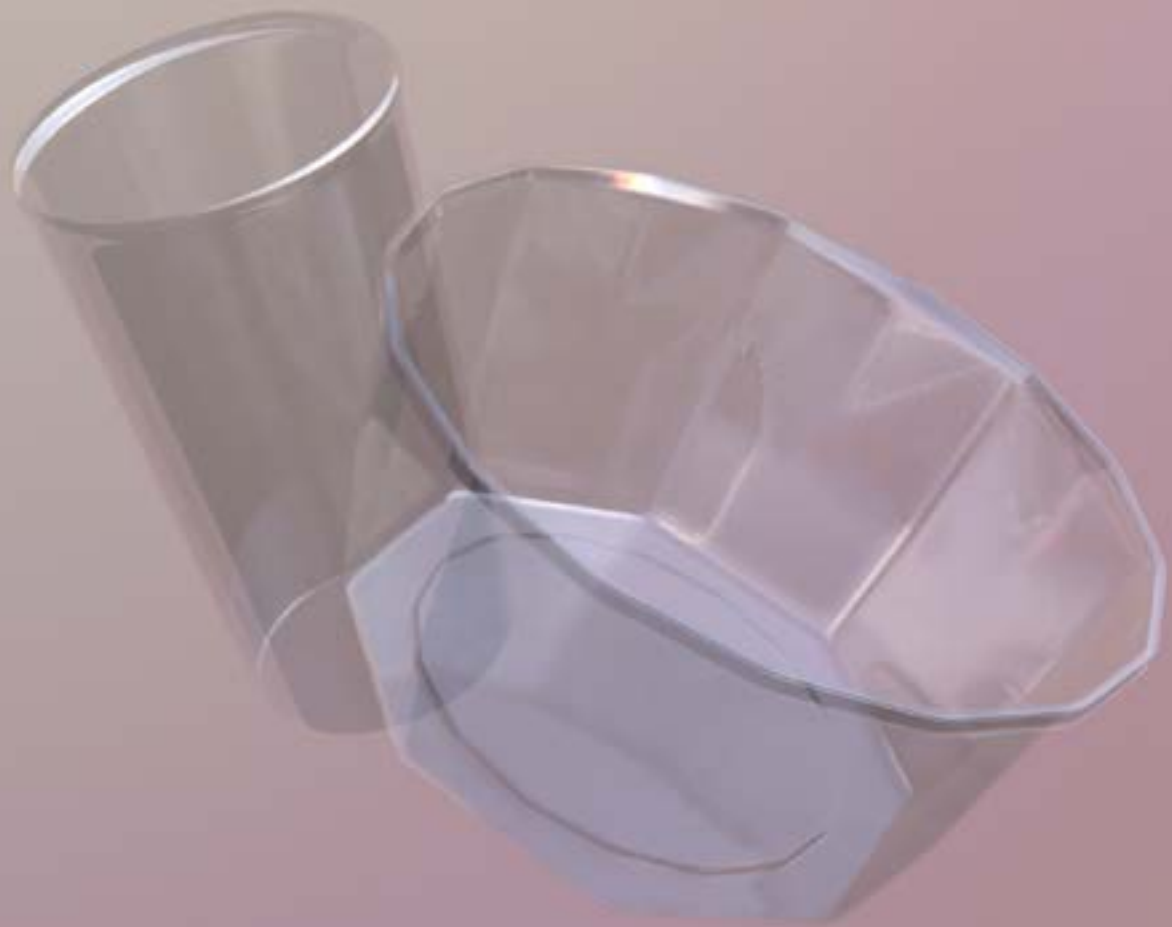
OUR KILO

Creating filament from PLA



OURKILO REPORT

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SUMMARY:

This document shows the learnings in recycling PLA containers. The aim was to reuse the plastic material for 3D-printed objects. In this document, we explain the following steps to achieve a printable spool of PLA using shredded plastic from various PLA plastic containers. Our experiments focused on proving that recycling PLA from waste packaging is a viable option to use waste streams for 3D printing. And furthermore to create spools with different qualities that are not commercially available, like different formats of weight and size, and the color options of individual spools as well as customized color options within a single spool.

TYPE IN OF INPUT

| Picture 1: Different kinds of PLA plastic objects.

