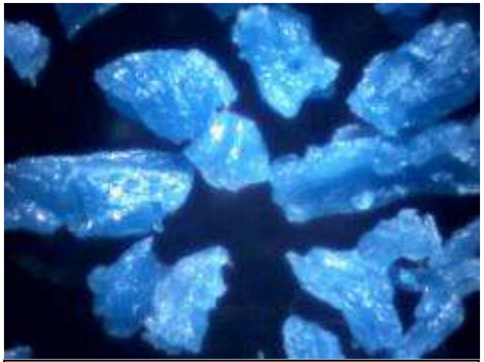
Dry flow depends mostly on the particle shape and, to a lesser extent, particle size. Particles that have been ground poorly will have ‘tails’ and tend to be ‘fluffy’. These two characteristics will give the powder poor flow properties - possibly leading to uneven wall thickness, bridging across narrow recesses and a high void content within the moulded product.

While there are many factors involved in assessing quality, measuring Dry Flow is probably the single most effective method to determine powder quality.

ARMO funnel shown mounted in purpose built stand, with bulk density ‘cup’



Particles with ‘tails’



Particles without ‘tails’

Background – ARMO Dry Flow funnel

ARMA formed a Materials Committee in 2008 to develop a simple Materials Testing Guide for rotomoulders to be informed on quality issues.

3 batches of polyethylene powder were pulverised by 3 different powder manufacturers.

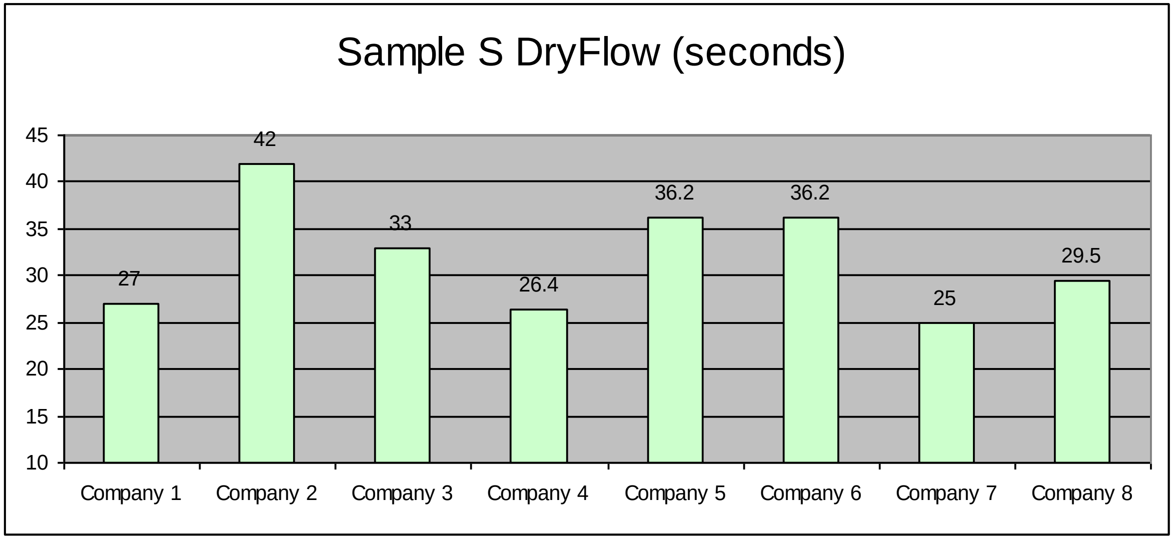
The 3 batches of powder were tested by 8 different companies, using their own dry flow funnels.

The funnels had exit holes within the tolerances specified by the standard – 9.0mm to 10.0mm

The results were found to differ substantially.

Shortcomings of Dry Flow funnel ‘standard’ exit hole were identified as a major influence.

