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POST- PROCESSING FOR THE INDUSTRIAL PARTS BUILD ON FUSED DEPOSITION MODELING (FDM)

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Abstract*: In many Rapid Prototyping applications, surface is a major concern of importance. Not all RP technologies produce finished parts, which makes secondary processes, such as grinding or polishing, possible. These additional steps add time and cost to prototyping. As the goal of RP technology is to produce finished models quickly and at a low cost, producing the right surface on RP parts is important. Industrial Parts makers and manufacturers usually describe the performance of their devices in terms of accuracy or minimal layer thickness, and minimal surface roughness achieved.*

Keywords: *Rapid Prototyping, Fused Deposition Modeling, Additive Manufacturing, post-processing, surface finish.*

1. INTRODUCTION

The final step in rapid prototyping is post processing. This step generally involves manual operations where an operator does the post processing with extreme care, otherwise, the part may be damaged and should need to be prototyped again (This manual operations unfortunately are not “technique”, are just so-called operator skills). The tasks for post processing are different for different prototyping systems. As materials continue to improve and techniques continue to get better, "prototypes" are becoming "parts"**.**

Matching the physical requirements of the prototype’s application is perhaps the most important factor in selecting a RP technology. The physical properties of the rapid prototype define its quality. Rapid Prototyping system are speed and accuracy, and they both are functions of vendor defaulted and user selected manufacturing parameters [1]. Part removal and cleaning refers to taking the prototype out of the prototyping machine and removing excess materials, including support materials, which may have remained on the part.

2. FDM- PART’S SURFACE ACCURACY

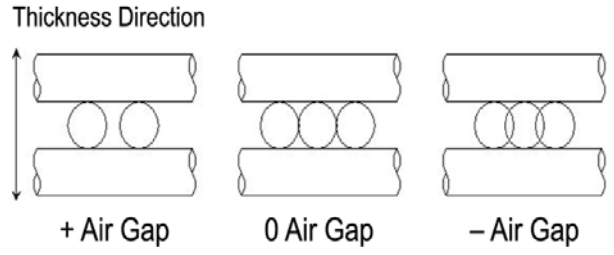
Fused Deposition Modeling (FDM) is a complex technology involving many different process parameters; FDM’s accuracy is affected by fewer variables. The most obvious limitation of FDM, acknowledged by both users and “Stratasys”, is surface finish. Due to the extrusion of a semi molten plastic, surfaces exhibit a rougher finish than SLA and PolyJet. The dimensional accuracy of any rapid prototype is dependent on many factors, and results can vary from part to part or day to day. An experimental design technique is a useful tool to improve the surface finish on a part by analyzing the effects. Surface finish is a function of a number of factors. Amongst them are Build Orientation, Air Gap, Layer Thickness, Road Width and Model Temperature [2]. (For dimensional accuracy, small shrinkage is desirable).

An optimal setting of these parameters involved in the build process would result in a FDM prototype with good surface quality. Applications in wax models demand a kind of processes which are able to produce the final shape and geometry of the part's critical features in near to the net shape with minimum post processing requirements.

2.1 Air gap

Air gap is the space between the beads of FDM material as shown in figure 1. The default

is zero, meaning that the beads just touch. It can be modified to leave a positive gap, which means that the beads of material do not touch. The air gap value can also be modified to leave a negative gap, meaning that two beads partially occupy the same space. This results in a dense structure, which requires a longer build time.