WE HAVE RECEIVED THREE TYPES OF OBJECTS:

1) PLA Lids

2) PLA Cups

3) PLA domes

All were from a discharged batch, which couldn't be used for food products anymore, due to changed regulations. Instead of throwing them away, we could use them as material for creating recycled PLA spools.

| Picture 1

RECYCLING PROCESS

Picture 2:Each type was made into a specific batch

Picture 3:Example of shredded PLA flakes.

The plastic given to us was already clean and unused so there was no need to clean them ourselves:

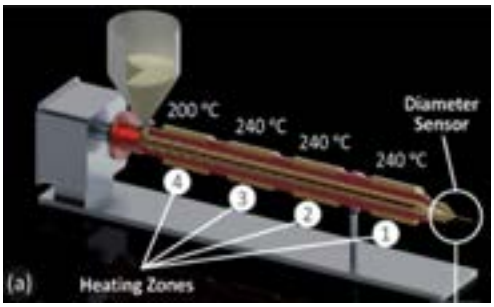
Step 1- Shredding-Initially, we decided to shred the 3 kinds of plastic in different batches, to experiment first if the type of object, which might be made from a different batch and have a different composition, would have an influence on the filament making. However, we found out that mixing the flakes was not an issue.

Picture 2, picture 3

Step 2- Drying -Using a flake/granulate dryer we dry the shredded plastic to remove moisture content from the plastic. We had to dry it for 3 hours at 60 degrees.

CREATING A SPOOL

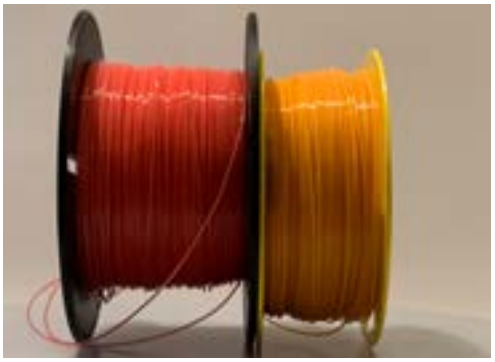
Picture 4: A good example of spooled filament.



Picture 5: Model image of what happens in a mixing screw and the placement of the four different heating zones (H): source: Vidakis et al. (2022)

Go to link

Picture 6: Close-up of our self-made spools.



Picture 7: Difference between a reused commercial spool and a custom printed spool.

THE LENGTH OF THE SPOOL

A commercial spool PLA usually contains 1 kilogram. With PLA, we wanted to match this. We managed to achieve consistent spool weights of around 1Kg. However we went above this result also by using custom printed spools (STL files are provided by 3Devo). With them we achieved rolls of 1.5Kg. These spools were printed also with own recycled PLA and could be reused and unscrewed for storage and reuse.

Picture 4, Picture 6, Picture 7

Our goal was to achieve the same output as a regular commercial PLA spool that is available for purchase online. A consistent diameter throughout the whole length of the spool, never going above 1.9mm or below 1.6mm

The shredded plastic was processed in our designated PLA filament maker machine at the following temperatures:

H4- 170° H3- 180° H2- 190° H1- 180°

The goal is to achieve a temperature setting that is able to push a constant stream of molten plastic out of the nozzle to create a filament with an average 1.75mm diameter to be used. PLA plastic has a really good flow inside of the plastic melting screw meaning there is not a lot of variation of diameter.

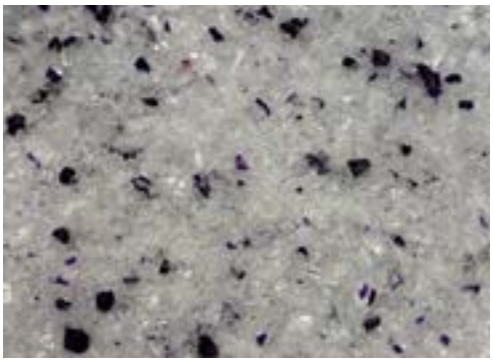
Picture 5

With the temperature settings mentioned above, you can get to that consistency. Going lower would cause the material to come out brittle and bumpy, because it will not fully molten.

At a higher temperature, the material would be too liquidy to spool with a round shape, and the strands of filament would come out flat, and tiny which do not feed well into the printers.

ADDING COLOR TO THE SPOOL

Picture 8: Variety of coloring plastic we have available for PLA experiments.



