flonio™ ptfe

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GRANULAR POLYTETRAFLUOROETHYLENE

Processing Guidelines for Flonio™ PTFE Resin Powders

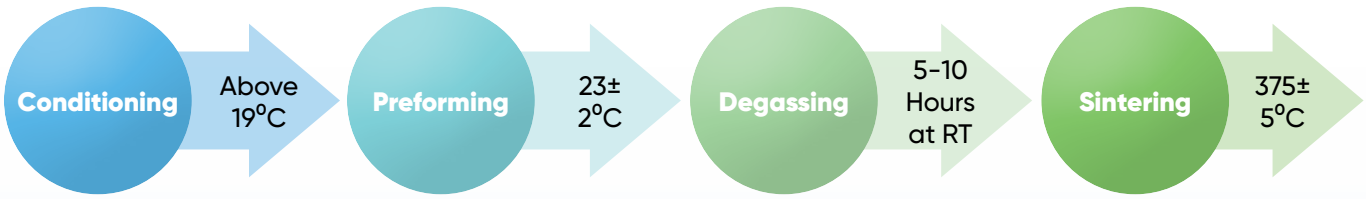
These guidelines are applicable for SRF's Flonio™ suspension grade granular PTFE resins, encompassing general moulding grade, Flonio™ S-120 and fine-cut grades, Flonio™ S-202, S-203, & S-208.

The processing involves two key stages: preforming and sintering. The powder is initially compressed using a cold compression moulding machine to create a preform, which is then subjected to specific sintering cycles to obtain the final product. The article's properties depend on factors such as preforming pressure, dwell time, sintering time, temperature, and cooling rate.

During sintering, PTFE moulded articles experience significant changes in dimensions. There is a reduction in dimensions perpendicular to the direction of performing pressure, known as "shrinkage" and an increase in dimensions parallel to the pressing direction, termed 'growth'. These changes are influenced by preform size, shape, preforming pressure, and sintering cycle.

General workflow for processing of granular PTFE resin is shown in Fig-1

Fig-1, Flow of PTFE processing



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Preforming

This operation involves compacting PTFE powder in a mould using a hydraulic press, applying defined pressure to create a robust green part for handling. It's crucial to condition the moulding powder above 19°C and mould the PTFE powder within the temperature range of 23±2°C. Uniform filling of the mould is essential, ensuring consistent pressure distribution on the resin to maintain uniform preform density and prevent cracking. The moulding process should proceed steadily without interruptions, with a recommended compression speed of 40-60 mm/min. Careful ejection of the preform from the mould is necessary to prevent cracking. For thin wall thickness applications and to avoid porosity, it is recommended to sieve the material under 1-1.5 mm mesh to ensure uniform and consistent powder, preventing defects and resulting in good quality final parts.

Mould design:

It's advisable to craft mould parts from high-quality stainless steel. If using mild steel, plating with chromium or nickel is recommended to prevent corrosion, contamination, and for ease of handling. Proper venting is essential for easy assembly and air escape. Careful mould design is necessary to prevent distortion under preform pressure, and the mould's length is calculated based on the powder's compression ratio, which typically ranges from 3:1 to 4:1.

Cleanliness:

Maintaining cleanliness is critical for successful PTFE performance. Good housekeeping and meticulous handling are imperative. It is strongly recommended that PTFE processing occurs in a clean - classroom environment or in a moulding area isolated from other processes, such as machining, where oil and dust may be present. Cleaning the mould and its accessories using a lint-free white cloth and a mild cleaning agent like IPA ensures a contamination-free preform. Proper storage of the die is crucial, employing a systematic approach to prevent accidents, physical damage in the die, and foreign particles in the PTFE article.

Weight measurement of resin, Table - 1

Solid preform	Hollow preform	Rectangular preform (moulded sheet)
$\pi r^2 \times H \times D$	$\frac{\pi \times (OD^2 - ID^2) \times H \times D}{4}$	$L \times W \times T \times D$

Where:

r = Radius of article

H = Height or length of article

D = Density of PTFE

OD = Outer diameter of article

ID = Inner diameter of article

L = Length of article

W = Width of article

T = Thickness of article

Note: Considered density of PTFE 2.2 g/cc

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Preforming pressure:

When the mould is closed with a top force or plunge ram by filling the required quantity of PTFE resin, an optimum pressure is applied to force the material to make a defined size & shape of the mould until the resin has compacted, which is called preform. Following moulding pressure is recommended to be fed in compression moulding machine.

