Research on Artificial Post-Treatment Technology of FDM Forming Parts

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Abstract. 3D printing technology is a high and new technology gradually developed from the mid-1980s, leading the manufacturing technology of the third revolution. The 3D printing process includes modeling, data processing, selective process printing and post-processing. FDM technology is the most widely used technology at present, but the molding accuracy is not high. Due to the "step effect", the printed parts have rough surface, obvious stripes, poor surface quality, and cannot meet the customer's or specified requirements, so post-processing is very important. This paper mainly studies and summarizes the manual post-processing technology of FDM printed parts, and provides the specific implementation method of post-processing, providing reference for the post-processing of FDM formed parts and other forming processes.

1. Introduction

3D printing technology is a kind of rapid prototyping technology, which appeared in the late 1980s [1]. It is a technology of solid model manufacturing by means of layer-by-layer accumulation of CAD design data materials. Compared with traditional reduction manufacturing, 3D printing technology is a "bottom-up" additive manufacturing. The 3D printing process includes data processing, forming and post-processing. The data processing stage is the basis for obtaining a good model, while the post-processing stage reflects the value of the model. After the printing model is finished, the formed parts are taken out from the forming platform, and then to remove support, sand, polish, secondary cute, or in the high-temperature furnace for sintering according to different processes, so as to further improve the surface quality and strength.
2. Molten Deposition Manufacturing

2.1. Principle of Molten Deposition Manufacturing
The principle of FDM technology is shown in figure 1. The filaments of hot-melt materials are heated and melted, driven by the operation of gears, and then they are uniformly extruded from the nozzle at the bottom of the nozzle. During the printing work, the nozzle moves along the X axis and the working platform moves along the Y axis and Z axis. After the extrusion is bonded to the upper layer of material, and then the printing platform will drop one layer thick and repeat printing until it is completed [2].

![Figure 1. FDM principle diagram.](image)

2.2. FDM Forming Parts Common Post-Processing Methods
(1) Mechanical treatment
In the processing of large print, usually can use a sander or small grinder for simple treatment of the surface of printed parts, and then use more than 800 mesh of sandpaper on its surface for round sanding. Sanding finished, the oil can be sprayed and lubricated using the traditional method. For most FDM materials, pearlescent treatment is a common post-treatment process. The principle of pearlescent treatment is to achieve the polishing effect through continuous injection of medium beads [3].

(2) Heat treatment
Due to the different properties of different polymer materials, heat treatment processes need to be adopted are also different. At present, there are few experimental data at home and abroad, and appropriate parameters need to be obtained through a large number of experiments [4].

(3) Surface coating treatment
The surface of FDM prints is coated, and the liquid coating is mainly used to fill the gap on the surface to make it flow downstream under the action of surface tension and gravity, so as to improve the surface lubrication [5].

(4) Chemical treatment
After being heated at a high temperature, organic solvent has a good compatibility with its surface. Steam dissolves it on the surface of plastic parts, producing swelling effect and achieving uniform grinding effect. However, most of the solvents used contain toxic substances, so it is not recommended to use for a long time [6, 7].

3. Manual Post-Treatment Process

3.1. Post-Processing Equipment and Tools
Spray pen air pump set with air storage tank, coloring tool set, airtight spray box, coloring pen, solvent bottle, 00000 phase pen, gloves, mask, water diluted solvent, water fill soil spray can, quick dry small fill soil, 80 to 3000 mesh sandpaper, cleaning agent, water paint, non-woven cloth, file, protection paint, water basin, etc.

3.2. The process flow
3.2.1. Model printing. The model was printed and formed by FDM, and the post-treatment model was vase, as shown in figure 2. PLA material was selected, and the printing equipment was Einstart printer produced by hangzhou xianlin 3d technology co., LTD., and the printing parameters were shown in figure 3.

![Figure 2. The vase model.](image1)

![Figure 3. Printing parameters.](image2)

3.2.1.1. Remove the support. Once the model is printed, as shown in figure 4, the printing plate is removed and the model is smoothly removed from the bottom plate with a shovel, and then to check whether there is strain concentration model, relatively weak parts with small first stripping knife to spin out the model and the support, and then has a long nose pliers clamping a direction support, applying a constant force, the location of the tiny support can use the file to remove, as shown in figure 5.

