General Guidelines for Casting Jewelry Using Visijet FTX Green & FTX Cast from the ProJet 1200
Overview

3D Systems offers a wide range of printers and solutions for jewelers. This guide focuses on the castable polymer patterns produced by the ProJet 1200 used for lost wax casting. This document is intended to help you develop your own casting processes for 3D printed patterns using your existing equipment and investments. This guide is not specific to any one casting process, but rather is a general guideline to help you test and develop your own processes to take advantage of the power of the ProJet 1200.

The ProJet 1200 utilizes castable polymer (plastic) materials. There are fundamental differences between casting wax patterns and castable polymer patterns. The main difference being that wax liquefies and flows out of the investment cavity, whereas polymers remain solid and decompose in the investment cavity.
What is Jewelry Lost Wax Casting?

In this process, a sacrificial pattern is made out of a low melt temperature material; this pattern is typically wax or castable polymer (plastic). This pattern is mounted to a base with sprues (base and sprues are typically made of wax) that serve as gates for the removal of pattern material and pouring casting metal.

When connected, the patterns, the base and the sprues are collectively referred to as a casting tree. The casting tree is placed into a cylindrical container called a flask which is then filled with liquid ceramic. As the ceramic dries, it forms a hard shell around the pattern. The entire assembly is placed into an oven to melt/burn out the casting tree, leaving a negative of the pattern called the investment cavity. The hot flask is then placed into a casting machine that melts and pours the metal into the investment cavity. Once the metal part has cooled to a solid state, the ceramic investment is removed from the metal part.
Benefits of 3D Printing with Lost Wax Castings

3D printing has been revolutionizing many industries since its invention. The casting industry is no different. Below are primary reasons for utilizing 3D printing for jewelry casting.

- Speed
- Produce patterns that are impossible to generate with CNC wax milling
- Customizability
- Digital workflow
- Additional production capacity without additional staff

Traditional vs. 3D printing

The main difference between the traditional casting process and a casting process utilizing 3D Printing all comes down to the pattern; specifically, how the pattern is generated. Traditional wax patterns can be created in three ways: manually crafted by technician, by an automated mill machine, or by molds created by a master pattern. With the addition of the ProJet 1200 the patterns are directly printed in a castable polymer which gives increased flexibility and speed to the pattern making process.

Casting Materials and Application Considerations

General Casting Steps

1. Create a pattern
2. Assemble a casting tree
3. Preparing the Investment
4. Burnout process
5. Pouring the metal

There are many aspects that make casting more of an art than a science. One process that works with one customer will not necessarily work with another. A few factors that affect casting results including:

- Pattern geometry
- Pattern post processing
- Investment type and brand
- Ovens type
General Guidelines for Casting Jewelry

White Paper
For: ProJet® 1200

- Burnout process
- Duration between Printing and Casting
- Casting Metal Used

ProJet 1200 Castable Materials

The ProJet 1200 offers two castable materials.

- VisiJet FTX Green
- VisiJet FTX Cast

VisiJet FTX Green

VisiJet FTX Green is a pure polymer. This material creates a stronger pattern, allowing for production of complicated geometries without risk of damaging delicate features. When casting with a VisiJet FTX Green pattern only use a Phosphate based investment.

VisiJet FTX Cast

VisiJet FTX Cast is a polymer-wax hybrid. The addition of wax reduces the overall strength of these patterns, making them easier to cast. Due to the reduced strength the designed supports must be larger to reinforce the pattern during the build process. Wax content enhances its cast-ability making VisiJet FTX Cast more compatible with both a Phosphate and Gypsum based investments. There are customers successfully casting this material in both Gypsum and Phosphate based Investments.

Investments

Investment is a ceramic compound that is used to create the investment cavity by encasing then removing the pattern. Most investments used in Jewelry and Dental applications are categorized into one or two types, Gypsum and Phosphate. The main differences between these two types of investments are their strength and their heat tolerances.

Phosphate

Phosphate based investments are harder and stronger than Gypsum based investments. Phosphate investment is typically used for Dental and platinum Jewelry casting. The strength of Phosphate investments allows it to withstand the expansion of the polymer patterns. This investment is also more heat resistant.
which allows the caster to ramp the temperature of the burnout oven higher without risk of damaging and breaking down the investment. For these reasons we recommend Phosphate based investments when casting polymers.