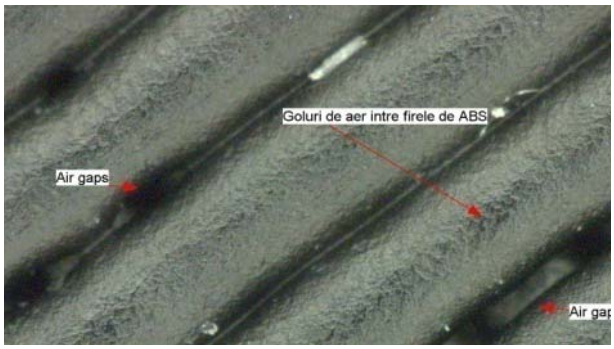


Fig.1 Air gap. Source FH Aachen

2.2 Road width and orientation

The accuracy and surface finish enhancement requires deposition of finer slices which leads to drastic increase in build time. By choosing a proper part deposition orientation and then slicing the CAD model adaptively, may be a solution to handle this contradicting issue. A suitable part deposition orientation improve part accuracy and surface finish and reduce the production time and support structures needed for building the part (Figure 2).

Fig.2 Road orientation

2.3 Stair step effect

In spite of the many potential advantages of Layer Manufacturing (LM), however, the surface quality of the fabricated 3D object is inferior to that of the general CNC machined part. This is due to the stair stepping effect, which comes from stacking layers with some level of thickness. This effect is prominent on the inclined surfaces of the fabricated parts (Figure 3) [2].

The stair case effect is a common effect of most RP methods and is caused by the slice method of manufacturing. Methods of treating this effect range from varying the thickness of the slice to intermediate processing. The former reduces the scale of the error without really eliminating it.

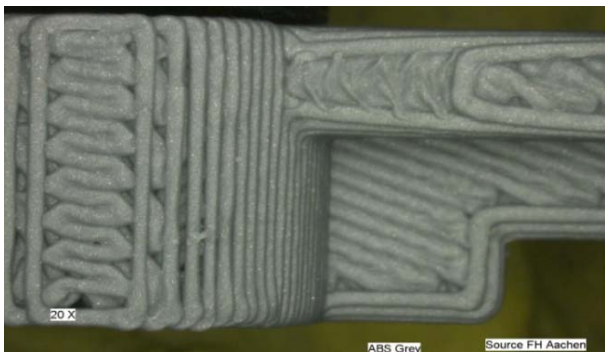


Fig.3 The stair step effect. Source FH Aachen

2.4 Support structure

Post-process such as support removal, polishing, washing, and other finishing work is generally performed for the green fabricated part at the last step of the LM.

Fig.4 Support structure. Source FH Aachen

The supports have done their job, so it is time to remove out (Figure 4). The removal depends on the support material type used:

1. *Soluble support material:* This method uses an automated support-removal process in which the material is removed in a tank via an agitated water-based detergent solution.
2. *Break Away support material:* This is a manual removal process, in which you twist, break, and scrape support material from the part. These supports can be easily removed and the surface there might need some finishing with metallic tools and sandpaper (Figure 5)[4].

Fig.5 Contact aria between part and support structure

3. D.O.E THE PAINTING

The term "post-process" in this paper means the additional process applied to the raw FDM specimens in order to improve their surface, to achieve higher surface accuracy. This additional process is the painting.

Painting parts technology as a functional post-processing relationship allow to fulfill the gaps between raster, allow to cover the macro and micro holes made by the support structure material and most important can also cover the spaces at the end surfaces (last layer surface) of parts built by FDM machine. The paint as row materials is not expensive and easy to get. The designed part and the real one could have the most favorable meeting using painting as final post-processing action in FDM industrial parts building.

Painting process can be lead by computer systems as the automated process, that means is easy to achieve the needed goals.

All this are advantages which allows to have easy acceptance and good understanding for painting process as a way to follow in post-processing FDM parts made by ABS. The key difference is how much time it will take to achieve the desired result (Figure 6). The paint used for parts should be acetone-based (Figure 7) [5]. The number of paints layers could be in accordance with the desired coating thickness; 1, 2 or 3 layers. The thickness of paint obtained are 0,047mm for one layer, 0,097mm for two layers, and 0,154mm for three layers (Figure 8).

The Parts under this study have been made in Germany laboratories, at FH Aachen University of Applied Science.

