CARPENTER ADDITIVE®

CASE STUDY

Powder Flow
After Recycling

As Additive Manufacturing is used in more demanding applications it has become necessary to better understand the powder feedstock it uses and how this deteriorates with repeated use.

This is key to understanding how quality, traceability, and material utilization are managed in this emerging technology. Carpenter Additive's PowderFlow™ kit is aimed at helping our customers better understand their powders and track how their powders evolve over time.

This case study looks at the effect of recycling – reusing powder that has been exposed to the build process–- on the flow properties of a single batch of Titanium powder (Ti6Al4V, 15-45µm) processed using a Realizer SLM system.

After each build, the exposed powder was sieved to remove oversized particles, and then blended with the remaining virgin powder, at which point a sample was taken. This was performed for 10 successive builds.

Each sample was then tested for flow properties using the four tests contained within the PowderFlow kit.

These are as follows:

Hall Flow
Follows ASTM B213. 50g of powder is timed passing through the funnel, result is given as seconds/50g. Well established and understood technique, applicable to gravity fed deposition systems such as those found on Renishaw, SLM Solutions and Realizer systems.

Carney Flow
Follows ASTM B964-09. 80 grams of powder is timed passing through funnel. Larger aperture, than Hall Flow, otherwise likewise applicable.

Apparent Density
Follows ASTM B212-13. Calculated from mass of powder that exactly fills Hall Flow meter cup (calibrated volume). Measure of how well the powder packs naturally, which influences the density of the powder layers.

Angle of Repose
Follows Carpenter Additive WP08. Calculated from height of powder pile at limit of slumping. Measure of the cohesivity of the powder and another way of quantifying flow. More applicable for systems which are not gravity fed such as Concept Laser or EOS.

PowderFlow testing apparatus

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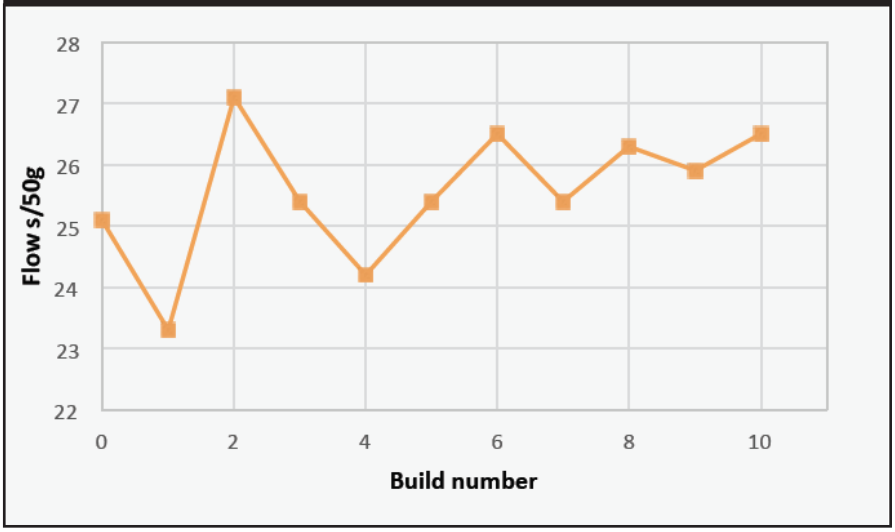
Results

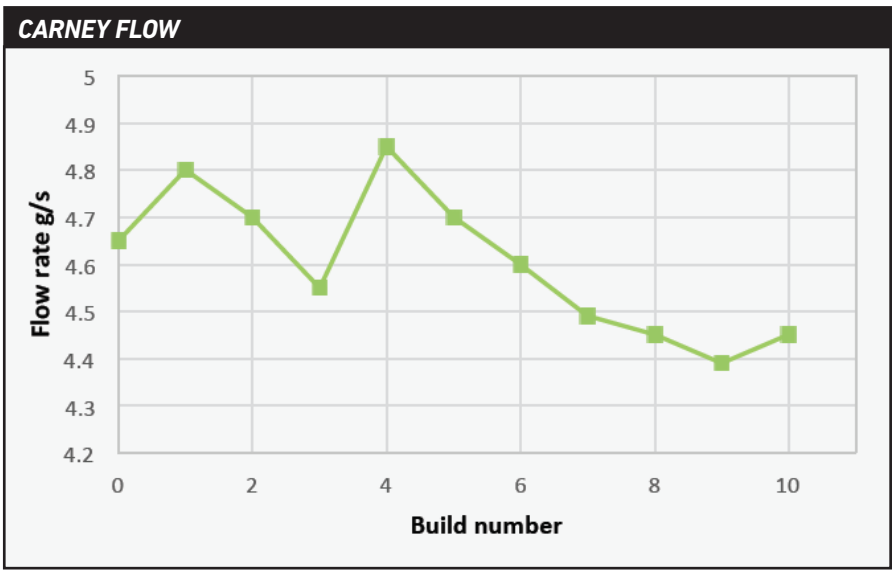
From the Hall Flow and Carney Flow tests one can see that over the initial few builds there is notable variability, after which the results converge. This level of variability is commonly seen in powders which have a low density.