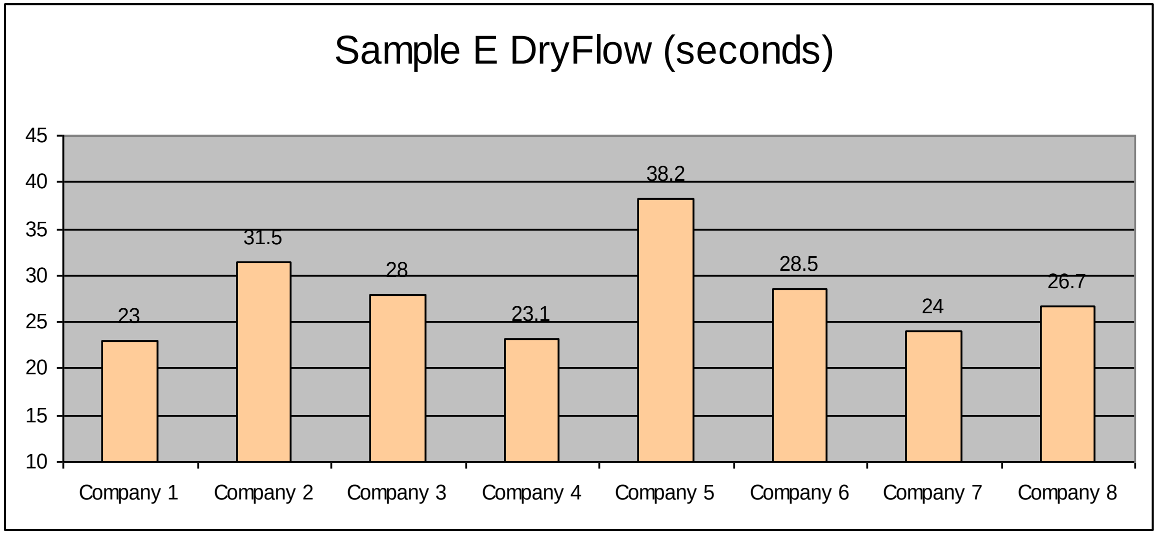
Results from funnels made to old standard



Minimum = 25secs

Maximum = 42secs

Difference 68%



Minimum = 23secs

Maximum = 38secs

Difference 66%

The most commonly used testing procedure is based on ASTM D1895, but has been recently modified for the rotational moulding industry.
ASTM standard allows for relatively large dimension tolerances in dry flow funnel equipment, which can result is significant differences between funnels. So care needs to be taken when comparing different powder manufacturers claimed results.
ARMO (Affiliation of Rotational Moulding Organisations) has agreed on a global standard for the fabrication of the funnel used in this test, to significantly improve the ability to compare different test results.
ARM Nordic and ARM Australasia are affiliated to ARMO

DRY FLOW TEST METHOD

Dry flow is tested in accordance with ASTM D1895 and ISO R60, and is the time taken for 100g of powder to flow through the ARMO funnel.
In practice, most of the industry conducts the Association of Rotational Molders (ARM) International Test Method for Flowability of Polyethylene Powders

