Debinding and Sintering Processes of Ceramics

File Number: 60-SINT-0002

Revision: 2.0

10 May 2026

Tritone
Industrial Additive Manufacturing

Contents

1. Purpose

This document provides instructions for Debinding and sintering MoldJet™ manufactured parts.

The Debinding process removes the binder materials from the manufactured green part. The process used is a thermal Debinding process.

The Debinding profile ensures that the binder is completely removed before sintering. After the Debinding, the part is porous, and the sintering process is carried out. During sintering, by a diffusion process, interparticle necks are formed and shrinkage (densification) of the part takes place (sintering process schematics are illustrated in Fig.1). If the sintering process is optimal, the sintered part has small round pores and the general porosity less than 2%.

For Ceramic green parts It is recommended that the Debinding and sintering processes be executed as two separate processes in different batch furnaces. The Debinding process must be finished by preforming the pre-sintering step with a temperature high enough for initiation of the diffusion process, and the formation of interparticle necks. This provides the deboned parts sufficient brown strength to avoid disintegration of the parts. The below profiles describe the continuous processes for each MoldJet™ Material.

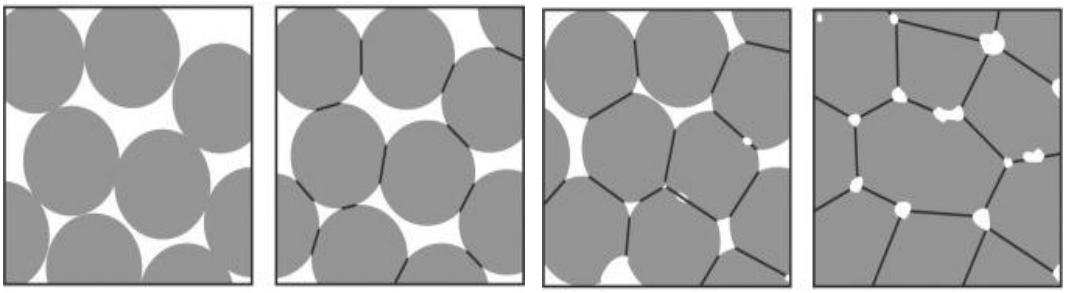

Figure 1: Schematics of the Sintering Process.

2. Debinding and Sintering processes

2.1. Required equipment (examples)

The debinding and sintering processes are performed in two different furnaces. The following furnaces were used with air as atmosphere were utilized to debind and sinter the MoldJet green parts.

There are ceramic sintering furnaces in the market that are equipped with a trap to collect the burned binders and enable a single process of debinding and sintering (such furnaces are available for example from Nabertherm, GMBH: (https://nabertherm.com/en/products/industrie/advanced-materials/furnace-solutions-1800-degc/combi-high-temperature-furnaces) and from Tisoma GMBH: (https://www.tisoma.de/en/products/furnace-technology).

Figure 2: Ceramic furnace used for debinding the Alumina parts described in this procedure.

Figure 3: Furnace used for sintering the Alumina parts described in this procedure.

2.2. Alumina Sintering

The tables and graphs below list the recommended temperature-time-atmosphere program and temperature-time profile for the Debinding and sintering of Alumina.

The following debinding profile was tested for wall thicknesses of up to 10 mm. For thicker wall thicknesses additional debinding time (slower heating rates) maybe required up to 600 deg C.

Stage #	1	2	3	4	5
Temperature [C]	380	600	600	950	20
Type R (Ramp-up); H (Hold)	R	R	H	H	R
Rate [C/Min]	0.7	0.5	-	1.0	2.6
Step Time /min	507 min.	440 min.	120 min.	350 min.	360 min.
Process gas	air				

Stage #	1	2	3
Temperature [C]	1630	1630	20
Type R (Ramp-up); H (Hold)	R	H	R
Rate [C/Min]	5.4	-	5.4
Step Time /min	300 min.	240 min.	300 min.
Process gas	air		