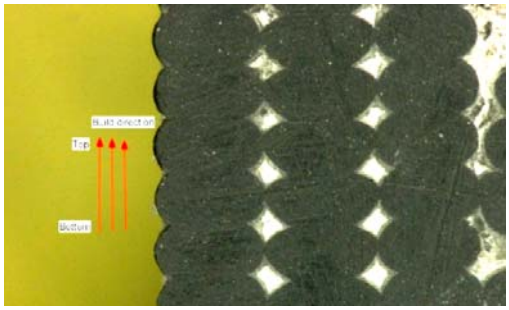


Fig.6 Part before painting. Source FH Aachen

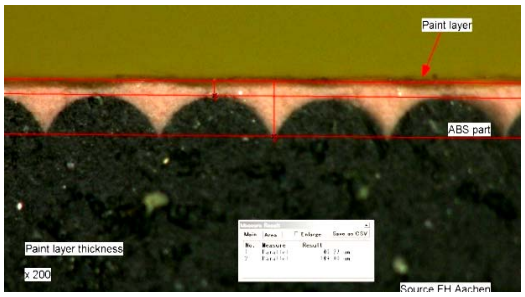


Fig.7 Part after painting. Source FH Aachen

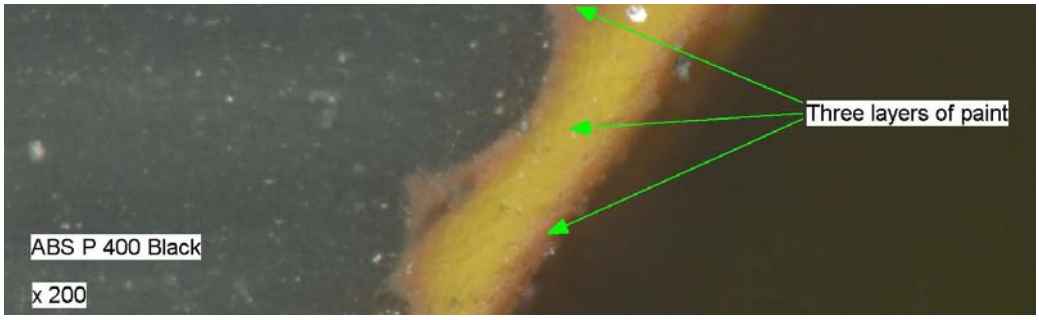


Fig.8 ABS part with 3 paint layers. Source FH Aachen

4. CONCLUSIONS

The quality of a rapid prototype is governed by its surface finish, accuracy and strength however the cost is directly related with the build time. There are two measures of quality. The first is form and fit resemblance in shape size, finish, and possibly even color to a production part. The other is function resemblance in strength, durability, chemical resistance, heat tolerance, and the like. Obviously, there is no single best choice for all needs.

Quality, one of the biggest hurdles faced by RP process, the dimensional accuracy, material properties, and surface finish are often inferior. When quality demands are high, RP may be unsuitable. For parts with less stringent quality requirements RP is more likely to be successful and may be the best option.

The next path to follow for this experiment should be the coating behavior in different environments such as; temperatures, humidity, dusty and most important goal, adhesion of the part after a period of time.

5. REFERENCES

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POST - PROCESAREA REPERELOR INDUSTRIALE OBȚINUTE PRIN FDM

Rezumat: La marea majoritate a aplicațiilor Rapid Prototyping, calitatea suprafeței este de importanță majoră. Nu toate sistemele RP permit obținerea unei suprafețe cu calitatea dorită, de aceea se execută o operație suplimentră de post-procesare. Aceasta conduce la costuri suplimentare și la mărirea timpului de execuție a prototipului. Deoarece scopul sistemelor RP este de-a obține piese în stare finită, în timp scurt si cu prețuri scăzute, rezultă că este importantă obținerea de repere industriale în conformitate cu prescripțiile tehnice. Producătorii de repere industriale pe sisteme RP, de obicei, își prezintă performanțele obținute în termeni de precizie dimensională, calitatea și grosimea suprafețelor.

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