Ministry of Education and Science of Ukraine

Odessa National Academy
of Food Technologies

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2020

Information Technology, Automation and Robotics

Proceedings

Odessa, ONAFT 2020

UDC 004.01/08

Black Sea Science 2020: Proceedings of the International Competition of Student Scientific Works. Information Technology, Automation and Robotics. / Odessa National Academy of Food Technologies; B.Yegorov, M. Mardar, S.Kotlyk (editors-in-chief.) [*et al.*]. – Odessa: ONAFT, 2020. – 365 p.

These materials of International Competition of Student Scientific Works «Black Sea Science 2020» contain the works of the contest participants in the section «Information technologies, automation and robotics» (not winners).

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RESEARCH AND IMPROVEMENT OF 3D PRINTING WITH ABS PLASTIC USING FDM TECHNOLOGY

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***Abstract**. The paper describes the main problems that may occur when 3D printing on printers using FDM technology. A literature analysis of the effectiveness of the use of volume printing in various industries is carried out, the sources of the difficulties encountered in printing with plastic are shown, the main difficulties of the process are listed.*

Various solutions to emerging problems have been proposed, based on the operating experience of the Smartprint HB-8 household 3D printer, implemented on the basis of the common Arduino Mega board. Various cases of ineffective 3D printing are considered, recommendations for its elimination are developed. The presentation is accompanied by original photographs of problem cases and scans of the slicer operation screen when solving such problems.

***Keywords**: 3d model, 3d printer, ABS-plastic, PLA-plastic, G-code, Slicer, FDM technology, .STL format, Arduino, Rep-Rap, Raft substrate*

1. Introduction

3D printing and 3D printers in our lives have already moved from the category of fiction to the category of domestic use. Indeed, quite a few companies offer to make an original birthday present in the form of a birthday bust, a broken plastic part in a car is much cheaper to make on a 3D printer made of plastic than ordered from a manufacturer or in a parts store.

Three-dimensional or 3D printing is a layer-by-layer creation of a physical object based on a virtual three-dimensional computer model. This is the ideal solution for creating models for design, architectural concepts, as well as products needed in the fields of education, art, medicine, cartography, etc.

FDM 3D printing technology involves the creation of three-dimensional objects by applying successive layers of material that follow the contours of a digital model. As a rule, thermoplastics supplied in the form of spools of thread or rods are used as printing materials.

The process of creating 3D models, even on modern printers using FDM technology, does not always go smoothly and flawlessly. This is to blame for both the design of 3D printers simplified for cheapness, the flaws of poor-quality plastic, incorrect settings for printing, and the mistakes made when creating models in a computer program.

This work is devoted to the analysis, research and solution of some problems that arise in the process of functioning of a 3D printer operating on the common FDM technology [7, 9].

2. Analytical review of literature

A 3D printer is a device that creates a three-dimensional object based on a virtual 3D model. Unlike a conventional printer, which displays information on a sheet of paper, a 3D printer allows you to display three-dimensional information, that is, to create certain physical objects. The technology of 3D printing is based on the principle of layer-by-layer creation (growing) of a solid model [1, 2, 3, 6, 7, 11, 12, 19]. 3D printing is performed using various materials (silicone, concrete, plastic, acrylic, hydrogel, paper, wood fibers, gypsum, metal, nylon, polymer or stone chips, etc.).

The use of three-dimensional printing is a serious alternative to traditional methods of prototyping and small-scale production. For example, to create any part manually, it can take quite a lot of time - from several days to months. After all, this includes not only the manufacturing process itself, but also previous work - drawings and schemes of the future product, which still do not give a complete vision of the final result. As a result, development costs increase significantly, the time period from product development to serial production increases [7, 11, 8].

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3D technologies can completely eliminate manual labor and the need to make drawings and calculations on paper - after all, the program allows you to see the model in all angles already on the screen, and you can eliminate the identified shortcomings not during the creation process, as happens with manual manufacturing, but directly during development and create a model in a few hours [1, 5, 11, 18].

3D printing has opened up great opportunities for experiments in such fields as architecture, construction, medicine, education, clothing modeling, small-scale production, jewelry, as well as in the food industry [4, 6, 8, 12].

Since the construction and modeling using 3D technology has become very common, many specialized software tools have been developed. The software that manages 3D printers accepts all major formats of files containing 3D geometry, including .stl .wrl .ply, and .sfx files; they can export all major 3D modeling packages [11, 12, 10, 19].

