THEORETICAL AND CONSTRUCTIVE CONSIDERATIONS ON THE METHODS OF IMAGING INVESTIGATION OF MATERIAL LAYERS DEPOSITED BY ADDITIVE MANUFACTURING PROCESSES

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ABSTRACT: Additive manufacturing is a relatively new technology that is increasingly used in both manufacturing and research. In the present paper, we discuss the constructive part of an observation system of the additive manufacturing process with the deposition of plasticized material on the printing support surface. The importance of observation of the deposition process is determined both by the chemical composition of the material deposited and by the technological parameters of deposition. From a constructive point of view, it should be noted that existing commercial printing solutions are not provided with such systems to track the submission process. The author of the study turned to specific components from the optical field of endoscope type to visualize the deposition areas, but also to the camera with magnification of up to 500 times with macroscopic visualization of the printed surface. The design of the mechanical ensemble was carried out with the INVENTOR program, the educational version, and the realization of the designed ensemble will be made through the process of fuse deposition material (FDM).
KEYWORDS: deposit materials, additive manufacturing, diffuse liver disorders, CAD, CAM, modelling materials, scanning surface.

1. INTRODUCTION

In the process of 3D printing by localised plasticization of the material and its deposit on the support surface for the realisation of the part, an important role in establishing the processing regime is played by the way in which it is discharged through the nozzle hole. To be able to study such a physical and, at the same time, thermodynamic phenomenon, visual control at the level of the printing area can provide a set of practical information that will subsequently allow either the modification of the regime parameters or the real-time correction of the additive manufacturing process. In this part of the study, the basis of studies carried out by various researchers was determined to take as accurately as possible the information from the additive manufacturing space.

Considering that the materials used for additive manufacturing have different properties, in terms of both mechanical strength [1-5] and physical properties of plasticising and flowing through the extrusion hole.

Gao et al. [1], study the influence of PLA and ABS colour materials on the tensile, compression and flexure properties. It starts with a clear natural material colour and after that it takes into consideration the red, yellow, blue, green, orange, purple, and black colours. It is important to note that the colour circle presented in Figure 1 is taken into consideration to select the materials used in the study.

From an experimental point of view the red colour has a high value for ABS and the yellow colour for PLA.

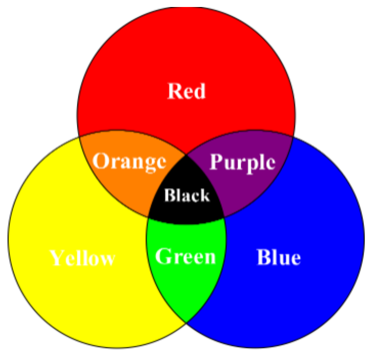

Figure 1 Colour code [1]

Günay et al. [2] study the dimensional accuracy of different factors used in the fused filament fabrication (FFF) process. These aspects are important due to the point of reproducibility of parts.

Valerga et al. [3] study the geometric deviation in relation to printed samples made from PLA with different pigments. Him takes into consideration pink, green, grey, and transparent material for printing.

Soares et al. [4] study the influence of colour (natural, green, and black) and printing with the same setting data after that the samples were scanned and verified with scan electron microscopy.

These phenomena occur because not only the chemical structure of the material granules differs from manufacturer to manufacturer [6] Figure 2, but also the granular dye used has a higher or lower concentration for the field studied Figure 3.

It should be noted that, in the field of additive manufacturing, the colour of the medium used can also influence the dimensional and environmental characteristics in which the processing is carried out using the solution for making parts with optically polymerizable medium [7, 8].

Figure 2 Granular materials with colorant in structure [6]

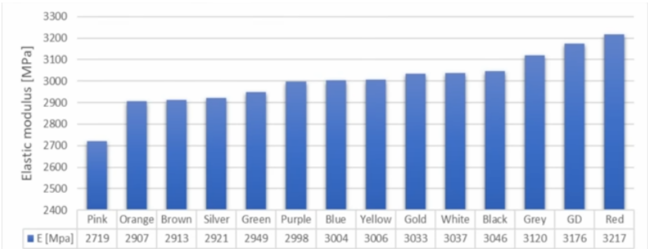

Figure 3 Elastic modulus in relation with colour of plastic material [1]

2. CLASSIFICATION OF ADITIVE FABRICATION SOLUTION

2.1 Fused deposition modelling (FDM)

FDM is based on the depositing of melted material by filament. From the point of view of the materials used in this type of printing, it is possible to observe that the usual PLA, PETG, ASA, and ABS are usually used, but there are applications in which thermoplastics use high temperature for plasticization type PEI or PEEK which are industrial materials used for aerospace (NASA). For printing, a printer is used which has a structure that can be seen in Figure 4 [9].

