

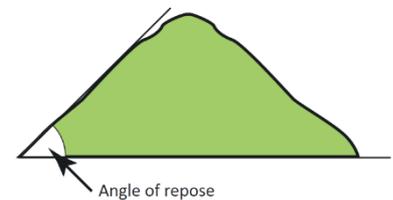
Angle of Repose Testing for Metal Powders

Why measure the angle of repose of metal powders for Additive Manufacturing applications?

The angle of repose gives an indication of how a powder flows, which affects its behaviour in Additive Manufacturing (AM). Moisture content, morphology, and particle size distribution, among other parameters, can all influence flow. Once a powder has been characterised and optimal parameters developed for a component, any change in the powder's behaviour can have an impact on the mechanical properties of the final built part. Different AM systems require different powder characteristics to produce high-quality parts, and while most gravity-fed AM machines require a powder to flow freely, many piston or mechanically-fed systems do not.

Why use the fixed funnel method of angle of repose calculation?

The angle of repose measurement offers a cost-effective method of characterising the flow properties of powders which do not readily flow through standard test funnels.



Generally, measuring the angle of repose follows on from the Hall Flow test method (ASTM B213, see Hall Flow Testing datasheet) and/or the Carney Flow test (ASTM B964, see Carney Flow Testing datasheet), providing specific information for certain applications and AM machines. There are no public standards governing angle of repose measurement for metal alloy powders, which has led LPW to develop its own test procedure.

The test measures the height and base of a pile of metal powder after it is poured onto a flat surface. The angle of repose can range from 0° (a theoretical, highly flowing substance) to 90° (a highly cohesive powder) and the shallower the angle, the freer flowing the powder.



Angle of repose methodology

The measurement is undertaken in a laboratory environment, and much of the required equipment can also be used for Hall and Carney flow testing and apparent density testing.

A cup with a consistent, flat, circular base is turned upside down and placed under a wide funnel. A height gauge is used to measure the height of the cup, and calipers to measure its diameter. Powder is then poured through the funnel, ensuring it pours evenly onto the centre of the upturned cup, and that unstable flow does not lead to intermittent lumps flattening the ensuing mound. When the powder has spilled over the side of the cup, the height gauge is used to measure the height of the resulting mound of powder to the nearest 0.01 mm. The test is repeated three times using fresh powder for each test, and an average result obtained. The angle of repose is then calculated using the formula ($Angle\ of\ Repose = \tan^{-1}\left(\frac{2H}{D}\right)$).

Typically, the results generated by angle of repose testing are used to provide a comparison against the powder's historic performance and previous powder batches to confirm consistency of performance.

All laboratory analysis reports are returned electronically via LPW's secure, encrypted system and treated in the strictest of confidence.

LPW PowderFlow kit

To conduct powder flow testing in your own laboratory or production environment, LPW offers PowderFlow. The PowderFlow kit contains a complete suite of powder flow measurement techniques, allowing the measurement of angle of repose and apparent density, and testing of Hall Flow and Carney Flow to relevant ASTM standards.



Additional metal powder and Additive Manufacturing testing services

LPW's PowderLab offers a complete suite of tests for enhanced characterisation of powders, fully optimised for specific applications. With our metal 3D printing industry expertise, we can test AM components in validation studies and root cause analysis of failed builds.

Chemical analysis

- Oxygen, nitrogen, and hydrogen analysis by Inert Gas Fusion
- Elemental analysis/Contamination screening (EDX)
- Moisture analysis by Karl Fischer titration

Full Chemical Analysis is available including residual elements and interstitials using various techniques as appropriate, undertaken by ISO17025/Nadcap Approved Lab

Physical analysis

A range of physical tests is available including:

- Apparent/Bulk Density (measurement according to ASTM B212)
- Tap Density (ASTM B527)
- Hall Flow (ASTM B213)
- Carney Flow (ASTM B964)
- Angle of Repose (LPW standardised internal procedure)
- Sieve Analysis (ASTM B214)
- Particle Size Distribution by Laser Size Diffraction (ASTM B822)
- Powder Imaging (SEM)
- Powder Cross-Section/Porosity Imaging (SEM)
- Metallographic sample preparation & examination (SEM)
- Rheometry and Shear Cell Analysis
- True Density by Helium Gas Pycnometry (ASTM B923)
- Quantitative Shape Analysis (Optical & SEM)

All our testing is undertaken to relevant ASTM as standard with ISO available on request, adding consistency and confidence to your process.

For further information on any of our analytical testing services, please contact your local LPW office at www.lpwtechnology.com/contact-us/ or email sales@lpwtechnology.com