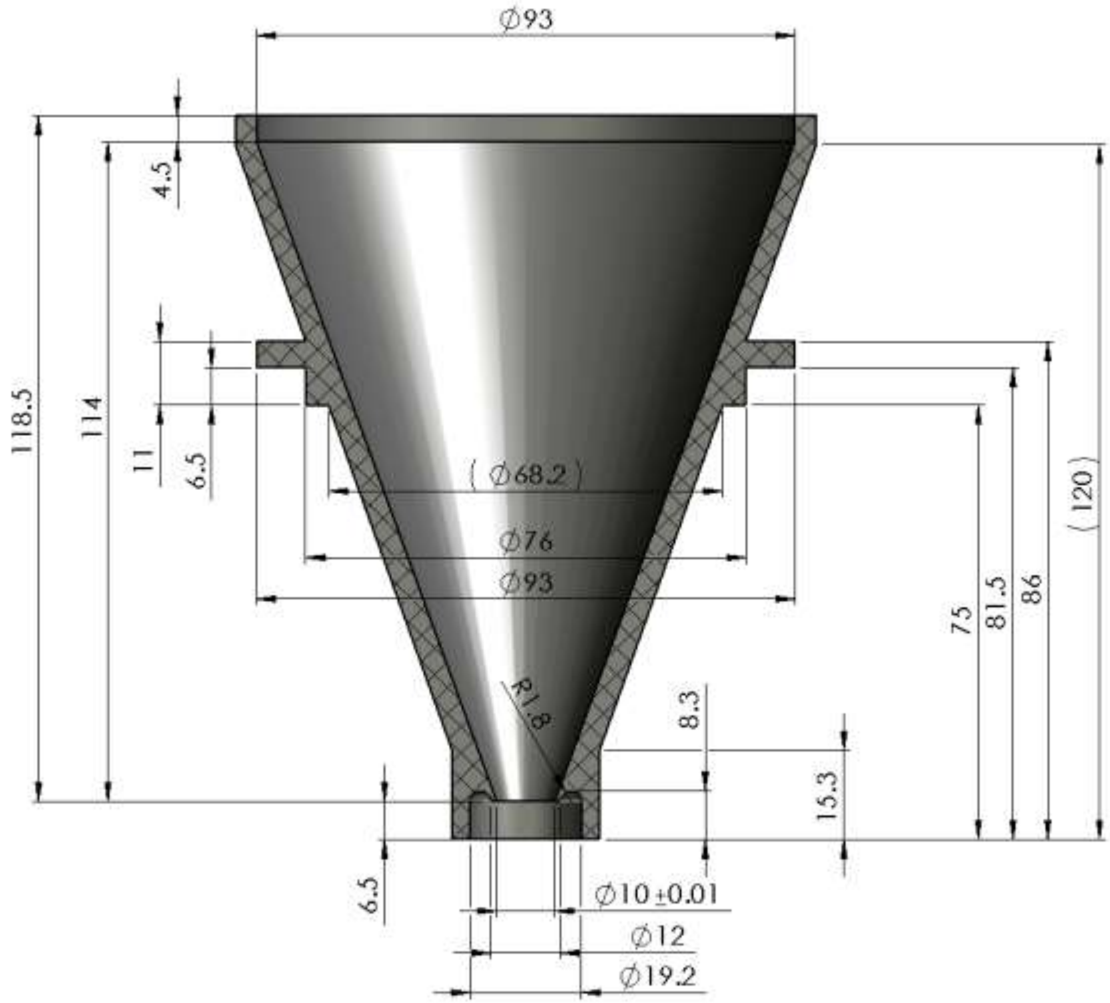
A recommended powder flow rate should lie between 25 and 32 seconds (Paul Nugent – Rotational Moulding – A practical guide).

TEST PROCEDURE

1.Weigh 100g of powder into a container (beaker).
2.Pour the 100g of powder into the dry flow test funnel while blocking the outlet. Remove the blockage from the funnel and record the time taken for all the powder to flow from the funnel.
3.The form below may be used to record the dry flow.

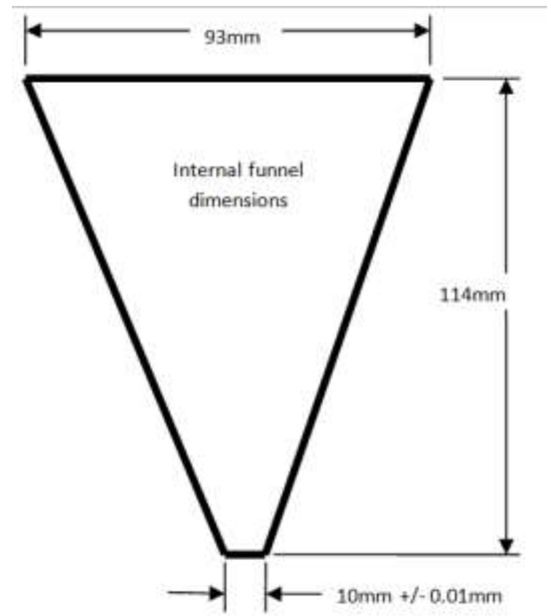
Supplier	Product Code	Batch no.	Sample Weight (grams)	Dry Flow Time (Seconds)	Powder temperature C
Vanglobe Matrix	6338	3456	100	28	27
Price Plastics	6100	5678	100	26	39

