

QUALITY OF 3D PRINTED SURFACE BASED ON SELECTED POST PROCESSOR

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Thanks to the open source project RepRap the 3D printing technology has been delivered from laboratories to normal households. Since the beginning of the project, 3D printing has been constantly gaining in popularity thanks to the relatively simplicity in the production or transformation of ideas into physical models. In addition to the choice of hardware for open-source 3D printer an important factor determining the quality of the finished product is the right choice and settings of the post-processor.

KEYWORDS

Cura Engine, Skeinforge, Slic3r, comparison

1 INTRODUCTION

The community dealing with 3D print technology has in recent years experienced an enormous increase of members who slowly approach and make available top-class equipment of specialized workplaces already for conventional households, for example thanks to the RepRap project. Manufacturers, considering competition, enter the market with new ideas, endeavouring to meet the diverse needs and requirements in individual areas of 3D printing use, whether it concerns the addition of various additives into the print media, optimization of structures, or an effort to simplify software interfaces for the end user.

2 CONTROL SOFTWARE

The market offers a wide assortment of programs that allow the creation of 3D models, but for the needs of 3D printing it is essential to promote exporting to a standardized STL format.

The software string of instruments that is used by RepRap printers consists of three main parts: firmware, print interface, and postprocessor. Properly configured firmware allows interpretation of the G-code into motion, control stepper motors, allows control of temperature of the heated plate and the end of the melting nozzle. Its other tasks include checking the switching of limit switches and identifying problems with the print set. More precise configuration is at best only required once, right at the start when buying equipment. It is located in the non-volatile memory of the control board, similar to BIOS in computers [Torok 2016]. Press interface is a software that runs on the host computer connected most often via USB or via network cable to the printer. It makes editing of the different variables relating to printing speed, temperature, and many other parameters, and monitoring the operation of the device in real time possible. A computer is not necessary for operation of the device if it contains its own external memory such as an SD card, which can store pre-generated G-code, while the process of printing is not possible to be directly

intervened. In Fig. 1 is a part of the printing interface of Host - Repetier software, which we used to control the RepRap Mendel equipment. The basic monitored variables include nozzle and heated washer temperature data, that are closely linked with used materials (PLA, ABS, nylon ...), and the print nozzle track, making known the current position in the real environment. [Vasilko 2003]

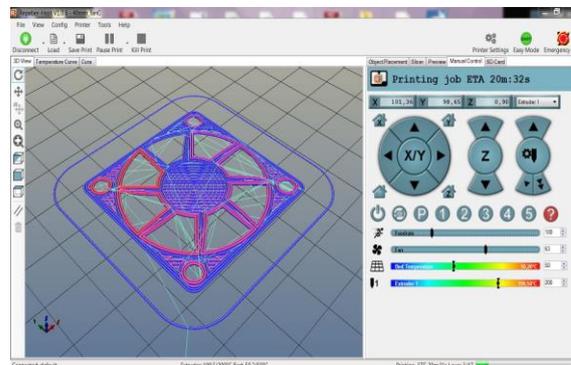


Figure 1. The main control window of Repetier - Host

3 POSTPROCESSOR

Probably the most important part of 3D printing is the selection of a suitable postprocessor and its correct configuration. Its main task is to divide the 3D model into dimensionally and geometrically correct layers and generate G-code that determines the most appropriate path for the melting nozzle and then interprets these tracks in the correct format for the firmware. G-code is the name for the set of instructions (commands) used by the CNC machine tool. After generating the G-code, data are transferred either to the micro - SD card inserted into the control board, or via USB port they are continually sent to the device in real time, as already described in the previous chapter.

Among other things, the postprocessor, with respect to specified parameters, decides where the support material must be added, so that the built structure of the model won't break down, since 3D printing is an additive method of creating bodies, so it is not possible to create larger overhangs. Under certain conditions, a bridging of two points can be done, but it requires precise alignment of the print nozzle and feeder speed, so that the material is able to sufficiently harden.

Each commercially marketed device is supplied with its own postprocessor perfectly matched with no need for additional improvement, but the market offers more and more structures of the RepRap type using postprocessors developed for other machines [Marcincin 2009]. Therefore, it is necessary to take note of this fact and fine-tune each open-source postprocessor to your own printer, which was previously relatively complicated, but continued progress in this area has helped to create very simple and user-friendly environments. The user need not manually recalculate the rotation of the motor with respect to the number of teeth, but the individual operations have been streamlined and automated with help of created macros from patterns and an expert knowledge base. [Thingiverse 2015]

4 TESTS OF INDIVIDUAL POSTPROCESSORS

The most used freeware postprocessors in the world include Slic3r Cura Engine, Skeinforge, and their variations. From control applications freely downloadable from the internet Repetier-Host control software was selected, which can be supplemented with various postprocessors.