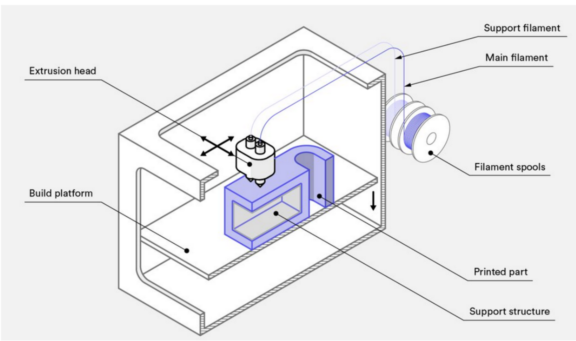

Figure 4 Schematic solution used for FDM printing [9]

The most important component in the manufacture of additives of the FDM type is the extrusion head part of the thread. From a constructive point of view, there are two variants, namely the one to which the wire is inserted into the extruder using a system of pushing it, a constructive solution usually used for printers with low office price Figure 5, and respectively those to which the pushing part of the wire is directly attached to the print head Figure 6.

Figure 5 Individual extruder head TRONXY 3D printer

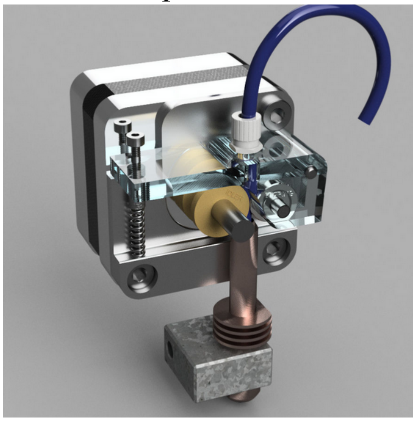

Figure 6 Extruder with stepper on printed head [10]

2.2 Fused Filament Fabrication (FFF)

The manufacture of the fusible filament (FFF) involves two different aspects in terms of its functional role. If the first concerns the obtaining of filament for 3D printing of the FDM type Figure 7, the second has implications for the deposition on flat or spatial surfaces of material that is of the cylindrical type of Figure 8 subjected to a plasticizing process.

Figure 7 Filament maker from pellet materials [10]

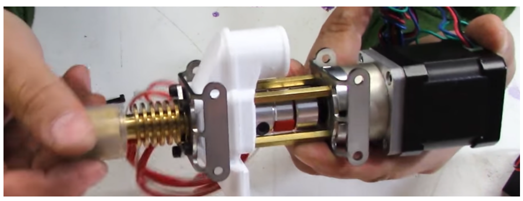

Figure 8 Pellet extruder head for 3D printer [12]

3. SOLUTION FOR OPTICAL VISUALISATION OF 3D PRINTING FDM OR FFF PROCESS

Optical visualization and, respectively, the management of the additive manufacturing process can be achieved by several methods. A first method is with Windows 8 systems or higher WIFI or cable connection. The WIFI variant is more convenient because it allows greater mobility of the 3D additive manufacturing process visualization system. For this phase of the additive view process, we will use a camera with the possibility of increasing the focal length of USB type (resolution 1920x1080 Max pixels). The positioning of the camera will be chosen in such a way that it does not inconvenience the printing process, but at the same time it is possible to achieve the best view and recording of the printing process Figure 9.

Figure 9 USB Web camera for view 3D printing process [13]

The second method is to track the process at the level of the print head using a USB camera with the possibility of focal magnification up to 500 times with manual adjustment of the focal length (manual focus range from 3 mm to 40 mm). The solution can be carried out both by viewing the printed surface in the vertical direction, but also by sliding the camera positioning system at a certain angle to the vertical surface. The advantage of the proposed solution is that one can inspect the printing process with better visual accuracy Figure 10.

