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Selected applications of the 3-D printing technology

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The spatial FDM Technology printing enables illustrating a great number of technical issues by creating a model of the analyzed object e.g. directly, during didactic classes. A three-dimensional printer may be used in any field of knowledge, from biology, where the printer can be employed for printing the models of organs (printing of the organs themselves is also possible following the modification of the printer – when printing with TAULMAN Nylon filament, we can print e.g. the elements of bones or cartilages which may be implanted into a living organism) to printing spare parts and prototype elements for equipment, in architecture for printing complex scale models etc. The printer itself is a fantastic device, interesting for many fields of study. The 3D printer will enable students to learn how to program the processors based on ATMega, may prepare new software controlling the printer, design 3D graphics on computers, edit "scans" and files downloaded from the Internet, use the CAD software in practice and print the results acquired on the sets of printers. Moreover, each printer may be freely modified according to our own needs – from the change or transfer of the drive to replaceable extruders – the mechanisms forcing materials. The printer may also be changed into a laser plotter or even a milling machine following a slight modification of the extruder's carriage or changing force belts into ball screws [1-4].

KEYWORDS: FDM 3D printer, extruder, rapidprototyping, filament

1. 3D technology

This paper mainly concerns one of the methods of Rapidprototyping which the 3D FDM printing is. The Rapidprototyping defines the methods which are used for repeatable, precise and, in the first place, rapid production of the elements using the additive technology – most frequently with the computer control. The 3D FDM printing, the technology of fused deposition modeling, is one of the methods of rapid prototyping and spatial printing. It lays down the thermoplastic material (most frequently - plastic) by extruding it through a nozzle. The nozzle is heated to the temperature in which the material will melt. The flow of the material is controlled by the nozzle which is automatically moved by means of the computer – aided design (CAD) software, whereas according to the determination of the additive technology, the element is printed layer – by – layer. [8, 10, 12].

2. The 3D printer

The 3D FDM printer belongs to the group of CNC machines although it has been more frequently treated as a computer's peripheral device owing to the fact that its usage is becoming gradually popular among home users. There are a few types of the 3D FDM printers. They may vary in terms of the drive applied, as shown in Figures 1 - (1), 2 - (2), 3 - (3), 4 - (4).

2.1. The general structure of the 3D printer

As mentioned before, the FDM 3D printers may vary in terms of the drive applied or their structure – however, they have some common features owing to which they all belong to one group of printers. Apart from the frame (each of them has a different type of the frame), they have a table – the working surface in other words. The table may be either preheated or not, depending on the requirements and the materials used.

Another characteristic element is an extruder – "a paintbrush" of the 3D printer. It is responsible for extruding the material through pushing the printer's wire to the hotend - a part of the extruder which melts the material and pours it out layer by layer to form the shape desired. The extruder end's – a nozzle's diameter may range from 0.1 mm to even 1 mm owing to which we can print absolutely precise, tiny elements, or we can print the bigger ones faster.

Moreover, the printers most frequently have a drive with stepper motors which is transferred on force belts, whereas the carriage of the printer (the carriage onto which the extruder is mounted) moves along the linear guides with the help of ball bearings, or less frequently, sleeves. The more and more commonly used are ball screws in the Z-axis as well as grease-free linear guides. [2, 6, 9].

2.2. Printing heads (examples)

Currently, there are a few types of printing heads i.e. extruders. The most common are the standard direct drive extruders with a toothed bar which, while biting in the wire (the plastic) moves it to the hotend, where the melting till liquid takes place.

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[1] Note: designfutures.pl
[2] Note: designfutures.pl
[3] Note: 3dprintingblog.com
[4] Note: 3dprintingblog.com

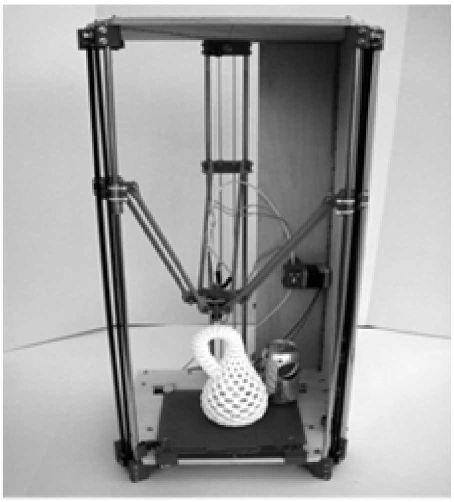

Fig. 1. The ROSTOCK - type printer – the drive transferred to three arms working independently relative to each other by means of stepper motors [(1)]

