ADDITIVE TECHNOLOGIES AND MATERIALS USED FOR MAKING CUSTOMISED GLASSES FRAMES

Daniel Besnea[1], Dana Rizescu[2], Ciprian Ion Rizescu[3],
Victor Constantin[4], Alina Spanu[5]
[1,2,3,4,5]University POLITEHNICA of Bucharest, Faculty of Mechanical Engineering and Mechatronics,
Department Mechatronics and Precision Mechanics
E-mail: d_bes@yahoo.com , dana.rizescu@upb.ro , ciprian.rizescu@upb.ro,
victor.f.constantin@gmail.com , spanu_alina@yahoo.com

Abstract: In the paper describes a method for making seeing glasses frames by means of additive technologies with the presentation of the main functional characteristics based on solid material deposition, the FDM technology, as well as the main materials used (ABS, PLA, Wood PLA composites), highlighting the properties and the technical and functional characteristics of the materials used in making custom eyewear frames according to the individual facial characteristics of each person but also by the specific ocular parameters.

Keywords: Additive technologies, materials specific to 3D technologies, personalized glasses frames.

1. Introduction

Eyeglasses are a tool that can help to correct eye defects or can be used as protection. They consists of two lenses and a frame for the glasses, the main role of the glasses frames is to position the lens as accurately as possible on the optical axis of the eye. The glasses frame is made up of a lens holder called a frame, the eye and nasal socket. It is generally recommended that the lens catches on its entire circumference, but the lens may be in contact with the frame only in certain areas.

Frames for glasses can be made of the following materials: plastics, metal materials or combinations of plastics with metallic materials known as mixed frames.

From the point of view of the materials from which glasses are made, the frames of spectacles can be classified as follows:

- metallic glass frames made of stainless steel is the most used material because it is cheap and resistant, gold in alloy with other materials like silver, copper, zinc, nickel, a combination that increases hardness and alloy resistance 4-5 times; titanium, is a very lightweight material, but at the same time very mechanical and corrosion resistant, if desired, it can be coated with a gold alloy; also cobalt is light, flexible and corrosion resistant;

- plastic glasses frames made of cellulose, epoxy resin with thermoplastic properties with the advantage that it is very light and can be colored; carbon fibbers characterized by high mechanical strength and elasticity and low density;

-rail glasses of other materials: wood; turtle shells characterized by being very expensive; animal horns, can be hand-processed by embedding different materials, obtaining individualized frames.

For the optician to recommend the best eyewear to the client, the following elements should be known: the shape of the skull, forehead, nose, face physiognomy, shape and position of the ears. To the facial shape of the client. The optician must be careful that the frame does not press nerves and blood vessels because it can produce unpleasant sensations to the eyes. Also, in cases where the face of the client is not symmetrical the optician must recommend the proper eyeglasses. The shape of the nose is a criterion for choosing suitable eyeglass frames. By choosing a suitable nosepiece of the eyewear to fit perfectly with the shape of the nose, it can give the face more harmony. When the nose is aquiline or nasal it is recommended to be deeper, when the nose is too small, or it will be tall.

An eyeglass must meet primarily its medical role of fixing the lens at a distance of 12 mm from the eyeball, to match the optical axis of the glasses to coincide with the eye axes of the eye, not to damage the field of vision. Consideration should also be given to the purpose of the eyewear if it is for distance, for reading, for physical exercise, for sports or as sunglasses.

For a round face a frame of rectangular, square, trapezoid or diamond shape it is recommended to contrast the face. For a rectangular or diamond shaped face, oval frames are recommended, for a square face, round or oval frames are recommended, in dark colours, for a heart-shaped face - round or

oval shaped frames with thin, colourful and light-colored frames, and for an oval face almost any frame, from round to square. Frame in the shape of a butterfly prints to the young girl, joy, make it friendlier. The rounded faces give the face fine, sweet, rectangular or square shapes face seriously. Frame width can change the look of the face. On an elliptical or oval face, the frame should not exceed the contour. The frame of the frame must match that of the eyes, the hair, the eyebrows and the complexion. A light frame will make a white face even more pale and a darker frame on a darker complexion it will darken you even more. Also, a darker frame does not fit a face with a very light face, revealing the too much difference in nuances. It is of great importance and the forms of the hinge applications. The vertical and narrow ones take of the width of the frame, the horizontal ones a lattice. The shape and size of the frames should provide a field of vision adapted to everyday needs, the frames of the glasses that are placed and removed from the head frequently must be more resilient than those for rarely sunglasses (bifocals, progressive), frames of the glasses for children will not have the same proportions as adults, they should provide a higher visual field, they should be lightweight and made of durable materials, and glasses should be comfortable and as stable as possible on the head. [4;7]

