Technical note

Technical Guideline for Material Development with HP 3D Open Materials Platform

This technical guideline is published with the intention to help potential material suppliers who are interested in developing suitable materials for HP Multi Jet Fusion (MJF) technology through HP Open Materials Platform. The guideline reflects the current knowledge within HP technical community on the material design space suitable for the MFJ technology. As our knowledge evolves, we will update this file with relevant new information. The scope of this guideline is to serve only as a starting point for material development. As each material is unique in properties and behaviors, the specifications of each materials developed for MJF should be defined through experimental iterations of design-build-test.

Concerning Multi Jet Fusion Process for Open Materials Platform (OMP)

For each material developed for MJF through the Open Materials Platform, there are several process settings with the HP 3D printing solution that can be used to optimize the properties and appearance of the printed parts.

Settings available to OMP materials:

- Amount of fusing agent used on each layer of powder
- How and where to apply detailing agent, e.g., amount and relative order to the fusing agent
- Powder bed temperature setting
- Number of passes of fusing lamp
- Speed of fusing lamp
- Speed of powder spreading of each layer

Settings not available to OMP materials:

- Different fusing or detailing agents designed to work with different materials
- Different hardware configurations

Concerning Material Selection for Multi Jet Fusion Process

Given the unique combination of technologies used in the Multi Jet Fusion process, there are a set of requirements defining whether a particular material is suitable for the process. When selecting and developing materials for Open Materials Platform, we need to take the following considerations in material requirement:

Selectivity Consideration

We define selectivity as the ratio of IR energy density absorbed by a fused powder layer (or parts) to the energy density absorbed by an un-fused powder. A higher selectivity is beneficial, and usually gives a better part quality in terms of mechanical properties, accuracy, surface finish, and improves powder recyclability.

IR energy absorbed by a fused powder layer is predominantly determined by the fusing agent jetted on the powder surface. In order to increase the selectivity, one would minimize the absorption of IR energy by white powder as much as possible. The IR emission spectra from our heating lamp in the printer is centered around 1100nm, so we want to minimize absorption near 1100nm by the powder. As long as the IR absorption profile in the near-IR range is low, in principal, the color of powder is not critical. However, dark powders or color powders should be avoided in general.

Melt Viscosity Consideration

For a given material, selecting the right molecular weight or melt viscosity is another consideration. A low melt viscosity material is easy to flow once molten and it consolidates quickly. On the other hand, high melt viscosity materials usually give a better part ductility, which is a desired attribute. However, if the melt viscosity is too high, the melt flow and part consolidation are slow in the MFJ process. In extreme cases, high melt viscosity materials may result in a very rough part surface, and sometimes visibly irregular surface defects.

You can measure the melt flow index (MFI) of a material at 40-50˚C above its melting point per ASTM D1238 procedure. A good starting MFI is in the range of 10-80cc/10 minutes under either 5.0kg or 2.16kg weight.

Semi-crystalline polymers have the following two critical advantages over amorphous polymers in MJF process. For these reasons, semi-crystalline polymers should be considered over amorphous polymers for MFJ applications.

- Once above its melting point, a semi-crystalline polymer rapidly becomes a liquid and its low viscosity helps the material to fuse and consolidate into solid parts.
- When in powder form below the melting point, particles of a semi-crystalline polymer are less likely to clump together to form a hard cake even at an elevated temperature, such as the one of build chamber. For this reason, materials with high crystallinity are usually desirable.

Melting Point and Process Window Consideration

MJF has been used to successfully process some of the materials with highest melting point in thermal-plastics. For initial commercialization, based on the formulations of our fusing agent and detailing agent as well as our hardware configurations, thermal-plastics, thermal-plastic elastomers, and their composites with melting point between 100˚C to 210˚C are most suitable for the MJF process.

Another consideration in selecting a material for the Multi Jet Fusion process is the process window of the material. The process window of a material is characterized by the difference in temperature between melting peak and crystallization peak in a DSC measurement cycle, i.e., in a constant heating ramp and a cooling ramp.   This process window defines the maximum allowable temperature variation within the build chamber of the 3D printer when this material is used to print parts. If the temperature is outside this process window, one would either get warped parts or have excessive caking of white powder.

A wider process window is important and sometimes is critical, as it makes easier to control the temperature inside the build chamber. For a plastic powder, a good process window would be greater than 35˚C. For elastomer or softer materials, MJF may be able to tolerate a narrower process window due to the fact that an elastomeric part may not warp as much as a plastic part.

Concerning Powder Form for Multi Jet Fusion Process

Powders used for the Multi Jet Fusion process need to be transported to the printing surface from powder supply compartments, compacted before fusing. They also need to be compatible with the layer thickness of the MJF process as well as with inkjet printing bars used to deposit fusing agent and detailing agent on demand. Therefore, there are considerations in the required particle size, particle size distribution, and powder flowability.

Particle Size Consideration

Particle size and size distribution in the follow ranges usually work well in MJF:

- D10 greater than 30μm
- D50 between 50-65μm
- D90 smaller than 100μm

Powder Flow Consideration

The ideal particle shape for powder flow is spherical. In general, with everything else being equal, particles with more isotropic shape provide a better powder flow. However, some powders that have irregular shapes have been found to be compatible with MFJ as well.

Powder flow can be improved with addition of flow aids. Those flow aids are typically metal oxides in a nano size scale with fumed silica being most commonly used. The loading of the flow aids can be optimized through experiments, and we found that a loading of <0.5wt% typically works well.

Moisture absorption in powders in some cases causes powder clumping and poor powder flow. Adding flowing aids sometimes will help to negate the effects of moisture. The issue related to moisture content in the powder may or may not impact the fusing process in MJF, but has impact on the powder manufacture, transport and pre-fusing processes of the MJF such as:

- Filling powder cartridge
- Recycling and mixing powder
- Powder transport from powder supply compartment to the surface of printing platform
- Spreading of the powder on to printing surface

Recyclability Consideration

In a typical 3D printing job with Multi Jet Fusion process, approximately 20% of powder is fused and consolidated into printed parts and the rest of the powder stays in powder form. It has a great benefit in reducing the customer cost if part or all of the remaining powder can be re-used in the next printing job by mixing it with fresh powder.

Among other attributes, powder with a good recyclability requires relatively stable molecular weight, color, particle size, and powder flowability after mixing re-used powder with fresh powder.

Adding antioxidants or other stabilizing agents into powder was found to be useful in improving powder recyclability.

Learn more at
hp.com/go/3Dprint

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