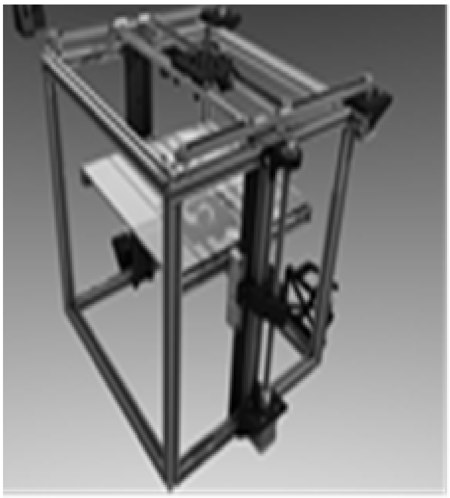

Fig. 2. The H-BOT - type printer – the Z-axis moves downwards along with the progression of printing, the X and Y- axes are connected by one force belt, working on horizontal planes [(2)]

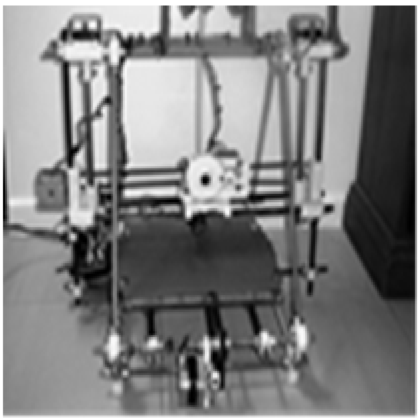

Fig. 3. The Basic System - type printer – in this arrangement, the movable table moves in the Y horizontal plane, whereas the X-axis suspended on two stepper motors, moves horizontally [(3)]

Fig. 4. The GUS - type printer – the line wrapping the arms, being clamped or released by the movement of the stepper motors, moves each of the three, independent arms [(4)]

Another solution is the Bowden's extruder where the filament feeder is affixed by the printer's frame, whereas the material is supplied through a Teflon pipe "Bowden" to the hotend itself. This solution provides us with a lighter carriage (faster printing), however, it causes problems with retraction - pulling down the filament by gravity while idle – Figure 5 - [(5)].

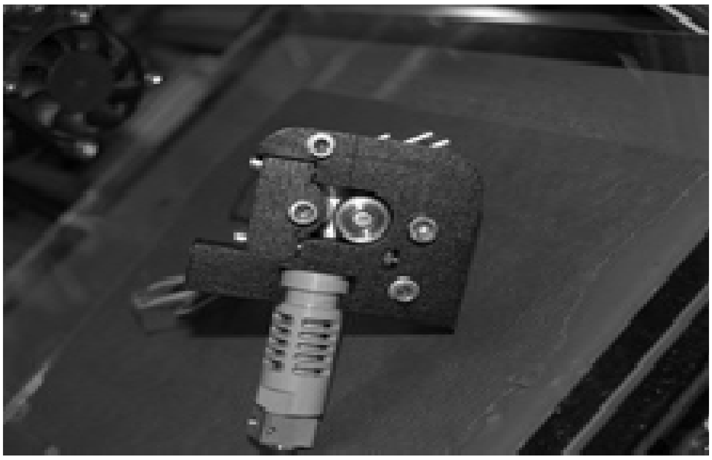

Fig. 5. A direct drive extruder. The wire pushed between a knurl and bearing by successions of the stepper motor pushes it or moves it back [(5)]

Another type of heads are the ones which "pour out the pulp" of dough, gypsum or other materials of similar consistency.

In such a case, the material from the feeder (e.g. the syringe) is pushed by means of the belt forced by the stepper motor which by clamping the pusher, pushes the pulp which is poured onto the surface, and makes a given model [9, 11] - Figure 6 – [(6)].

Fig. 6. The extruder for the material in the form of pulp. The force belt by means of the stepper motor is clamped around the syringe resulting in the pulp being squeezed through the extruder's nozzle [(6)]

[5] Note: Fucco Design

[6] Note: designfutures.pl

Apart from these three types of heads, also many variants of theirs may be found, from a direct drive to BOWDEN`s drive (Figure 7 – (7)) – the extruder is separated from a movable carriage – affixed to the housing.

Fig. 7. The Bowden's extruder affixed to the printer's housing - as a result, the carriage with hotend is discharged, however the problems with retraction – the filament's drawing back occur (7)

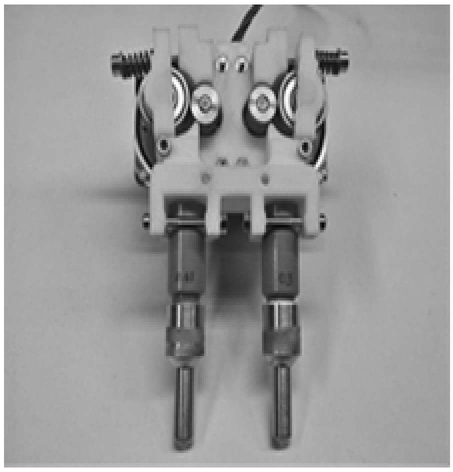

Fig. 8. A dual extruder. The connection of two extruders with a mirror reflection towards each other – owing to this solution one can use different colors of materials or various kinds of filament (8)

The third type of the extruders is a multi-extruder, namely a few heads on one carriage which may pour out, independently from each other, many different types of materials. The most common types are the twin, dual heads – Figure 8 – (8).