2. Technologies and Materials for Personalized Spectacle Frames Through Additive Technologies

The emergence of Additive Manufacturing (AM) technology in the early 1990s was a milestone in research and technology development. The new AM technologies are the result of intense research and progress in various areas: from fine mechanics to numerical controls, from laser technology to three-dimensional modelling packs, from IT to material science. Rapid Prototyping technologies allow for a great flexibility in application, an advantage to exploit micro components with a good dimensional precision used as conceptual models / functional prototypes or indirectly used as master models for the production of flexible tools for the manufacture of metallic or non-metallic parts in individual or small series production.

3D technologies allow you to assess the visual needs of the wearer taking into account the facial features and eyewear framing in accordance with eye parameters according to the individual facial physiognomy of each person but also to the unique design of the eyeglass frames. Also, 3D printing allows for the realization a suite of frames, designs and colours, the glasses being customizable with the name, customer initials, and the complementarily of the frames to adjust to any facial profile.

In recent years, a large number of innovative (Rapid-Prototyping) technologies have been developed to transform the concept of achieving a complex product into a solid replica in a short period of time. [1, 2].

Generally, Addition Material (AM) systems are a new class of virtual physical realization technologies using a family of special equipment. They provide the addition or bonding of material in successive sections as much as needed and where it is necessary. The production processes by adding material using solid matter in a solid state can be described as systems that take the virtual 3D geometric model of a three-dimensional object and generate a physical replica of it, the raw material can be in the form of yarns foil. One of these additive technologies is FDM (Fused Deposit Modelling), a process based on the extrusion of material using a yarn of different material qualities (polyamide, nylon, wax), which it heats up to a temperature a few degrees below the melting temperature, then reduces its diameter to 0.12-0.15 mm by extruding it into a depositing device, a device moving the XOY plane to materialize a section of the 3D virtual model. The key to the process is to rigorous control of the temperature at which the material is heated and maintained during the deposition. The material used can be an ABS wire that is heated at a temperature 270 C, where the material is in a semi liquid state, and can be extruded through a very small diameter nozzle (0.254 mm or 0.127 mm). The extruded plastic material in the semi liquid state can be displaced together with the heated head on which it is fastened. This movement is done in the XOY plane, the movement being numerically controlled on the computer. The construction part is on a platform that moves vertically, along the Z axis, motion controlled numerically by the 3D machine control equipment, fig. 1. In this way a piece can be made by depositing the material where the configuration of the piece demands it. [1]

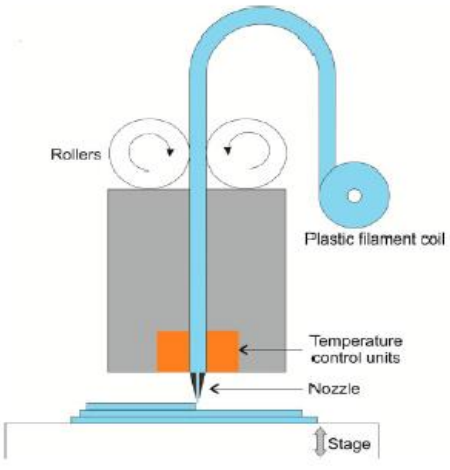


Fig. 1 FDM working principle [2].

The article presents the technology for making glasses customized by the FDM process, using three types of PLA (polylactide), ABS (Butadiene styrene acrylonitrile) and a Wood-PLA composite material.
PLA (Figure 2) is a brilliant, hard and biodegradable substance that is a more powerful and flexible material for the 3D printer. PLA chemically contains lactic acid and lactide. This has a low melting temperature of 173-178 ° C and a traction resistance of 2.7-16 GPa with several application areas, including medical implants and compostable packaging materials. PLA is mainly obtained by processing plants such as corn, sugar beet, potatoes, sweet smell, no hazardous components, considered compatible with the environment and which can come into contact with food and therefore environmentally friendly.