We should also dwell on the use of 3D-technologies in education. 3D printing technology is quite new, but it is developing really fast. More recently, rapid prototyping has been limited in schools, colleges, universities due to the high cost of equipment, supplies. But the technology of layer-by-layer build-up appeared, and designers are happy to use this technology for rapid prototyping and small-scale production [4, 6, 8, 19].

Using a 3D printer for students, it becomes possible to design objects that cannot be made even with 4-axis milling machines. In the past, students were limited in modeling and manufacturing things, since they had only hands and simple processing machines from production tools. Now, these restrictions are practically overcome. Almost everything that can be drawn on a computer in a 3D program can be implemented [5, 19].

Using a 3D printer in a classroom dramatically increases the effectiveness of training. Using 3D printing paves the way for iterative modeling. Students can design 3D parts, print, test and evaluate them. The use of 3D technologies inevitably leads to an increase in the share of innovation in student projects [5, 6, 8, 11, 18].

However, printing of volume models previously developed on a computer encounters numerous problems that are caused by the relative imperfection of the technology used, poor-quality plastic, and poor-quality three-dimensional models. This work is devoted to the analysis and solution of some problems that arise in the process of functioning of a 3D printer operating on the common FDM technology [13, 14, 15, 18, 20].

3. Object, subject and research methods

The purpose of the study: to experimentally investigate and improve the technology for printing models on household 3D printers that print with plastic using FDM technology, to develop recommendations for solving the most common printing problems.

Object of study: FDM technology for printing models using 3D technology.

Subject of research: development and printing of a 3D model using the Smartprint HB-8 consumer printer.

The Smartprint HB-8 3D printer, along with the Prusa i3 model, is a household representative of the Rep-Rap family of printers, developed as a project for open and cheap DIY products. For research, we used a 3D printer assembled on the basis of the common Arduino Mega board (Fig. 1).

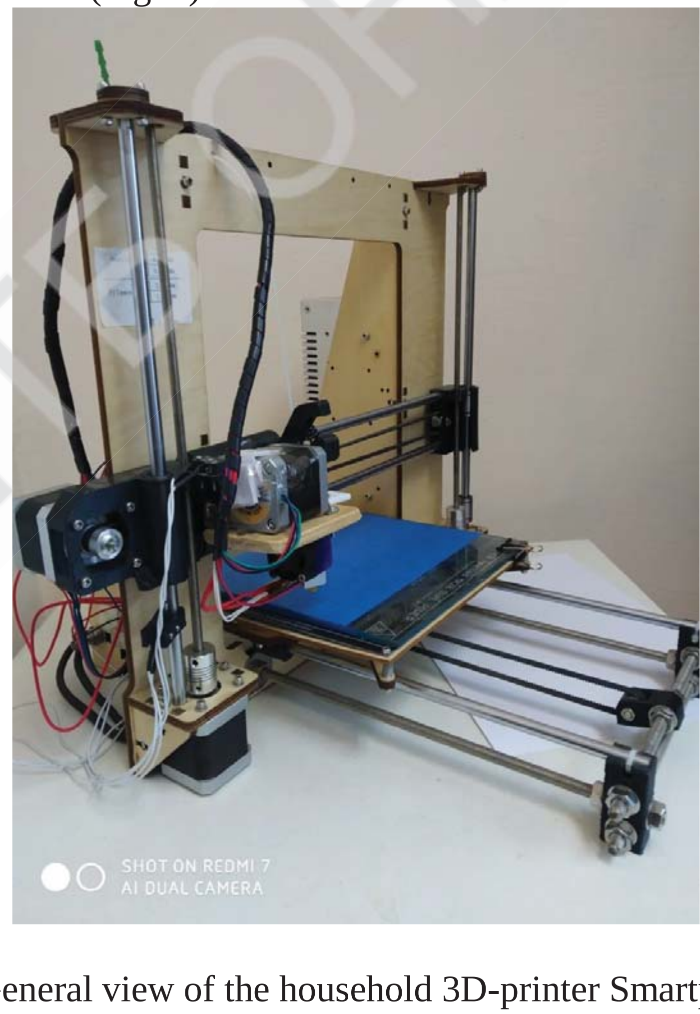

Fig. 1. - General view of the household 3D-printer Smartprint HB-8

4. Results of work

For the correct analysis of printing imperfections, it is necessary to clearly know the technology of model preparation. First, the volume model is created in one of the specialized programs that take into account the specifics of their further use (the most common ones are Rhino, Blender, 3D Max or SketchUp), after which its image in the form of a file with the .STL extension is transferred to a special slicer program.

