GRANU TOOLS™

ALL WE DO IS
POWDER FLOW
CHARACTERIZATION

ADDITIVE MANUFACTURING PROCESS OPTIMIZATION WORKFLOW

Granular materials and metallic fine powders are widely used in many industry (3D Printing, sintering, alloys, ...). To control and to optimize processing methods, the physics of powders must be precisely analysed. In this flyer, user cases and concrete examples will be shown regarding powders selection and process optimization for Additive Manufacturing (AM).

COMPANY PRESENTATION

GranuTools improves powder understanding by delivering leading edge physical characterization tools. Combining decades of experience in scientific instrumentation with fundamental research on powder characterization, we offer a unique set of complementary instruments.

A SET OF COMPLEMENTARY TOOLS

Named after their purpose our instruments are tools to understand the macroscopic behaviour of powders: GranuFlow is an automatic funnel flowmeter, GranuDrum is a Dynamic Angle of Repose analyser, GranuPack is a high resolution tapped density meter and GranuCharge is a tribo-electric charger.

POWDER PROPERTIES

The quality of the powders used in additive manufacturing is highly important because these powders will impact the physical properties of the final product. Moreover, improvements in the quality of the powders used will help to increase the number of products that can be made and, in addition, to save money.
That is the reason why, powder quality assessment is an important question for the AM process. To answer it, properties such as powders spreadability, flowability, compaction dynamic must be investigated.

POWDER BED FUSION (PBF)

A schematic diagram of a typical laser PBF machine is described by the following figure (Figure 1). The metallic powder is stored in a hopper and progressively exposed by a rising piston to the recoater. This part, can either be a blade or a roller that spreads the exposed powder across the bed. The main purpose of this operation is to create a thin and uniform layer. The powder excess is captured in a secondary container for re-use / recycling. The same cycle of spreading, melting is repeated several times, to build the component, layer-by-layer.