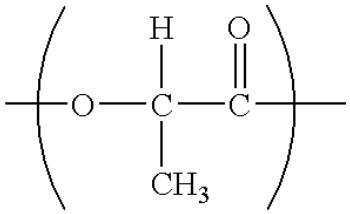


Fig. 2 PLA – chemical structure.

Stronger and more rigid than ABS, PLA is more complicated to use in assembling parts that require bonding, and the deformation property at temperatures lower than the ABS (about 65ºC) prevents its use in engineering projects.

ABS (Butadiene styrene acrylonitrile, a highly versatile polymer used in many industries and exhibiting a variety of properties), in 3D printing, the ABS is a hard plastic, high temperature resistant (it begins to deform at about 100 ° C) and with slight flexibility (compared to PLA) which helps to achieve the objects that require joining. It is soluble in acetone - with a brush soaked in acetone, the surfaces can be easily finished, becoming shiny, and the various parts of an object can be glued together. In large dimensions, it presents a risk of deformation. Certain manufacturers have modified the materials specified above, in particular PLA, to obtain materials with new aesthetic and structural properties: flexible, phosphorescent or mixed with wood or stone particles. These materials are specially designed to give objects a unique finish, but also certain qualities as required.

Flexible material can be used for objects that are subject to stretches or compressive forces, from fashion design (e.g. a shoe, a frame of glasses) to engineering (a robot with multiple components that can withstand small shocks etc. 3D phosphorescent print media can create objects that light up in the dark.

The PLA - Stone mixture is recommended for objects that look nice with a texture similar to the stone. 3D Printed Architecture Machetes can have stone-like components (or can be built entirely with this material). Other 3D printable objects with this material: statuettes, busts, small bas-reliefs, candle holders, etc.

The PLA - Wood mix, available in 2 variants, offers a special, smooth texture with a colour that tends to open wood, such as Balsa or coconut wood darker in colour that can give the character of the glasses' uniqueness. [3]

3. Execution of Custom Glasses Frames Using the FDM-Fused Deposition Modelling Process

The manufacturing process using the FDM system comprises of three main stages, namely the pre-processing stage, the actual construction stage of the part and the post processing stage. During the pre-processing stage the CAD model of the part is loaded, fig. 3, designed in the Solid Works 3D design environment [5,6], in the Quick Slice specialized program - a program that generates the FDM machine code where the CAD model is located in the workspace of the machine so that the piece construction is optimal in terms of working time and material consumption.

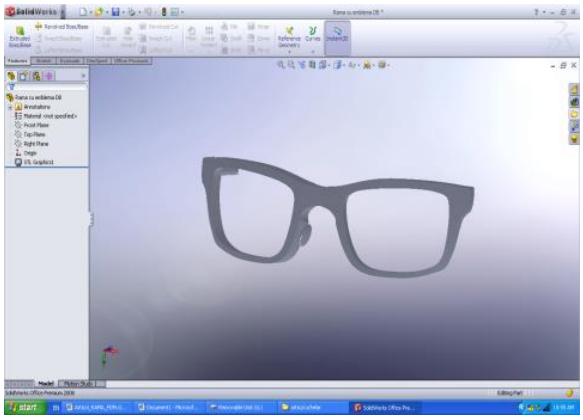


Fig. 3 CAD model of the personalised eyeglasses.

After the orientation of the CAD model, its sectioning is carried out with planes parallel to the plane of the machine (horizontal planes), operation resulting in several sets of level curves called perimeters. The sectional section along the Z axis is 0.2 mm is chosen according to the diameter of the extrusion nozzle diameter, in the case presented in the article the diameter of the extrusion nozzles is 0.4 mm. The Quick Slice program [8] generates the paths that the extrusion device must follow to materialize section of the piece, fig. 4.