New ARMO standard for Dry Flow Funnel fabrication



A simple sketch of the 3 key *internal* funnel dimensions is shown below:

Height 114.0mm, tolerance +/- 0.1mm
Opening at top 93.0mm, tolerance +/- 0.1mm
Opening at bottom 10.00mm, tolerance +/- 0.01mm



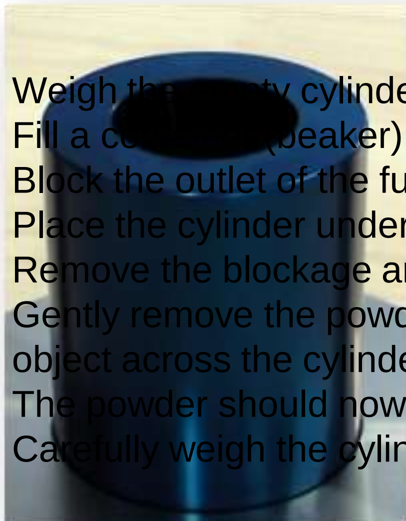
EVALUATION 3 – APPARENT BULK DENSITY

Bulk density is the measure of how well the powder particles will pack together. A good quality powder with few ‘tails’ or ‘fluff’ will pack together very well and have a high bulk density. Powders with a very high number of ‘tails’ and that tend to be ‘fluffy’ will not pack together well and have a lower bulk density.

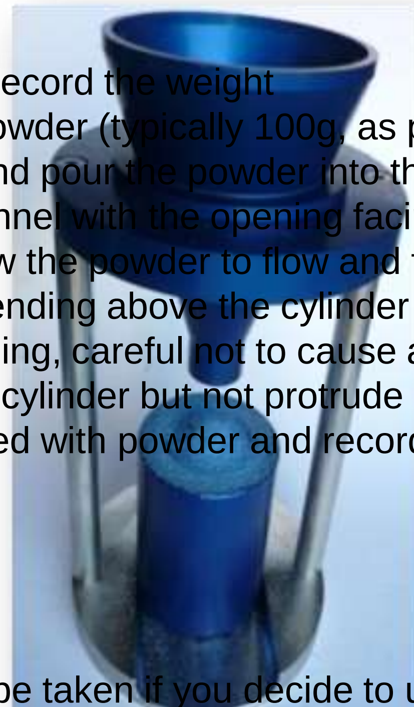
BULK DENSITY TEST METHOD

Bulk density is tested in accordance with ASTM D1895. Here, the bulk density is calculated by measuring the mass of powder needed to fill a known volume. In this case, a cylinder of known volume (100ml) is used. Typically you would undertake this test in conjunction with the Dry Flow test

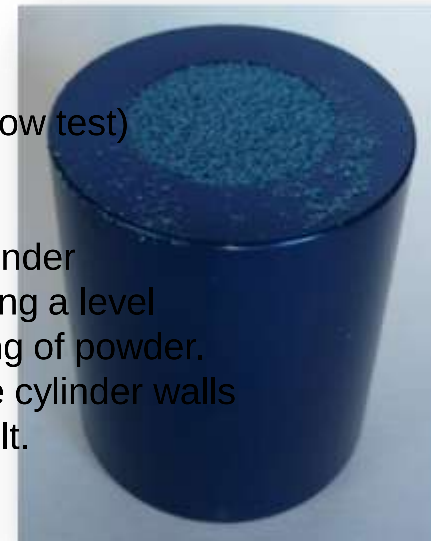
1. Weigh the empty cylinder and record the weight
2. Fill a container (beaker) with powder (typically 100g, as per Dry Flow test)
3. Block the outlet of the funnel and pour the powder into the funnel
4. Place the cylinder under the funnel with the opening facing up
5. Remove the blockage and allow the powder to flow and fill the cylinder
6. Gently remove the powder extending above the cylinder by scraping a level object across the cylinder opening, careful not to cause any settling of powder.
7. The powder should now fill the cylinder but not protrude above the cylinder walls
8. Carefully weigh the cylinder filled with powder and record the result.