When compared to the virgin powder (build 0), one can see that powder flow rate has started to degrade in the later builds, although the powder is still shown to be flowing.

HALL FLOW



CARNEY FLOW



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As with the flow tests, the powder displayed initial variation for angle of repose, but converged for the latter builds. This is again attributed to the low-density Titanium powder.

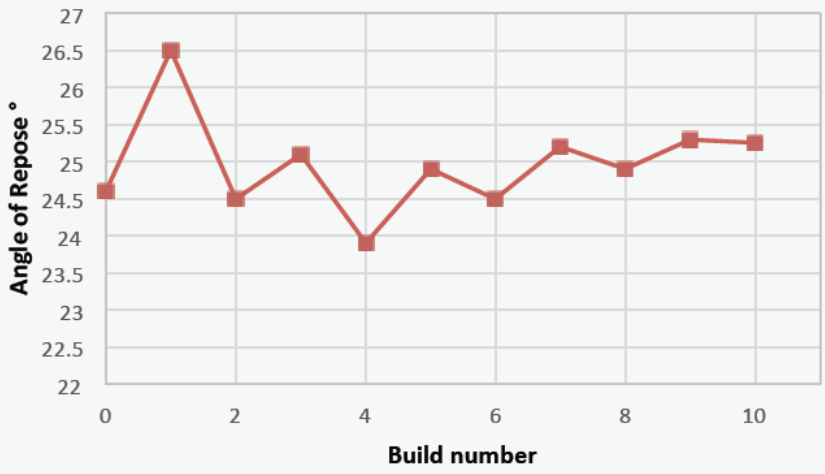
Apparent density was consistently measured at around 2.5 g/cm3 and was clearly not greatly affected by the recycling/blending.

Importantly the results show that the powder flows freely after each blend, however the flow rates were observed to decrease slightly with increasing build number.

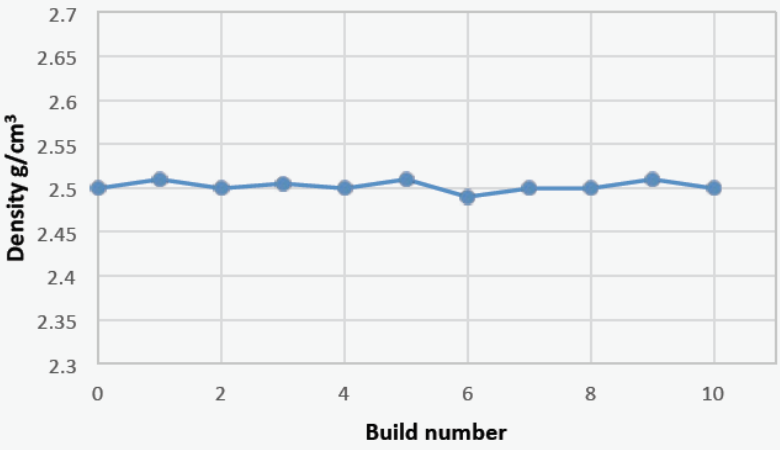
This level of degradation is unlikely to be noticed through visual checks, and only quantitative analysis of flow properties with the appropriate apparatus will reveal these trends. In this case, flow properties remained at an acceptable level, and a consistent apparent density gives confidence layer that quality will be maintained.

However, other powders may experience sharper falls in degradation which will not be so easily revealed without frequent analysis.

ANGLE OF REPOSE



APPARENT DENSITY



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Discussion

Powder flow and powder packing can have a significant influence on quality of the powder layer, depending on deposition system, and it is therefore important to understand how it is behaving in real world applications, and be able to predict this behaviour.

By tracking the powder flow properties after each build, we established that the Ti6Al4V powder flow was not significantly affected by the recycling process, but signs of potential future degradation were revealed. We also gained build specific data which could be used to aid process and part qualification for both present and historical builds.

PowderFlow

The PowderFlow kit will allow users to perform this type of analysis in house, providing quick results and process qualification and improved knowledge of powder behavior and processing.