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# THE PROBLEM OF 3D PRINTING PROTECTIVE FACE SHIELDS

The paper deals with the problem with 3D printing based on the COVID-19 situation. The protective face shields were 3D printed. As a material of filament, PET-G was used. For 3D printing, a GERMAN RepRap X400 CE PRO v3 3D printer will be used based on the standard fused deposition modeling method [1, 2]. It was necessary to solve the optimal use of the entire printing area (bounding size) of the heated bed of the 3D printer. The protective face shield according to standard EN 166:2001 consists of four parts: upper part – headband, lower part – chin, elastic band with holes, and visor. The 3D printer was used to produce the two first parts listed.

These 3D standard models were created to print two or three shields at the same time. During the test print, it was found that the entire print space is unnecessarily unused, as well as the inefficiency of 3D printing 2 or 3 protective face shields altogether. It was necessary to find a solution to print significantly more shields altogether for a heated bed with a dimension printing area of 370 x 400 mm and at the same time reduce the printing time by half with different settings. The purpose was to increase the quantity, quality, and efficiency of shield production by 3D printing.

Before 3D printing with PET-G, the verification of the correct temperature distribution of the heated bed of 80°C was done using a BCAM Flir AB thermal imaging camera. The goal is to find the optimal temperature setting of the heating bed to obtain high-quality 3D printing of shields from PET-G and to confirm whether the heated bed meets the minimum required temperature for PET-G filament material at a temperature setting at 80°C on the 3D printer (Fig. 1). Based on Fig. 1, the difference between the real and set temperatures is up to 4 °C, which is a difference of 5 % from the set temperature of 80 °C. The differences between the other real and set temperatures are comprehensively processed in Table.

**Table – Differences between the real and set temperatures on the heated bed**

| Set temperature, °C | Real temperature, °C | Difference, °C | Difference, % |
|---|---|---|---|
| 60 | 58.7 | 1.3 | 2.1 |
| 80 | 76 | 4 | 5 |
| 100 | 94.2 | 5.8 | 5.8 |
| 120 | 111 | 9 | 7.5 |


**Figure 1 – Heated bed temperature – comparison between temperatures set to 80°C and the real state of temperature on the heated bed**

The difference between the real temperatures of the heated bed and the setting temperatures on the 3D printer increases with increasing temperature.

The graph in Figure 2 with the linear regression equation between the interval from 60°C to 120°C can be used to predict how the heated bed temperature on the 3D printer should be set to achieve the desired heated bed temperature for specific materials of filaments.

The Simplify v4.1 program was used to create the G-code for printing based on the 3D geometry models of the shield parts. G-code was sent to the RepetierServer program in 3DPrintBox from the RepetierHost program. First, a total of 5 pieces of the upper parts – headbands with 5 pieces of the lower part – chins were printed at once with the printing time of one shield being approximately 1 h and 20 min.

This time had to be optimized also for the possibilities of a large printing area. Therefore, printing was carried out on 7 pieces of shields at once (7 pieces of the upper parts – headbands with 7 pieces of the lower part) plus the next 2 pieces of the lower part (as spare parts for final shields), Figure 3.

After optimization of the printing speed with the acquisition of print quality, it was possible to reduce the printing time for a shield to 1 h and 16 min. The final print setting is a layer height of 0.47 mm (the first layer has 90% of 0.47 mm).

As an evaluation can be stated, if the adjusted temperature on the 3D printer for printing the shields is set to 85°C, the heating pad would have a real temperature of 80.6°C. The maximum printing speed is 60 mm/s for the quality printed protective face shields from PET-G on a given 3D printer. For the first layer, the printing speed is half that, 30 mm/s.

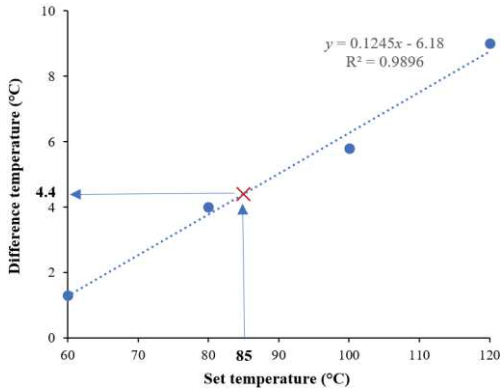


**Figure 2 – Dependence between difference and set temperature with the regression equation**

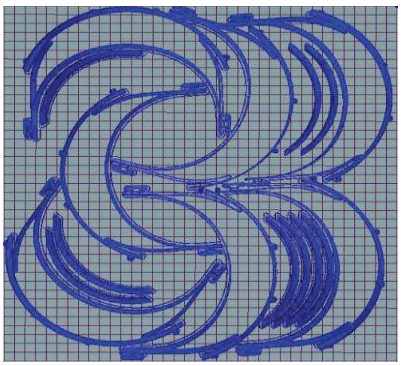

**Figure 3 – Distribution of seven pieces of shields plus the next two pieces of the lower part in the printing area**

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