Ministerul Educației Naționale
ROMÂNIA
UNIVERSITATEA DE MEDICINĂ, FARMACIE, ȘTIINȚE ȘI TEHNOLOGIE DIN TÂRGU MUREȘ

Acta Marisiensis. Seria Technologica
Vol. 16 (XXXIII) no. 1, 2019
ISSN 2668-4217, ISSN-L 2668-4217

STUDY ON DESIGNING THE EXTRUDER FOR 3D PRINTERS WITH PELLETS

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Abstract

The purpose of the paper is to design an extruder to ensure continuous flow of material and retraction of the melted material into the extruder of the printers operating with pellets ABS, PLA or other materials used. The way in which 3D printers work differs from that of plastic injection machines by the fact that for the execution of a piece it is necessary for the extruder to position itself at different points of the surface without depositing the material. If it does not stop the flow of material during the repositioning move, then the executed piece will be compromised. Designed pieces were designed with the help of the Inventor Software and it was determined experimentally whether the extruder is working. It was found that the original design did not fully meet the requirements of the coat-coat process, which is why rethinking of the extruder's operation and modifications to ensure retraction of the material is necessary.

Keywords: retraction, extruder, conveyor worm, pellets, continuous flow

1. Introduction

There are several ways in which a product, from the stage of the idea, becomes reality. However, in the case of prototype execution by conventional technologies (casting in molds executed by means of milling, followed by machining) [3], [4], [11] they reach high manufacturing costs and a long time. This is why the 3D printing industry has developed.

Some methods melt or soften the materials to produce layers such as FDM [7] and SLS [6] technology, these being the most common technologies in the 3D printing industry. In the following are present details of the most common technology used in 3D printing, namely FDM fast prototyping.

Rapid prototyping technology FDM (Fused Deposition Modeling),is the most widely used manufacturing technology due to its simplicity and affordability. It is used in modeling, prototyping and also in production applications. Other names used are: MEM (Melting Extrusion Modeling), TPE (Thermoplastic Extrusion), FFF (Fused Filament Fabrication).The way a prototype is born is relatively simple Fig. 1 and the stages we are going through in this manufacturing technology are the following:
In the first stage, the product is represented by 3D CAD modeling software like Inventor [5], Solidworks, Catia [2].

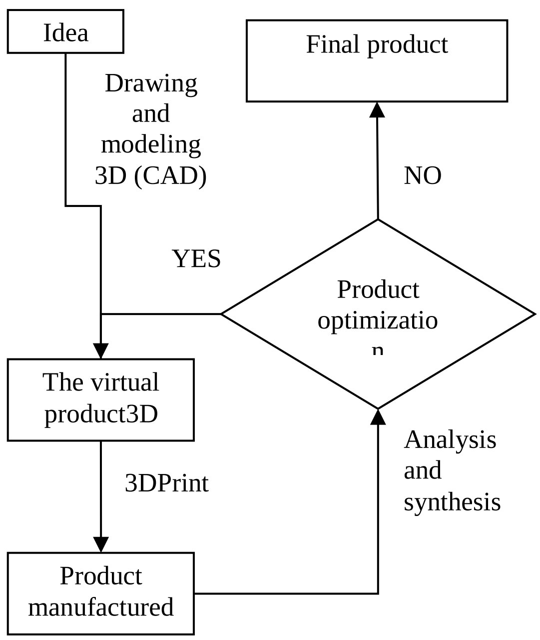

Fig. 1: Steps to finite product design[12]

Having the 3D-modeled product, using a dedicated software like Cura , is prepared the product for 3D printing. The desired 3D model is initially sliced in cross sections called layers. Printing technology consists, at most FDM printers, in passing a plastic filament through an extruder that heats it up to the melting point, then applying it uniformly (by extrusion), layer with layer, with great accuracy to print physically 3D model according to CAD file.

The head (extruder) is heated to melt the plastic filament, moving horizontally in two directions under the coordination of a numerical control, directly controlled by the CAM application of the printer. The printer table performs the vertical movement. On the move, the head puts a thin strip of extruded plastic that cools immediately upon deposition, sticking to the previous layer to form the desired 3D model. Following a step of analyzing and synthesizing the resultant product, if the product has to undergo some changes, the CAD file changes and then are underway the same steps until the modified product is obtained.

To reduce the cost of printing, an extruder designed to operate with PLA or ABS pellets was designed to replace the filament. The need to develop an extruder to operate with plastic pellets is justified by reducing the cost of printing the price of kg of filament being biggerthan pellets Table 1, Fig. 2. The price of ABS pellets is approximately 5,4% of the price of the ABS filament, in the case of the PLA, the price difference being approximately the same.

