International Joint Conference Radio 2019

Visual impact of infill percentages for 3D printed radiologic simulators

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Introduction: The 3D printing of anatomical models from medical images is nowadays used in the production of living tissues and organs, the creation and customization of prostheses, implants, for pharmaceutical use (1,2), among others. In radiology can be presented as an alternative for the development of radiographic simulators to be used in education, training (3), optimization of techniques and images (4), evaluation of radiographs, in aid of Radiation Protection and Quality Control programs of equipment (5,6). The function of a simulator is to attenuate the radiation mimicking the different tissues of the human body. This study seeks to verify specifically one of the printing parameters, filling, in the final homogeneity of printed samples (7). The infill affects mainly the filament spent, print time and resultant attenuation (8). It is believed that is imperative finding a balance between the these three factors to maintaining a homogeneous visual appearance on computed tomography for in the future may aid in the development of radiological simulators.

Methodology: In order to test the influence of the fill on the visual tomographic aspect, a total of 16 cubes with 8 cm³ of each type of filament were printed, being PLA with 27.5 ± 2.5% copper (Cu) and ABS. The printing considered a range of infill variation between 15% and 90%, in increments of 5%. The internal pattern of the cubes was constructed from layers of rectilinear lines intersected at angles of 90 degrees. The extrusion diameter used was 0.4 mm, and the height of each layer is of the order of 0.2 mm. The cubes were irradiated in a Phillips Brilliance CT 6 channel scanner with exposure factors of 120kV, 200mA in 0.4mm slices and reconstructed with Standard filter. Each cube had the mean values of Hounsfield Units (HU) and standard deviation (SD) determined in a Region of Interest (ROI) of ~ 115 mm². Visually, the inner reticulate of each cube was evaluated by counting line pairs per millimeter (lp/ mm) through the DICOM Weasis viewer.

Results: It was observed that the HU values presents a linear behavior in terms of the infill variation, as shown in Figure 1. Figure 2, in it turn, shows the results of measurements of these values, in the samples of 15% to 50%, for ABS and PLA + Cu. Infill values above 50% for PLA + Cu and 40% for ABS showed a high homogeneity that do not allow differentiation in the line pairs. For both filaments the lp/mm for PLA + Cu ranged from 0.227 to 15% and at 0.759 for 50% infill. As for ABS composite samples, the ppl / mm variation was from 0.217 to 15% and 0.579 to 40%. It was observed that the mean standard deviation is lower at 5 points in the PLA + Cu filament than ABS and that for both filaments a decrease in the standard deviation of HU from 15% to 55%

Figure 1: HU values evolution in relation to the infill percentages (left) and Lp/mm resolution variation of different infill percentages(right).

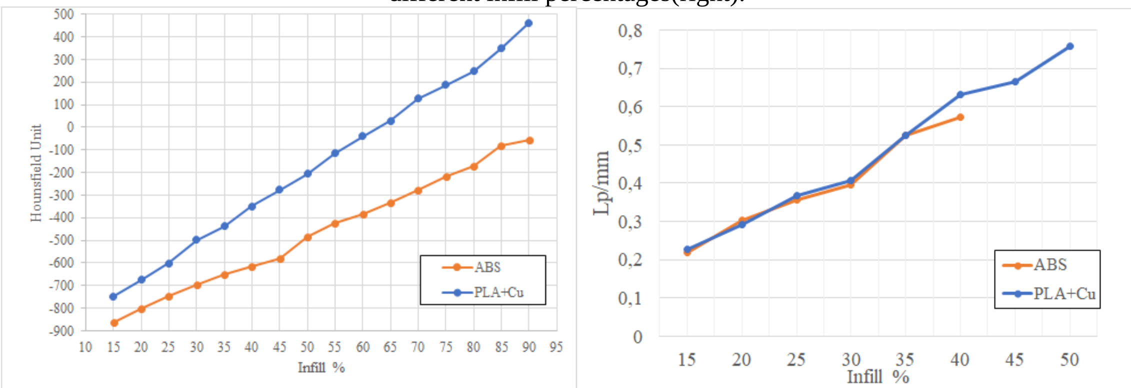
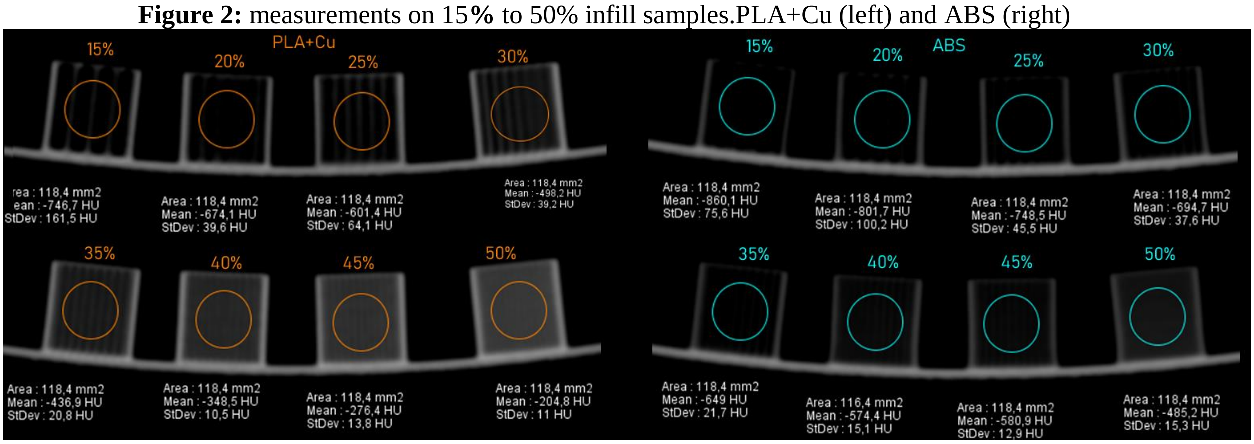


Figure 2: measurements on 15**%** to 50% infill samples.PLA+Cu (left) and ABS (right)



Conclusion: It was possible to visually perceive that when the PLA+Cu filament was used, the lower limit of infill percentages is 50%, while is 40% to the ABS. Values above those percentages are recommended to use in radiological simulators constructed with the respective materials, whereas it presents sufficient homogeneity. It is suggested to perform this study for each filament, as one more parameter to be taken into account in the construction of radiologic simulators, broadening the options of materials that could be used with this goal.

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