Figure 10 USB camera for view 3D printing process [14]

For a visualization with even greater accuracy of the material deposition process, an endoscopic system for tracking the 3D printing process can be used. The proposed solution is the one in which at 90 degrees from the USB camera previously proposed to be used is arranged at 15 degrees an endoscopic camera that allows us to study after a second direction the 3D printing process and at the same time be able to determine how the material is sent through the extrusion nozzle and deposited on the surface of generating the part Figure 11 [15].

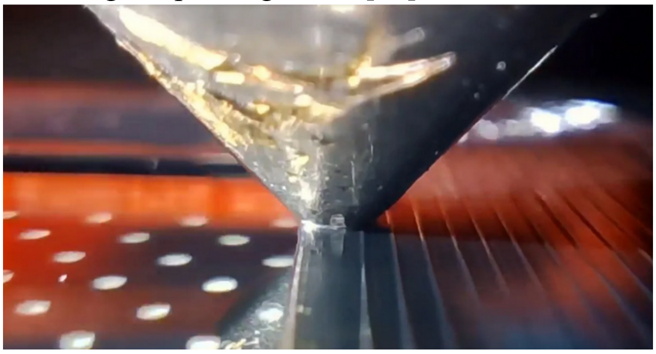

Figure 11 Endoscope camera for view 3D printing process [15]

The additive manufacturing process tracking solution can also be achieved using an additive manufacturing process processing and saving system using a system based on ROSSBERY PI and OCTOPI using USB camera.

A third solution is to use an Android video image retrieval system. The disadvantage of the latter is that, to carry out commands, specific sub-programs must be made and subsequently loaded that allow the printer to be ordered from the Android system.

For the case of the first two solutions, the advantage is that it is possible from the program for generating printing layers based on programs or subprograms / subroutines written with PYTHON program integrated directly in the previous mentioned programs (Cura, IdeaMaker, Ultimaker Cura, SuperSlicer, etc.) to make real-time corrections in the printing phase ordered either from the automatic program, or by stopping printing and entering data from the keyboard.

4. DESIGN OF CONSTRUCTIVE ELEMENTS FOR MOUNTING AND POSITIONING OF CAMERAS FOR VIEWING AND TRACKING THE PRINTING PROCESS.

The first optical system to be positioned was that of visualization of the assembly generated by additive manufacturing. It was positioned at the top of the TRONXY 2PRO printer Figure 12.

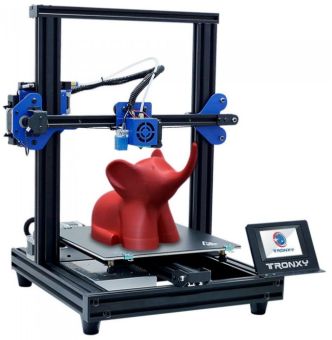

Figure 12 Printer TRONXY XY-2 used for 3D printing process [16]

The assembly with the mounted camera can be seen in Figure 13. Its arrangement is in the central position because usually the printing is done in the middle area of the printer's printing surface.

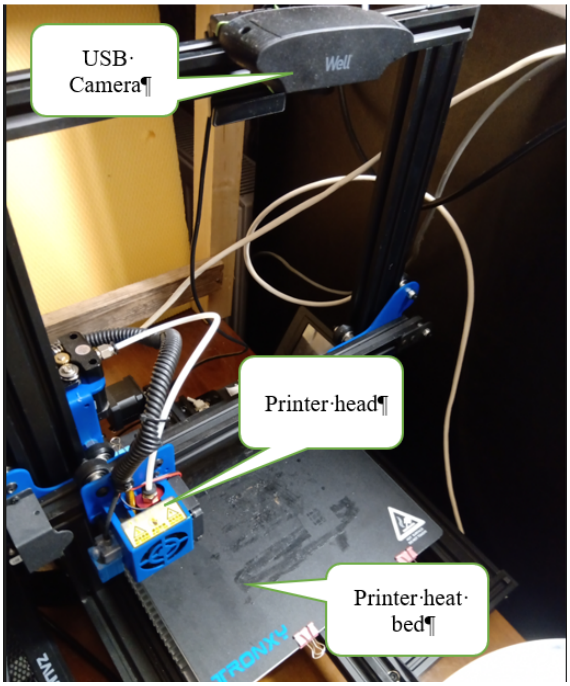

Figure 13 USB camera used on printer TRONXY XY-2 used for visualization of 3D printing process.

