Polypropylene filament for 3D printing manufactured with recycled raw material

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Tekes

European Union
European Regional
Development Fund

Leverage from
the EU
2014—2020

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Introduction

The aim was to produce filament with the equipment available at Turku AMK material laboratory. As a raw material was used recycled PP from car industry. At the beginning the PP bumper was crushed and then the crushed PP was mixed with virgin PP (50-50). Using this blend new filament was extruded and finally the PP-filament with 50 % recycled PP was 3D-printed.

Extrusion process

Plastics extrusion is a continuous process in which thermoplastic polymer is converted to a molten fluid and then extruded into various shapes such as filament. Plastic extrusions are performed in a screw extrusion machine. The machine's main components are a hopper, heated feed barrel, extruder screw, and a die. After a die the filaments are cooled in cooling tank filled with water. The diameter of filament is adjusted by the speed of pulling.
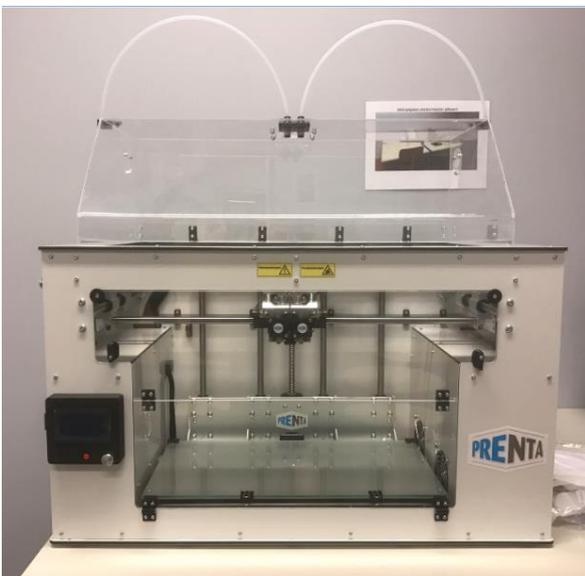

Table 1. Extruder

PP properties and Polypropylene as a raw material for the 3D printing

Polypropylene (PP) is one of the most used plastics in the world. It is used in a variety of applications to include packaging for consumer products, plastic parts for various industries including the automotive industry.

According to the several sources, Polypropylene filament is very difficult to print. Most 3D printers find it hard to control the results of PP prints because of the heavy warping that takes place during the printing process. PP is semi-crystalline polymer and this means that the material cools and solidifies differently than PLA and ABS, resulting in much more stress within the material (warping) (2).

3D-printing of PP

Because of the closed chamber and heated bed PRENTA DUO XL SE printer (Picture 1) was used at the tests. Filaments were made at Tuas material laboratory. As a test components was a box and a 3D model of box is presented at drawing 1.

Picture 1. 3D printer.
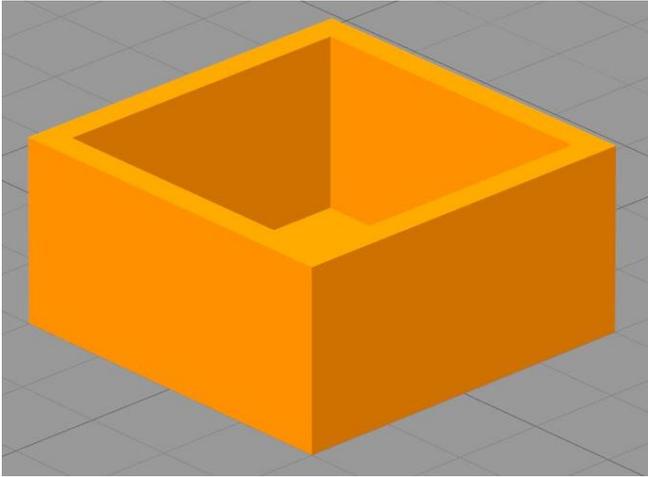
Drawing 1. 3D model of printed box.

Extrusion

The raw material was not dried before the extrusion process. The temperature zones on the extruder were set as shown in table 1 and other parameters are presented in table 2.

Table 1. The temperature zones on the extruder.

block	die	10	9	8	7	6	5	4	3	2	1
C°	205	205	205	205	225	225	215	215	185	185	185

Table 2. Process parameters for the extruder.

| Extrusion speed	45 rpm
Pulling speed	13,5 rpm
Cooling	water bath

Picture 2. PP filament.

When examining the quality of filament there are two things to inspect; the diameter of the filament and the roundness of the filament. The filament (Picture 1) was measured and results are in Table X. The measurements were done by slide gauge and therefore the numbers could be inaccurate.
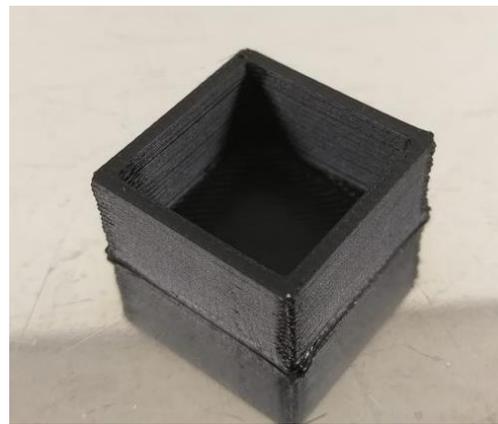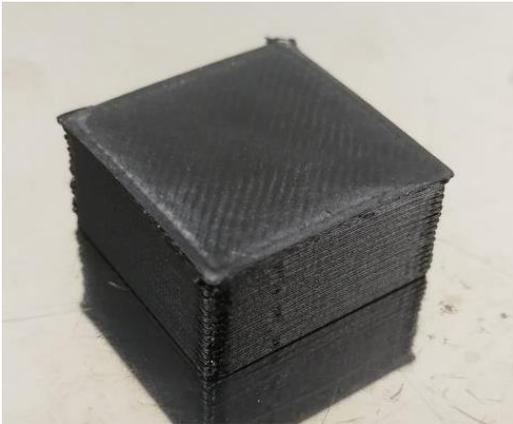
Table 2. Measurements of the filament

Length of the filament (m)	X	Y
0,0 m	1,6	1,9
0,5 m	1,8	1,8
1,0 m	1,6	1,9
1,5 m	1,7	1,9
2,0 m	1,8	1,9
2,5 m	1,7	1,9
3,0 m	1,6	2
4,0 m	1,8	1,9
4,5 m	1,6	1,9
5,0 m	1,6	1,9
Diameter of the filament (mm)	1,68	1,90
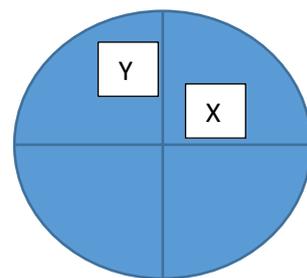
3D-printing

Extruder temperature (3D printing) was 190 °C and 100 °C for the heated bed.

Picture 3. 3D printed component.

Discussion

These are preliminary tests but it was find out that it is possible to manufacture PP filament with 50 % reused raw material. It was also find out that the quality of filament has to be better because with better quality filament it is possible to produce better surface quality. It was also find out that PP is hard to print without a heated build platform and anti-slip tape.