![Figure 4. Model finished printing.](image3)

![Figure 5. Demolition of support.](image4)

3.2.1.2. Low mesh sandpaper polishing. For the “step effect”, the model printed by FDM has a rough surface and clear texture. It should be sanded first with a low number of pieces of sandpaper (80-120-240-400-800-1000 mesh). As shown in figure 6, the model and sandpaper are immersed in water and sanded along the model’s texture (step texture). Sanding the surface for a period of time if the surface is the same as before, you need to replace a higher number of sandpaper. Wet-water sanding has the advantage of smoothing the surface of the model while extending the lifetime of the sandpaper.
3.2.1.3. Quick dry small fill. Apply a small amount of filling material to the gaps or defects in the model, and the fill is daubed quickly and evenly with a hard scraper, as shown in figure 7. Then wait for 30 seconds, after filling soil has hardened, using 1200 mesh to 1500 mesh sandpaper in, as shown in figure 8. If there are still tiny grooves and repeat the above steps. To be in addition to the groove after no large-area fill soil, feel smooth, can proceed to the next step.

3.2.1.4. Spray can water fill soil spraying. The surface of the model should be washed with water before using the spray pot to fill the soil, wiped with non-woven cloth, dried, and sprayed. The model should be sprayed at the ventilated position. In addition, the model and the nozzle should be kept at about 20cm during spraying, and uniformly and rapidly sprayed 1-3 times, as shown in figure 9. Generally, choose gray spray pot water to fill the soil, because gray is a neutral color, the next step on the color paint less impact.

Figure 6. Sand paper for grinding.

Figure 7. Apply small patch of soil evenly. Figure 8. Polished to make it smooth.

Figure 9. Spray can of water to fill the soil spraying.
3.2.1.5. High mesh sandpaper grinding. After spraying water and filling the soil, place the air outlet. After air drying, use 2000-3000 mesh high-mesh sandpaper for slight grinding. When polishing, pay attention to smooth and uniform grinding along one direction, as shown in figure 10.

![Figure 10. High mesh sand paper grinding.](image)

3.2.1.6. Coloring. Wash and dry the polished and processed models before coloring with pigments. The base color or large area color can be sprayed with a spray gun, as shown in figure 11. The ratio of diluent to pigment should be 1:2 when spraying. The amount of air injection can be adjusted when spraying. Brushes of different thicknesses and sizes can be used to paint the details. It is accessible to use 00000 pens to paint the detailed parts of the figures, or use different widths of the cover tape to cover and then spray the spray gun to paint.

![Figure 11. Spray paint.](image)

3.2.1.7. Spray protective paint. After the paint and spray paint are completely dried, protective paint can be sprayed. This model USES B603 water-based extinction, and attention should be paid to uniform spraying, with 2-3 times of external spraying, as shown in figure 12.

3.2.1.8. Complete the work, as shown in figure 13.
Figure 12. Spraying protective pain.

Figure 13. The vase is finished after processing.

Conclusion
First of all, the model should be observed when in printing, reduce unnecessary support as far as possible, when putting the model through software to remove or add support Magics, before printing, printing platform for leveling, a large model, plate coated with a thin layer of printing glue, to prevent buckling deformation, etc. This is the foundation of the late better artificial post-processing.

Secondly, in the manual post-processing should look to the protection work, grinding water mill is the best way to model processing, be patient, 80-2500 mesh, use each mesh sandpaper required time from long to short, low mesh sandpaper grinding along the texture of the model, high mesh sandpaper grinding should be turned around. When mixing colors, you should understand in advance the relationship between light and shade, brightness and purity of various colors, warm and cold color selection, etc. When coming to spray, it ought to be kept at an appropriate distance.

This paper mainly carries out manual post-processing of FDM printing model. According to different models, the degree of difficulty of post-processing method is different, and the process method is also different.

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