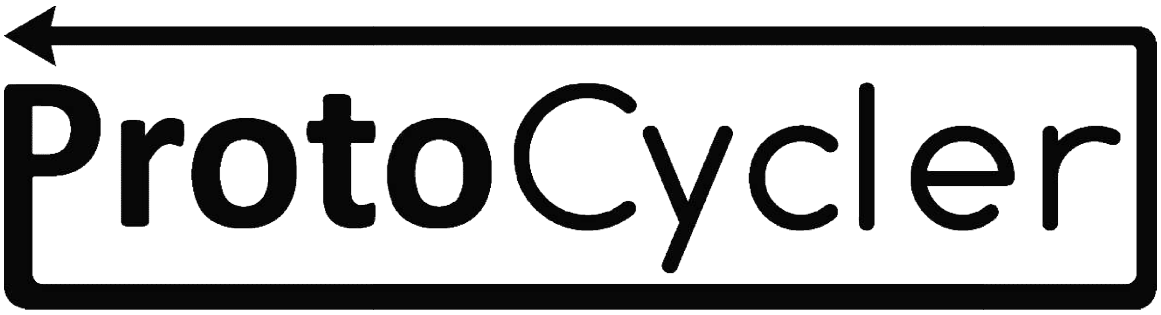

Troubleshooting Guide

RELEASE 0.1

ReDeTec

TABLE OF CONTENTS

1. Overview: 3

2. Out of Box Issues 3

2.1. Broken Parts 3

3. Extrusion Troubleshooting 3

3.1. Extrusion General Troubleshooting Procedure: 4

3.2. Automatic Extrusion Start-up Failure: 5

3.3. Filament Diameter Too Small 6

3.4. Filament Diameter Inconsistency 7

3.5. Low/No Flow From Nozzle 7

4. Specific Component Issues/Debugging 8

4.1. Diameter Sensors 8

4.2. Spooler-less Extrusion 13

4.3. Auger Jam Debugging 14

4.4. Tuning Spooling/Cooling (Debug Drawdown/Over-pulling) 15

5. Grinder Troubleshooting 18

5.1. Grinder Doesn't Drive Forward, Drives backwards 18

5.2. Grinder Doesn't Drive Forward or Backward 19

1. Overview:

This document will serve as a framework for troubleshooting all basic issues that may arise with ProtoCycler during grinding or extrusion. This is still under heavy development, and will be updated frequently as new issues arise and are addressed. This will eventually be implemented as an interactive webpage which will serve as the foundation for our support forum.

Following this guide should solve most basic issues, and help to narrow down the cause of any issues not addressed. If your issue is not solved by following this document, please contact support@redetec.com outlining the issue and results that you have seen in the troubleshooting process. Including this information in your support request will help us to identify the cause of the problem and implement a solution faster!

NOTE: Troubleshooting the extrusion process relies heavily on connection to the ProtoCycler Command Center desktop app for viewing parameters and collecting data. If you have not already, it is recommended that you review the information at http://www.redetec.com/support/software/ and download and install the software.

Future improvements to this document:

- Formatting
- High level, linked flow chart for each major branch

2. Out of Box Issues

2.1. Broken Parts

While we have done our best to test ProtoCycler's packaging and ensure it will not be damaged in shipping, it has come up that several accessories and cosmetic parts may be broken in transit. We believe this may be caused by lower temperatures during shipping causing these parts to become more brittle.
We are implementing changes to our packaging to reduce this as much as possible, and will replace any parts that arrive broken. Please email a request to support@redetec.com including pictures of the damaged parts and we will sent you replacement parts ASAP.

3. Extrusion Troubleshooting

ProtoCycler's extrusion is a very complex system that we have made simple through sensors, control and automation. When set up correctly ProtoCycler is able to take care of the entire extrusion process with minimal operator involvement, though we are still facing some bugs that may require the user to tweak things to get it set up properly in their specific environment. Many of these issues will become more automatic, standard procedure with future firmware updates and modifications.

This section outlines the methodical approaches to identifying the cause of common symptoms and errors seen in the extrusion process.

3.1. Extrusion General Troubleshooting Procedure:

Many dependent systems means that a small, trivial issue may manifest itself in many different ways. Thus, it is important to follow a methodical procedure of ruling out the trivial before proceeding to check each system in a cascading order. Review the section on the system in question first to rule out any trivial causes, and if the issue does not become apparent in isolation, proceed with general troubleshooting:

1. Ensure that you are using the correct settings for the plastic, and that you are using appropriate sized, dry plastic granules with colorant. Please review the full user manual if size, colorants or wet plastic issues are news to you. Failure to understand these limitations may be the cause of many issues.
2. For issues with getting Automatic Extrusion up and running, go to Section 3.2.
    - If Automatic Extrusion is starting up successfully, troubleshooting may be done in Automatic mode but with connection to a computer with ProtoCycler Command Center to properly monitor operation.
    - Otherwise, manual mode must be used to verify that each system is operating correctly, as various issues may be causing the automatic sequence to fail.
3. Verify that the diameter sensors are working correctly (Refer to section 4.1)
    - Incorrect diameter sensor readings may trick you into thinking there are other problems!
4. Ensure plastic is flowing properly through the extruder (Section 3.5)
5. Assess/debug spooling and cooling (Section 4.4)

Following this procedure and noting what you have tried and results observed before contacting support will help us to identify possible causes and solutions more quickly.