Slicer is a program for translating 3D models into a control G-code for a 3D printer (the Repetier-Host program was used in research). In this case, the model is cut into layers, each layer consists of a perimeter and / or fill. The model may have a different percentage of filling with a fill, and there may also not be a fill (hollow model). On each layer, the printer extruder moves along the XY axes with the application of plastic melt. After printing one layer, the Z axis moves to the layer above, the next layer is printed, and so on [1, 2, 9].

It should be noted that today the .STL file format is widely used for printing, which contains the model by writing it in separate triangles (Fig. 2) [19]. At the same time, there are no curved surfaces, regions, and tori; all objects are approximated into figures consisting of many triangles. Slicer reads triangles from the STL file, cuts this set into thin layers, which eventually turn into separate movements of the printing carriage.

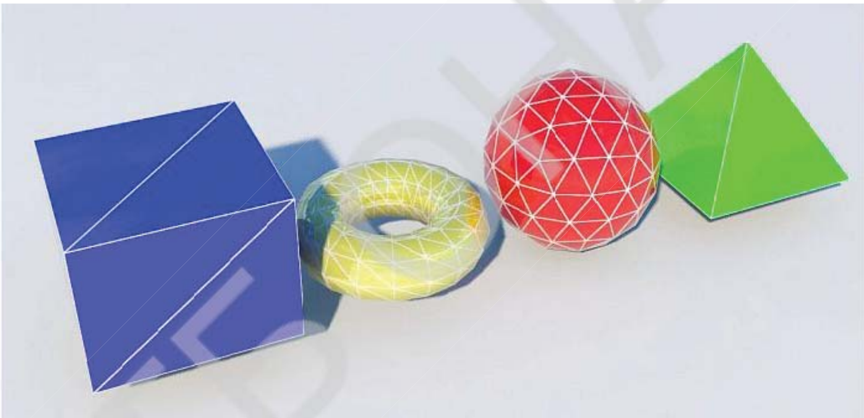

Fig. 2. - Illustration of saving a volumetric figure in STL format [19]

In studies, a 3D printer Smartprint HB-8 was used, which has the following main characteristics: printing dimensions 200 * 200 * 200 mm; interface - USB; printing material - ABS, PLA, PVA; filament diameter 1.75 mm; printing accuracy 0.1 - 0.2 mm; layer thickness 0.2 - 0.4 mm; number of nozzles - 1; nozzle diameter 0.4 mm; temperature of the support stand 110-120^{o}C; extruder temperature 210°C for PLA, 230°C for ABS; spindle speed 40 mm / s; nozzle flow rate 24 cm3 / hour.

FDM technology is highly flexible but has certain limitations. Although the creation of overhanging structures is possible at small angles of inclination, in the case of large angles, the use of artificial additional supports. These supports are typically created in the process of slicing and printing, and are separated from the model at the end of the process.

In addition, various problems may arise during the printing process itself. They can be caused by incorrect print settings, hardware problems, lack of practical experience with a 3D printer. Basically, such complications include the following: insufficient adhesion, displacement or absence of some layers in the model, holes and slits on the upper surface of the printout, displacement of layers, formation of spider webs between model elements, absence or poor printing of the internal structure of the model, gaps between filling and walls.

Most of these problems can be corrected with the appropriate model location and the correct settings for printing and slicing in the Repetier-Host program (setting the correct temperature, starting point, printing speed, separation of the technology for passing individual layers, etc.). The recommendations described below were obtained during experiments when printing 3D models with the Smartprint HB-8 printer using ABS and PLA plastic.

The list of printing problems and recommendations for solving them:

1. Inadequate adhesion (the model does not adhere well to the 3D printer table (Fig. 3). The deformation of the base of the printout is due to the characteristics of the plastic, as the ABS and PLA plastic cools very quickly, which leads to the sticking of the first layer. Solution : recalibrate the working platform, reduce the gap between the nozzle and the 3D printer table; apply special materials on the platform for better adhesion: kapton, blue adhesive tape or special glue; use an additional Raft substrate (removable layer); reduce the print speed first layer to 30% (Fig. 4), set the initial temperature of the heated platform to about 100 ° C - 110 ° C.