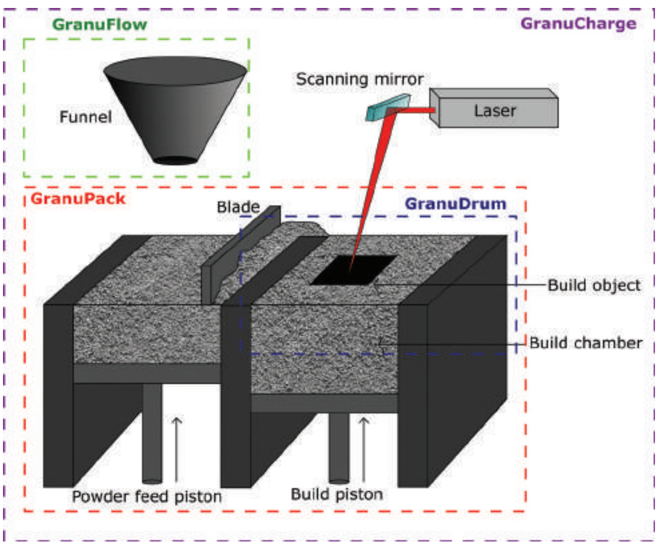
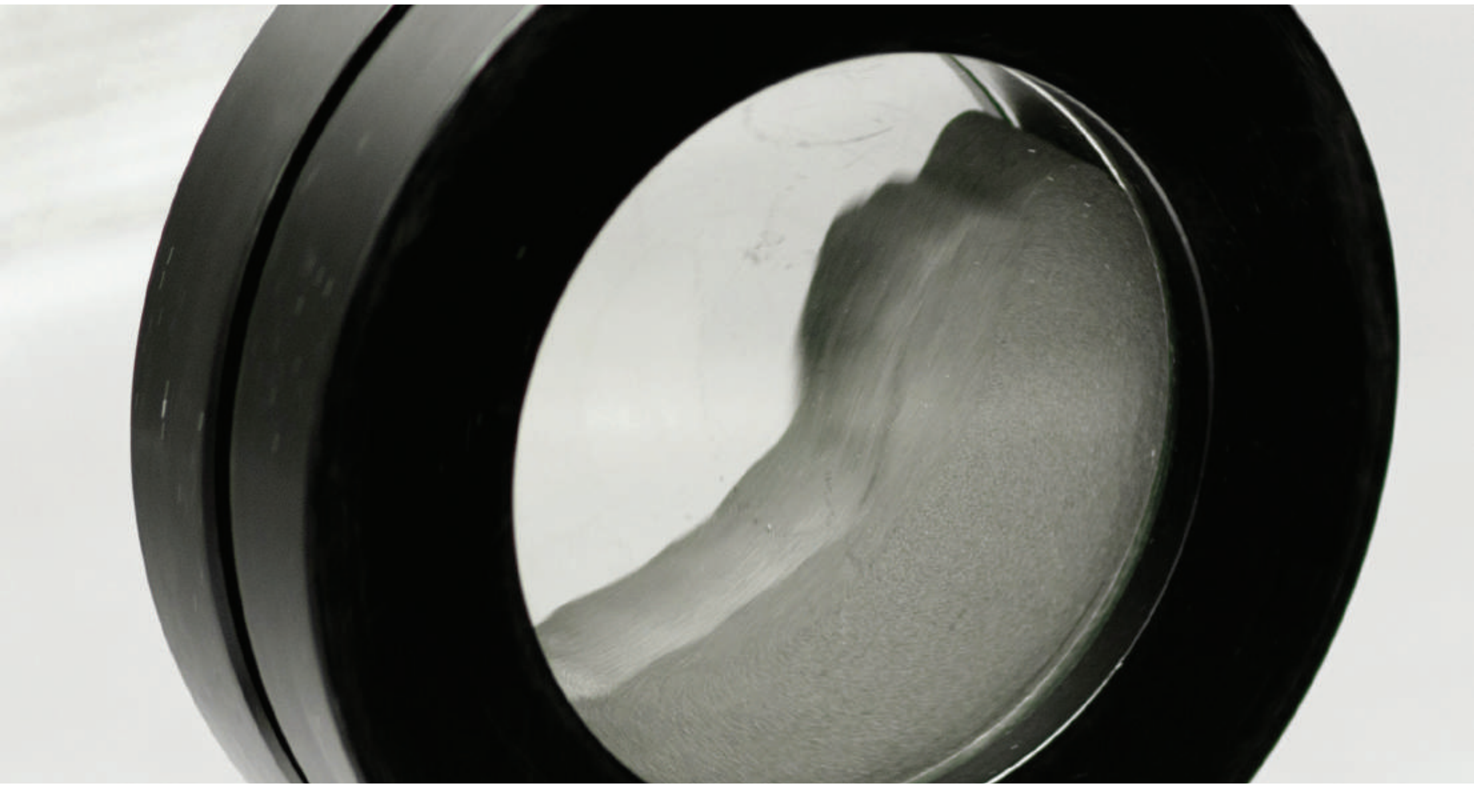


Figure 1 *Schematic diagram of a PBF process.*

In SLS (selective laser sintering), SLM (selective laser melting) and EBM (electron beam melting) techniques, successive thin layers of powder are created with a ruler or with a rotating cylinder. Each layer is partially sintered or melted with an energy beam (laser or electron beam). The layer thickness defines the vertical resolution. Therefore, a thin layer leads to a better resolution. In order to obtain a thin layer, the powder is as fine as possible. Unfortunately, when the grain size decreases, the cohesiveness increases and the flowability decreases. Moreover, the powder becomes more and more sensitive to moisture. Therefore, a compromise between grain size and flowability has to be found. The quality of the parts build with AM is directly related to the powder flowing properties. The flowability must be good enough to obtain homogenous successive powder layers.

For all the processing method dealing with powder, the measurement method used to characterize the powder should be as close as possible to the process. In particular, the stress state and the flow field of the powder should be comparable in the measurement cell and in the process.



Different recent publications have evidenced that the classical flowmeters are unable to give pertinent information about powder spreadability in powder-bed-based additive manufacturing.