3.2. Automatic Extrusion Start-up Failure:

Issue: In basic automatic extrusion, ProtoCycler does not make it through the startup sequence correctly.

Case 1: Control enters cool-down sequence partway through start-up.

Sometime in the start-up sequence before you have pushed >>Spooling Ready, ProtoCycler switches to cooling mode, showing "Cooling Extruder" on screen.

Cause:

During startup, ProtoCycler prompts you to select >>Filament Ready once you have strung the plastic through the puller wheels, and (after stabilization) select >>Spooling Ready once you have taped the filament to the spool. Once prompted, you have 100 seconds to complete the operation and select the prompt. For safety reasons, if you do not proceed within this time ProtoCycler will enter shutdown mode.

Solution:

Review the section on Automatic mode to ensure you fully understand the sequence of operations & prompts.

Keep an eye on the display and as soon as it gives you the option, perform the operation and select the prompt immediately. If plastic is not flowing enough to complete the "Filament Ready" operation in time, you may have selected the wrong plastic setting, or have a clog issue. Please double check your plastic selection, and otherwise review Section 3.5 on low flow.

Case 2: Control Cannot Stabilize diameter

During Stabilization (after >>Filament Ready is selected) puller speed varies sporadically, slows to a stop, or filament is drooping excessively.

Cause:

This could be due to a number of issues:

- Incorrect settings selected for plastic
- Extruding transparent plastic
- Wet plastic -> Low viscosity causes drooping
- Low flow causes control instability
- Diameter sensor misaligned, obstructed, or dirty
- Error with automatic settings

Solution:

If the problem persists, you must extrude using manual mode to narrow down the possible causes. Refer to the full user manual for instructions on manual operation. Complete the general troubleshooting procedure in manual mode to identify possible cause before returning to Automatic.

If manual mode debugging is successful but returning to Automatic still shows issues, please contact support@redetec.com as this is likely an error in the automatic settings stored in the EEPROM.

3.3. Filament Diameter Too Small

Issue: Final filament diameter is found to be undersized after extrusion

Possible Causes:

- Transparent filament causes incorrect diameter reading
- Improper Cooling/Spooling causes stretching between puller and spooler
- Misaligned sensors cause incorrect diameter reading
- Control settings incorrect

Identify Cause -> Action:

1. Is extruded plastic transparent?
   Plastic must be opaque for sensors to read correctly. Please review section 3.2 in full user manual.
2. Display reads desired diameter, but filament measured to be undersized after spooling
   Most likely cooling/spooling. Refer to Section 4.4.
3. Display reads desired diameter, but filament measured to be undersized, NOT caused by Spooler Drawdown.
   One or both diameter sensors are not working properly. Refer to section 4.1.
4. Display reads undersized diameter, which corresponds to the measured diameter
   If this is happening in automatic mode it is likely a bug in the EEPROM settings. Try extruding in manual mode following section 4.5 in the full user manual to verify that it is an issue with automatic settings, and then contact support@redetec.com.
   .

3.4. Filament Diameter Inconsistency

Issue: Filament diameter is varying wildly during extrusion

Possible Causes:

- Transparent, wet, or inappropriate sized plastics.
- Spooler over-pulls filament, interfering with control system
- Misaligned sensors cause incorrect diameter reading
- Low flow rate causes control system instability

Identify Cause -> Action

1. Ensure you are using colored, dry, appropriate sized pellets/granules
   Review section 3 in the full user manual for more information.
2. Check for spooler interference by running without the spooler following Section 4.2
   If consistency is good without the spooler, debug spooler performance following Section 4.4
3. Verify that the diameter sensors are aligned and behaving properly
   Refer to Section 4.1
4. Reduced flow increases time delay in the control system, causing instability
   Check + debug extruder output flow rate following Section 3.5

3.5. Low/No Flow From Nozzle

If the flow rate of plastic out the nozzle drops too low it can lead to control system instability or halt extrusion altogether.
Possible Causes:

- Clogged Nozzle
- Jammed Auger feed

Identify Cause -> Action

1. Start extrusion in either manual or automatic mode while connected to a computer through PCC to properly view Auger pressure and speed data.
2. Once temperature and auger are both at operating points for the plastic, assess AgSpd and AgPrs figures that are displayed in PCC data.
   - If AgPrs has increased and is holding at a high value (35-50), while AgSpd has dropped and is holding near 0 (may be pulsing to low values here and there, but for the most part auger is not moving), It is likely an auger jam. Plastic will hardly be flowing from the nozzle at all. Refer to Section 4.3.
   - If AgSpd is low but moving, and plastic is flowing from the nozzle but at a consistently low flow, it is likely that the nozzle filter is clogged. Refer to Section 4.6 in the full user manual on Extruder Nozzle removal/replacement.

4. Specific Component Issues/Debugging

This section gives procedures on properly setting up an debugging each subsystem in the extrusion process.