Fig. 3. - Illustration of poor adhesion of the first layer to the platform

In general, experiments showed that the temperature of the platform when printing should be about 100 ° C (the model adheres well to it), and after the end of the process - about 70 ° C (otherwise the model cannot be removed without damage from the platform). It is also effective to turn off the cooling fan at the beginning of printing, for the first 3-4 layers.

You also need to choose the correct height of the first layer of printing (First layer height), which should be less than the height of the other layers, because the first layer should be distributed horizontally, if it is too high, it can affect the print quality of subsequent layers (Fig. 5). In general, the Layer height value should not be larger than the nozzle diameter of your printer, otherwise the print quality will be rough.

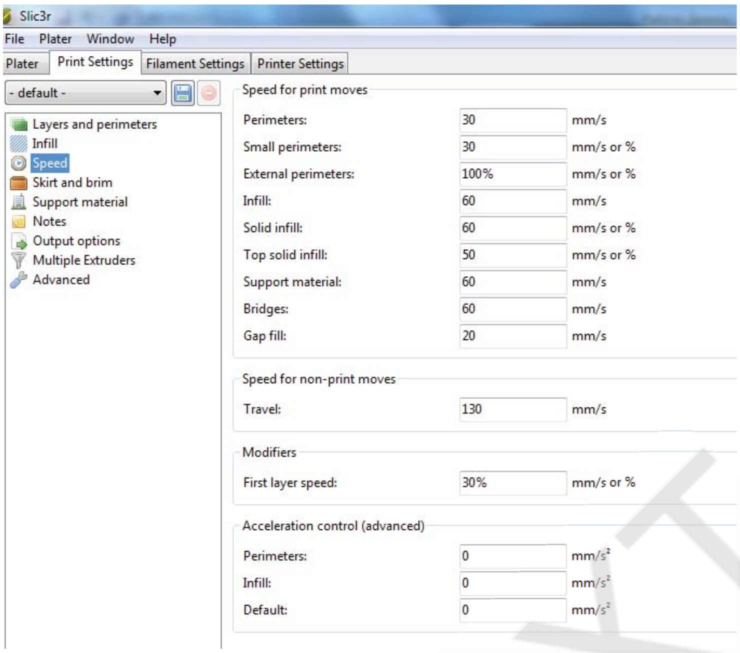

Fig. 4. - Print speed settings in the Slic3r slicer (Repetier-Host program)

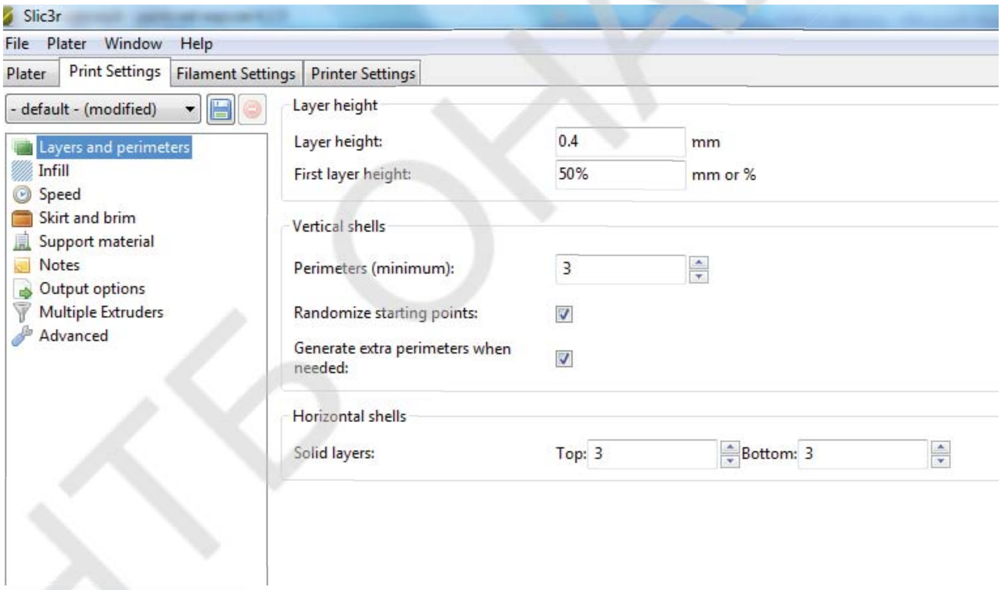

Fig. 5. - Illustration of setting layer heights when printing

2. Displacement or absence of some layers in the model (Fig. 6) - insufficient extrusion. In this case, it is necessary to check the tension of the belts (Fig. 1), moving both the extruder along the X axis and the platform along the Y axis: they should not hang freely, but also should not be too tight. It is also necessary to check the oil lubrication of all rubbing parts of the printer. Checking the extrusion coefficient in the slicer (or flow rate) may help, it may be too small. It is also necessary to check the correspondence of the diameter of the thread to the characteristics of the printer (there were cases when the set diameter of the thread did not correspond to the diameter set in the slicer). Also, insufficient extrusion can provoke a clogged nozzle.