In shear cell testers and classical rheometers, the existence of a compressive load is incompatible with the free surface flow used in AM devices.

However, the measurement method based on the rotating drum can serve this purpose because the powder flow is analysed precisely (2.2%) at the powder / air interface without any compressive load.

Moreover, the rotating drum geometry allows studying **the relevant powders properties for AM**: The Powders spreadability. Indeed, we have shown recently that the probability to obtain waves during the layer formation is proportional to the Cohesive Index measured by GranuDrum instrument [1]. Moreover, GranuDrum can also predict the optimal ruler speed to obtain a homogenous layer.

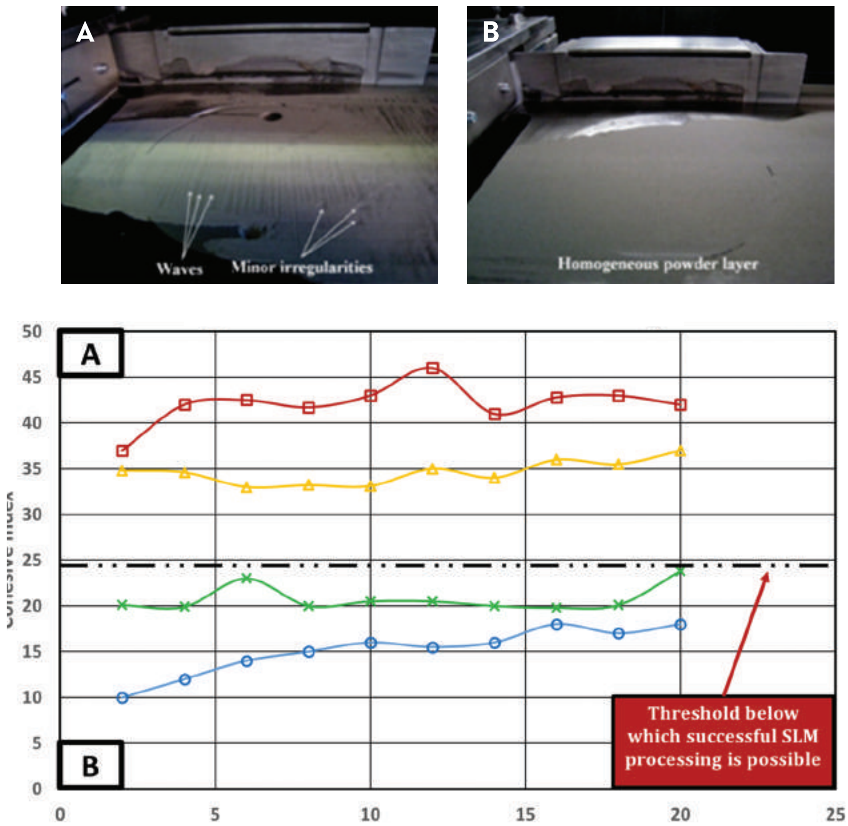


Figure 2: *Evolution of the Cohesive index versus drum rotating speed for TiNb, TNZ, NiTi and Ref-Ti titanium powders (adapted from Yabokova et al., 2015).*

[1] Powder Technology **283**, 199–209 (2015)

In addition to the flowability & spreadability, the powder packing fraction is the other key parameter. Indeed, a high packing fraction reduces the porosity of the produced part. Therefore, a precise measurement of the range of packing fractions accessible by the powder is also necessary as precursors quality control **with batch to batch differentiation**.

GranuPack instrument measures a compaction curve (density plotted as a function of the tap number) very precisely (0.4%) [2]. The precision arises from the measurement automation (operator independence) and from the use of an initialization protocol. The bulk density, the optimal density, the compaction range and speed are extracted from this compaction curve. Moreover, the compaction curves of different samples can be compared to evidence differences regarding both density and flowability.