Bulk Density Cup



Cup and Funnel shown mounted in purpose built stand



Bulk Density Cup with powder

More accurate measurements can be taken if you decide to use a larger container with a larger calibrated cylinder. However, for simplicity and speed, most powder processors would measure using 100ml cylinder.

The bulk density is measure in grams per cubic centimetres and is calculated by subtracting the gross weight (cylinder + powder) from the cylinder weight, giving the powder weight. Then divide this net weight by the volume of the cylinder.

Example:

Empty Cylinder weight …………….

Cylinder + powder weight ………………………..

Net weight (powder) ………………………

Cylinder volume …………………

Bulk density = (full cylinder – empty cylinder) / cylinder volume

Bulk density = …… - …… / ……

= …. g/cc

The bulk density of a suitable rotational moulding powder should be between 0.320 and 0.400 g/cc

(Reference: Paul Nugent – Rotational Moulding – A Practical Guide).

The above information may be recorded on the following document

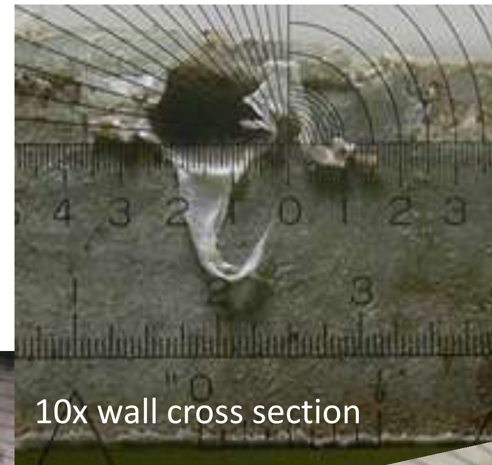
Supplier ……………………… Product code ………………………..

Batch no …………………….. Cylinder volume ………………………

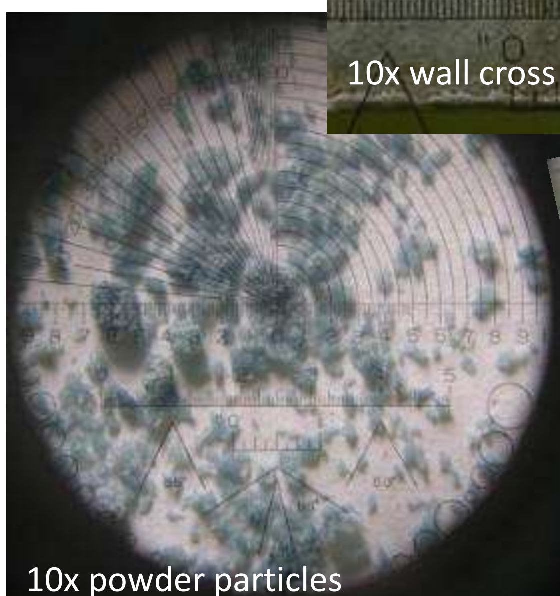
supplier	Product code	Batch no.	Cylinder volume	Cylinder weight	Cylinder + powder weight	Powder weight	Bulk density	Powder temperature
………….	…………..	……….. …..	…………….	……………..	……………	……….. ……		……………