Fig. 6. - Illustration of offset layers in the middle of the printout

3.Holes and crevices on the upper surface of the printout (Fig. 7). The two most common causes of this problem are improper cooling of the top layer and an insufficiently thick top layer. The solution is to increase the thickness of the top layer, which can be adjusted in the slicer using the advanced settings ‘Bottom / Top Thickness setting’. It is necessary to increase the thickness of the upper and lower layers up to 6 times in comparison with other layers and up to 8 for smaller nozzles and plastic. If the layer height is 0. 1mm, then the height of the upper and lower layers should be 0.6 mm. If you still have holes and bald spots in the top layer, you need to increase the thickness to 0.8mm.

Fig. 7. - Illustration of holes on the top of the printout

4. Offset layers. The upper and lower layers are shifted, creating the effect of a step in the printout (Fig. 8). There can be many reasons for the shifting of the layers - even a jolt of the printer during printing can provoke this. Also, this may be affected by bent or incorrectly aligned studs, a nozzle that touches the printout and moves it on the platform, etc. Solution: the printer should be on a stable stand; the printer platform must be securely fixed and placed in a place safe from shock; it is necessary to reduce the print speed in the slicer (Fig. 3). Printing time can be increased by increasing the temperature and flow rate, this can affect the amount of filament released. If you hear tapping while printing, it means the printer is working too fast.

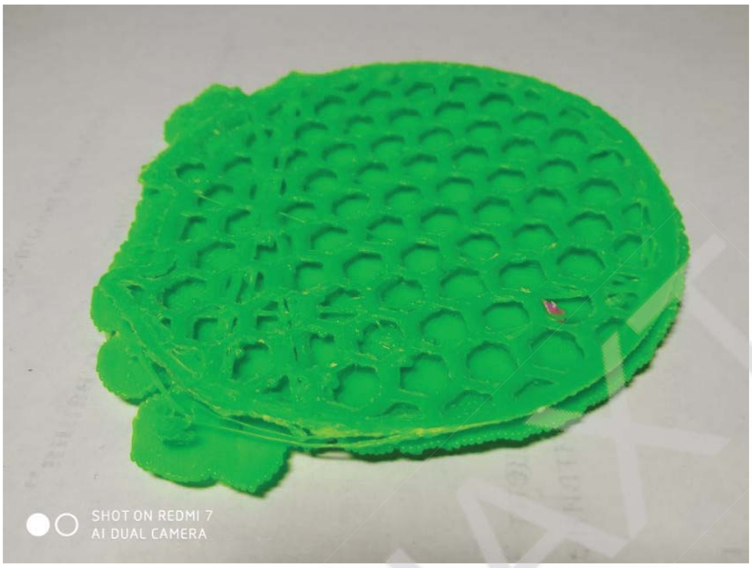

Fig. 8. - Illustration of offset layers when printing

4. **The formation of "cobwebs" or "hairs" between the elements of the model** (Fig. 9). This problem occurs when the printer head moves on an open surface (without extrusion), that is, it moves from one object to another, while the plastic continues to drain from the nozzle. In this case, it is necessary to activate the retraction mode in the slicer (rollback / retract). It functions quite simply and works on the principle of drawing the thread back into the nozzle before the head begins to move. The bottom line is that it prevents the leakage of plastic from the nozzle during the movement of the extruder above the layers where clearance is needed.
5.

Fig. 9. - Illustration of the formation of "cobwebs" when printing

6. The internal structure of the model is missing or poorly printed (Fig. 10). It is necessary to check the percentage of filling in the slicer. Performance in the region of 20% is considered normal, if less - there may be problems with printing. Also, when the model is not full, you can reduce the print speed (Fig. 3). The internal structure is affected by the structure of the filling (it can be mesh, triangular, honeycomb or other filling). For the Smartprint HB-8 printer, experiments showed that cellular filling is optimal; the models are light and durable (Fig. 11).