Table 1: Raw material price

Raw material	Company	Price (lei/kg)
Filament ABS	Optimus Digital	79,9
Pellets ABS	Romcarbon Sa	4,34
Price difference		75,5

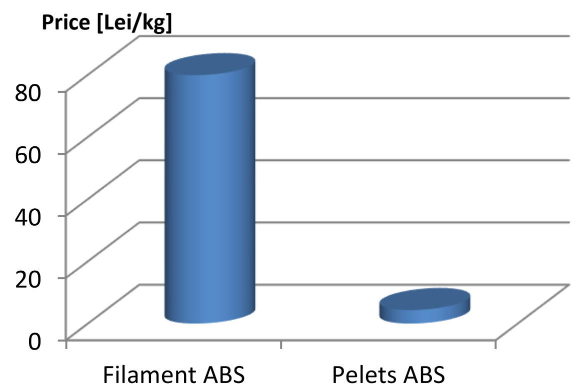

Fig. 2: Price difference of row material

When designing the extruder, Fig. 3, aspects regarding the stiffness of the system [8], [9] were considered during extrusion [10].

2. Designed extruder

The projected extruder is shown in Fig.3.

The main aspects to be considered when designing the extruder are:

- Ensuring the continuous flow of the molten material;
- Retrieving the material when repositioning the extruder head.

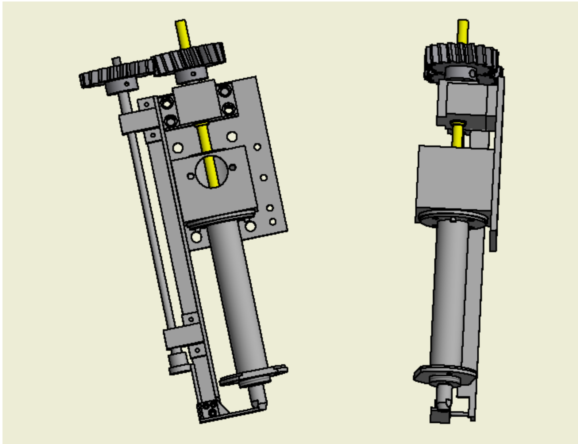

Fig. 3: Designed extruder

2.1. Ensuring the flow

To ensure the continuous flow of the melted material, it was chosen to design a conical conveyor worm [12] with two beginnings in Fig. 4, for which AutoLisp was used, and the representations were made in Autocad then imported into Inventor [1].

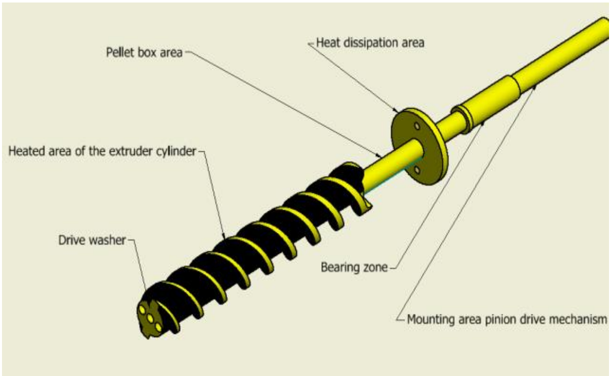

Fig. 4: Conveyor worm[12]

In the front of the screw there are provided holes for fixing a piece hereinafter called a drive washer. This will be fastened by means of three bolts with a diameter of 4 mm and a length of 16 mm. There follows an area where the pellets are transported over the helical surface length. Next, there is an area corresponding to the vat in which it is to be pellets. A heat dissipation area is provided, followed by a bearing attachment zone, a gear wheel for driving a swinging mechanism, and an area where it will be connected to an electric motor step by step via a resilient coupling. The material from which it will be machined is stainless steel, and then it is rectified in the cylindrical area of the helical rib and in the bearing zone to have deviation from the cylindricity and deviation from the concentricity in the 6th, 7th precision.

2.2. Ensure the retraction of the material

To block the flow of fused plastic at certain times of printing, a two-piece assembly having two contact positions according to the direction of rotation of the motor has been designed. The two parts are referred to as the drive washer and the tapered piece.

The drive washer Fig. 5 is fastened by means of three bolts in the holes shown above at the front of the conveyor worm. On the circumference there are provided recesses through which the molten fluid will pass. In the front there is provided a cylinder for centering a conical piece and two engagement zones located diametrically opposed to the axis of symmetry of the part.

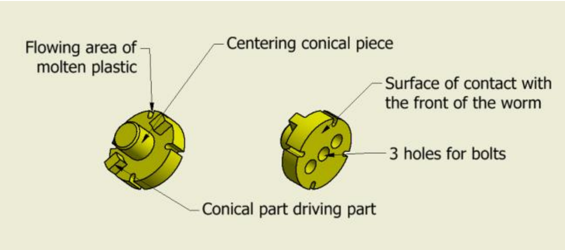

Fig. 5: Drive washer

The fluid material will penetrate into the flow area from where, depending on the direction of rotation of the screw, it will penetrate or not through the holes in the conical piece Fig.6.

