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DEFINITION OF PARAMETERS BY PROCESS OF ADDITIVE MANUFACTURING FOR TACTILE PERCEPTION

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Abstract. *Tactile surfaces auxiliary in the perception of people with visual impairment in the most diverse supports, such as tactile maps, tactile models, learning object, decorative objects, art object, clothing tag, packing. In this context, solutions aim than improve tactile language system is important to facilitate the communication to people with visual impairment. However, it is necessary to improve communication. Thus, this study aims to verify the printing processes by fuse deposition modelling (FDM) and certifies the use of materials: ABS, PLA; In addition measuring heights, dimensions, shapes, dots, thicknesses, visual inspection measured through the microscope and comparing with the Polyjet process and RGD720 acrylic resin material.*

Keywords: *Tactile Perception, FDM, Rapid prototyping, Visual impairment, Blindness.*

1. INTRODUCTION

In Brazil, according to data collected in 2010 by the Brazilian Institute of Geography and Statistics (IBGE), there are more than 6.5 million people with some visual impairment, of these people, 528,624 are blind and 6,056,654 have low vision or Subnormal vision. Another 29 million Brazilians reported having some permanent difficult seeing using only glasses (IBGE, 2010).

To translate or share the world on its surroundings, human beings resort to an analytic attitude, based on their own perceptive information. To achieve this, the sensory organs capturing information that is processed and signified in the brain (NOGUEIRA, 2009).

The sensation of touch begins in the skin, and is skin that provide our contact with the world; Being the large censorial organ that we possess (BEAR and CONNORS, 2002). Consequently, test efficient and accessible processes with the aim of facilitating visually impaired inclusion in society, improving the quality of life through autonomy.

Thus, rapid prototyping (RP) is used as process in view of be one of the most promising techniques to reduce product development time by way of realizing the prototype that can be directly used in assemblies (Anitha, Arunachalam, Radhakrishnan, 2001).

2. TATIL PERCEPTION AND SURFACE QUALITY

Several studies about the influence of parameters in surface quality were performed using acrylonitrile butadiene styrene (ABS); Anitha et al. (2001) investigated the influence of Layer Thickness, road Width and Speed Deposition on surface roughness, with Layer Thickness being the most influential parameter in roughness. In addition Nancharaiah et

al. (2010) investigated the contribution of Layer Thickness, road with, raster angle and Air Gap in surface quality and dimensional accuracy, also verifying that Layer Thickness is the most influential surface quality factor, with an contribution of 48.53%; and the Road Width is which most affect dimensional accuracy.

Dedijer (2017) analyzed the influence of the fused deposition modeling (FDM) process on dimensional accuracy and surface quality, finding an inverse proportional relationship between speed and dimensional accuracy, and found a limitation on the impression of elements with a diameter of less than 2mm.

Ramsamy-Iranah et al. (2016) compared the tactile perception of three materials, embroidered thread, heated 'swell' paper and additive manufacture (AM) with the polylactic acid (PLA) material and found that tactile symbols are easier identified when produced by the AM process than by the other two methods.

3. MATERIALS AND METHOD

3.1 3D Model

The code system created for blind people to identify the colors by doctoral student Sandra Marchi of the Post-Graduation course in mechanical engineering at UFPR was used as a means of testing the different. The code consists of dashes and semi-spheres that indicate colors based on the chromatic circle, it was modeled in SolidWorks® version 2010 and saved in the ".stl" format. Three sizes of tactile code were printed on the different materials (PLA, ABS, and Acrylic Resin), totaling 9 samples. The tactile code has the following dimension:

Table 1 – Dimension of the design code in CAD

	S	M	L
∅ CIRCLE (a)	1,2	1,6	2
LENGHT (b)	3,9	4,3	4,7
HEIGHT (c)	0,6	0,8	0,8
WIDTH (d)	0,6	0,8	1
DISTANCE(e)	2,1	1,9	1,7

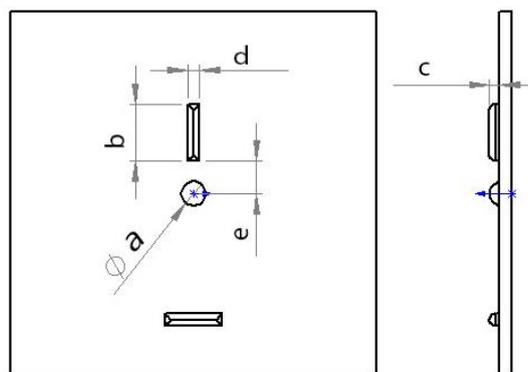


Figure 1. 3D model.

3.2 3D printing setup

For the purposes of this investigation, 3DCloner ST and DH were used as 3D FDM printer. The manufacturer's Slicer, CloneGen 3D, was used employing the following parameters for printing, layer thickness of 0.100 mm; fill of 30% of the linear type; 2 layers at the edges and on the floor and 3 at the top; temperature of 220° C at the base and 215° C in the body for the PLA and 245 ° C and 240 ° C respectively for the ABS.