Fig. 10. - Illustration of the poor internal structure of the model

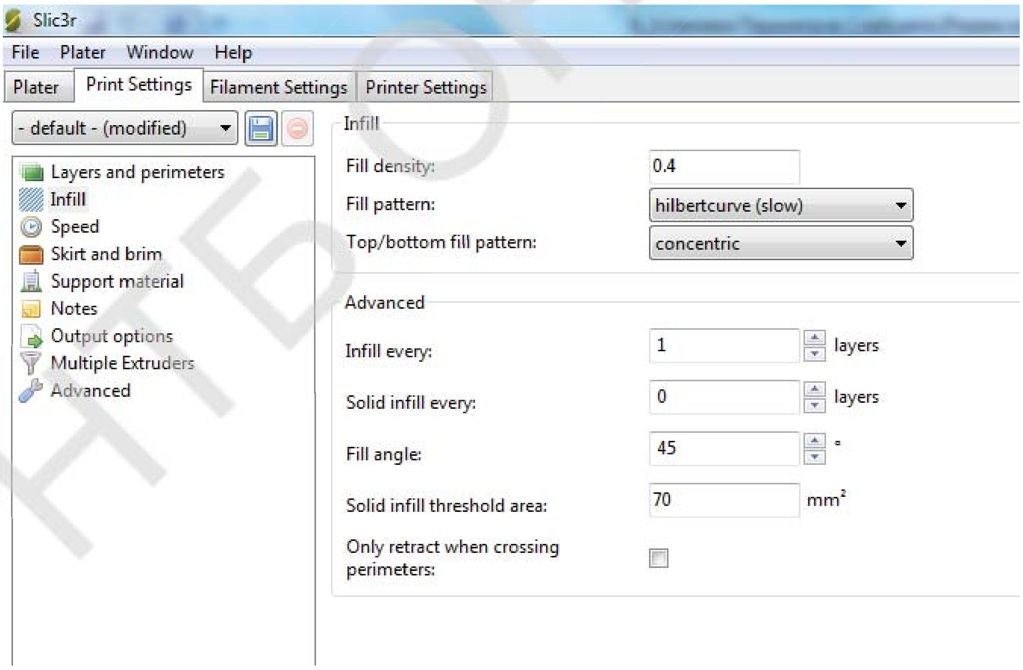

Fig. 11. Illustration of filling changes in slicer

7.The gap between the filling and the walls (Fig. 12). Slots appear due to the fact that the plastic used to print the filling and contour does not bind. Solution - in the slicer you need to select the Infill Overlap parameter and increase the values to 30%. Changing the print order of the outline and fill can also help. If you first print the outline and then the filler, this should not be a problem. You can change the order in the slicer by checking the “Infill prints after perimeters” option. Increasing the hotend temperature by 5-10 degrees and slowing the print speed by 10-20% can also help.

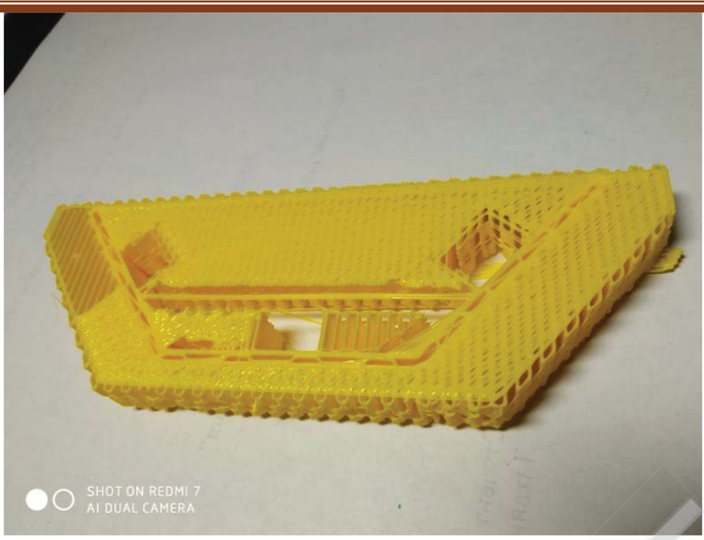

Fig. 12. - Illustration of the gaps between the filling and the walls

5. Conclusions

The paper describes the main problems that may occur when 3D printing on printers using FDM technology. A literature analysis of the effectiveness of the use of volume printing in various industries is carried out, the sources of the difficulties encountered in printing with plastic are shown, the main difficulties of the process are listed.