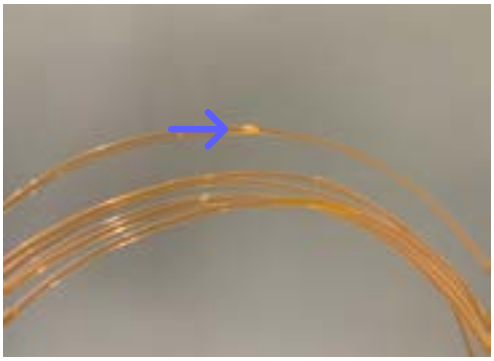
Picture 9: A visual example of PLA mixture with 20% coloring plastic.

Picture 10: Resulting spool of the mixture of PLA from the image above.

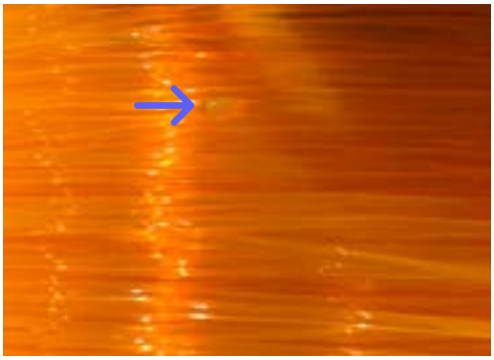
To color the plastic we used a mixture of shredded transparent PLA plastic and old shredded prints or unused filament. We have noticed that 20% of the flakes being colored PLA give a consistent color throughout the spool. So, in a mixture of 100g of plastic, 20g should be colored PLA flakes or granules and 80g transparent PLA flakes.

Picture 8, Picture 9, Picture 10

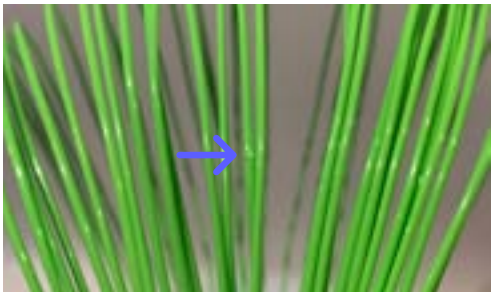
TESTING THE QUALITY OF THE SPOOL



Picture 11: Very noticeable piece of contamination inside the filament.



Picture 12: contamination plastic in the middle of a roll

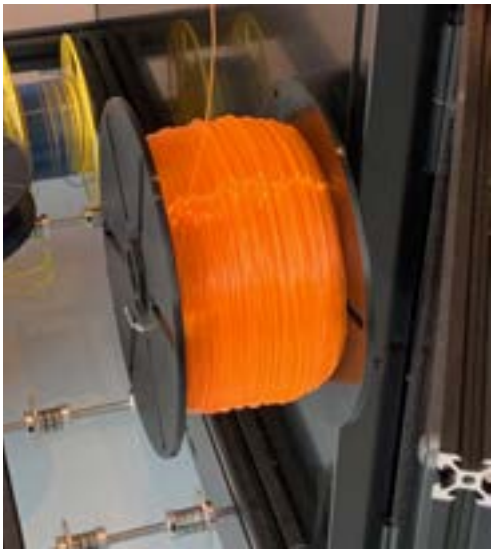


Picture 13: A bad example of spooled filament. You can see a big blob in the middle of the spool.

During the production process, it is advised to keep record of the spooling process.This can be done through the App from 3Devo, or by standing close to the machine. The main issues that need to be noticed are sudden drops or a raise in the diameter of the filament and/or contaminated material present in the filament. Once you have your spooling graphs checked, you can proceed to print with it.

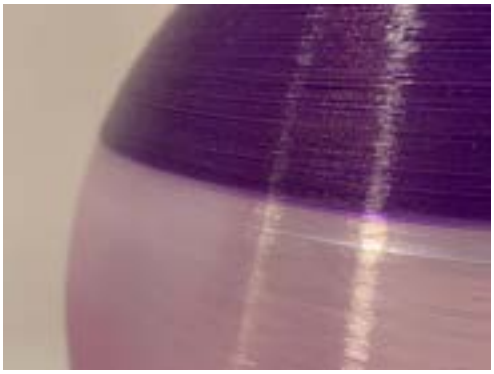
Picture 11, Picture 12, Picture 13.

PRINTING WITH RECYCLED PLA



Picture 14: Big roll being used in a print.

Picture 15: Big results in size of printing with recycled PLA, BioFutura cup for scale.



Picture 16: A chunky look achieved with a bigger diameter nozzle.

