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AUTOMATIC DETECTION OF POROSITY FAILURE MODES

HP INC

Automatic detection of porosity failure modes

Overview of the system

We have identified that printmodes have a very high dependency on the powder properties and that powder lots having certain properties that can affect the melt completion may lead to look and feel defects. Having bubbles and lateral porosity in PA12 based printing is one of the major escalations of the field today. That is why having a solution based on, at least, a warning on the printer before printing, will help clients take actions before printing.

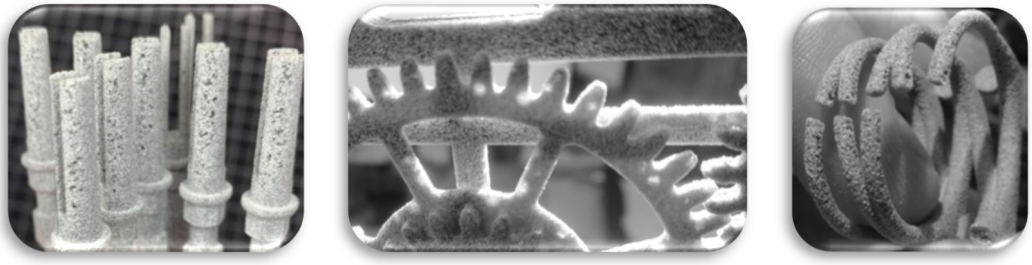

Figure 1. Customer parts and designs that have lateral porosity and bubbles

Detecting the probability of poor part quality before printing by using the time to melt metric, which is calculated during the Tmelt process.

Which are the problems that this system solves?

The aim of this disclosure is to mitigate the effect of the inherent porosity that MJF has. This can be done by detecting the state of the powder during the Tmelt process. After the Tmelt process, the customer will be advised about the possibility of porosity issues due to the state of the powder, and corrective actions will be suggested before continuing with the printing process.

How does the systems work?

By using the Tmelt algorithm, we can detect if the job has a risk of producing porosity. Porosity is caused by poor melt completion % of the layers, which can be detected before starting the job, through the Tmelt process.

Inherent porosity existing in the MJF technology can be mitigated by increasing the melt completion by using process knobs. However, the limitations of the technology cause that full melt completion can only be achieved by severely damaging the powder and compromising other part attributes. For that reason, melt completion is not achieved in MJF and thus bubbles and porosity cannot be eliminated completely. More porosity is observed, for example, in the

Balanced printmode in comparison to the Robust printmode. This is caused by the fact that Balanced printmode has less melt completion % than the Robust PM.

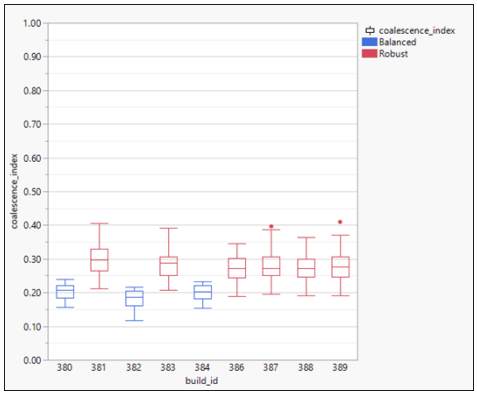

Figure 2. Melt completion % is lower in the Balanced PM (blue) than in the Robust PM (red)

Time to melt is a metric that is obtained from the Tmelt process. When this time is too high, melt completion % of the parts during printing is compromised. Time to melt correlates to the time to coalesce measured in the powder lab and with the complex melt viscosity of the powder.

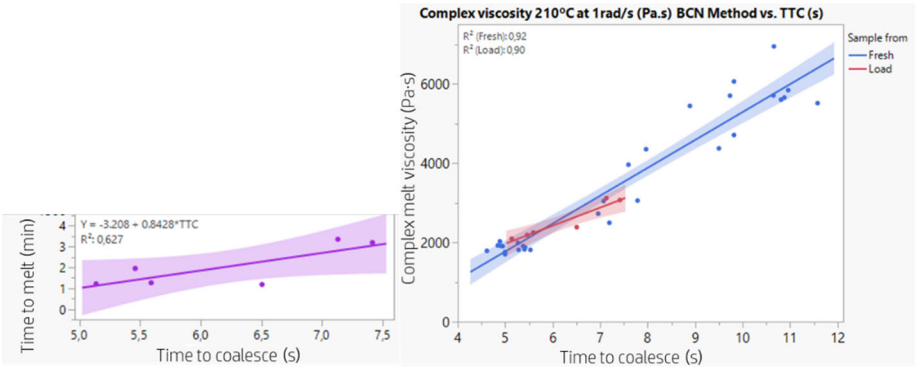

Figure 3. Time to melt (from the printer) correlates with time to coalesce (from the powder lab), which in turn correlates to complex melt viscosity of the powder

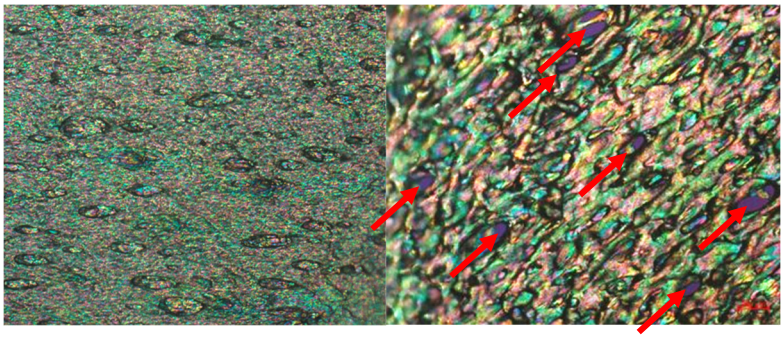

Figure 4. Melted layer on the melt tester from a powder with low viscosity and medium viscosity (left and right respectively). The bubbles in the layer can be appreciated on the medium viscosity powder

When complex melt viscosity is too high, time to melt (from the Tmelt algorithm) and time to coalesce (from the powder lab) are higher, and bigger pores are produced in the parts. When a high time to melt is obtained from the Tmelt algorithm, preventive actions will be shown in the screen, for the customer to decide whether to proceed or not:

- Stop
- Continue at client's risk
- Stop and perform increase of mix ratio: the increase of mix ratio will reduce the complex melt viscosity of the powder (since fresh powder has a lower complex melt viscosity), and this will improve the time to coalesce, time to melt and melt completion % of parts, reducing porosity.

Which are the advantages on doing in this way?

- Decreased powder and part waste
- Increased TCO since yield is expected to be improved
- Decreased number of customer complaints and compensations
- Avoid returned powder to company
- Increased customer confidence in MJF

Are in the market other kind of solutions?

The current solution for this issue is to clean all the subsystems and start using a different powder. This can only be done once the job is clean and the defect has been detected. A few jobs will potentially have been printed before the issue is detected. This causes a lot of waste, at least:

- 80kg of powder from trolleys
- Powder from the overflows
- Powder in the Jedha
- Parts printed before the detection of the issue
- Jabbas returned to company

All these solutions cause a TCO reduction for the client and additional costs for company.

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