Table 1: Debinding (Left) and sintering (Right) Program for Alumina

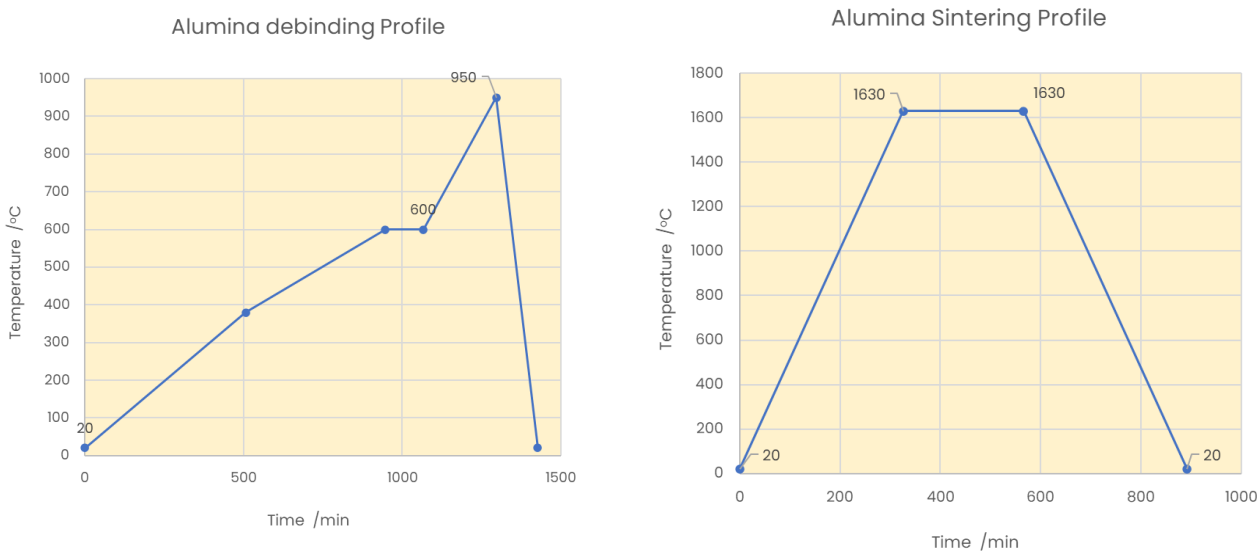

Figure 4: Temperature-time Profiles for Debinding (Left) and Sintering (right) of Alumina

1.1. Zirconia (3YTZ) Sintering

The tables and graphs below list the recommended temperature-time-atmosphere program and temperature-time profile for the Debinding and sintering of Yttria stabilized zirconia.

The following debinding profile was tested for wall thicknesses of up to 10 mm. For thicker wall thicknesses additional debinding time (slower heating rates) maybe required up to 600 deg C.

Stage #	1	2	3	4	5
Temperature [C]	380	600	600	950	20
Type R (Ramp-up); H (Hold)	R	R	H	H	R
Rate [C/Min]	0.7	0.5	-	1.0	2.6
Step Time /min	507 min.	440 min.	120 min.	350 min.	360 min.
Process gas	air				

Stage #	1	2	3
Temperature [C]	1480	1480	20
Type R (Ramp-up); H (Hold)	R	H	R
Rate [C/Min]	5.0	-	5.0
Step Time /min	292 min.	120 min.	240 min.
Process gas	air		

Table 2: Debinding (Left) and sintering (Right) Program for 3YTZ

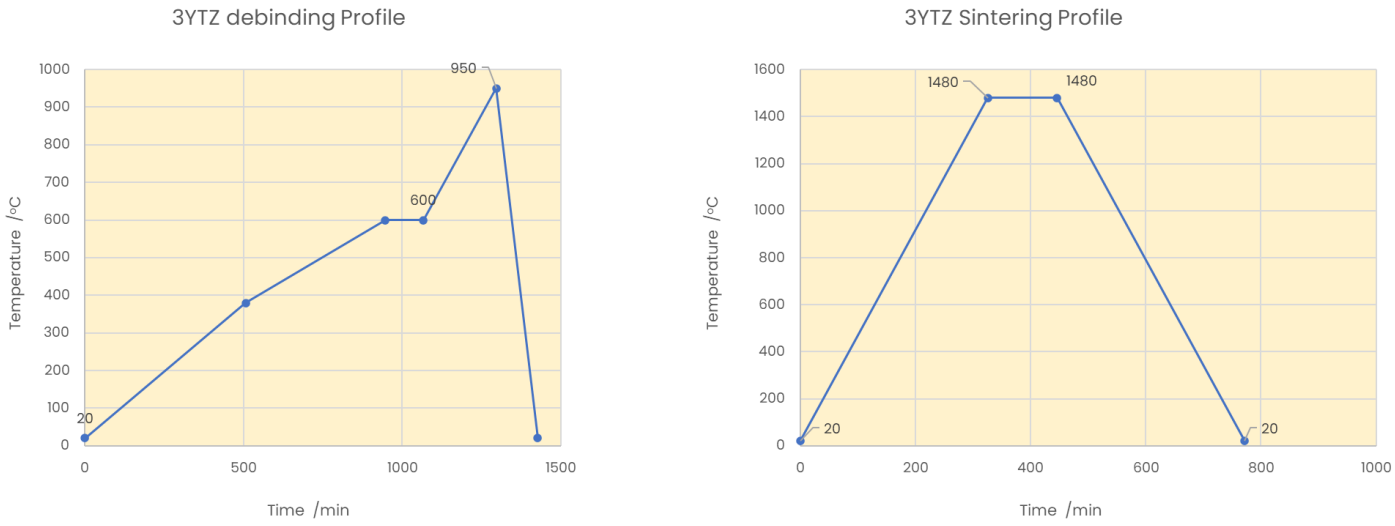

Figure 5: Temperature-time Profiles for Debinding (Left) and Sintering (right) of 3YTZ

2. Comments

The above temperature-time profiles are developed using a relatively small capacity (40 Liter) furnace. In practice, it is necessary to adjust these parameters with the corresponding program controller of the specific furnace to be used.