Moulding pressure range for preforms, Table - 2

Flonio™ Grade	Operating Range (MPa)
S-120, S-208	18-26
S-202, S-203	16-26

Degassing:

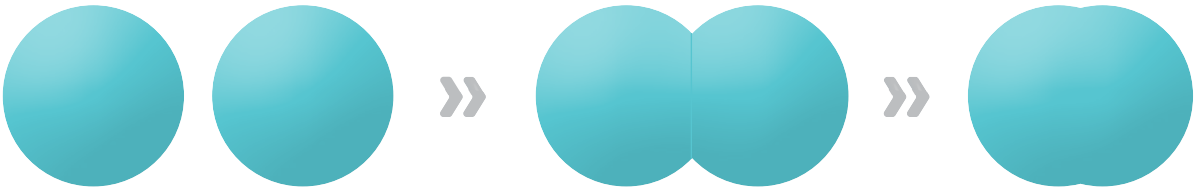
Prior to sintering, degassing the preform or article is essential. Entrapped air and residual stress must be relieved beforehand. Not all air exits the resin during compression, leaving a small, pressurised volume. This air needs time to escape, as failure to do so can lead to significant expansion during the sintering cycle's heat-up phase, potentially causing billet cracks. Allowing a suitable time interval helps alleviate stresses and permits air to escape, indicating the need for resting periods to prevent cracking. The degassing duration may vary based on the size and shape of the article or preform.

Sintering

Sintering is the meticulous process of binding particles into a unified solid mass through heat, without melting the materials. Given the preform's limited cohesive strength, it enables the coalescence of resin particles, enhancing strength and reducing voids. Coalescence involves the fusion of adjacent molten particles, forming a neck and rendering two particles indistinguishable from a larger one. Sintering temperatures, ranging from 370°C to 380°C, surpass PTFE's melting point of 342°C. Due to PTFE's low thermal conductivity, it should be heated slowly.

During the cooling cycle, crystallisation and annealing occur. Crystallisation, happening between 320°C and 325°C, involves orderly packing of polymer chains and is influenced by the cooling rate. Annealing, conducted at temperatures between 290°C and 325°C, removes residual stresses.

Fig-2, Mechanism of the sintering of PTFE



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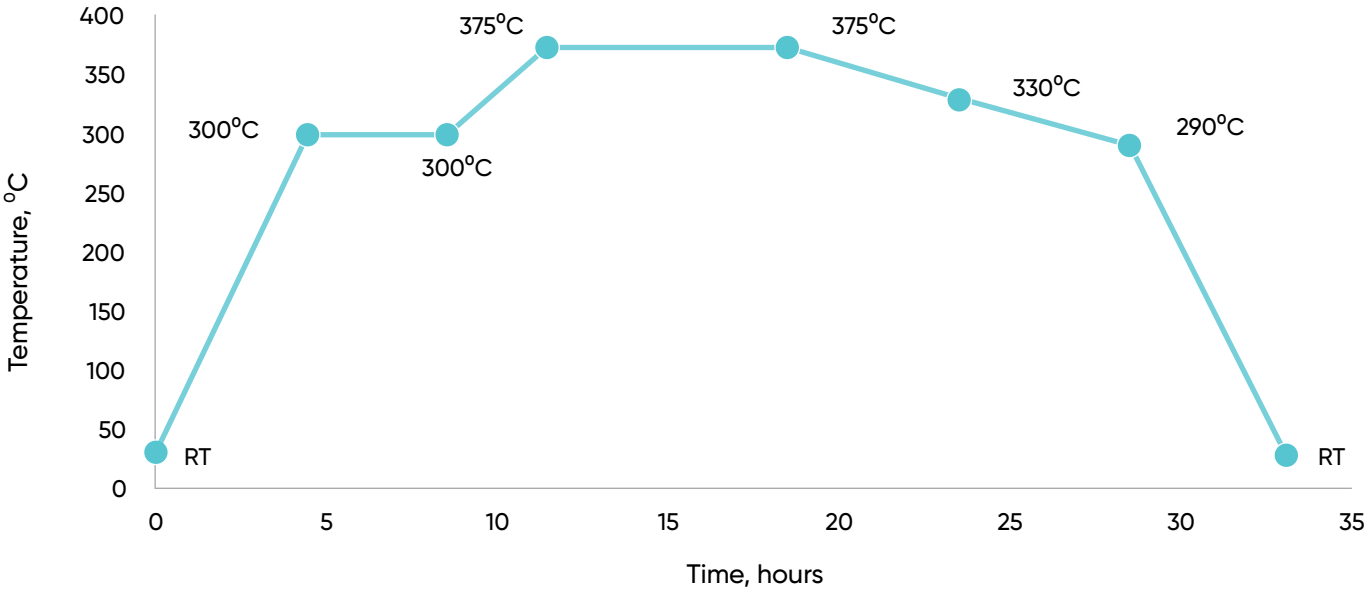
In the sintering oven, uniform hot air circulation throughout is essential, directly impacting the article's properties. Installing a PLC controller is recommended to prevent overheating, and supporting the door gasket prevents leakages. Proper exhaust leading outside, along with adequate ventilation, is crucial to avoid inhaling hazardous fumes. Preventive maintenance and cleanliness of the sintering oven significantly influence the properties of the PTFE article.