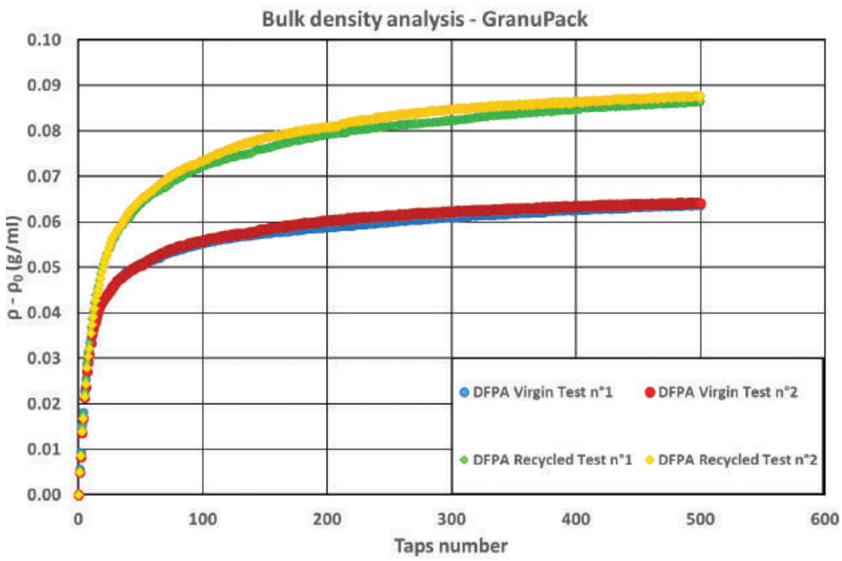


***Figure 3**: Bulk density variation for a Duraform Polyamide 12 virgin and recycled powder (after a SLS process). GranuPack can make differentiation between the two powders.*

[2] Powder Technology **224**, 19–27 (2012)

The funnel or silo configuration is a common way for powders feeding. Therefore, the product flowability must be perfectly known. However, nowadays, basics flowmeters only give information for one aperture diameter (usually 2.5mm). To fill the gap in terms of powders flowrate measurements, the GranuFlow was developed.

This instrument is a straightforward powder flowability measurement device composed of a silo with different apertures associated with a dedicated electronic balance to measure the powder flowrate.