In order to correctly compare all three postprocessors they were consistently given initial parameters for the layer height, the diameter of the material used and the working temperature when generating model G-code. Layer thickness was set at 0.20 mm for better processing of details at the top of the tested model, and the diameter of the material used was 1.75 mm. The resulting model was printed using PLA print medium, which was chosen because of its beneficial properties even in a device which was not fine-tuned. Other variables were left in their native baseline values. For testing a model was chosen thanks to its details suitable for a basic comparison of postprocessors (Fig. 2). Each of the mentioned postprocessors had the support material function turned on, but only Skeinforge, considering its parameters, used this option. [Marcincin 2011]



Figure 2. Tested model

4.1 Cura engine

This software is open source, based on the Printrun program. Cura has very nice and simple properties, and produces one of the best and cleanest G-codes which can be created. It was designed for Ultimaker printers but its features are useful also when using other printers of the RepRap project. The Printrun control program is combined with the Cura Engine cutting tool, which converts a 3D model from the given computer to instructions for printing. The great advantage of this software is a preview of the object and this way errors can be identified before sending to print. [Marcincinova 2012]

This postprocessor generates the first layer, where blue lines show the printed material that flowed through the nozzle on a heating pad, and the green layers show the print head movement to no purpose (Fig. 3). This postprocessor worked very fast and reliably, but there was a problem in creating layers on top of the object, where it could not create more precise details.

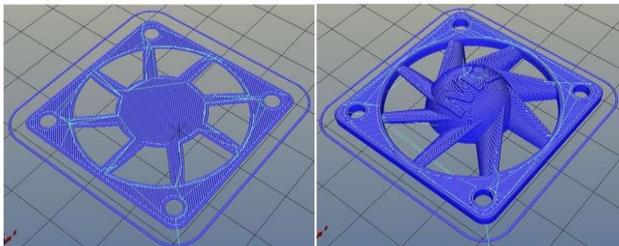


Figure 3. The first and the final model generated by a Cura Engine postprocessor

4.2 Slic3r

The Slic3r tool for converting a digital CAD model to print instructions for a 3D printer is the most popular choice among users because of its simplicity, speed and versatility. Its great advantage is a guidance built-in module, which is mainly used by beginners with minimal experience in creating 3D print models. In the production of models using this method, several possible causes for the emergence of errors during printing occur. One of the most common mistakes is if support material calculation of the postprocessor is wrong. These postprocessors

include also Slic3r, which feeds material in the wrong direction and therefore it is difficult to remove from a heated pad, which could be solved by the proper treatment before printing, but mainly from models which, if incorrectly separated, may result in breaking or deformation. [Liu 2010]

Under the same conditions as the Cura Engine we can compare the first layer and the final model of postprocessor Slic3r (Fig. 4). It is clear that this G-code generator performs not quite logical movements of the print head, resulting in a longer print time, but with proper calibration of printer and changing settings in Slic3r, this problem can be minimized.

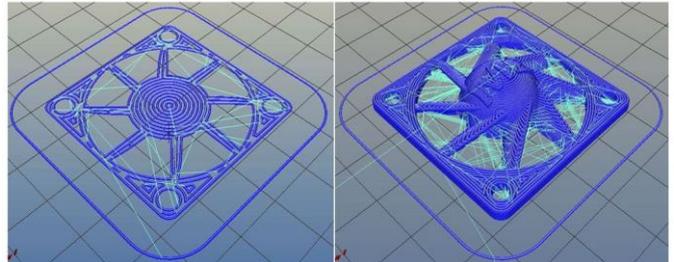


Figure 4. The first and the final model generated by a Slic3r postprocessor

4.3 Skeinforge

The Skeinforge modular system, version 41, is a string instrument created in the Python programming language and its main task is to transform a graphic model into G-code, which is then sent to the printing device in a format understood by the 3D printer's electronics, which is: x3g. or S3G. This postprocessor is quite confusing and intricate but working with it, after refining profiles, allows individual parameters to be set to make it possible to create the best possible details, and the fastest and highest quality results.