4.1. Diameter Sensors

ProtoCycler's diameter sensors function by measuring the shadow cast by the filament from the light of an LED. A linear array of photo resistors detects the light, and ProtoCycler decodes the data to determine the diameter.
Since each plastic tends to droop a different amount between the nozzle and puller, the diameter sensors are able to be adjusted vertically to align properly with the filament. The LED's must also be aligned properly to ensure that the sensor is getting enough light at the set position.

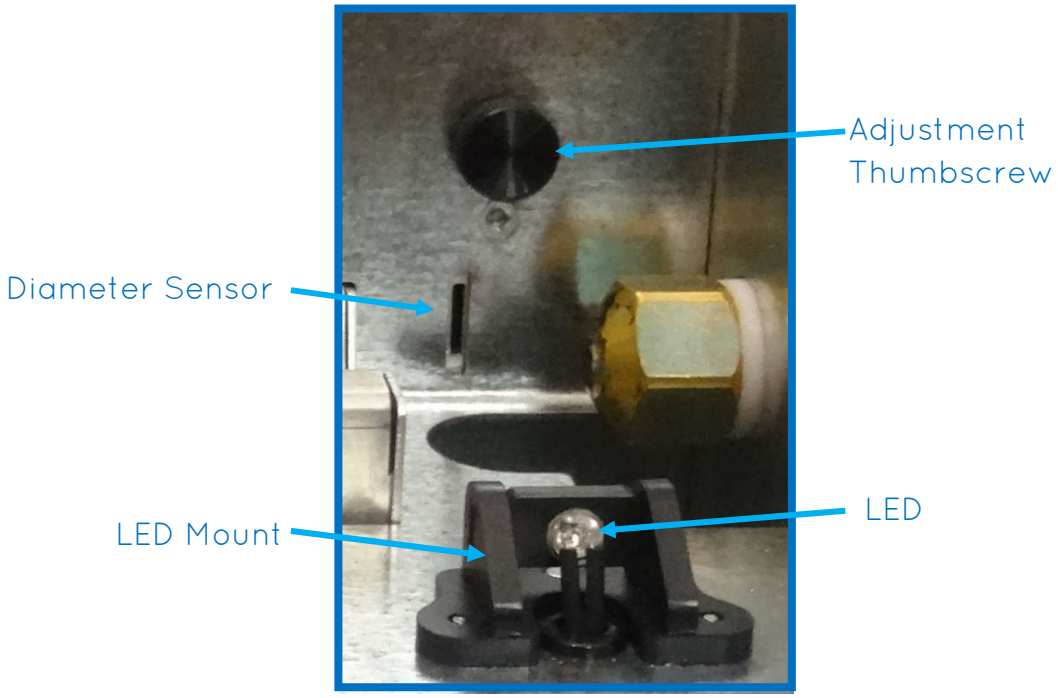

Figure 3.1 Filament Sensor Close-up

ProtoCycler ships including LED mounts that are suitable for ABS and PLA at the settings provided. During calibration we align the LED's and sensors for the plastic which it is primed with but it is possible that things shift during shipping, so it may be necessary to realign them. Dust or dirt may also accumulate on the sensor, blocking out pixels and causing faulty readings.

When experiencing any issues with extrusion it is always a good idea to check that your sensors are operating correctly before troubleshooting other areas, to make sure the data you are getting is accurate!

If you are experimenting with new plastics or settings, you will also likely have to realign our LED's and sensors.

To assess and debug sensor performance, you must be connected to a computer with the ProtoCycler Command Center desktop app, and have started extrusion in either manual or automatic mode. Figure 3.2 shows where the sensor data is displayed in the graph area.

