CARPENTER ADDITIVE®

CASE STUDY

Using Carpenter Additive's Lab to Rapidly Complete a Root Cause Analysis of Powder Contamination

Carpenter Additive was approached by a customer operating an SLM Solutions machine to manufacture a component for an Industrial Gas Turbine application. Cracking was observed in the built component.

The customer approached Carpenter Additive to quickly determine the source of this cracking and allow them to recommence production. Below is an outline of how Carpenter Additive supports customers in a professional and responsive manner.

Day One

An American customer contacts us regarding severe cracking in some Aluminum components manufactured using Selective Laser Melting (SLM).

Time and expense had been invested in multiple build cycles, modifying the design and parameters to rule out geometry and poor melt characteristics as root cause.

Customer believed the powder feedstock was faulty - either contaminated or not within specification.

On receipt of images of the components, Carpenter Additive's technical team suspected that the powder could be contaminated.

Day Two

Carpenter Additive tested the retained sample which Carpenter Additive holds from every shipment. Using our internal lab equipment, we undertook a full chemical and size analysis. Powder was found to be in specification.

Scanning Electron Microscopy (SEM) Energy Dispersive X-ray Spectroscopy (EDX) was also undertaken on the retained sample. No contamination was identified.

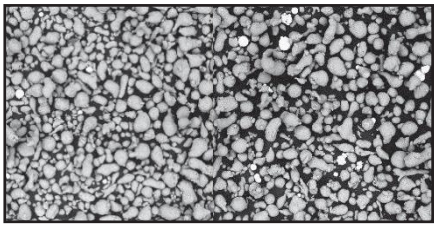
Day Three

A sample of the powder and a cracked component were shipped from America to Carpenter Additive's site in the UK.

Day Four

The sample is passed to Carpenter Additive's diagnosis lab. Analysis by SEM EDX revealed that the powder returned from the customer was contaminated. The images below show foreign particles when analyzed using SEM EDX.

Further investigation using Energy-Dispersive X-ray spectroscopy (EDX) enabled Carpenter Additive to identify the particles as Inconel 625.



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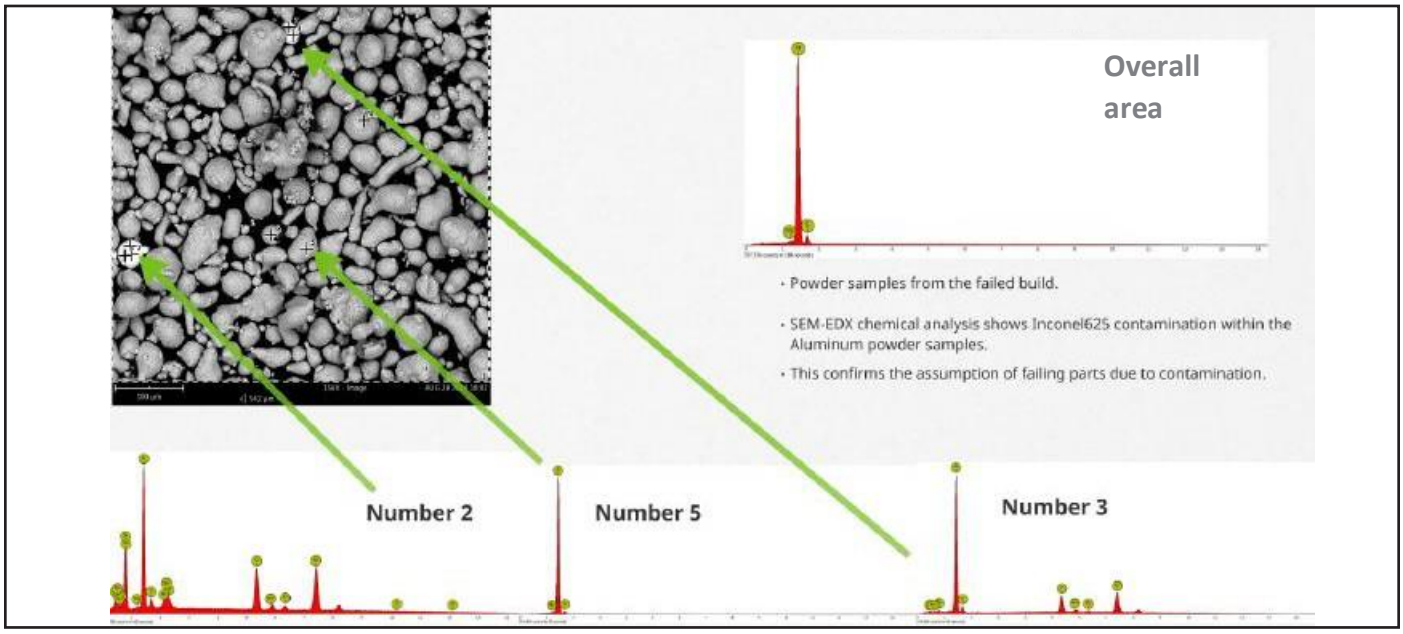


The image in the top left shows two brighter particles in this sample of material. The chart in the top right of the slide shows the analysis for the overall area of the powder whereby it detects Aluminum, Silicon and Magnesium as you would expect for the material.

However, when we analyze the brighter particles more closely you can see that the EDX spectrum has detected Ni, Cr and a number of other peaks. We identified this material as Inconel 625.

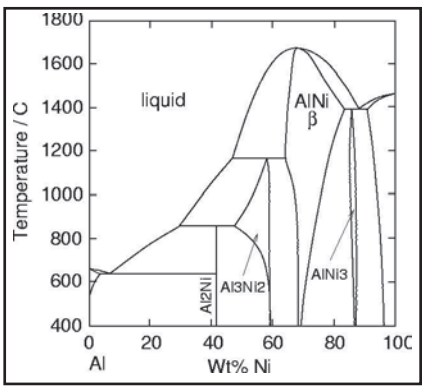
So just four days after the customer contacted Carpenter Additive, we were able to inform them of contamination and advise that the machine be restocked with only virgin powder from the same lot.

The components were re-built and in the subsequent days the customer informed us that the parts had been "built beautifully".

On further investigation, the customer confirmed that the machine had been recently changed from Inconel 625 to AlSi10Mg by a relatively junior operator who had not followed cleaning procedures.

This is a prime example of the complexity of the AM process and how working with the highly experienced Carpenter Additive team can limit exposure to risk. The customer had been unaware that a few stray particles left from a machine changeover could have such an impact on the part quality.

To fully understand the reasons why a small amount of Nickel alloy contamination could cause such devastating effects on the part quality, Carpenter Additive's metallurgists researched the issue. They found that Nickel has a very limited solubility in Aluminum which means that the brittle AlNi phases appeared in the microstructure, resulting in cracked propagation sites.



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Further analysis of the parts which failed revealed that the Nickel was fairly homogeneously spread throughout the Aluminum matrix of the component. An average of 5.2 wt% could be observed.

In specific areas wt% in excess of 40% could be identified, which indicates that we would have a presence of the very brittle intermetallic phases.

This information was fed back to our customer in America who was very happy to fully understand the issue and has subsequently improved their training techniques and internal procedures.

This service is offered to all of Carpenter Additive's customers – **Total Powder Management.**