

Case Study

Summary of the Process Rapid Ice Prototyping Case Study

1. Background and Introduction

During recent ten years, the combination of RP and Investment Precision Cast technology becomes an effective approach to produce metal tools quickly.

The Center for Laser Rapid Forming (CLRF) of Tsinghua University in China has studied and developed RP and RT technology since 1992. In the course of developing Melt Extrusion Modeling (MEM) process, when applying prototype of MEM to Investment Casting, the thermo-plastic material expands and then cracks the ceramic shell during the course of “losing pattern”, the expansion of the prototype may even breaks the ceramic shell completely. Considering this disadvantage of applying prototype of MEM to investment casting, the CLRF in Tsinghua University started to use water replacing thermo-plastic materials and put forward a new RP process-Rapid Prototyping Technology of Low Temperature Ice Forming.

2. Fundamentals of the process

This new process is similar to the MEM. The Rapid Freezing Forming (RIF) uses pure water or water with some agents as building material. In low temperature forming environment, water is extruded through a nozzle to the selective place under the computer's precise control, and is frozen rapidly upon deposition; the 3D solid part is built from the bottom up to the top layer by layer. Fig.1 shows that water extruded out in a continuous method (on left) or water extruded out in a droplet method (on right).

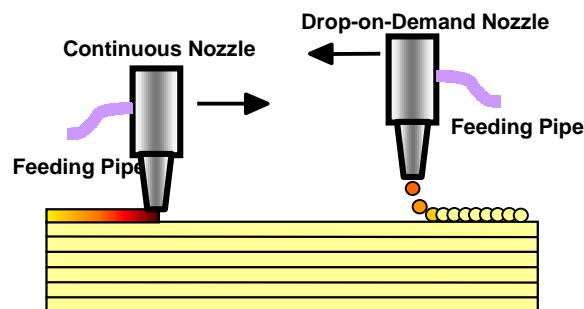


Figure 1 Principles of Rapid Freeze

3. Advantages

- 1 High precision. When using ice prototype in Investment Precision Casting, as ice pattern shrinks not like wax pattern which expands when heated to losing, it wouldn't crack the ceramic shell, in turn the precision and smoothness of ceramic shell could be kept to the most extent.
- 2 Low cost. Because water is so cheap and wildly that the material cost can be neglect.
- 3 No pollution. The building process and the building material have no negative impact on the operator and the environment.

4. Suitable Applications

- (1) Rapid Tooling. Similar to “losing Wax” Investment Casting, using the ice pattern instead of the wax pattern, metal parts can be cast through Investment Precision Casting at low temperature. Advantages of ice pattern casting include easy pattern removal, less shape limitation, better part mechanical properties, and better surface finish as compared to sand casting with wood patterns Table I lists a comparison of several casting processes



Figure 2 ice prototype



Figure3 ceramic shell

Table 1. Performance Comparison of some casting processes

Casting Process	Sand	Lost Wax	Lost Foam	Freeze Cast
Linear Dimensional Tolerance: in./10 in.	0.100	No Data	0.077	0.027
Surface Finish : (RMS)	300-700	125	125	90
Casting Defects (Scale 1-10, 10 being Worst)	10	5	6	2

- (2) To converse ice pattern to silicon rubber mold.
 (3) Used as cheap 3D printer

5. Some cases of Ice prototype



Ice link-rod

Half circle

Spiral solid in sin curve

Figure 4