It is also necessary to note, that for mass production the dwell time of the intermediate steps should be tuned (increased) to achieve the temperature uniformity depending on the furnace loading. Generally, the heating rate is applicable for different loading.

Cooling is an important step of the sintering process from the economical and components properties point of view. Cooling rate generally depends on furnace design, components material, shape, and furnace loading.
From economic point of view, the production process should be as short as possible and therefore with a high cooling rate. A too high cooling rate may also cause the distortion of the sintered components - especially for parts with both thin and thick sections. In this case, the optimal cooling rate should be determined empirically. If the furnace doesn't consist of a heat exchanger and it isn't possible to do forced convection, a maximum possible cooling rate is determined by furnace design and mass of sintered components.

3. Requirements for Placing Parts in Debinding and Sintering

Debinding and sintering processes are done by placing the parts on furnace trays. Material of trays must provide rigidity at high temperature.

In order prevent chemical interaction between the trays and the manufactured parts, intermediate plates are used. The intermediate plates should have a thickness of at least 1.0-1.5 mm or more, and their length and width are selected so that several intermediate plates are placed on the tray.

The arrangement of the components on the tray and the distance between them should provide optimal conditions for binder removal and prevent components from welding together during sintering. This varies with the manufactured components size, shape and depends on the furnace design. The distance between the components for sintering can be less than that used for Debinding, and both are determined empirically.

It is recommended that during the sintering step the parts are covered by Alumina cover plates to avoid temperature gradients directly on the part surface (due to airflow or during heating or cooling) so to prevent deformations and cracking of the parts during sintering (see figure 3).

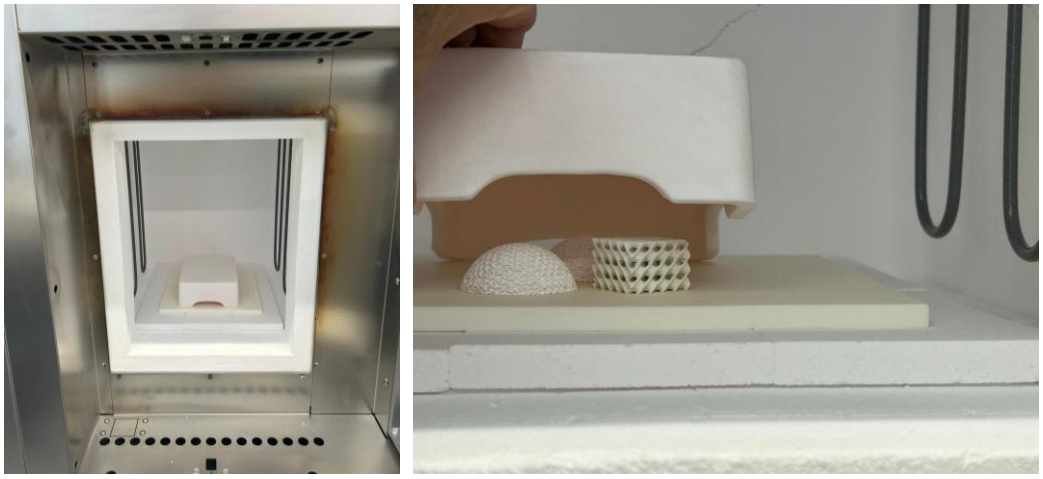

Figure 6: It is recommended to cover the parts during the sintering process

Appendix 1: Scale-up factor of MoldJet® Ceramics

Use this appendix to adjust the Scale-up Factor (SF) in the slicing software to calculate the dimension of the part to be manufactured according to the shrinkage in the following table.

- The scale-up factor (SF) compensates for the linear shrinkage of the part (in all directions) during sintering. **SF is the inverse shrinkage** of the part upon sintering the green part.
- For example -
  - SF of 1 means that your part is manufactured at its original size (no shrinkage considered).
  - SF of 1.15 for Alumina (XY directions) means that the final linear dimension of the part will be 86.6% of the printed part (13.4% shrink of the manufactured part).
- You should use the scale-up factor to adjust the scale of the parts in your slicer software.

The table below also lists the following build material properties:

- Paste density - the density of the Build material in gr per cc.
- Sintered density % - typical values of the relative sintered part density (%).

Material	Paste density gr/cc	Sintered density %	XY Shrink %	Z Shrink %
Alumina	2.4	98.5%	13.4%	17.8%
Yttria stabilized Zirconia (3YTZ)	3.1	98.5%	22%	22%

Important notes:

1. The shrinkages provided are typical values obtained after sintering to the final density listed in the table according to the debinding and sintering profile provided in this document.
2. User should adjust the final dimension of the parts according to the sintering and/or HIP processes used.

Revision History

Date	Comments	Revision
July 28, 2025	First Release	1.0
May 10, 2026	Addition of 3YTZ, Update of debinding profile	2.0