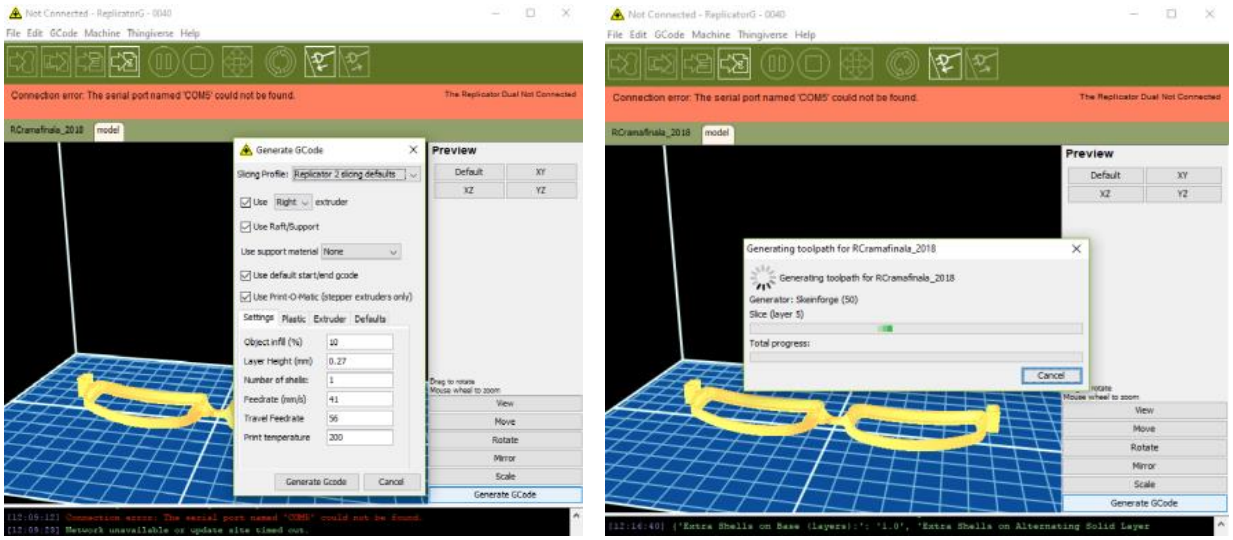
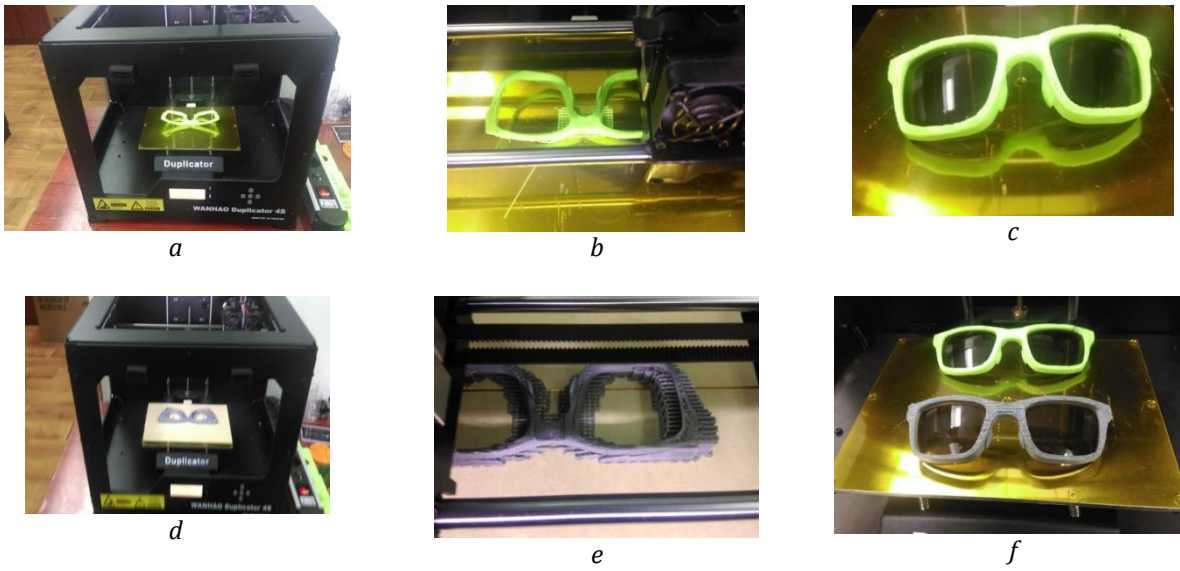


Fig. 4 Slicing of the model using Quick Slice

In the stage of construction of the piece manufacturing the extrusion head of the machine deposits a thin wire of construction material along the curves defining the perimeter of the section and after the materialization of the perimeters the deposition of the building material takes place in the areas corresponds to the full areas of the piece, after the entire section is fully materialized, the platform descends with a step equal to the section of the virtual model and the entire process resumes for a new section until the last section of the virtual model of the piece is materialized, fig. 5.



