



MATERIALS MADE **SIMPLE.**

EXTRUDING PRIMETEC PEEK 10G

Extrusion Walkthrough

Our experience with the extrusion of PrimeTec PEEK 10G, a grade of Polyether ether ketone (PEEK). The material will be referred to as "PEEK" in this report.



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PEEK IN A NUTSHELL

- *Semi-crystalline, it becomes opaque when solidifying*
- *Outstanding mechanical resistance and chemical stability, even at high temperatures*
- *High heat resistance (typical processing temperatures around 360-400°C)*
- *High performance applications, can be processed only by certain extruders and 3D printers*

1. INTRODUCTION AND CONTEXT OF THIS REPORT

This document guides the reader through the extrusion process of PEEK, performed in our test lab at 3devo. It describes the experimental process that led to the optimal settings and the best product quality.

The goal of the test was to extrude filament of **1.75mm** thickness out of PEEK pellets. Figure 1 is a picture of the original pellets.

Chapters 2 to 5 explain more in detail the main experimental steps of the extrusion test, which consisted in a series of adjustments. The extrusion test was performed on a **Precision Filament Maker** equipped with a **4mm nozzle**. Chapter 6 gives an overall conclusion regarding the processability of PEEK, and summarizes the entire report.



Figure 1 - Pellets of PEEK



Figure 2 - Picture of the Dryer (the picture was not taken during this specific project)

2. PREPARATION AND PRE-PROCESSING

The material was supplied in a plastic bag, unprotected from moisture. Drying is typically a crucial step when trying to process PEEK-based formulations.

The **drying** was performed at **150°C for 3 hours** in our Dryer, as shown in Figure 2.

Before the extrusion test, the machine was purged with the following compounds:

- Devoclean MidTemp at 295°C
- Devoclean HighTemp at 295°C, then continuously up to 400°C

This purging/transitioning process was performed in two steps, with a transition between the two cleaning materials at 295°C (all four heaters). Here, Devoclean MidTemp and Devoclean HighTemp serve as purging compounds, but also as transitioning compounds to reach 400°C.



Figure 3 - Feeding PEEK into the hopper of the extruder

PEEK was then introduced at 400°C.

WARNING When experimenting with a new grade of plastic, it is of the utmost importance to introduce said plastic at temperatures high enough to ensure sufficient melting and to avoid the clogging of the machine.

Figure 3 is a picture of the feeding. Because the material came in pelletized form, no feeding issues were faced : the pellets were flowing easily down the hopper

3. EXTRUSION (1): STARTING POINT AND FIRST OBSERVATIONS

The following settings were used as a starting point during the extrusion test:

Parameter	H4	H3	H2	H1	Screw speed	Fan speed
Set value	400 °C	400 °C	400 °C	400 °C	5.0 RPM	50%

WHY 400°C? As mentioned earlier, it is wiser to start at a temperature that is too high, to avoid the clogging of the machine. For most grades of PEEK, 400°C is on the high end of the thermal window of operation (360-400°C).

WHY 5.0RPM AND 50% FAN SPEED? These values are very often appropriate values to start experimenting with a new material. In order to extrude stable filament of 1.75mm thickness, the best rotation speed is usually found between 3.0 and 6.0 RPM, which is why the starting value of 5.0RPM is always a good start. As far as the fan speed is concerned, it is harder to define an ideal percentage that works by default, because this parameter can vary a lot; it is good to start with a medium value and be ready to make quick adjustments.

THE FIRST RESULTS: The transition from Devoclean HighTemp was fast, as shown in Figure 4. The flow appeared to be rather stable, the extrudate was fully molten and free of impurities and bubbles. The extrudate was slightly too liquid when reaching the puller and therefore flattened by it.