With this positioned system, the camera was connected to the ZOOM program and the 3D printing process for the basic part to fix the second optical printing system Figura14 was recorded. For the 3D dimensional design, the FUSION 360 educational variant program was used. From a constructive point of view, the support is designed on an anterior part that provides the fixation on the 3D print head and, respectively, a semicircular part that ensures the positioning of the USB camera. The central part is provided with a free zone to prevent obstructing the cooling air circuit of the plasticizing body of the printing wire with a diameter of 1,75 mm.

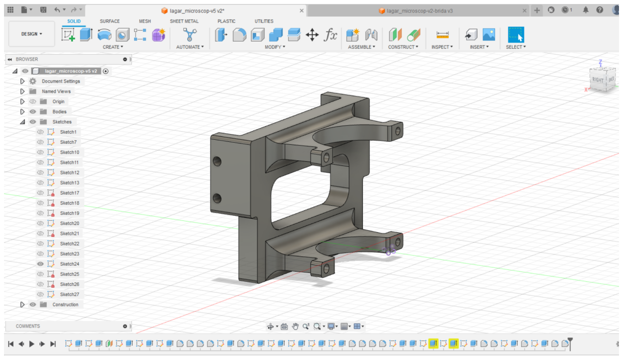

Figure 14 Support USB 500x camera body used for visualization of 3D printing process.

For realization of the 3D printer control program was based on the CURA software and consisted of checking the integrity of the STL part generated with the FUSION 360 program, followed by a stage of setting the printing parameters. The density of the structure chosen based on the information in [17-20] was 20% Figure 17, and compared to the same bibliography, the printing speed of 40 mm/second and a support structure of 5% density were chosen. generated program is a code G type that ensures the linear movement of the print head and obtaining the part Figure 15.

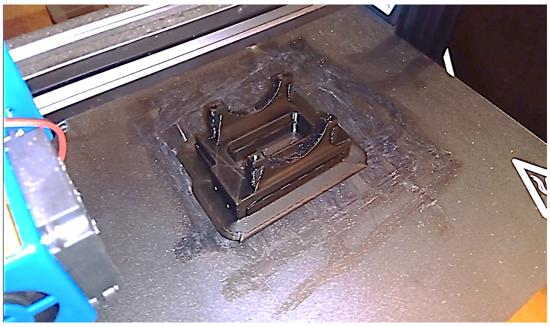

Figure 15 Structure 3D printed support for camera.

In Figure 16 one can observe the first stage of 3D printing with the generation of the lower layers of the sample.

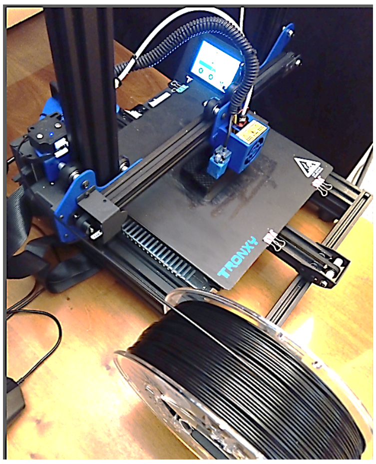

Figure 16 First layer 3D printed.

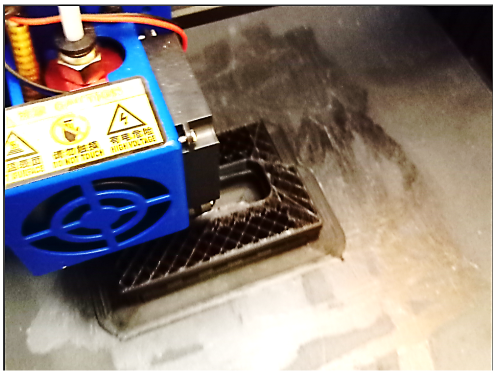

Figure 17 Structure 3D printed infill zone with 20% density.

The first printed part is very important given the previous experiences of generating such landmarks and is that of adhesion Figure18. It has the role of preventing the detachment of the part from the printing surface during printing.