WE PRINT OUR OBJECTS WITH: 0.4 up to 1mm nozzle

That is mainly to avoid impurities from clogging the nozzle. Clogging is a physical constraint, meaning either the filament was too thick to go through the heating element or there is a piece of alien material that does not melt and now is stuck inside the nozzle. A bigger hole in the nozzle means bigger particles can go through.

The print bed has to be set at a minimum of 50° degrees to maintain adhesion to the PLA and the nozzle set between 200° and 215° degrees to melt the plastic at the optimum rate for printing.

To facilitate the testing of the material, we operated with a printer that has a clog detector attachment (Clog Detector – Modix Large 3D Printers). This is a sensor that detects if the filament is still moving- if not, the print is paused automatically so that you can inspect it, remove the bad part of the filament and reload the plastic to continue printing.

Picture 15, Picture 16

IDENTIFIED OPPORTUNITIES WHEN PRINTING

Picture 17: Diverse sizes of the same print using different rolls of colored filament.

Picture 18: Picture showing an the inside of a print that could not be resumed due to the lack of a filament clog sensor.

When creating spools we have the opportunity to plan prints without constraints of the regular commercial standards of PLA. For example, creating a single spool with a planned color change, meaning you do not need to stop the print and change to a different filament. You can change for example: the color of a spool, the duration of said color change, the moment it happens in the roll, mix different colors. All of this, of course, using recycled materials, such as plastic objects and old prints.

Picture 17

IDENTIFIED ISSUES WHEN PRINTING:

In our process, we have identified a few issues that happen when printing with a spool that was not 100% consistent in diameter or free of impurities.

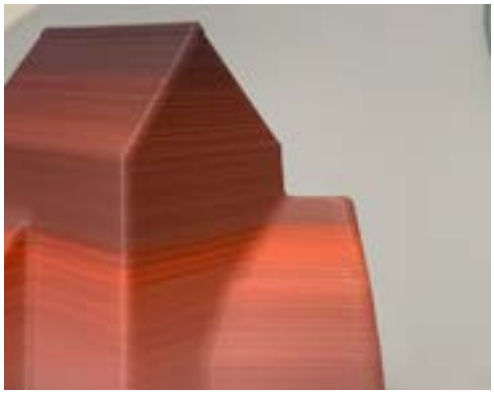
Due to Clogging: When printing, we observe that is common to have a clog just before the filament gets to the nozzle. This happens occasionally when the filament gets too thick and cannot be pushed through into the nozzle. This causes the machine to stop and you have to remove the filament from the machine, cut the bad piece and return the filament back into the machine. This only happens if there is a lot of contamination in the filament.

Due to insufficient feeding: The opposite can also happen, if the filament gets too thin the gears in the extruder cannot push enough filament into the nozzle, thus causing the clog sensor to be triggered and stop the machine. The process to restore the machine is the same as the one above.

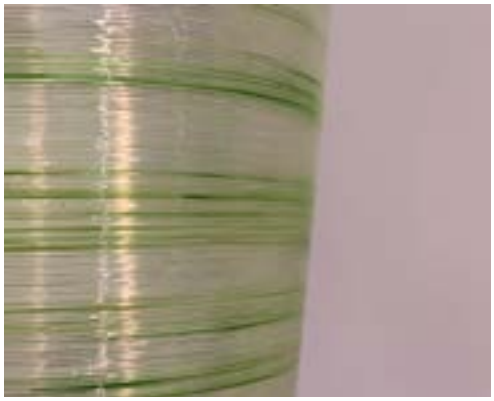
However, above is rare when printing with one of our PLA spools, due to the checks already during the spooling process.

Picture 18

CONCLUSION



Picture 19: Different transitions of color with a smooth gradient in one spool of recycled PLA.



Picture 20: Result achieved by using coloring PLA sparingly in the hopper, giving a striped look to the filament, not found in commercially available PLA.

The PLA plastic was a successful attempt at transforming waste plastic into a 3D printing filament. The filament was okay to mix with other batches of recycled PLA, for example, old prints that were also shredded to achieved colored filament. We reached also bigger spools than the conventional 1kg available online with many color options and using reusable custom spools. We printed many successful long prints (6 hours) with them , including sequential objects running for a full working day and overnight without issues.

While there is the occasional clog this is mostly due to contamination, and often because we used the space for testing both PET and PLA, which is not an ideal working condition.

Picture 19, Picture 20

MORE INFORMATION