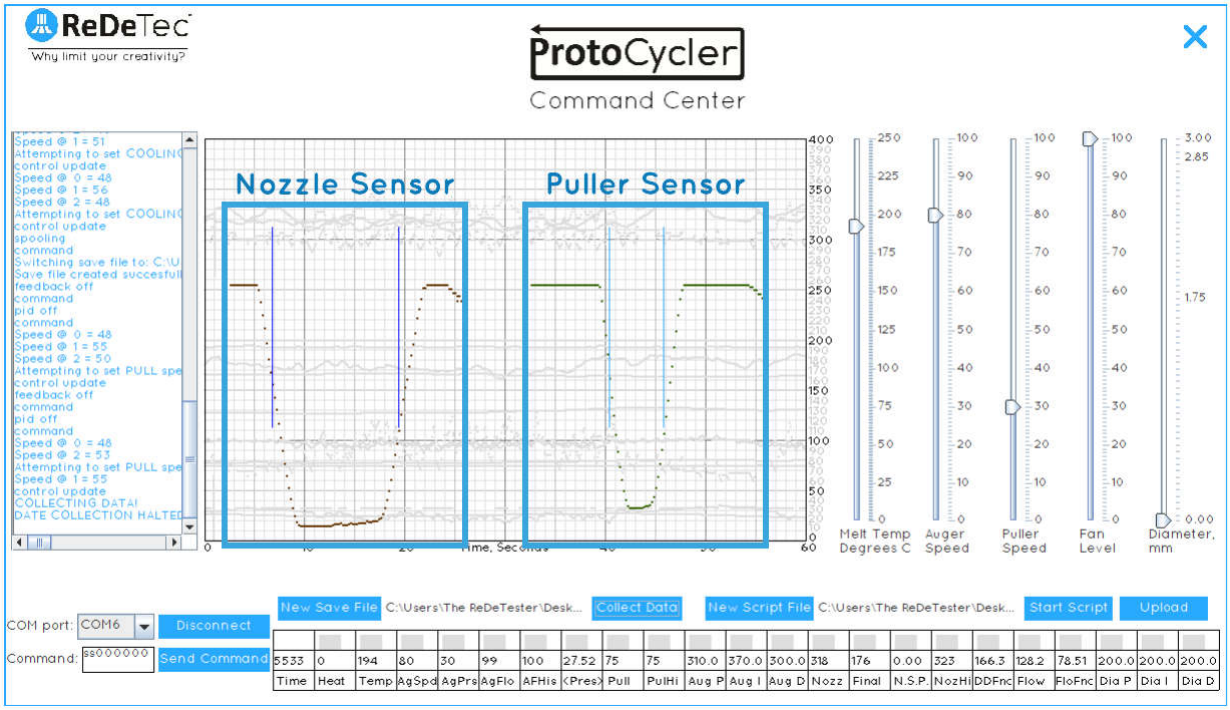

Figure 3.2 Sensor Data Graphs

This data shows ideal sensor behaviour during extrusion. Figure 3.3 gives a closer look.

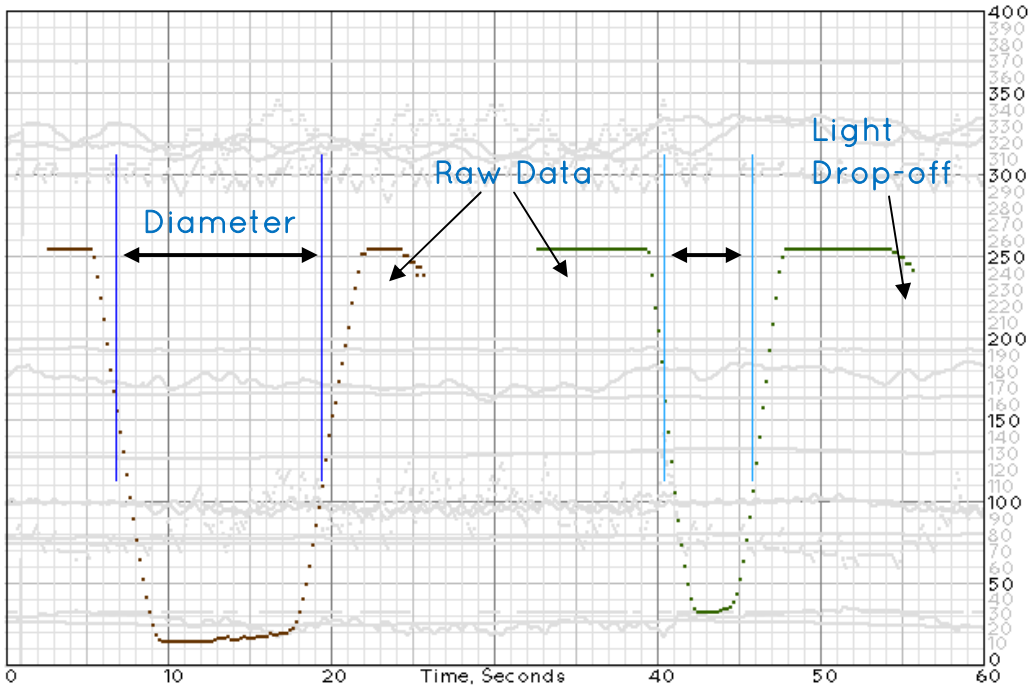

Figure 3.3 Ideal Sensor Reading

Note that in Figure 3.3:

- The light does drop off on the right side of each data set, but only a small amount that is not interfering with the filament shadow
- The filament shadow is in the center of the sensor
- There are no irregular dips in the sensor data apart from the shadow
- Both sides of the shadow have the same slope

These are the requirements for best results.

NOTE: Whether in manual or automatic mode, it is important to be running at steady state operation before assessing and adjusting sensors. Different parameters, startup, wet plastic, etc. can all effect how much the filament droops.
If sensors are misaligned to the point of giving inaccurate readings the diameter control will not work and puller speed will vary wildly making adjustment impossible. You must disable diameter control by setting the "Puller Speed" slider so it pulls at constant speed. Adjust the pull speed until the final diameter is roughly averaging the desired diameter before proceeding with adjustments. This may need to be done iteratively.

Possible issues/actions:

1. Filament shadow is not in the center of the sensor (Figure 3.4)
    - Sensor is misaligned with filament.
    - Loosen adjustment thumbscrew and adjust vertical position of sensor until the shadow is in the middle.
    - Doing this may cause excessive light drop-off, and so you may have to iterate with (2) until sensor and LED are properly aligned.
2. Excessive light drop-off at side of sensor (Figure 3.5)
    - LED is misaligned, so the full brightness is not aligned with center of the sensor
    - Switch for alternate LED mount (See note on LED mounts below)
    - Changing the LED position changes the angle of the light, and this may affect sensor alignment, and so you may have to iterate with (1).
3. Blocked or obstructed sensor pixels (Figure 3.6)
    - The pixel is obstructed by dust or debris and needs to be cleaned
    - Blowing on the sensor with a compressed air can may work. Otherwise, clean manually by rubbing the sensor with a long, thin piece of plastic (harder materials may scratch your sensor irreparably!)