Phosphate investments are more expensive, and are difficult to break away from the metal parts after casting. These investments also take hours to setup and require an overnight burnout process. Removing cast parts usually require an acidic solution or a water/bead blaster. For these reasons they are not as common in the silver and gold Jewelry industry.

Sample Phosphate investments:
- Randsom & Randolf Astrovest
- Whipmix Formula 1

**Gypsum**

Gypsum based investments are designed for lower temperature metals. Gypsum investments are softer, weaker investments compared to Phosphate investments. This investment produces superior surface finish, costs less and is easier to remove finished part. These investments setup in minutes and can be burned out and cast within a few minutes. For these reasons, Gypsum based investments are the standard for casting gold and silver in the Jewelry industry.

Gypsum investments break down at lower temperatures, limiting the maximum burnout temperature. The lower strength of Gypsum investments makes it vulnerable to the expansion of the polymer pattern. A broken investment from expansion creates inclusions in the metal pattern, reducing the quality or making the final product unusable.

Sample Gypsum investments are:
- Randsom & Randolf Plasticast
- Randsom & Randolf Ultravest
- Kerr Satin Cast 20

**Material Expansion:**

As with all materials, the patterns and the investment expand when heated in the ovens. This means you have two materials with different strengths expanding against each other; this has a potential to break or damage the investment cavity. We have found that thicker geometries are harder to cast successfully because expansion is directly linked to thickness. The thicker a volume is, the more expansion you will have.
Due to the effects of expansion on the casting process we recommend using a thin ring or coping design to refine your process before progressing to thicker more challenging geometries.

### Burnout Process

As mentioned before the traditional method of creating patterns in the Jewelry and Dental industries are to carve or mold the part out of wax. When using a wax pattern, the wax flows out of the mold prior to reaching wax's combustion temperature. This means there is only residual amounts of wax left in the investment cavity when the oven reaches the combustion temperature of the wax. When using polymer patterns, the patterns remain in the investment cavity while it combusts. During combustion the internal surfaces of the investments cavity is subjected to higher temperatures. Elevated temperatures may deteriorate the investment. Using a gas oven (kiln) is suggested as it has suitable air flow to aid in a clean burnout. Electric ovens may need modification to increase airflow.

### ProJet 1200 Casting Process

#### Printing the pattern(s) to be cast

The first step in the casting process is setting up the build with the CAD files of your pattern. Follow the steps in the user manual to properly setup the build as well as the following best practices:

**Orientation**

- Orient critical features up facing
  - This will ensure best accuracy and build finish

- Orient parts to have the smallest footprint on the build platform
  - This will provide the best surface finish on the Pattern
Generating Supports

- Use the manual support function to minimize supports.
  - Reduces post processing time
  - Better surface finish

Print
After the pattern is arranged and supported in the software, the build is sent to the printer.

Post Processing parts
After the pattern has been sent to the printer and has completed building it will need to be post processed. Start with the standard post processing procedure located in the user manual, and consider these best practices specific to casting.
General Guidelines for Casting Jewelry

White Paper
For: ProJet® 1200

Best Practices

- During the washing steps verify the parts are completely clean with no residual uncured material or IPA (Isopropyl alcohol) on the part
  - This will require soaking in fresh IPA (should be above 90% IPA)
  - Parts should be blown dry with compressed air to verify removal of all IPA
  - Part should look matted and should not be shiny or wet, if this is not the case, repeat washing and drying process
- Use flush cut clippers to remove supports from delicate features to avoid breaking when removing supports

Modification

- If you are curing more than one part on a Build plate you need to remove them prior to post cure and place them on the bottom of the Cure Chamber. We have found that parts located close together can have inconsistent curing if not removed from plate prior to curing. This is due to part surfaces being shadowed from the UV light by adjacent geometries.
- For VisiJet FTX Cast it is helpful to remove parts and supports from the build plate before post curing. Doing this before post curing will decrease the chances of damaging the parts when removing Supports.
- Curing time
  - We recommend running two 30 minute curing cycles on the parts, if parts are on the bottom of the build chamber flip/turn them between cycles.

Creating a Casting tree

Attach the 3D Printed patterns and sprues to the tree according to your flask size. This step is the same as traditional lost wax casting process and does not depend on how the pattern was created. Select your patterns by choosing freshly printed models. We have found that degradation occurs over time leading to poor burnout.

*Note: We recommend casting parts within two weeks of printing.*

Once the patterns have been fully cleaned and cured it is time to attach sprues to the patterns.
Preparing the Investment
For Phosphate based investments follow the manufactures casting procedures of the investments.