EVALUATION 4 - POCKET OPTICAL COMPARATOR

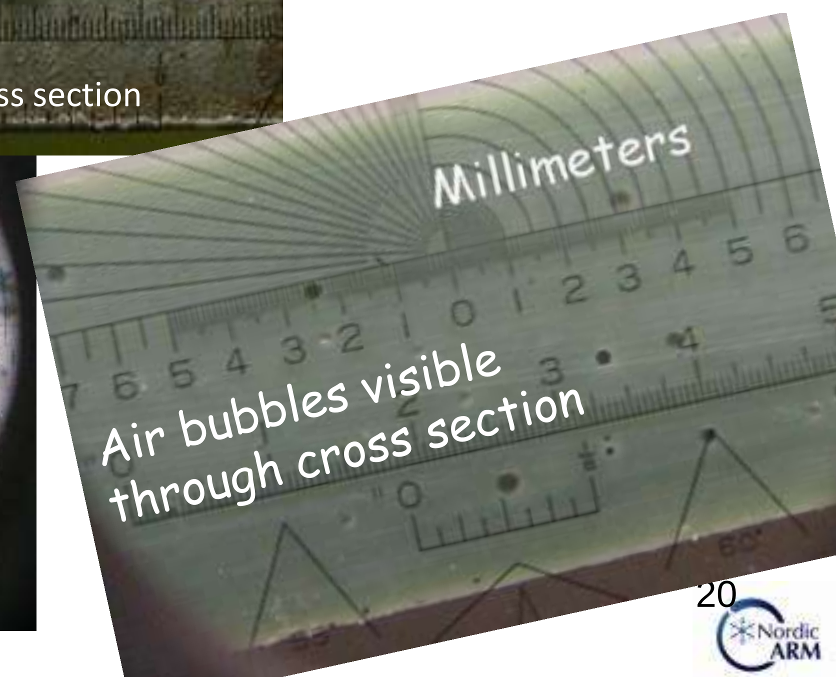
A more traditional method to achieve enlarged images is to use a 10X optical comparator, which comes with a range of photo etched glass lenses, which are placed in actual contact with the measured object, thus obtaining simultaneous enlarged and measured objects. While this does not allow screen shots to be captured for reference, it is a very useful tool



10x wall cross section



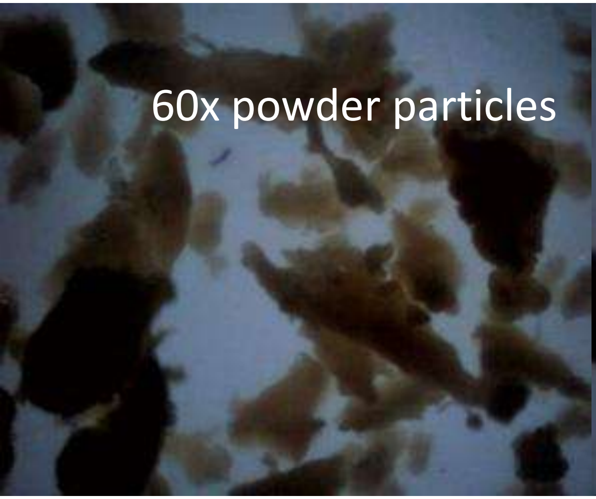
10x powder particles

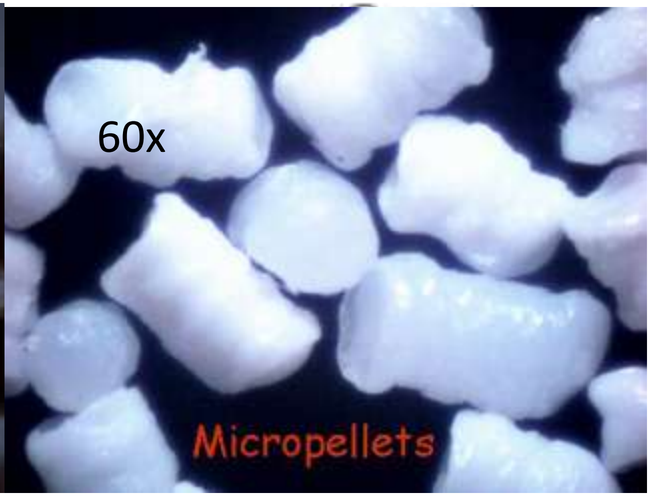


EVALUATION 4 – BASIC MICROSCOPIC TEST

A quick look at the powder under a high resolution microscope may begin to tell you the story of the material. Using a simple and easily affordable USB microscope you should be able to identify if the powder apparently has a high amount of tails and if particles sizes vary. Some microscopes will even allow you to perform simple on screen measurements. The benefit of these tests are that screen shots of the powder can be taken and easily sent to the supplier for more information or comment.