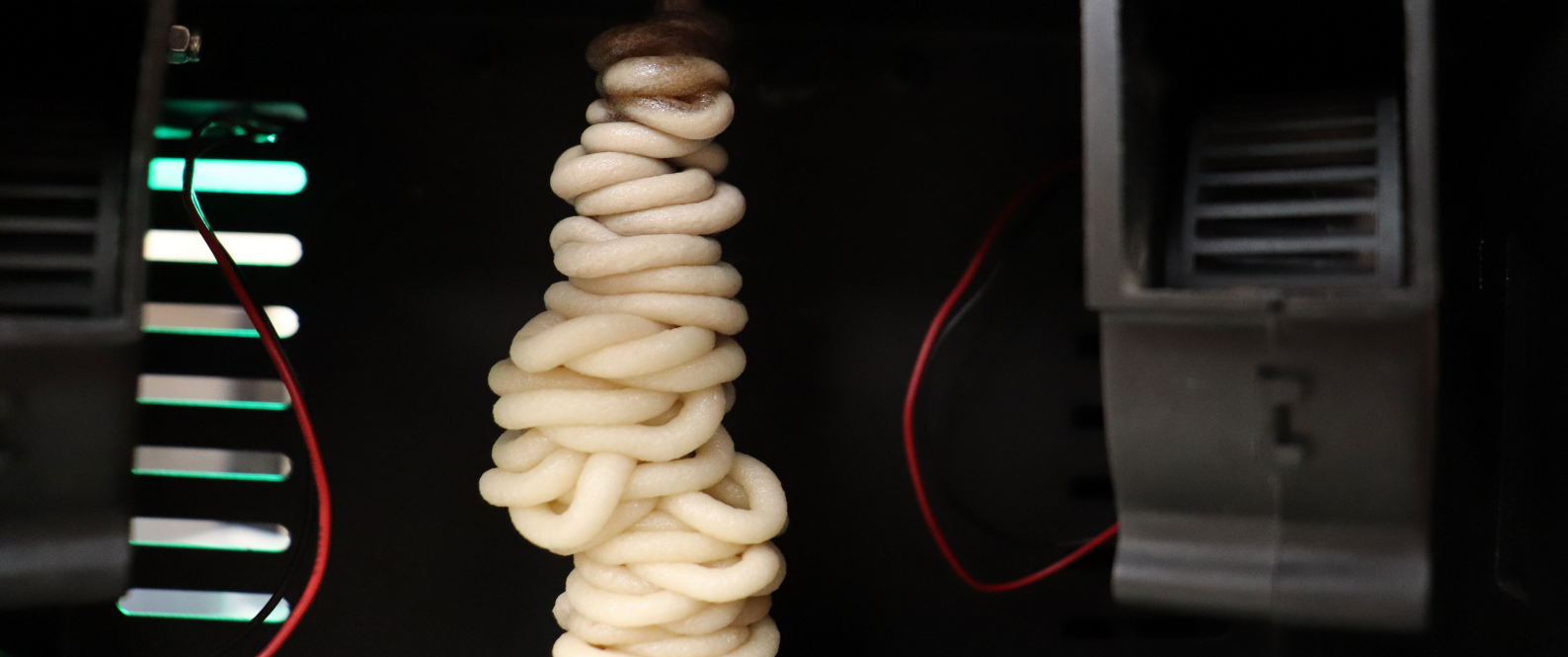


Figure 4 - Transition from Devoclean HighTemp (bottom) to PEEK (brown color, on top of Devoclean HighTemp)

4. EXTRUSION (2): AJUSTMENT STEPS

The objective was to find the optimal extrusion settings with the help of the filament sensor. Because the flow was very stable, the challenge was to make sure the extrudate was fully solidified before reaching the puller, without disturbing the flow or creating instabilities. Figure 5 is a picture taken during the adjustment phase, before the filament was of sufficient quality to be spooled.

FILAMENT FAN SPEED: It was found that to achieve optimal quality, a high fan speed was preferred, around **100%**.

SCREW RPM: In order to maintain a steady flow and just enough pressure inside the barrel, without affecting the initial good results too much, the solution was to decrease the screw speed slightly, to **4.5RPM**. This way, the extrudate was given additional time to be cooled down by the fans.

TEMPERATURES: When working with PEEK, it is crucial to keep the temperatures high enough. In particular, H1 should be left as close to 400°C as possible. Knowing this, the temperatures were lowered slightly by 5°C to 10°C, to allow the filament to be cooled down a little more easily.

THE IMPORTANCE OF DRYING: Not drying the PEEK may result in the formation of bubbles in the filament, that will dramatically damage the mechanical properties of the material, and increase fluctuations and inconsistencies in the flow.