The Objet Eden 250 was used with the pre-defined parameters of high quality with the acrylic resin RGD720

3.3 Methodology

After the samples were manufactured, the surface roughness and dimensions of the code were measured.

The impressions were visually evaluated with the Olympus SZ51 stereomicroscope, with the ToupCam UCMOS05100KPA camera and the ToupView 3.7 software.

The prototypes were submitted to roughness analysis using Taylor Hobson Surtronic S-100 Rough Meter with the radius of the probe tip of five micrometers and resolution of 50 nm. Because the surface had well-oriented grooves, the roughness was evaluated using the average roughness parameter (Ra). Ra is the most common parameter of roughness. It is the arithmetic mean of the absolute departures from the mean line.

4. RESULTS AND DISCUSSIONS

4.1 Visual quality

Analyzing the elements produced by FDM with PLA, it verifies various irregularities in shape and defects when compared to the 3D CAD model.



Figure 2. Microscopic images of colors code (Magnification of 1.2X) in PLA, the left top view and the right front view.

It also shows a similarity in the surface quality between the prototypes produced with ABS and PLA, both presents very similar defects in the form, besides the marks of the deposition path characteristic of the FDM process.

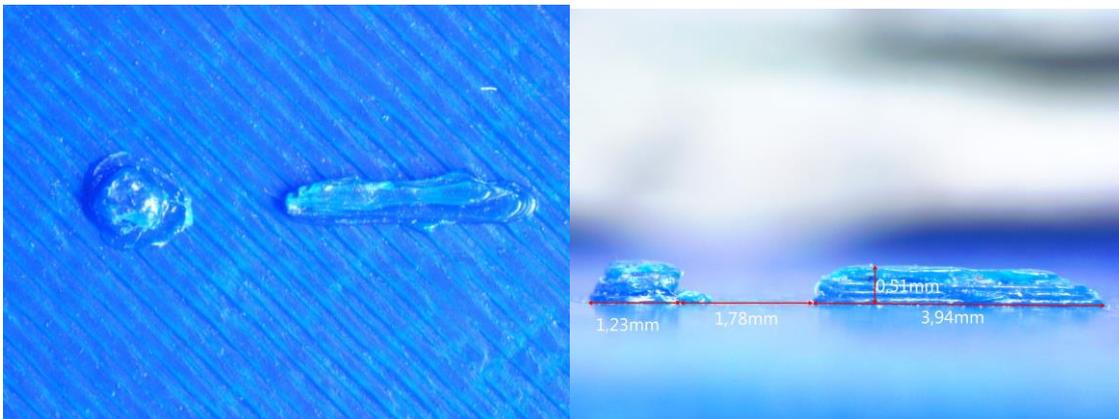


Figure 3. Microscopic images of colors code (Magnification of 1.2X) in ABS, the left top view and the right front view.

The impressions made in the Stratasys Eden250 show a superficial quality superior to the samples produced in the 3D Cloner ST and DH, a surface with higher resolution, with faint stairs effects and the format near to the 3D CAD model.

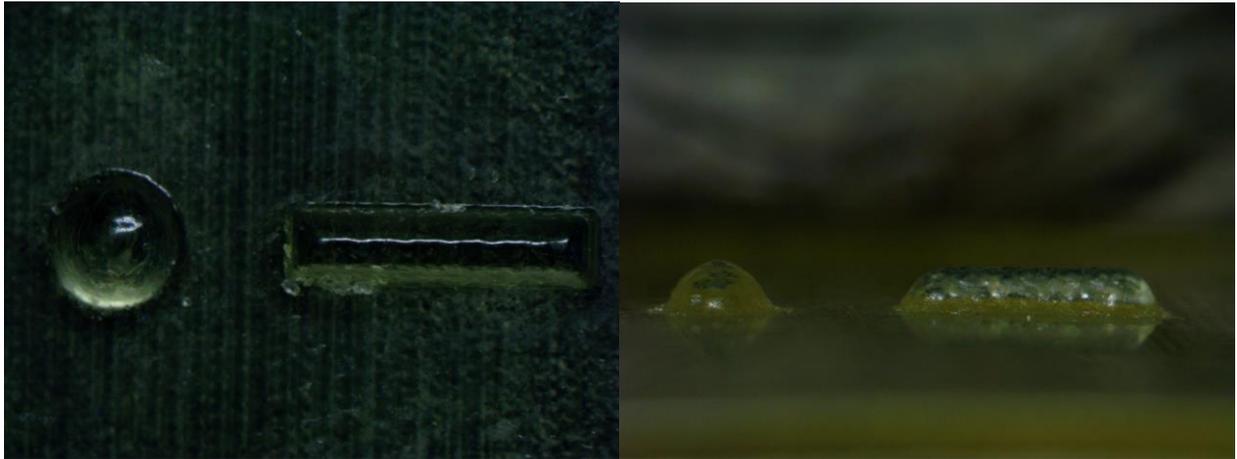


Figure 2. Microscopic images of colors code (Magnification of 1.2X) in acrylic by Eden 250, the left top view and the right front view.