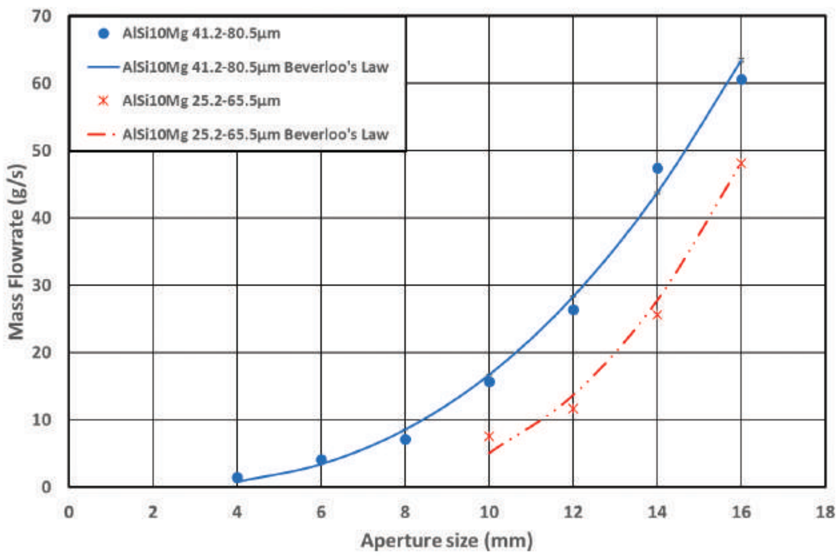
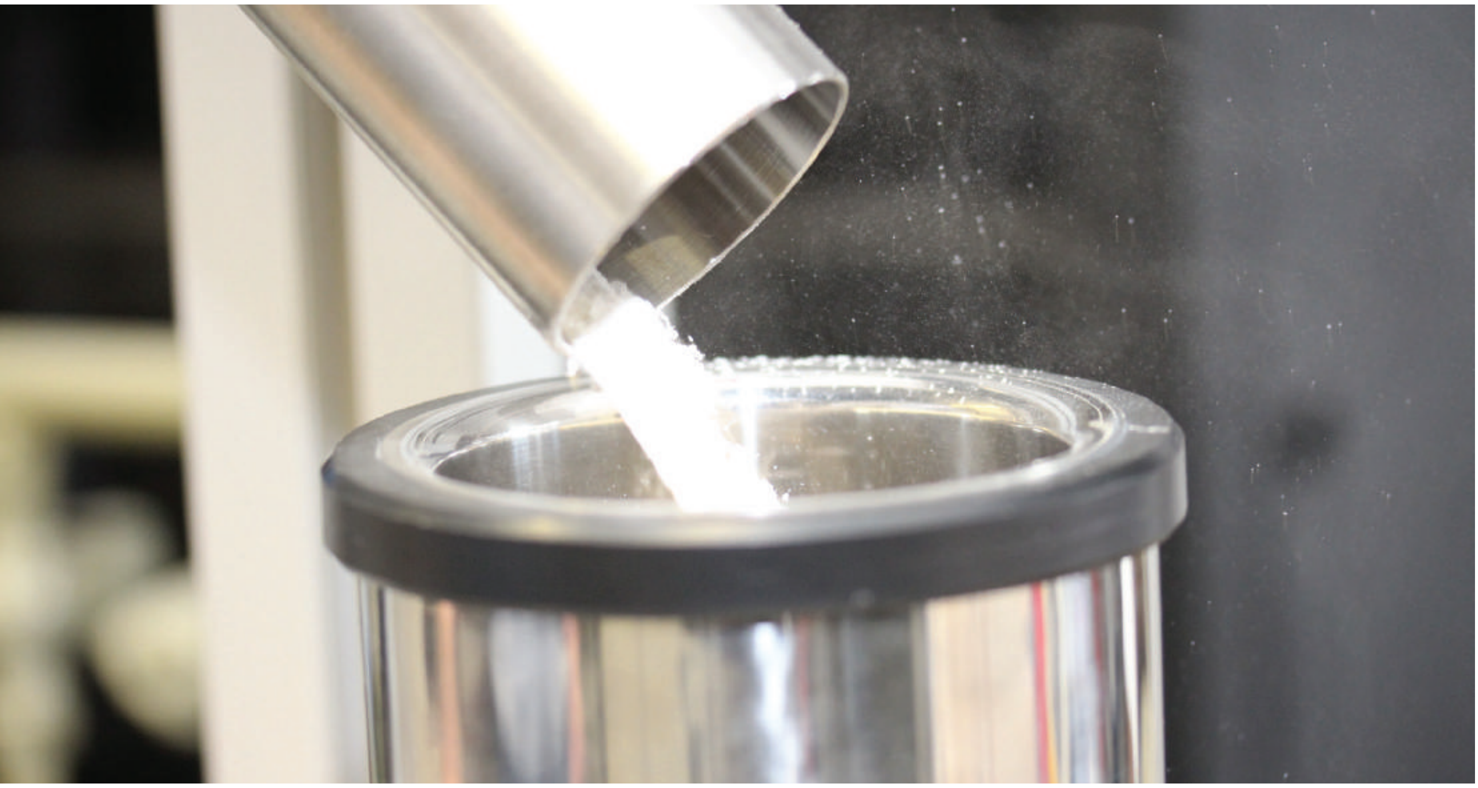


***Figure 4**: Mass flowrate versus aperture size for AlSi10Mg powders with two different Particles Size Distributions (25.2-65.5µn and 41.2-80.5µn).*

This parameter is computed automatically from the slope of the mass temporal evolution measured with the balance. The aperture size is modified quickly and easily with an original rotating system. Thus, the flowability in a die filling configuration can be easily achieved with great accuracy (1%). The measurement and the result analysis are assisted by software. The flowrate is measured for a set of aperture sizes to obtain a flow curve. Finally, the whole flow curve is fitted with the well-known Beverloo theoretical model to obtain a flowability index (Cb, related to the powder flowability) and the minimum aperture size to obtain a flow (Dmin). The whole measurement is performed easily, quickly and precisely.