Recommended sintering cycles for Flonio™ resins :-

Fig-3, Typical sintering cycle for Flonio™ resins, Solid billets



Typical sintering cycle steps for solid billets, Table - 3

Diameter or size of solid PTFE billets (mm)	Time duration (Hours)							
	Step-1	Step-2	Step-3	Step-4	Step-5	Step-6	Step-7	Total time (hrs)
	RT to 300°C	Hold at 300°C	300°C to 375°C (±5°C)	Hold at 375°C (±5°C)	375°C (±5°C) to 330°C	330°C to 290°C	290°C to RT	
25	3	1	1	3	1	1	3	13
50	3.5	2	1.5	4	2	1.5	3.5	18
75	4	2.5	2	5	2.5	2	4	22
100	4	3.5	2.5	6	3.5	4.5	4	28
125	4.5	4	3	7	5	5	4.5	33
150	5.5	4.5	3.5	9	6	6	5.5	40
175	7	5	4	11	6.5	6.5	6	46
200	8	6	5	13	7	7	8	54

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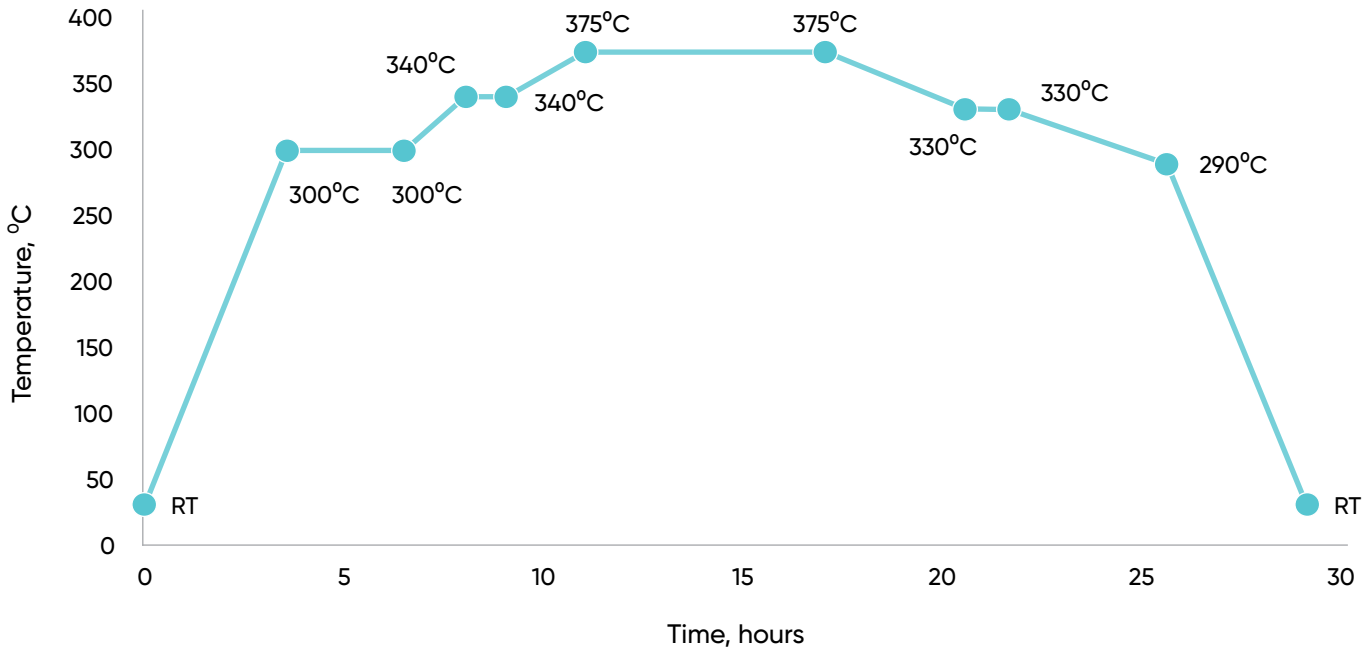
Fig-4, Typical sintering cycle for Flonio™ resins, Hollow billets