When comparing all three postprocessors, this one, similarly to Slic3r, failed in slow generating and also in redundant paths of print nozzles (Fig. 5). These transitions to no purpose have their justification in certain cases, where you need to have a longer time for printed material solidification. When creating this support material, this postprocessor, as one of the three selected, didn't disappoint and created basic support for the model, but the big drawback is the excess layer between two blades (at the top right), which was inefficient and unnecessarily added generating time. These shortcomings can be eliminated by refining the software; however, considerable experience in working with this postprocessor is required.

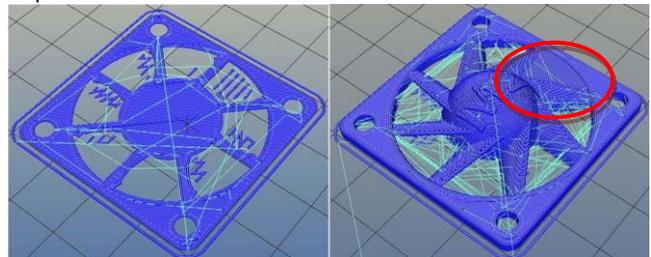


Figure 5. The first and the final model generated by a Skeinforge postprocessor

5 RESULTS VALUES ASSESSMENT

Based on a comparison of individual postprocessors with the same parameters in settings, a concise table of measured values was created (Tab. 1). It shows that the best option in terms of speed is the Cura Engine, but it should be noted that this generator is not suitable for parts with fine details, since in

complex rugged shapes it usually arbitrarily omits some contours.

For hollow objects such as vases or objects with soft contours, Slic3r is the best, but the heavier material used must be taken into account.

The Skeinforge postprocessor is suitable for users who already have some experience with RepRap community printers and are committed to experimenting with the settings for the best possible print. The advantage of this postprocessor is the thorough adding of support material, which the other software applications neglected.

Each of the selected postprocessors after generating G-code assumed the time required for printing, but their values were, compared to real time, optimistic (Fig. 6). Working waveforms can be fine-tuned by changing settings or adding expansion knowledge modules.

Comparing the time of printing and the quality of the final product it is surprising that a model created in the minimum time possible has the most beautiful surface appearance (Fig. 7).

In this case, the greatest impact on the quality of the surface was from careful layout of working tracks to no purpose using the postprocessor, while the print nozzle left the model's work surface minimally. Thanks to appropriately defined paths, trapping excess plastic from a nozzle along the edges of the model, as can be seen on the body created on the basis of Slic3r postprocessor data, didn't occur. Skeinforge has a similar problem, but it is able to compensate for it partially by acceleration of working movements to no purpose and by return pulling of the print string using the feeder, but for short distances fine fibres resembling a net may be formed.

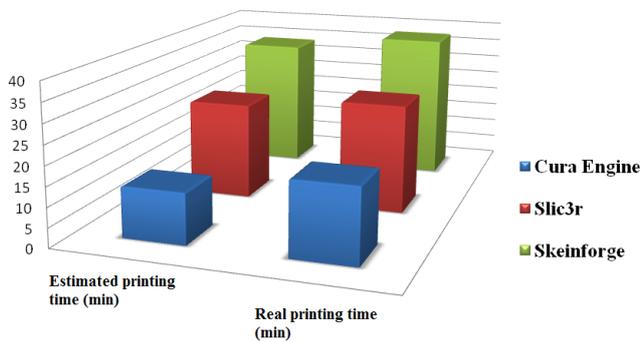


Figure 6. Comparison of estimated time to real time print

Postprocessor	Cura Engine	Slic3r	Skeinforge
Estimated print time (min)	13	25	34
Real print time (min)	19	28	38
Length of used material (mm)	1069	1287	1196
Number of coated layers	48	47	49
G-code generating time (s)	3	8	92
G-code size (kB)	1001	722	668

Table 1. Resulting values



Figure 7. The real model made on the basis of data from the postprocessor (from Left) : Cura Engine, Slic3r, Skeinforge

CONCLUSION

This document describes 3D printer basic software equipment and then also a comparison of the most common freeware postprocessors. With the unceasing rise in popularity of 3D printing, the software base is constantly expanding and control software is gradually becoming part of operating systems such as Fedora, Android, Windows 8 and 10, while each application is surprising with new features and user-friendly environment.

A very positive feature of the postprocessor, for example Repetier-Host, is the possibility, in real time, even during the very printing cycle, to affect printer conditions not only by interference to the temperature, but also by changing the speed of the printer head movement and by feeding the working medium. In the future it may be possible in this way to also affect the thickness of the formed layer.

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