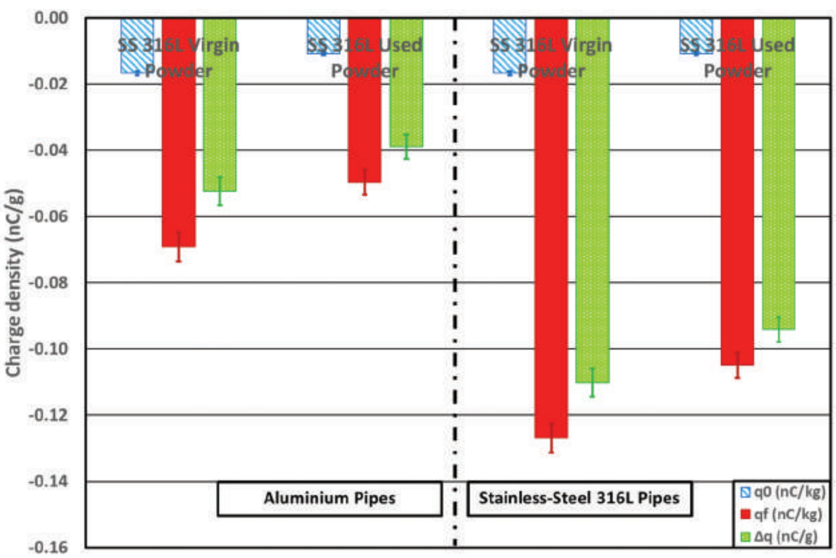


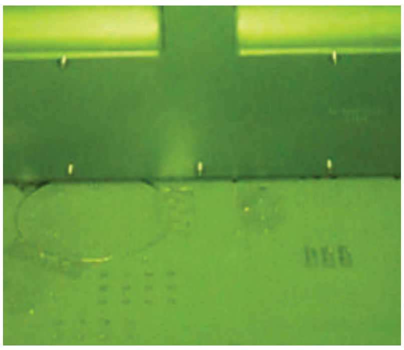
***Figure 5**: Charge density of a Virgin and Recycled (after only one SLM process) Stainless-Steel 316L powder in contact with different pipe materials (SS 316L and Aluminium). The ageing is perfectly highlighted.*

GranuCharge measures the ability of a powder to create electrostatic charges during a flow in contact with a selected material. The presence of electric charges in a powder induces cohesive forces leading to the formation of agglomerates. Therefore, GranuCharge is able to predict the flowability deterioration during a processing, for example during the layer formation in additive manufacturing. Moreover, the result of a GranuCharge measurement is highly sensitive to grains surface state (oxidation, contaminants and roughness). Then, the ageing of a recycling powder can, be quantified precisely (4%).

WORKFLOW FOR PROCESS OPTIMIZATION

Granutools is proud to introduce the revolutionary workflow for the process optimization of 3D printing.
The workflow is essential for parts producers, 3D printer manufacturers and powder companies.

WORKFLOW = GRANUDRUM + GRANUPACK + GRANUCHARGE



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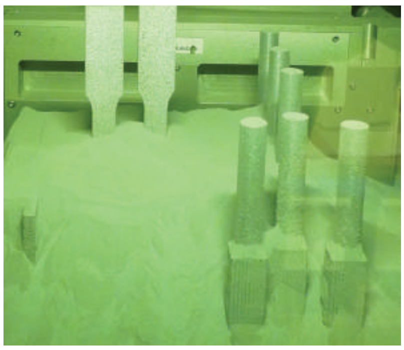

GRANUDRUM™
for re-coater speed optimisation

GRANUPACK™
for part porosity and surface roughness

GRANUCHARGE™
for powder re-usability

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