You can also use this equipment to perform rudimentary tests on the finished product which may help identify surface imperfections, air bubbles and other inconsistencies.

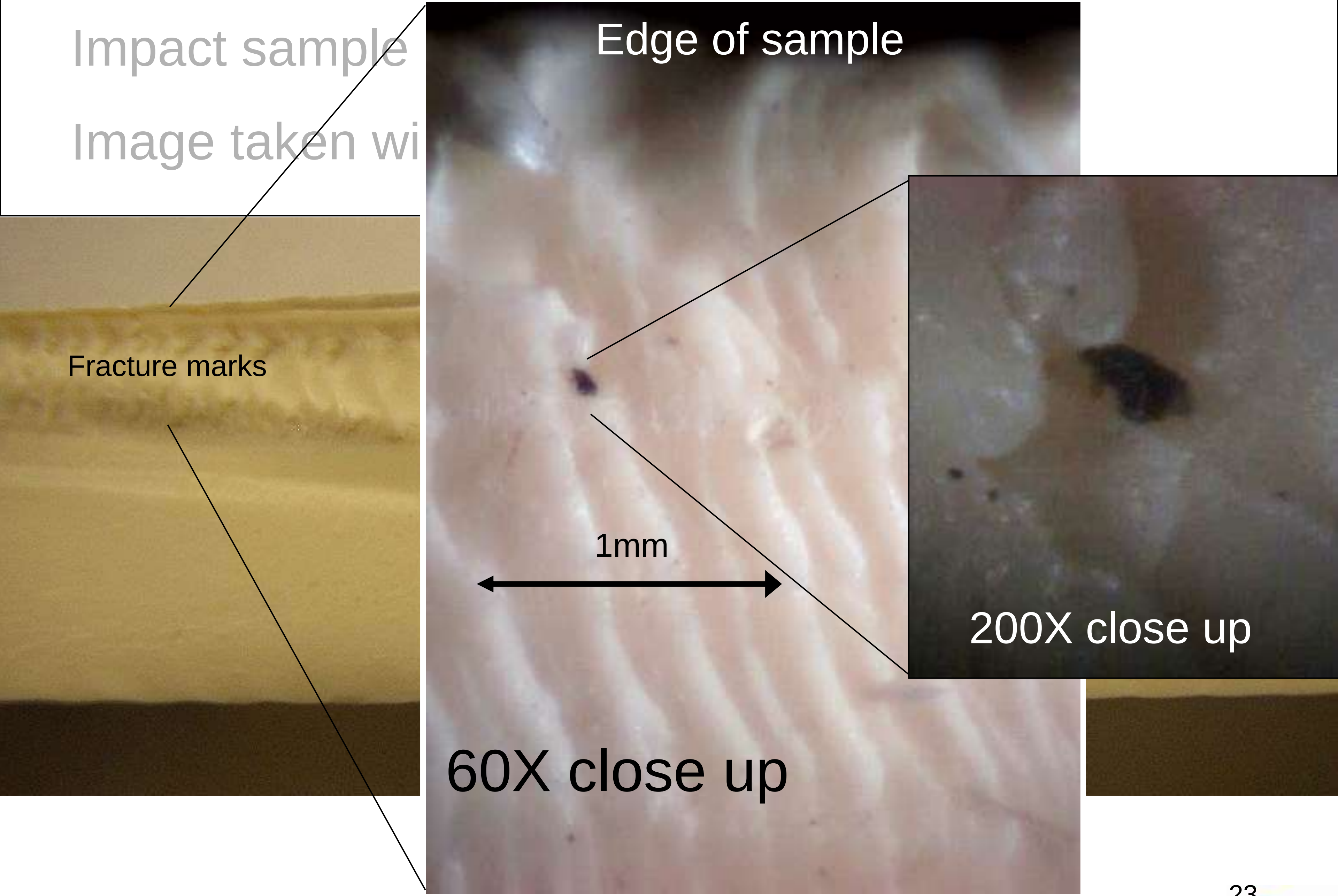




Powder Particles Magnified 200X

Impact sample

Image taken wi



Good ideas, but too expensive?