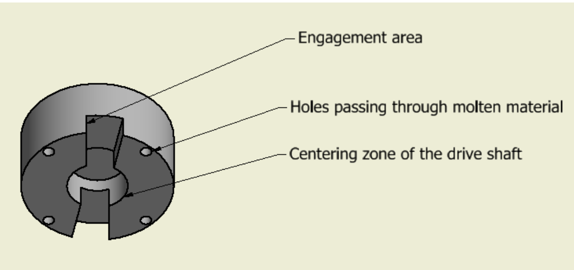

Fig. 6: The tapered piece

Four holes are designed for the molten fluid so that when the feed worm is rotated in the feed direction of the material, it continues in the recesses on the drive shaft. In the opposite direction of rotation, the contact surface will be the opposite of the holes on the conical piece not continuing in the recesses on the drive washer.

Fig. 7 shows the situation in which the wormis rotated in the sense of the material. It is clear that the holes on the conical piece communicate with the holes on the drive washer. If the direction of rotation of the conveyor auger changes, the coefficient of friction between the conical piece and the driving washer is less than the coefficient of friction between the conical piece and the bearing surface thereof, the contact surface will change and the holes on the conical part will also communicate with the recesses in the drive washer. When the screw is rotated in the opposite direction, a vacuum will be created and the problem of the retrieval of the melted material will be solved.

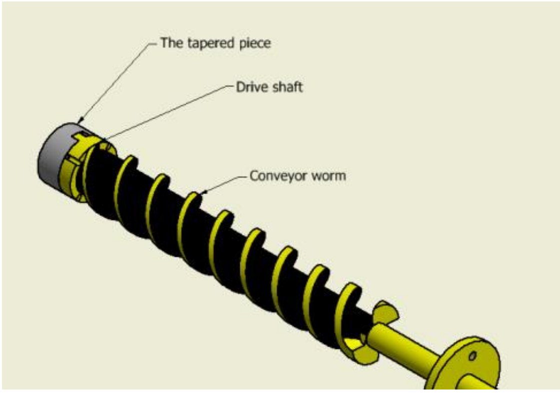

Fig. 7: Assembly consist in worm, washer and tapered piece

The other parts of the extruder are in conformity with Fig. 8 extruder cylinder with electrical resistance, pellet bucket, extruder base plate, bearing housing, pinion swing mechanism

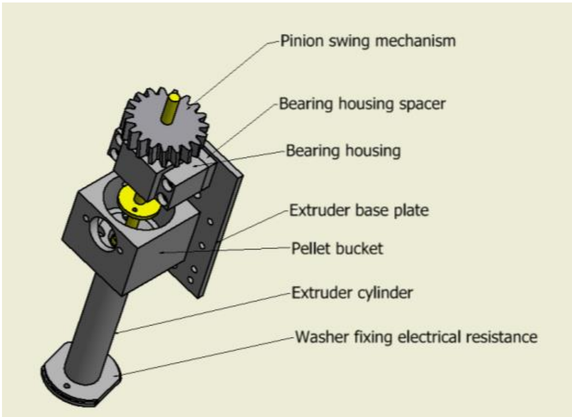

Fig. 8: Extruder without swinging mechanism

3. Obtained results

Following the design of the 3D printer extruder, it went to the execution of the assembly parts and the tests. The assembled extruder is the one from Fig 9.

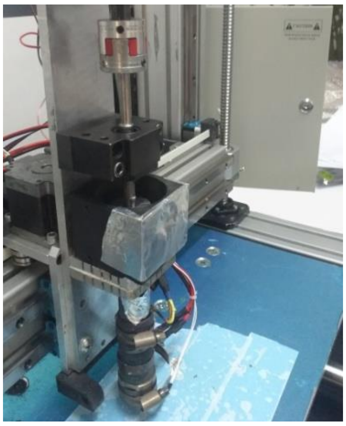

Fig. 9: Assembly extruder

Several attempts have been made with different printing parameters, resulting in a continuous flow of fluid material obtained from ABS pellets Fig 10.

Fig. 10: The ABS wire obtained

Whenthe direction of rotation of the worm changes, the melted material continues to flow and the retraction being therefore not controlled in the projected version. Probably, due to the high pressures developed inside the extruder, the molten material pushes the conical piece and thus creates a space between the conical piece and the drive washer. In order to ensure retraction, changes to the designed extruder must be made.

4. Conclusions

For the good operation of the extruder must be ensured:

- continuous flow of melted material;
- retrieving the material when repositioning the extruder head.

The designed conveyor worm ensures the continuous flow of the material, but the assembly of the drive and the tapered piece does not provide the retraction required for layer-to-layer printing.

The designed extruder can be used on 3D printers if constructive changes are made to the assembly of the drive and the tapered piece so as to resolve the issue of the retrieval of the molten material.

Acknowledgement

The authors thank Research Centre TAPFAAC of the Faculty of Engineering, University of Medicine, Pharmacy, Science and Technology of TîrguMures, Department of Industrial Engineering and Management and 3D Creativity SRL-D for providing opportunities to use machines and equipment.

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