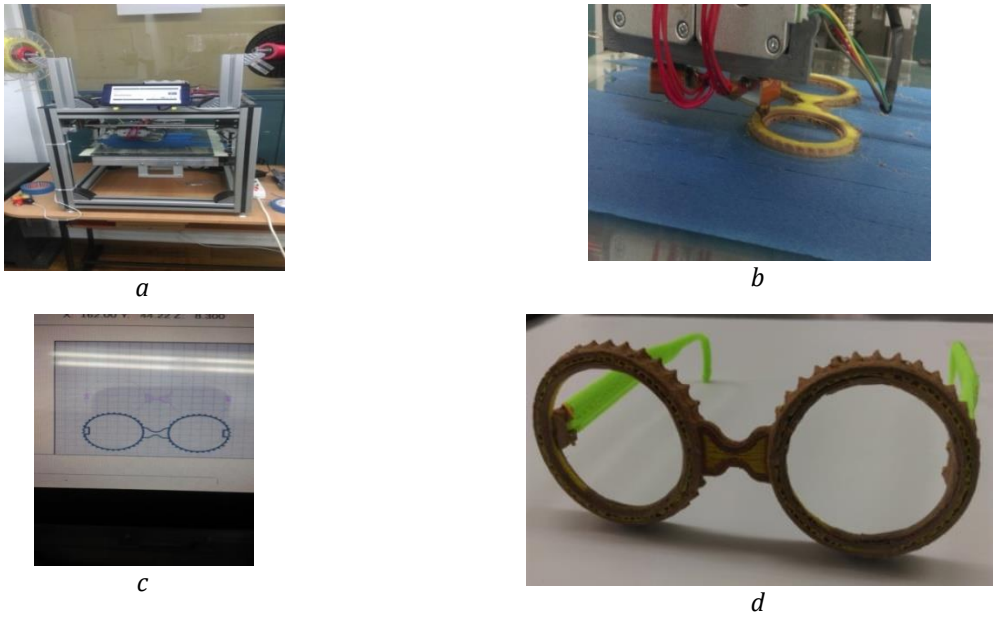
a *b* *c*

d *e* *f*

Fig. 5 Achieving ABS and PLA glasses on the Wanhao 4S Duplicator printer with two print heads: a - 3D printer overview; b-view stage realization of custom ABS glasses frame; c- custom lens glasses made of ABS with lenses; d - viewing the frame of personalized glasses from PLA; e - view personalized glasses frame with sacrificial layer; f - the two custom glasses frames made of ABS and PLA materials. [8]

For the manufacture of Wood -PLA composite glasses, an experimental installation with two heating / extrusion heads has been used, with the following technical characteristics: 400 x 400 x 250 mm working volume, WI-FI, SD / MMC card reader, operating system Arduino / Repetier-Host, fig. 6.

The last post-processing step consists of separating the work platform from the workpiece, removing the connecting element between the workpiece itself and the platform, removing the supports (if any) and finishing the workpiece if necessary.



a *b* *c* *d*

Figure 6. a - Double extruder 3D printer general view b - composite material printing detail view; c - print head trajectory; d - personalised eyewear obtained from Wood –PLA.

4. Conclusions

The main factors influencing the accuracy of execution obtained by the process FDM parts are precision .stl file that affect the precision part in that its poor quality, translated by relatively large deviations from the original CAD model leads to obtaining improper parts; the orientation of the model in the working space of the machine is important from the point of view of the manufacturing precision of the piece, because during the process, the elements that are made by contouring will result more precisely than the elements that are made by construction; diameter extrusion nozzle material influences the precision of execution of play in that according to it, will result section dimensions yarn made with diameters of extrusion nozzle is greater, the more you increase the section width wire material submitted, which leads to limiting the possibilities of realizing the fine details of the piece and to a lower precision; the step of cutting the virtual model influences the execution precision of the piece through the so-called step effect that occurs during the construction process; the complexity of the piece and the fineness of the details if the piece to be constructed contains elements of a size smaller than the dimensions of the thread of the deposited material, then these details will be lost; the type of material used to make the piece influences its machining precision in that, depending on the material used, the diameter of the extrusion nozzle and the dimensions of the thread section of the deposited material are established. [1]

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