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LOW COST FDM 3D PRINTER WITH FUZZY - PID TEMPERATURE CONTROL AND COOLING SYSTEM

Christian Barros[1], Paul López[1], S. D. Castellanos[1,2(*)], Isaac Ferreira[2], J. Lino Alves[2]
[1]Universidad de las Fuerzas Armadas-ESPE, Dept. Ing. Mecánica (DECEM), Sangolqui, Ecuador
[2]INEGI, Faculdade de Engenharia, Universidade do Porto, Porto, Portugal
[(*)]*Email:* svilla@inegi.up.pt

ABSTRACT

Nowadays, 3D printing is a technology well established and with a continuous growing application in various fields of engineering. Different features contribute to this technology but one of the principal reasons is certainly the development of concepts like DIY (Do It Yourself), Open Source Software, End of term of patents and the propagation of multiple 3D printing communities such as REP RAP, THINGIVERSE, 3DERS.ORG, MAKERBOTS and others [Wohlers, 2016, and Gonzales, 2016]. These communities are involved in the study, construction and integration of 3D printers, as well as providing free access software and firmware, including printer parts models for self-replication. In this way, allowed the appearance of other projects and rapid evolution of this technology. Although the advances already reached, the open source machines still show weaknesses, especially regarding mechanical stiffness, safety, and repeatability.

Currently the 3D printing systems based on FDM (Fused Deposition Modeling) process, mainly with PLA (Polylactic Acid) and ABS (Acrylonitrile Butadiene Styrene) materials use open source control firmware such as MARLIN, REPETIER, and GRBL, among others. These systems apply a classical PID (Proportional Integral Derivative) control for heating the extruder. Heating up this element until stabilizes it for the PLA extrusion temperature, at 200 °C, takes about 180 seconds.

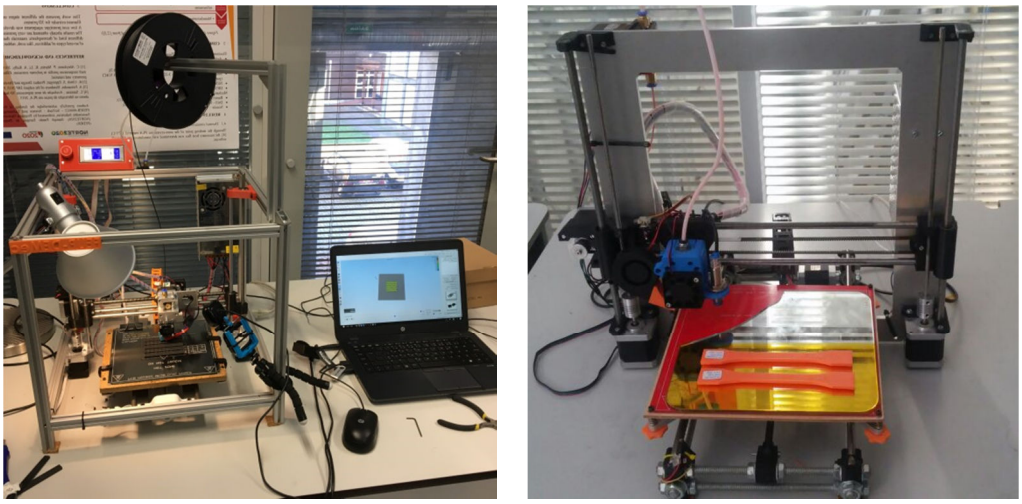
Actually it is common to use cooling systems on the extruder to reduce the probability of using supports and at the same time improving parts surface quality. The refrigeration system causes perturbations in the process of heating the extruder, which means that this problem must be corrected by the machine controller. A traditional PID control is not robust enough to keep a suitable and constant extrusion temperature under these conditions.

The application of new patterns and printing strategies, the usage of new types of materials, as high cost materials, propelled the idea of building our own machine. Considering the exposed scenario, the goal was developing a machine that combines the customization potential proposed by free movement with the accuracy and efficiency desired in commercial equipment´s. This research presents the design and manufacturing of a low cost 3D printer (Figure 1a) and the study of the suitability of incorporation a control system that optimizes the heating process through fuzzy logic control, even combining a PID-FUZZY controller (Fig. 1b).

Figure 2 presents the extruder heating curve as a function of the time with the different control types. As one can see, the combined control allows a faster response towards a better temperature stabilization control. This effect will be analyzed in terms of printed parts mechanical properties (tensile tests) to check the advantages of using it in low cost FDM 3D printers.

It was defined that the structure would be box shaped, increasing stiffness, with two direct extruders, reducing the number of moving parts and allowing the use of two materials simultaneously. To promote stiffness and durability, some of the parts were CNC machined. As every part designed was different from any part available, the 3D modelling of this machine was important to set measurements, clearances and other important dimensions.

The equipment was developed keeping in mind future expansions and iterations that would occur.



(a) (b)

Fig. 1 - (a) 3D printer developed in the laboratory of products and services development of FEUP (b) study of implementation of a PID-FUZZY controller.

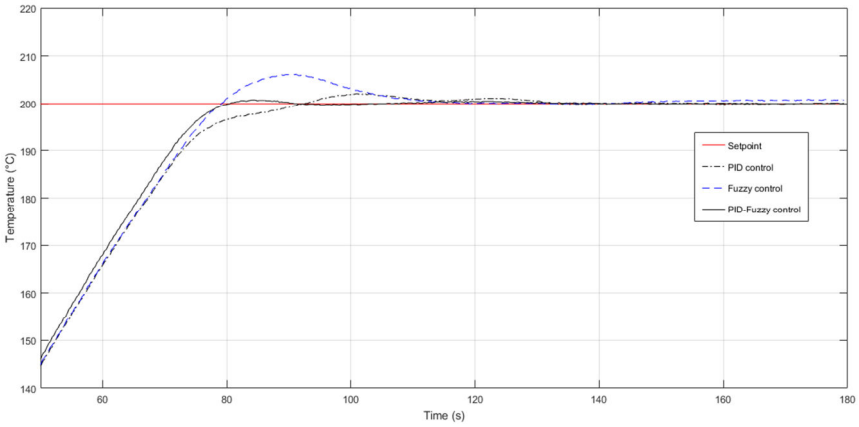


Fig. 2 - Heating curve as function of the time with different control types

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