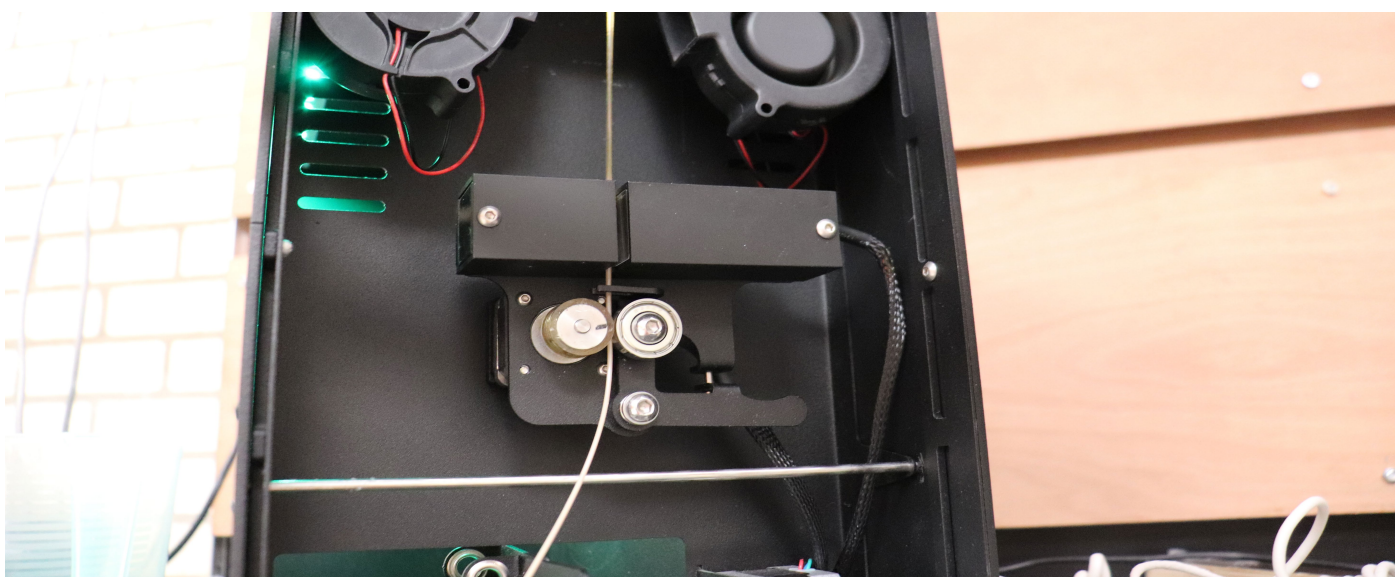


Figure 5 - Filament flowing freely during the adjustment phase

5. EXTRUSION (3): SPOOLING

The filament was spooled using the final settings found during the adjustment phase:

Parameter	H4	H3	H2	H1	Screw speed	Fan speed
Set value	390 °C	395 °C	395 °C	395 °C	4.5 RPM	100%

A spool was successfully manufactured using these settings. Figure 6 is a microscope shot of the product.



Figure 6 - Microscope shot to show the visual aspect of the PEEK filament : smooth, homogeneous, consistent

Figure 7 is the graphical representation of the datalog which corresponds to the produced spool. It shows that the filament thickness was extremely stable during the entire spooling process. The filament is well kept within the usual industry tolerance ($1.75 \pm 0.05 \text{ mm}$), over a long time.

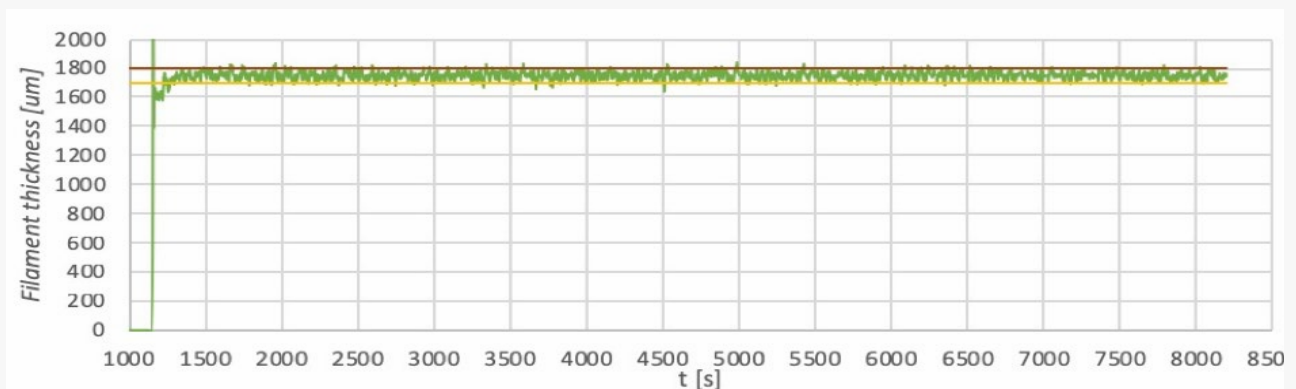


Figure 7 - Datalog : filament thickness (set value : 1.75mm, red line : 1.80mm, yellow line : 1.70mm)



Figure 8 - Spool of PEEK

6. CONCLUSION AND RECOMMENDATIONS

This extrusion experiment was extremely positive. Indeed, 1.75mm filament of excellent quality was obtained using a Precision equipped with a 4mm nozzle. The final spool is visible in Figure 8. Even though the 3D printing of this filament remains to be investigated, it can be said that the material could be extruded quite easily, without facing any major issue, and that the resulting filament's thickness was well-kept within industry tolerance standards (+/- 50 microns).

REPORT SUMMARY:

TO DOs:

- Keep temperatures around 400°C for optimal quality (especially H1 in order to avoid nozzle buildup)
- Dry the material at 150°C for at least 3h in a dryer or an oven
- Purge thoroughly before and after the extrusion
- To start extruding PEEK, start by purging at 295°C with Devoclean MidTemp, then transition to Devoclean HighTemp, then heat up to 400°C, then introduce the PEEK
- At the end of the extrusion, transition back to Devoclean HighTemp (at processing temperatures), then cool down to 295°C, then transition to Devoclean MidTemp, then switch the machine off

WARNINGS:

- It might be necessary to adjust the fan speed around 100% depending on the room conditions
- If 100% of cooling do not suffice (filament flattened by the puller), decrease the screw speed slightly, down to 4.3RPM for example
- Do not leave any trace of PEEK or Devoclean HighTemp inside the machine over a shutdown period. Only Devoclean MidTemp can be left inside a cold machine.

Parameter	H4	H3	H2	H1	Screw speed	Fan speed
Set value	390 °C	395 °C	395 °C	395 °C	4.5 RPM	100%