        You may make a sensor cleaning tool by increasing the pull speed and producing thin filament. Let cool and trim a short length of the thin filament!

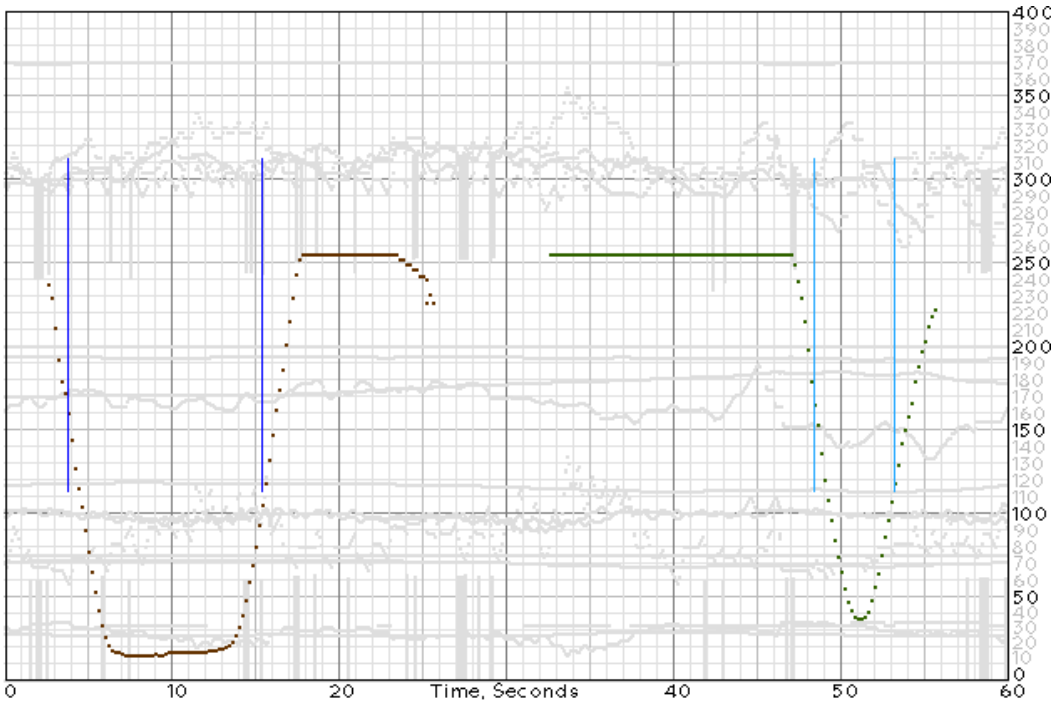

Figure 3.4 Misaligned Sensors

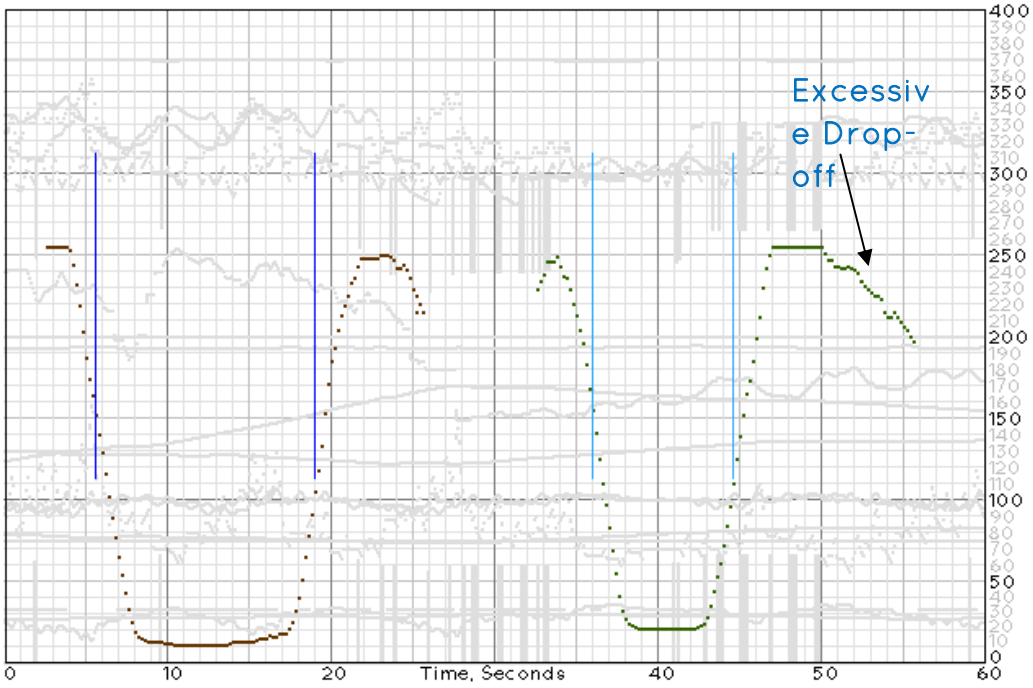

Figure 3.5 Misaligned LED

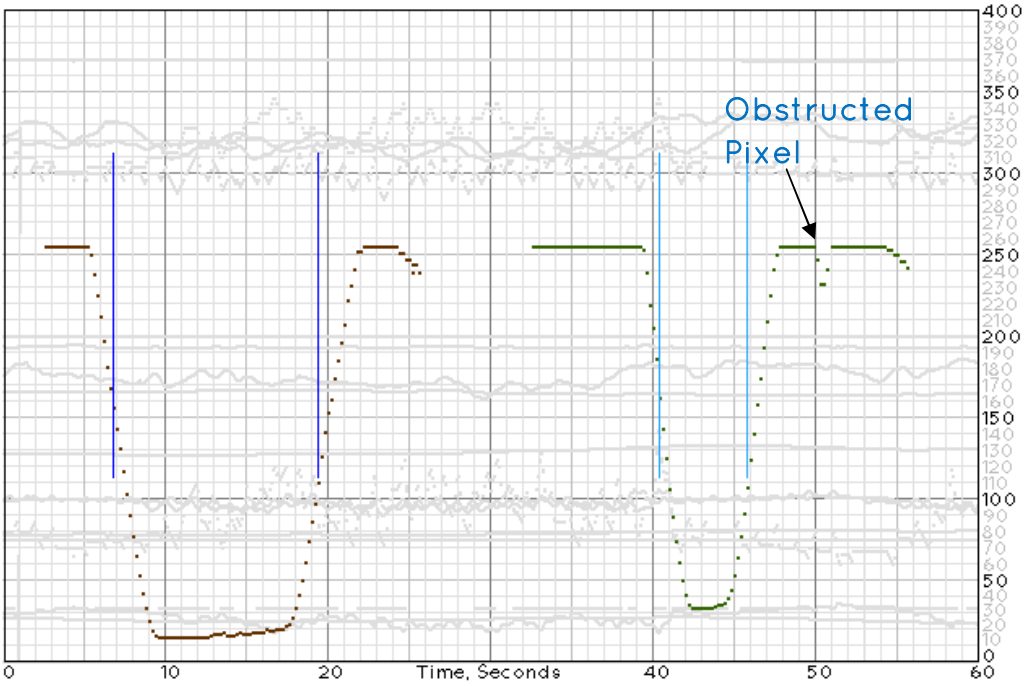

Figure 3.6 Dirty/Obstructed Pixels

Note on LED Mounts:

Due to slight variations in manufacturing of the sheet metal, the LED mounts are unfortunately not a "one size fits all" deal. While some units are able to cover the entire sensor movement range with one LED mount as designed, others display excessive light drop-off at the extremes with the standard mount. This is tested during calibration, and a secondary LED mount is provided with units showing this issue.
Since sensors are aligned for the plastic the unit is primed with, switching LED mounts should only be necessary when switching plastics or testing with new plastics.
We aim to implement an upgrade to improve this by providing a wider field of highly collimated light. This would remove the need for aligning LED's, as well as increasing sensor accuracy and viewing field (as the shadow edges would not be sloped), but have not yet found a practical, cost effective solution. If you have ideas, please share!

4.2. Spooler-less Extrusion

It order to assess other systems independently or rule out issues with the spooler, it is sometimes desirable to run extrusion with the spooler detached. This can be done at any point in either manual or automatic extrusion, but must be done carefully to ensure that filament does not stick to the puller wheels or bunch up between the puller and spooler.

1. Either snip the filament and tape to the spooler, or don't start spooling at all. In automatic mode you may select >>Spooling Ready even though you have not actually attached the filament to the spool.
2. Gently pull the filament through the spreader grommet and keep an eye on it!
    - If filament is soft, it can easily buckle after the puller. This can lead to it bunching up and eventually start wrapping around one of the puller wheels, which can be very annoying to untangle!
3. If you are trying to assess something like diameter consistency, make sure you are pulling with as constant of force as possible. Due to backlash in the puller motor gearbox, changing forces may actually transmit through the puller and effect diameter consistency!

Following the above precautions will ensure smooth operation without spooling.

4.3. Auger Jam Debugging

In the extruder's drive section, plastic particles may be pinched between the leading edge of the auger and the front face of the feed throat. Under normal operating conditions the auger has enough torque to shear through without effecting operation, but it is possible to jam if fed incorrectly.

Possible Causes

- Too high of regrind concentration in feed material
- Too large of regrind particulates

Ie. it is most commonly a result of improper use of regrind particles from the grinder. Please review Section 3.4 of the full user manual on extruding recycled plastics.