4.2 Quantitative analysis

As can be seen in Table 2, the three materials presented dimensional errors in relation to the CAD model, and the acrylic resin showed the greatest difference in the width of the trace, on the other hand, it presented the best precision in the distance between the circle and the trace.

Table 2 – Absolute error between CAD and print model measurements, color coding at size Small (S).

	ABS(mm)	PLA(mm)	RES(mm)
∅ CIRCLE (a)	0,03	0,08	0,16
LENGHT (b)	0,09	0,34	0,25
HEIGHT (c)	0,09	0,05	0,02
WIDTH (d)	0,03	0,16	0,2
DISTANCE(e)	0,12	0,11	0

Table 3 – Absolute error between CAD and print model measurements, color coding at size Medium (M).

	ABS(mm)	PLA(mm)	RES(mm)
∅ CIRCLE (a)	0,05	0,05	0,09
LENGHT (b)	0,13	0,03	0,21
HEIGHT (c)	0,03	0,09	0,08
WIDTH (d)	0,05	0,04	0,17
DISTANCE(e)	0,11	0,09	0,06

Table 4 – Absolute error between CAD and print model measurements, color coding at size Large (L).

	ABS(mm)	PLA(mm)	RES(mm)
∅ CIRCLE (a)	0,14	0,04	0,03
LENGHT (b)	0,26	0,05	0,02
HEIGHT (c)	0,04	0,02	0,06
WIDTH (d)	0,02	0,03	0,25
DISTANCE(e)	0,05	0,19	0,03

Comparing the results of the three tables above it is possible to verify that the absolute maximum deviation was 0.34 mm in the trace length (3.9 mm) and that there is no relation between the size of the elements and the absolute dimensional error.

Table 5 – Average error in element size for each material.

	ABS (%)	PLA(%)	Resina(%)
Ø CIRCLE (a)	4,21	3,93	6,82
TRACE (b)	3,62	3,49	3,91
HEIGHT (c)	7,92	7,36	6,94
WIDTH (d)	4,42	11,56	26,53
DISTANCE(e)	4,81	7,05	1,64

Analyzing table 4, it is possible to notice that for the three materials most of the average error values are between 3% and 8%. Except for variable (d), there was a more marked variation for the different materials.

Table 6 – Average roughness of each material..

Material	Ra (µm)
ABS	3,3
Resina	1
PLA	7,9

The data presented in table 6 shows that the surface roughness of the acrylic resin is lower than that of the other materials, followed by the ABS and finally the PLA, which presents the highest roughness.

5. DISCUSSION AND CONCLUSION

The study of tactile material produced by additive manufacturing highlights an important application of this technology, and the results presented point out the need to establish quality criteria to guarantee a more efficient tactile perception for blind individuals. Among the materials applied in this study, a better visual reproduction quality of the acrylic resin RGD720 was obtained through the microscopic images, which presented a shiny and smooth appearance. The material that presented the most irregularities was PLA. On the other hand, ABS can be classified as an intermediate visual quality when compared to PLA and resin. However, it was important to evaluate the dimensional and verify the absolute error of each piece, since three sizes of the tactile code were printed on the different materials (PLA, ABS, and Acrylic Resin), totaling 9 samples. The different geometries of the code formed by: circle, rectangle, spacing between the geometries and height of the rectangle and semi-sphere, presented distinct variations of absolute error. However, a constant absolute error was not identified among the selected materials, but a greater absolute error of 0.34 mm in the PLA was obtained for the smaller sample size, obtaining a zero error value (0,0) in the variable (e) in the acrylic resin material, also for the smaller dimensional size of the code. Although the acrylic resin had the appearance of a smoother surface, a greater absolute error of 26.53% was identified in the variable width (d). And the results presented led us to conclude that the behavior of the ABS material obtained a certain constancy in the range of variation of the absolute error in relation to the other materials.

Variables (b) and (c), in the formation of the geometry of the trace, presented with a maximum absolute error very close, with greater balance, without great discrepancies. In the present study, it was concluded that the pieces with the analyzed geometry destined for tactile perception, even presenting a dimensional variability, with an absolute error, should be within an acceptable pattern of tactile perception. Mainly because the code has as main characteristic the small reliefs, emphasizing therefore the necessity of these elements to be sufficiently distinct for the perception to the touch. It is also considered necessary to know the maximum permissible limits for the perfect tactile perception of the code. As a future work, perceptual evaluation with code users in different materials is suggested to compare the variability observed in this study with the tactile perception of blind individuals.

6. ACKNOWLEDGEMENTS

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8. RESPONSIBILITY NOTICE

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