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## IMPROVING THE QUALITY OF PLASTIC PARTS OBTAINED BY 3D PRINTING

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**Abstract:** In the present paper authors propose an approach for obtaining a better roughness in terms of plastic parts resulted from 3D printing process. The main objective involves obtaining a surface roughness of the plastic parts through combining additive manufacturing technology and conventional technology, milling. In order to validate the settle aim there was established three dials on the top of the plastic printed part, test sample, which has been machined with two different cutting tools with different diameters. Also the machining process of the three areas was performed using two different toolpaths generation parameters. The machining process was performed on a vertical milling center, Challenger 2418. After performing the establish steps was performed a roughening measurement of the initial test sample surface as well as those resulted from the milling. This step was employed using a complete roughness measuring instrument, TR-220, which allows obtaining 19 different roughness parameters.

**Keywords:** additive manufacturing, plastic parts, roughness, milling

### 1. INTRODUCTION

3D printing process knows in the literature as the additive manufacturing process has become a widely used and is usable in various fields advancing the state from prototyping stage to end-product manufacturing [1].

The principle of obtaining the plastic parts using the process known as additive manufacturing is based on overlapping of layers resulting in this way the physical model based on the CAD model [2].

Plastic parts resulted from 3D printing process are used in fields like army, domestic or automotive industry etc. [3][4]. Unconventional technologies same as additive manufacturing proved to be a solution in the medical filed that requires the obtained plastic parts need to have a specific quality of the surface being used to specific deeds [5].

Given that a plastic part is used as a direct element in a filed such as medicine or even mechanical gears and not only it requires that

the plastic parts need to have a high quality of surface roughness. Certainly there are situations where this aspect is requires by the end user.

The additive manufacturing process generally has experienced significant growth in the recent years worldwide [6]. This aspect involves development of 3D printing equipment's capable of high precision plastic parts in accordance with the assessments provided by the end-user.

Appearance of the plastic parts obtained from 3D printing process is influenced by the parameters of the process, such as the distance between passes. Also an important factor with high level of influence on the resulted plastic parts from the 3D printing process is the diameter of the extruder, printer head. This element serves to melt the raw material and results a continuous profile across the moving plate.

There is a wide range of thermoplastics type materials that are used in additive manufacturing process. The most used one is

acrylonitrile butadiene styrene (ABS) or polylactic acid (PLA) [7]

The present study wishes to improve the surface quality of plastic parts by combining 3D printing technology processing, additive manufacturing, with conventional technology milling cutting process.

### 3. CASE STUDY AND RESULTS

To extend the utility of plastic parts produced through additive manufacturing method authors propose the use of the processing methods in combination with the classical method. Thus to increase surface quality obtained by 3D printing plastic parts it can be processed on conventional milling or turning.

By combining the two technologies of production (additive manufacturing technologies and conventional cutting) is increased the productivity and also significantly improves the quality of the plastic parts.

Most of the 3D printers work with three axes numerically controlled while the milling NC machine with five axes are easily accessible. Thus the geometry of a 3D printed plastic part can be improved if it is processed by a five-axis milling machine.

In the study conducted by the authors it was used a desktop 3D printer in order to make the plastic test sample. The material used in the printing process was acrylonitrile butadiene styrene (ABS) with 1.6 mm diameter wire roll.

It was choosing this material due to its mechanical proprieties, due to a good rigidity, good dimensional stability and due to it good stability at heat.

Machining through milling process of a surface is allowed from 2.5 axes to 5 axes but for the present study the authors chose to achieve a 3 axis surface machining of the test sample plastic parts for conventional cutting technology.

#### 3.1 3D Printing

In figure 1 it is shown the 3D printer used to realise the plastic test sample. This is a structure in three axes, XYZ, with a positioning precision for X and Y axis of

0.002343mm. For the Z axis the positioning precision is 0.003125 mm

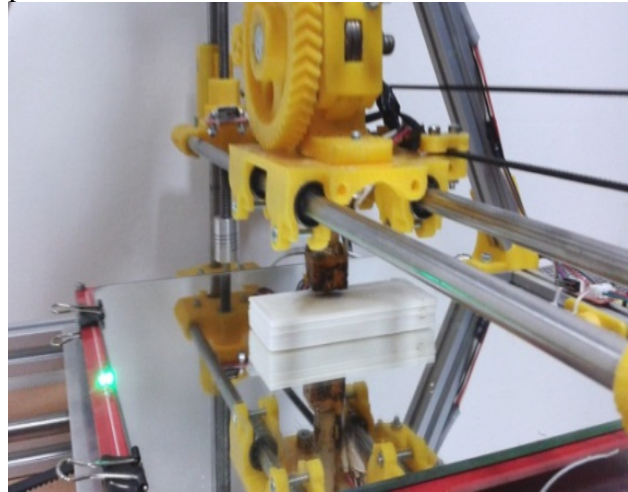


Figure 1. 3D printer

To realize the test sample, Figure 2, the following parameters were used in the 3D printing process:

- thick filament Ø 1.6mm
- melting temperature of the material - 225°C
- printing table temperature - 105°C
- thickness of the printing layers - 0.3 and 0.4 mm
- wire diameter exiting the extruder tip is - Ø 0.5mm
- test sample dimensions: 80x30x10 mm
- processing trajectories : parallel and tilt at 45°



Figure 2. Test sample

#### 3.2 Machining

The technology for the manufacturing process and generating the NC code for the test sample was used PowerMill 2014 software. The manufacturing process was carried out on a vertical milling center machine, Challenger Microcut 2418, with a with a maximum spindle speed of 10000 rpm and with a positioning

precision of 0,005 mm and repeatability of 0,004 mm.

The test sample was clamped into a vice, Figure3, and machined with two different diameter end-mill cutter, 4 mm and 10 mm.

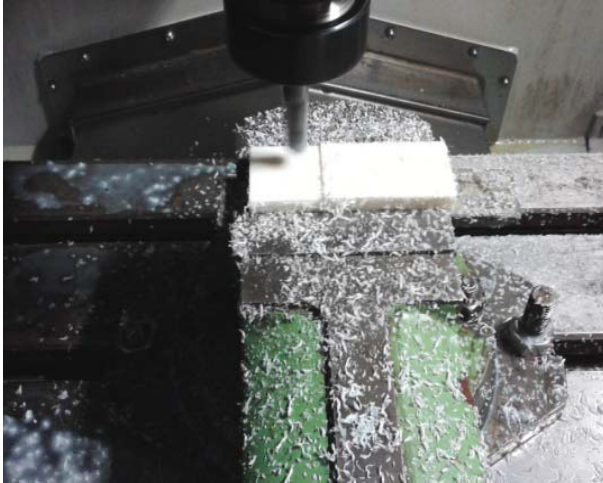


Figure 3. Machining the test sample

The top surface of the test sample was divided in three areas, Figure4, in order to use different technological parameters of machining. The parameters for the end-mills used were:

- **Area 1:**
  - Tool diameter:* 10 mm
  - Stepover:* 0.5mm
  - Tolerance:* 0.01mm
  - Direction:* X axis
  - Feedrate:* 1000 mm/min
  - Spindle Speed:* 8000 rpm
- **Area 2:**
  - Tool diameter:* 4 mm
  - Stepover:* 0.3mm
  - Tolerance:* 0.01mm
  - Direction:* Y axis
  - Feedrate:* 1500 mm/min
  - Spindle Speed:* 8000 rpm
- **Area 3:**
  - Tool diameter:* mm
  - Stepover:* 0.2m
  - Tolerance:* 0.01mm
  - Direction:* X axis
  - Feedrate:* 1500 mm/min
  - Spindle Speed:* 8000 rpm



Figure 4. Machined test sample

### 3.3 Results

The roughness measuring process was realized on all three areas that were machined. The length of measuring was of 12.5 mm and for a relevant result the roughness was measured for each of the three areas in two zones (tracks). The equipment used for roughness measurement is TR-220.



a



b



c

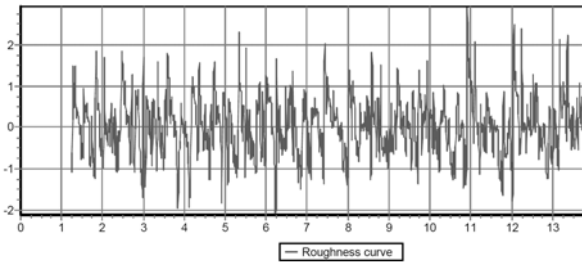
Figure 5. Measuring Roughness a) area 1, b) area 2 and c) area c

The results of the measurements regarding the surface roughness after the machining process are presented as follows having the roughness graphics attached:

• **Area 1 - 10 mm diameter end-mill - X axis**

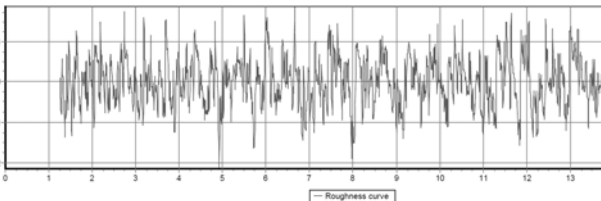
Track 1

Ra = 0.547 μm  
Rz = 4.007 μm



Track 2

Ra = 0.482 μm  
Rz = 3.359 μm

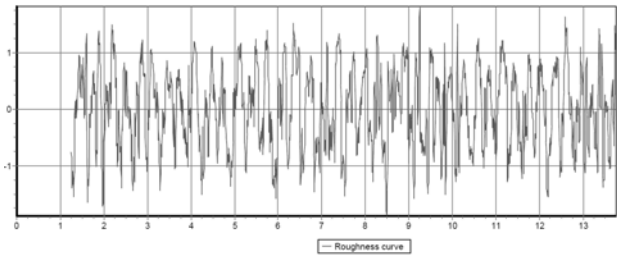


• **Area 2 - 4 mm diameter end-mill - Y axis**

Track 1

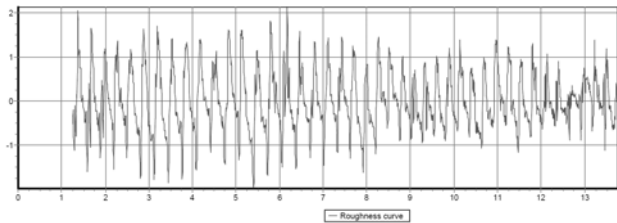
Ra = 3.891 μm  
Rz = 13.060 μm

Ra = 0.602 μm  
Rz = 3.234 μm



Track 2

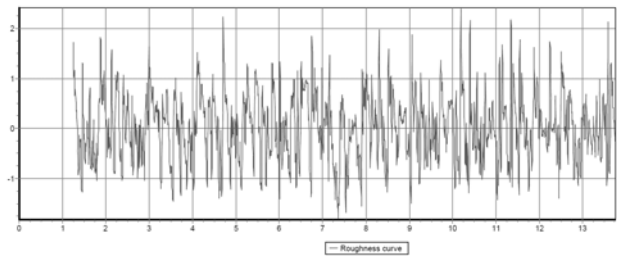
Ra = 0.587 μm  
Rz = 3.234 μm



• **Area 3 - 4 mm diameter end-mill - X axis**

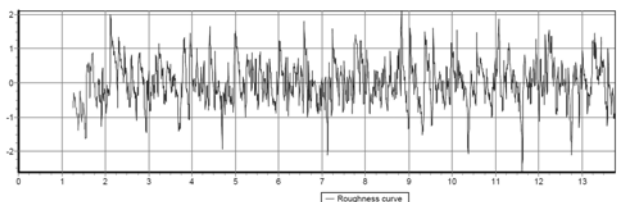
Track 1

Ra = 0.466 μm  
Rz = 3.644 μm

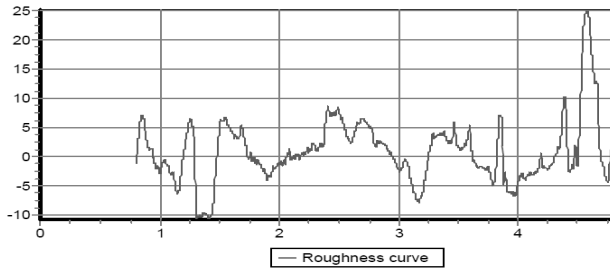


Track 2

Ra = 0.481 μm  
Rz = 3.859 μm



In terms of initial plastic test sample obtained using the 3D printer the roughness measurements of the surface roughness were the following:



#### 4. CONCLUSIONS

The present paper presents a study of the way in which it can be obtained an improvement of the quality surface of plastic parts resulted from the additive manufacturing process. The entire study aims combining the unconventional technology to achieve layer by layer of plastics parts with conventional milling technology in order to reach the proposed objectives.

Additive manufacturing technology has improved significantly in terms of equipment's that are used but the quality of the surface can be improved by processing the plastic parts through milling or turning.

Plastic parts resulted from additive manufacturing can have complex shapes which can offset their processing on 5 axes milling equipment in order to improve their quality over the entire surfaces.

The results of the study presented in this paper by the authors validate the main purpose as a reliable solution by comparing the roughness measurements results.

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## **IMBUNATATIREA CALITATII PIESELOR DE PLASTIC OBTINUTE PRIN IMPRIMARE 3D**

### **Abstract:**

In cadrul lucrari de fata autorii propun o abordare prin care se doreste obtinerea unei rugozitati mai bune in ceea ce priveste piesele de plastic rezultate din procesul de imprimare 3D. Scopul principal presupune obtinerea unei rugozitati mai bune pe suprafata piesei de plastic printate 3D prin combinarea tehnologiei additive manufacturing si tehnologia conventionala, prin frezare. Pentru validarea celor propuse s-au stabilit trei cadrane pe zona superioara a piesei printate, epruvetei, care ulterior au fost prelucrate cu doua scule aschietoare de frezat de diametre diferite. Totodata prelucrarea celor trei zone s-a realizat folosind doua strategii de prelucrare avand parametrii de generare a traiectoriei diferiti. Prelucrarea prin frezare a piesei s-a realizat pe un centru de frezare vertical Challenger Microcut 2418. Dupa parcurgerea pasilor propusi s-a realizat masurarea rugozitatii initiale a piesei rezultate din printarea 3D precum si a celor rezultate din procesul tehnologic de frezat. Acest pas a fost realizat cu instrumental de masurare a rugozitatii TR-220 care este unul complet ce permite obinerea a 19 parametrii diferiti de rugozitate.

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