Typical sintering cycle steps for hollow billets, Table - 4

Wall thickness of PTFE hollow billets (mm)	Time duration (Hours)										
	Step-1	Step-2	Step-3	Step-4	Step-5	Step-6	Step-7	Step-8	Step-9	Step-10	Total time (hrs)
	RT to 300°C	Hold at 300°C	300°C to 340°C	Hold at 340°C	340°C to 375°C (±5°C)	Hold at 375°C (±5°C)	375°C (±5°C) to 330°C	Hold at 330°C	330°C to 290°C	290°C to RT	
25	3	1	1	0.5	1	3	2	0.5	2	3	17
50	3.5	3	1.5	1	2	6	3.5	1	4	3.5	29
75	5.5	4	2	1	2	9	5.5	1.5	6	5.5	42
100	6.5	6	3	1.5	2	11	7.5	2	8	6.5	54
125	8.5	8	4	2	2.5	14	9	2.5	10	8.5	69
150	10.5	10	4.5	2.5	3	17	11	3	12	10.5	84

Note: The above-mentioned processing parameters are for reference guidelines only. Processors can use them at their sole discretion and are free to choose and design their own process parameters to best suit their specific needs and requirements.

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General handling of Flonio™ resin:

PTFE resin is meticulously packaged in a robust plastic drum safeguarded by two flexible polyethylene bags. The bag on top is twisted, folded, and securely tied. Prior to untying, it's crucial to vacuum clean the outer bag surface, ensuring the removal of any foreign particles. Remove the tie, untwist the bag top, and unfold the bag over the rim of the drum. This precaution shields the powder, preventing contaminants from becoming trapped between the bag's exterior and the drum's interior. After moulding, ensure the remaining material is reclosed, tightened by twisting & folding the top of the polybag and securely tying it to avoid entry of foreign contamination.

PTFE has a natural tendency to agglomerate during transport and long storage, it is important to break the agglomerates by manually shaking with stainless steel scoop tool (avoid using bare hands or other objects which may contaminate the PTFE).

Appropriate storage and handling of Flonio™ PTFE powder is essential to ensure the integrity of the final products. The powder must be stored in a clean and dry area and handled with care to prevent any irregularities in the end results. To avoid lump formation, it should be stored at a temperature of 19°C or lower, as higher temperatures can lead to concerns during the moulding process.

As PTFE resin is very pressure sensitive, prevent any kind of activity where it is subjected to any pressings. Even under low pressures, PTFE resin tends to form lumps. These lumps can lead to various issues such as foreign particles, cracks, or voids, resulting in potential failures.

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SALES AND TECHNICAL SUPPORT

Headquarters:

SRF Limited
Block - C, Sector - 45,
Gurugram, Haryana, India - 122 003
Tel: +91-124-4354400
Fax: +91-124-4354500
Email: FP@srf.com

Works:

SRF Limited
D - 2/1, GIDC Phase II,
PCPIR, Village - Dahej,
District - Bharuch,
Gujarat, India - 392 130
Tel: +91-2641-289222