Various solutions to emerging problems have been proposed, based on the operating experience of the Smartprint HB-8 household 3D printer, implemented on the basis of the common Arduino Mega board. Various cases of ineffective 3D printing are considered, recommendations for its elimination are developed. The presentation is accompanied by original photographs of problem cases and scans of the slicer operation screen when solving such problems.

References

1. Enrique Canessa, Carlo Fonda, Marco Zennaro. Affordable 3D printing for science, education and sustainable development. - ICTP Department of Scientific Development, 2013. - 88 p.

2. Основы 3D печати. [Electronic resource]: Access mode: URL: http://3d-only.ru/articles/osnovy-3d-pechati

3. История появления 3D печати. [Electronic resource]: Access mode: URL: http://3dcorp.ru

4. Применение инновационных технологий и 3D-печати в дизайне ювелирных изделий: monograph / L.A. Ivanova, S.V. Kotlik, M.A. Pomazenko, O.P. Sokolova. - Odessa: Astroprint, 2018 .-- 260 p.

5. Petelin, A.Yu. 3B modeling in Google Sketch Up - from simple to complex. Tutorial. - M .: DMK Press, 2012 .-- 344 p.

6. Что такое 3D-принтер, и для чего он нужен? [Electronic resource]: Access mode: URL: http://www.hint4.me/5386-chto-takoe-3d-printer-i-dlya-chego-on-nuzhen.html#ixzz3HLDrSyEG

7. Обзор технологий 3D печати. [Electronic resource]: Access mode: URL: http://www.orgprint.com/ru

8. Сферы применения 3D печати. [Electronic resource]: Access mode: URL: http://www.orgprint.com/ru/

9. Конструкция FDM-принтеров. [Electronic resource]: Access mode: URL: http://www.ixbt.com/printer/3d/3d_fdm.shtml

10. Сравнение FDM 3D принтеров на основе особенностей конструкций. [Electronic resource]: Access mode: URL: http://3dprinter.org.ua/comparison_of_3d_printers/#sthash.fSLAhEAL.dpuf

11. Гайд по 3D-печати. [Electronic resource]: Access mode: URL: https://3dpapa.ru/3d-printing-guide/

12. Введение в 3D печать, Часть 1: Принципы работы, пластики, выбор принтера. [Electronic resource]: Access mode: URL: http://3dtoday.ru/blogs/harh/introduction-to-3d-printing-part-1-principles-of-operation-plastics-pr1/

13. Руководство по решению проблем качества 3D печати. [Electronic resource]: Access mode: URL: http://www.it-aspect.ru/3D/Troubleshooting/

14. Проблемы, типичные для 3D печати. [Electronic resource]: Access mode: URL: https://3dprinter.ua/problemy-tipichnye-dlja-3d-pechati/

15. Дефекты 3D печати - Классификация. [Electronic resource]: Access mode: URL: http://3dtoday.ru/blogs/leoluch/defects-3d-printing-will-try-to-introduce-a-classification/

16. Виртуальность как моделирование реального мира. [Electronic resource]: Access mode: URL: https://younglinux.info/blender/virtualreality.php

17. 10 правил подготовки модели к 3D печати. [Electronic resource]: Access mode: URL: http://3dcenter-idea.ru/blog/10-pravil-3d-pechati.html

18. Как создавать 3D модели для принтера. [Electronic resource]: Access mode: URL: https://st-martin.ru/raznoe/kak-sozdavat-3d-modeli-dlya-printera-kak-sozdat-model-dlya-3d-printera.html

19. Энциклопедия 3D-печати. [Electronic resource]: Access mode: URL: http://3dtoday.ru/wiki.

20. Barnatt C. 3D-Printing: Second Edition / CreateSpace Inde-pendent Publishing Platform. 2014. 306 p.

ANALYSIS OF RELEVANCE OF DEVELOPMENT OF INFORMATION RESOURCE OF WORKFLOW PLANNING FOR BUSINESS ADMINISTRATORS

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***Abstract**.This paper examines the relevance of creating a new workflow planning product for business administrators.*

In time when time management is an important part of our lives, there are many programs that help to organize the time, but all programs have their pros and cons. We will carry out the analysis of time planning on several currently relevant programs for planning the time, will consider the advantages and disadvantages, and on the basis of