This solution allows to print faster but it's more difficult to control the retraction, the pulling down the filament by gravity [3, 7].

3. The laboratory station for didactic purposes (an example)

The laboratory station for operating the 3D printer consists of the printer itself, which is almost an autonomous device. Having been equipped with a display and appropriate electronics, the only function of the computer would be modeling for the purposes of printing and the export of the models to the format accepted by the printer (*.gcode) – Figure 9 – (9).

[7] *Note: mojreprap.pl*
[8] *Note: mojreprap.pl*
[9] *Note: velleman.com*

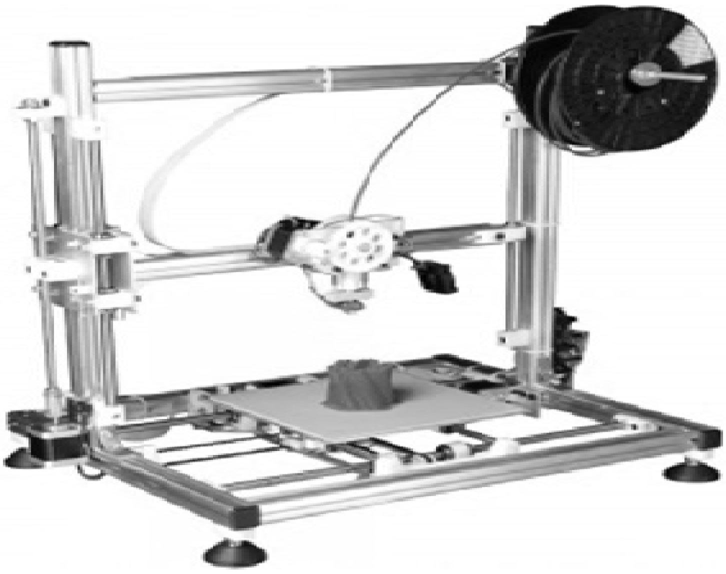

Fig. 9. The extruder type Classic – a movable table, the carriage is lifted along with the progression of printing [9]

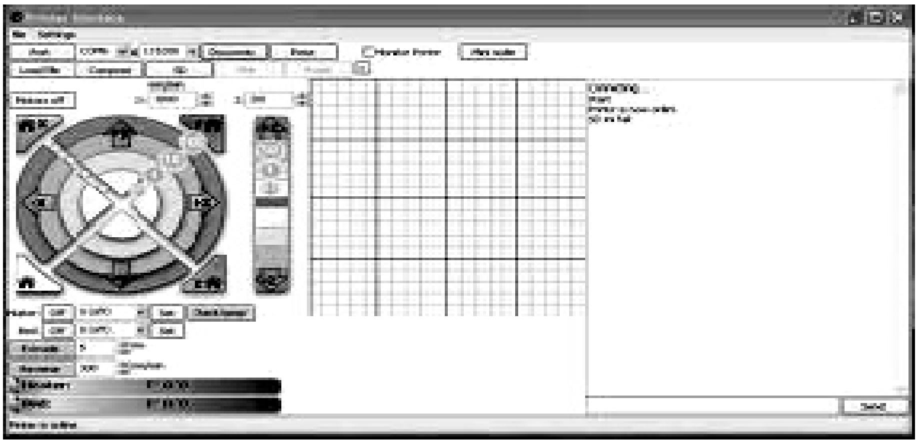

Fig. 10. The window of the Pronterface. It`s the software of the HOST - type for printers which allows operating, calibrating the printer and activating the computer or memory card printouts [10]

In addition, the computer for operating 3DSMax Studio, Blender or Trimble SketchUP- type with the software for printing, the host – Pronterface, CURA, MakerWare, Repetier Host are indispensable. (Figure 10 – [10]).

[10] *Note: mojreprap.pl*

The computer should also be equipped with the FLIP – for programming electronics as well as the Arduino package – for making and editing the printer controlling software. The laboratory should be also equipped with thermoplastics – the most preferably – basic types such as PLA and ABS (Figure 11 – [11]).

Fig. 11. The filament. Materials for printing – except for different types of materials (from the most commonly used ABS to wood, gypsum composites to Nylon which may be transplanted into a human organism as an implant) come in various colors [11]

The devices are user-friendly and cheap to maintain, and provided the producer's instructions are followed, safe to use.

5. Summary

To sum up, it must be stated that due to gradually wider application of 3D printers in engineering, medicine etc., the idea of introducing them to the didactic process seems absolutely appropriate [5]. Moreover, the laboratory stations equipped with 3D printers will facilitate understanding a great number of issues for which so far students have had to use imagination or have been presented with virtually.

The 3D printers are also an indispensable tool for carrying out practical experiments within many fields of study as they combine numerous problems and issues, from programming to the mechanics of the device. They are particularly important for robotics, mechatronics, car electrical engineering as well as IT and electronics.

[11] *Note: devildesign.pl*

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