- At the very least, get the ARMO Dry Flow funnel and have the ability to measure the pourability rates.
- Your investment is around US$500 or Euro400
- This is BEST price/performance quality tool available to you.

Still not convinced you should measure your powder?

Your powder is never going to be the cause of a problem?

If you don't want to measure any of your incoming raw materials, then you should at least request Quality Certificates for incoming powders.

Any powder supplier will be able to provide you with a basic quality report for each batch of powder delivered to you.

Negotiate with your supplier on the information contained within this report.

MicroTuff POLYMERS
PRICE PLASTICS PTY LTD
Your first step to Quality Manufacture

Price Plastics Pty Ltd
Phone +61 3 8792 5300
Fax +61 3 9768 2536
Email tech@priceplastics.com.au
Address 515 Hammond Road, Dandenong. Victoria, 3175 Australia

CERTIFICATE OF ANALYSIS

Customer: Bushmans

Date:	07.05.08	Batch No.:	MPA0508945BM
Colour:	ARMA Gold	Grade No:	2923 D
Masterbatch Supplier:	Gudda	LDR:	25
Additive Supplier:	Ciba	Polymer Grade:	NG2432UE

TEST RESULTS

Melt Index Spec	Supplier	Minimum	Target	Maximum
NG2432UE	Dow	3.0	3.8	4.6

Melt Flow: 3.93 Actual compound result PASS ✓ Fail

Moisture Test: 0.18 % Maximum Moisture = 0.25% PASS ✓

Colour - CIE LAB Value Maximum Delta E = 1.0
L: -0.25 A: 0.75 B: 1.03 Delta E: 0.8175 PASS ✓

Opacity: 0.298%T @ 780nm Maximum Opacity @ 780nm = 0.50%T PASS ✓

Dispersion against standard : ✓ Ok; no visible specks

	Actual	Minimum	Target	Maximum		Test Method
Particle Size Distribution:	265.82	256	285	313	Average Particle Size	ASTM D1921
Bulk Density:	35.7	31	35	40	Grams/cc	ASTM D1895
Flow:	32	27	30	33	Seconds/100grams	ASTM D1895

DSC against Standard: FAIL ☐ PASS ✓

FTIR against Standard: FAIL ☐ PASS ✓

Signed: M.Bourke Date: 20-May-2007

Nordic ARM

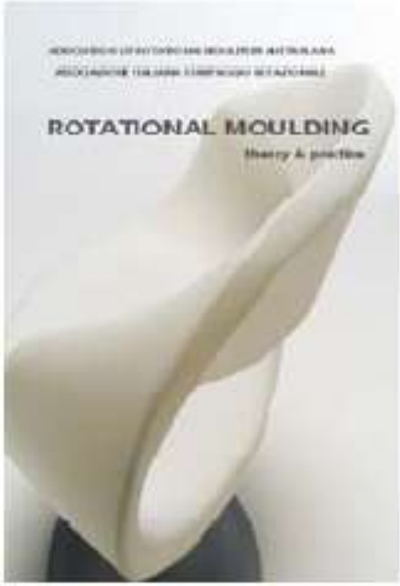
Reference Books

I would recommend that you consider obtaining the following reference book, copies of which may be purchased directly from AISR or ARMA (www.rotationalmoulding.com)

- **Rotational Moulding : Theory & Practice**

  AISR & ARMA

- *Still fresh off the press! This fantastic, easy to read complete guide to the process and design was originally authored by members of the Italian Association and it has recently been translated into English by ARMA.*
- *The book includes comprehensive chapters on the process, machines, moulds, materials, thermal cycles, designing, secondary operations and other applications for the process.*
- *Its the newest “must have” for your specialist library.*
- ***Price approximately USD50 plus postage***



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Remember ;
What can be measured can be controlled

Ian Hansen
Email Contact : ihansen@bushmans.com.au

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