This document provides information on tuning the "pressure advance" configuration variable for a particular nozzle and filament. The pressure advance feature can be helpful in reducing ooze. For more information on how pressure advance is implemented see the kinematics document.

Tuning pressure advance

Pressure advance does two useful things - it reduces ooze during non-extrude moves and it reduces blobbing during cornering. This guide uses the second feature (reducing blobbing during cornering) as a mechanism for tuning.

In order to calibrate pressure advance the printer must be configured and operational. The tuning test involves printing objects and inspecting the differences between objects. It is a good idea to read this document in full prior to running the test.

Use a slicer to generate g-code for the large hollow square found in docs/prints/square.stl. Use a high speed (eg, 100mm/s) and a coarse layer height (the layer height should be around 75% of the nozzle diameter). It is fine to use a low infill (eg, 10%).

Prepare for the test by issuing the following G-Code commands: `SET_VELOCITY_LIMIT SQUARE_CORNER_VELOCITY=1 ACCEL=500` and `SET_PRESSURE_ADVANCE ADVANCE_LOOKAHEAD_TIME=0` . These commands make the nozzle travel slower through corners and they emphasize the effects of extruder pressure.

For the first print use a pressure advance of zero by running `SET_PRESSURE_ADVANCE ADVANCE=0.000` . Then print at least 10 layers of the test object. While the object is printing, make a note of which direction the head is moving during external perimeters. What many people see here is blobbing occurring at the corners - extra filament at the corner in the direction the head travels followed by a possible lack of filament on the side immediately after that corner:

This blobbing is the result of pressure in the extruder being released as a blob when the head slows down to corner.

The next step is to increase pressure advance (start with `SET_PRESSURE_ADVANCE ADVANCE=0.050`) and reprint the test object. With pressure advance, the extruder will retract when the head slows down, thus countering the pressure buildup and ideally eliminate the blobbing.

If a test run is done with a pressure advance setting that is too high, one typically sees a dimple in the corner followed by possible blobbing after the corner (too much filament is retracted during slow down and then too much filament is extruded during the following speed up after cornering):

The goal is to find the smallest pressure advance value that results in good quality corners:

Typical pressure advance values are between 0.050 and 1.000 (the high end usually only with bowden extruders). If there is no significant improvement after gradually increasing pressure advance to 1.000, then pressure advance is unlikely to improve the quality of prints. Return to a default configuration with pressure advance disabled.

Although this tuning exercise directly improves the quality of corners, it's worth remembering that a good pressure advance configuration also reduces ooze throughout the print.

At the completion of this test, update the extruder's pressure_advance setting in the configuration file and issue a RESTART command. The RESTART command will also return the acceleration, cornering speeds, and look-ahead times to their normal values.

Important Notes

- The pressure advance value is dependent on the extruder, the nozzle, and the filament. It is common for filament from different manufactures or with different pigments to require significantly different pressure advance values. Therefore, one should calibrate pressure advance on each printer and with each spool of filament.

- Printing temperature and extrusion rates can impact pressure advance. Be sure to tune the extruder E steps and nozzle temperature prior to tuning pressure advance.

- It is not unusual for one corner of the test print to be consistently different than the other three corners. This typically occurs when the slicer arranges to always change Z height at that corner. If this occurs, then ignore that corner and tune pressure advance using the other three corners.

- Check for warping at the corners during the test prints (the corners detaching from the bed and rising a small distance upwards during the print). If one corner appears warped then ignore that corner when tuning. If significant warping is seen throughout the test then typical solutions are to reduce the slicer's first layer speed, adjust the bed temperature, and/or to use the slicer's brim feature. Pressure advance itself is unlikely to impact warping, but this tuning test is sensitive to it.

- If a high pressure advance value (eg, over 0.200) is used then one may find that the extruder skips when returning to the printer's normal acceleration. The pressure advance system accounts for pressure by pushing in extra filament during acceleration and retracting that filament during deceleration. With a high acceleration and high pressure advance the extruder may not have enough torque to push the required filament. If this occurs, either use a lower acceleration value or disable pressure advance.

- The pressure_advance_lookahead_time parameter controls how far in advance to check if a head slow-down is immediately followed by a speed-up - it reduces pointless pressure changes in the head. It is recommended to follow the steps above so that it is set to zero during tuning and to use the default (0.010) during normal prints. It is possible to tune this setting - higher values will reduce the amount of pressure change in the nozzle during cornering, but setting it too high can cause blobbing during cornering. (Tuning this value is unlikely to impact ooze.) The default of 10ms should work well on most printers.

- Once pressure advance is tuned in Klipper, it may still be useful to configure a small retract value in the slicer (eg, 0.75mm) and to utilize the slicer's "wipe on retract option" if available. These slicer settings may help counteract ooze caused by filament cohesion (filament pulled out of the nozzle due to the stickiness of the plastic). It is recommended to disable the slicer's "z-lift on retract" option.

- Configuring pressure advance results in extra extruder movement during move acceleration and deceleration. That extra movement is not further constrained by any other other configuration parameter. The pressure advance settings only impact extruder movement; they do not alter toolhead XYZ movement or look-ahead calculations. A change in pressure advance will not change the path or timing of the toolhead nor will it change the overall printing time.