If you are experiencing an auger jam but have not extruded recycled plastics yet, please contact support@redetec.com

De-jamming:

1. Remove any plastic from the extruder hopper by removing the filter and sucking particulates out with a vacuum.
2. Inspect what is left behind and look for plastic clearly stuck between the auger flute and front face of the feed throat. Try to pull as much out as possible using needle nose pliers.
3. While connected through PCC get extrusion up and running at operating temperature. (if not already there)
4. Drag the "Auger Speed" slider to 100 and watch the AgPrs and AgSpd values. Initially AgSpd should increase, but then decrease again as AgPrs increases to ~50 at which point AgSpd will drop to 0 as the control system tries to limit the pressure.
    - Wait here for a minute and see if the pressure slowly starts to drop and AgSpd starts moving again. It is holding force against the jam and given time may shear through. If AgPrs slowly drops and AgSpd starts moving again, eventually returning to running constantly, you have de-jammed the auger!
    - It is possible that the Auger motor may stall during this time. This would be seen as a sudden drop in pressure and a loud "BANG" sound of the stepper motor stalling. The drop in pressure will cause a quick spike in AgSpd, and AgPrs will increase again. AgPrs may stop at or below 50, or it may stall again as it tried to compensate too quickly for the sudden drop. It may cycle in this way (BANG BANG BANG BANG!). If this happens, reduce "Auger Speed" slider to 0 and proceed to the next step.

5. Try running auger at low speed with PID disabled:
    - Set "Auger Speed" Slider to 0
    - Enter "kp000000" into the command window.
        This disables auger PID. The auger will now run at constant speed regardless of pressure (unless it exceeds 50).
    - Set "Auger Speed" Slider to 2. This will turn the auger incredibly slowly.
        Stepper motors give higher torque at low speed. Hopefully it will be able to shear through the jam without stalling.
    - Wait. This may take some time. AgPrs should build until it reaches 50, and hold (setting AgSpd to 0). If from time to time AgPrs drops below 50 and AgSpd engages again, bringing it back up to 50 and stopping this is good! Dropping of pressure and movement of the auger means it is slowly shearing through the jam.
        If AgPrs is staying over 50 and not dropping, and AgSpd is never changing from 0 then it is really, fully jammed. Contact support@redetec.com and we will advise on how to proceed.

If this procedure has successfully de-jammed your auger you may now return to normal operation. Note that prolonged heating without the auger moving may have over-melted the plastic in the melt section so it may have to be purged before operating normally again.

4.4. Tuning Spooling/Cooling (Debug Drawdown/Over-pulling)

Cooling and spooling must be working properly in tandem or it may cause a number of issues in the extrusion process. If cooling is not effective enough the filament will be soft and will be stretched by the spooler, whereas if too effective it will be too rigid to spool at all.

Possible Issues:

6. Spooler Drawdown - Filament is over stretched after the puller by the spooler
7. Over-cooling - Spooler unable to spool tightly because filament is too rigid

Ambient temperature has a large effect on cooling! The settings provided for ABS and PLA have been tuned for operation in environments with ambient temperature of 22C-26C. Please refer to full user manual Section 3.5 on ambient temperature.
If you cannot get ideal ambient conditions, you may have to re-tune your cooling/spooling. As well, once delivered, some units have shown issues in cooling and spooling even within the ideal temperature range, and have had to be re-tuned. We are trying to find the cause of this and implement an automatic solution, but for now it will have to be tuned manually following this procedure.

Solutions:

Spooler Drawdown is most likely caused by higher ambient temperature which makes the cooling fan unable to sufficiently cool the filament before it reaches the puller, and so it is still soft afterwards when it is being tensioned for spooling, resulting in stretching the soft filament. This often happens if the ambient temperature exceeds 25C. The simple solution to this would be to lower your ambient temperature, though that can be tricky in some environments.
The ideal temperature is 23C, and if you go too far below this it will over-cool the filament making it too rigid to spool, in which case you would need to dial the fan power back to reduce cooling.

To tune cooling:

1. Connect to the desktop app and get extrusion up and running in manual or automatic mode.
2. Once running at steady state and experiencing spooler drawdown, start adjusting the "Fan Speed"
    - Increase fan speed to make filament more rigid
    - Degrease fan speed to make filament softer
3. If you are at the max fan setting and are still experiencing drawdown, you may need to decrease your extrusion speed or temperature to limit the flow of heat.
    - Decreasing temp or pressure will reduce the output flow rate. If flow rate drops below 75 the control system will become unstable. If you are getting low flow rate and the fan is still unable to cool effectively, contact support.
4. If filament is too rigid for spooling, it will help to do this process with the spooler disconnected (Refer to section 4.2).
    - Reduce fan power until filament is nice and soft after the puller.
    - Reattach filament to spooler, it should now be able to spool properly, but maybe with drawdown.
    - Gradually increase the fan speed until the spooler just stops being able to spool tightly, and then decrease to the previous, lower setting (Wait at least a minute between changing fan speeds to let the behaviour settle!). This is the ideal setting!
5. Note all of the adjustments you made, these new settings can later be implemented in automatic settings stored in ProtoCycler (Documentation on custom automatic profiles coming soon!)

Your spooler clutch may also need to be tuned. In testing, we have found that a clutch spring length of 13.5mm is ideal for spooling with ABS and PLA if cooling is set properly. The spring length is the length of the spring contained between the two bushings on the spooler clutch, see Figure 3.7.