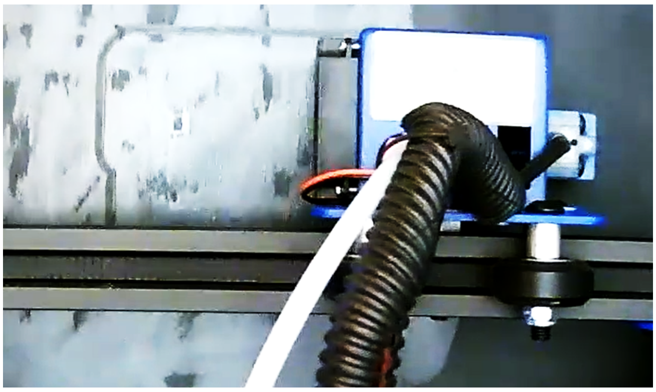

Figure 18 First layer brim structure 3D printed.

After completing the successive lines submitted, we proceed to the printing of the first layer of the part structure Figure 19 which has a part consisting of three layers with a density of 100%.

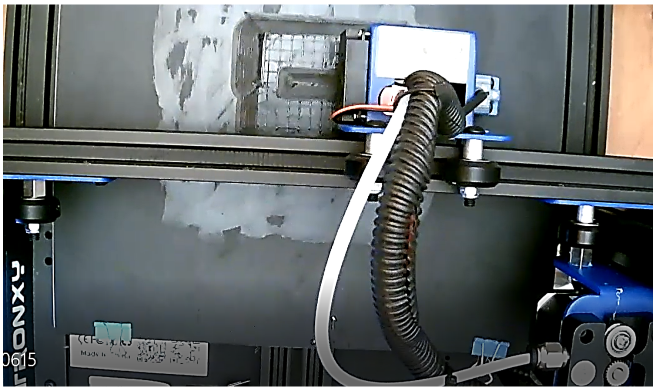

Figure 19 First layer base structure and supports structure 3D printed.

In Figure 20 you can see the structure of the body of the sample and respectively in Figure 21 the area of positioning elements of the camera.

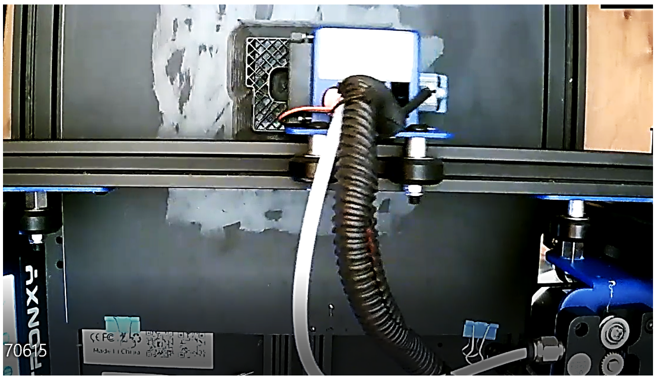

Figure 20 Body structure of structure 3D printed sample.

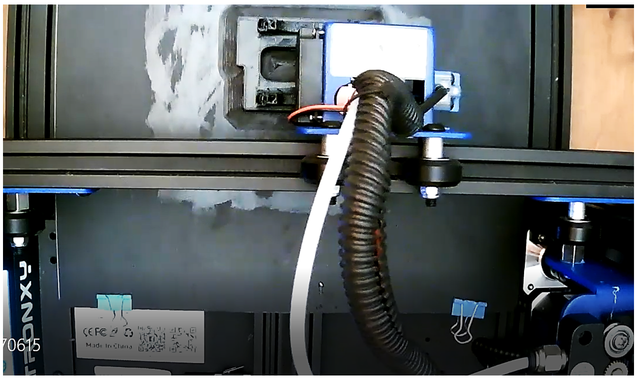

Figure 21 Area for positioning camera 3D printed.

5. CONCLUSION

Several conclusions emerge from the study. The first is related to the way of tracking the printing process which from a visual point of view can be done with a camera arranged at the top and not with a camera arranged on the sides of the printing surface. It should be shown that for better research of the material deposition process from a dimensional point of view but also visually, a positioning of the investigation chamber as close as possible to the printing surface is advisable. Consequently, it is recommended to perform and investigate the results with a camera arranged at the level of the print head as recommended on the second variant, but the third variant considered should not be neglected either.

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