For Gypsum investments use manufactures recommendations with the following modifications and best practices.

**Best practice**
- Use cold, deionized water that when mixing the investment
  - Using another kind of water can reduce investment strength by up to 70%

**Modifications**
- Increase the strength and hardness of the investment by using less water than recommended by manufacturer.
  - Typically manufactures give different water to powder mixing ratios, we suggest choosing the one with the ratios and lowering it by one more increment.
    - For example if the ratio is 40/100 you want to use a ratio of 39/100

  *Note: If too little water is used the investment will get brittle and cause the investment cavity can crack when pattern expands*

- Allow the investment additional 30 minutes to 2 hours drying time to setup before beginning burnout process

**Burnout Process**

**Phosphate**
For Phosphate based investments follow the manufactures casting procedures of the investments. Below is a known investment.

**Astrovest**
Gypsum
For Gypsum investments use manufacture’s recommendations with the following modifications and best practices.

Best Practices
- We recommend using casting patterns within two weeks of printing. Parts that sit longer than this time reduce the success rate.
- Below is our recommended burnout procedure for Gypsum investments.
  - This will allow for slow expansion of the investment and pattern reducing the chance of damaging the investment cavity.

<table>
<thead>
<tr>
<th>Start time</th>
<th>Duration (hours)</th>
<th>Action</th>
<th>Start Temp (F)</th>
<th>Target Temp (F)</th>
<th>Ramp Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.3</td>
<td>Ramp</td>
<td>70</td>
<td>175</td>
<td>9999</td>
</tr>
<tr>
<td>0.3</td>
<td>1</td>
<td>Dwell</td>
<td>175</td>
<td>175</td>
<td>0</td>
</tr>
<tr>
<td>1.3</td>
<td>0.3</td>
<td>Ramp</td>
<td>175</td>
<td>300</td>
<td>9999</td>
</tr>
<tr>
<td>1.6</td>
<td>1.5</td>
<td>Dwell</td>
<td>300</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>3.1</td>
<td>1</td>
<td>Ramp</td>
<td>300</td>
<td>750</td>
<td>9999</td>
</tr>
<tr>
<td>4.1</td>
<td>2</td>
<td>Dwell</td>
<td>750</td>
<td>750</td>
<td>0</td>
</tr>
<tr>
<td>6.1</td>
<td>0.5</td>
<td>Ramp</td>
<td>750</td>
<td>1350</td>
<td>9999</td>
</tr>
<tr>
<td>6.6</td>
<td>5</td>
<td>Dwell</td>
<td>1350</td>
<td>1350</td>
<td>0</td>
</tr>
<tr>
<td>11.6</td>
<td>0.25</td>
<td>Ramp</td>
<td>1350</td>
<td>1125</td>
<td>-9999</td>
</tr>
<tr>
<td>11.85</td>
<td>3</td>
<td>Dwell</td>
<td>1125</td>
<td>1125*</td>
<td></td>
</tr>
</tbody>
</table>

Note: *Final temperature varies depending on the type of metal and flow characteristics.

Modifications
- When investing wax parts the button (opening of investment cavity) is pointed downward to allow the wax to flow out of the cavity. When casting with a polymer you should start with the button pointed down to melt out the casting tree. Before ramping above 300F (150C) flip the flask over so the button is pointed up. This allows for maximum airflow when the pattern begins to combust.
- Optional: After burnout, apply a vacuum for a brief moment to button before placing in casting machine.
  - This will remove any residual ash in the cavity.
  - Do not apply for more than 2 seconds to avoid cooling the mold.
Pouring the Metal and Finishing

There are no modifications required for these step.

Conclusions

- The ProJet 1200 can produce parts for lost wax casting
- The process of casting with a polymer varies from traditional wax casting method and can require slight modifications to existing casting process.
- Applying best practices for build orientation and part post processing will lead to better patterns for casting.
- It is vital for successful castings that the patterns are cured with UV.
- We recommend starting with a thin ring or coping as a sample casting geometry to tune your process before attempting thicker, more complicated geometries.
  - Expansion of investment and castable polymer pattern can damage investment cavity.
  - Smaller geometries are easier as a result of less expansion.
- It is recommended to use Phosphate based investment for castable polymers due to the investment's higher strength and heat tolerance.
References
Adler, S. (2015, April 5).