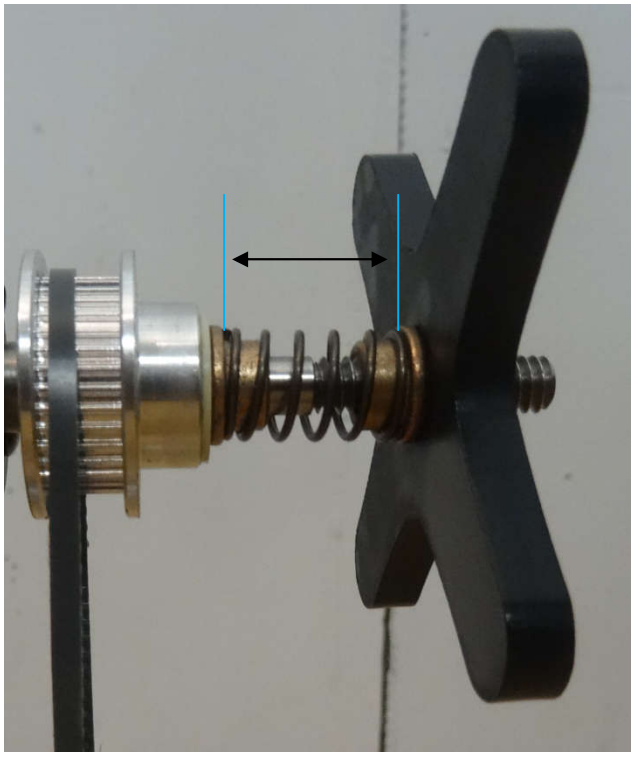

Figure 3.7 Spooler Clutch Spring Length

To tune spooling:

1. Start with the spring clutch length at 13.5mm, and get spooling going in normal operation.
2. Adjust the fan first so that the filament is mostly cooled, but still bendable as it reaches the spool.
3. If it is not being spooled tightly, decrease the clutch spring length by tightening the adjuster knob until there is a constant, but gentle tension in the filament between the puller and spooler.
    - If there is a high tension between the puller and spooler but filament is still not being pulled too tightly, filament is being cooled too much. Reduce fan speed (Refer to above on tuning cooling).
    - If you are now spooling tightly but getting spooler drawdown, filament is not being cooled enough. Increase fan speed (Refer to above).

In this way, cooling and spooling may be tuned together. As filament rigidity increases, higher spooling forces are required to spool tightly. If this is tuned too tightly then the spooler can cause excessive force that may be transmitted past the puller and interfere with diameter control. Thus it is a fine balance point between minimizing spooler drawdown without effecting the control system.

5. Grinder Troubleshooting

The grinder is a much less complicated system, with much less things that can go wrong. Most basic issues arise as a result of improper understanding of the interlock, or interlock malfunction.

5.1. Grinder Doesn't Drive Forward, Drives backwards

When you rotate forwards, you hear a clicking/grinding sound and the wheels do not move. When driven backwards it engages and wheels spin backwards.

1. **Ensure your machine is plugged in and the power is on.**
    - **Grinder operation relies on an electronic interlock to keep the drive train engaged, and will not work without power!**
2. Check that the grinder lid and drawer are properly in place.
    - The lid and drawer both engage switches that power the interlock, so they must both be in for the grinder to operate.
    - The drawer must be fully in and seated against the back wall to engage its switch. This may easily be obstructed by grinding debris. Make sure that the drawer slot is unobstructed and the drawer is fully seating.
3. Check if the drawer switch isn't engaging properly.
    - There is a tab on the drawer that is engaging a switch at the back of the drawer slot. It is possible that the tab isn't properly hitting the switch. Use a long stick of some sort to manually engage the switch (you will feel it click), and test the grinder this way, then contact support.

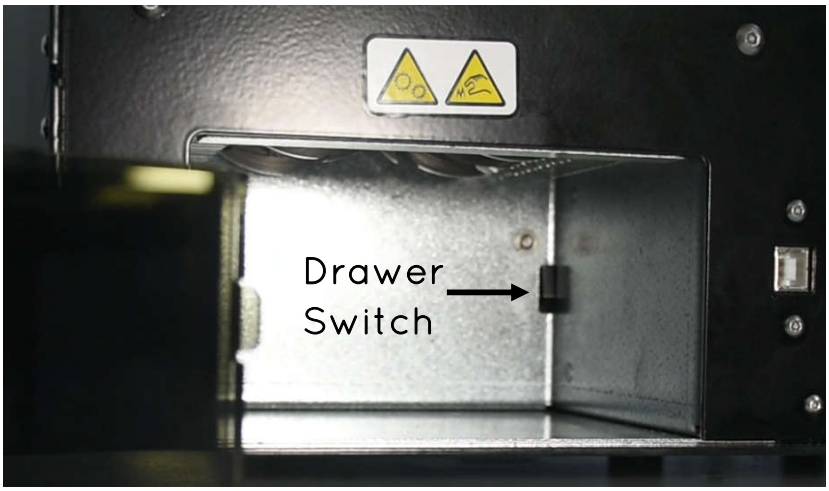

Figure 3.8 Grinder Drawer Interlock Switch

NOTE: Each time you test it, you must first rotate backwards until the wheels begin to rotate backwards before driving forwards. Rotating backwards ensures that the gear train is engaged, and when rotated forwards the interlock should keep it engaged. The interlock will not properly hold unless the gear train is properly engaged first!

5.2. Grinder Doesn't Drive Forward or Backward

When the crank arm is rotated backwards, the output does not turn. This may be accompanied by a clicking/grinding sound, or no sound/resistance at all.

- Contact support@redetec.com