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Wall ironing during Fused Filament Fabrication

Jiri Konvicny

Jaime Van Kessel

Title: Wall ironing during Fused Filament Fabrication

Authors: Jaime van Kessel, Jiri Konvicny, Ultimaker B.V. Utrecht, The Netherlands

This idea aims to increase the 3D printed objects strength in Z-axis by ironing each layer of the printed walls of the objects.

It is a well-documented fact that strength in Z-axis is influenced by the shape and size of the voids between the layers and individual lines of filament, see e.g. Kuznetsov et al. - Increasing of strength of FDM (FFF) 3D printed parts by influencing on temperature-related parameters of the process, available online: https://www.preprints.org/manuscript/201803.0102/v1.

Publication EP3541551 (A1) describes a solution on how to increase the strength in the Z-direction. The patent publication suggests to arrange a control system of a FFF printer so as to generate machine ready code for execution by the printer to fabricate a 3D object, wherein the control system deploys a number of strategies to improve the resulting physical object structurally or aesthetically.

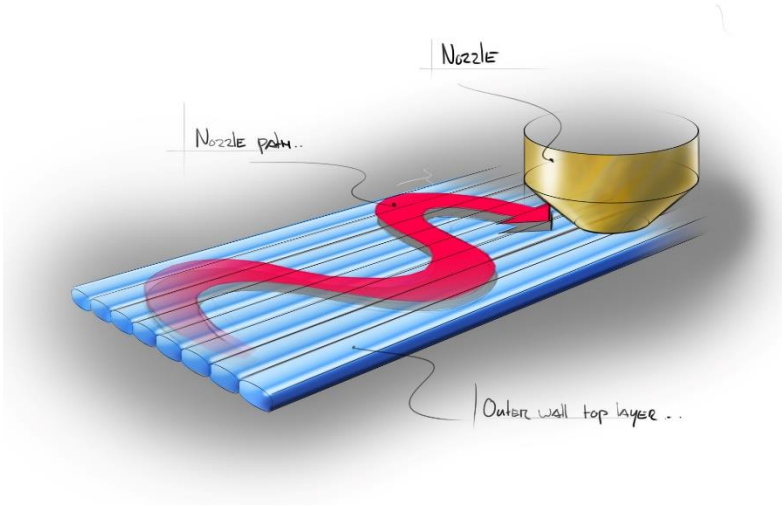
The control system may use plowing, ironing, planing, or similar techniques where the one or more nozzles run over existing layers of deposited material, e.g., to level the material, remove passivation layers, apply an energy director topography of peaks or ridges to improve layer-to-layer bonding, or otherwise prepare the current layer for a next layer of material. The one or more nozzles may include a low-friction or non-stick surface such as Teflon, TiN or the like to facilitate this plowing process. Further, or instead, the one or more nozzles may be heated and/or vibrated (e.g., using an ultrasound transducer) to improve the smoothing effect. In one aspect, surface preparation may be incorporated into the initially-generated machine ready code. In another aspect, the printer may dynamically monitor deposited layers and determine, on a layer-by-layer basis, whether additional surface preparation is necessary or helpful for successful completion of the object.

The authors have realized that ironing the whole surface of the last deposited layer may require a lot of manufacturing time. Furthermore, most of FFF printed objects contain a relatively open infill structure made of thin walls. These thin walls are not needed to iron since the chance of having voids in those structures is relatively low.

The following solution is now proposed. After all perimeters of the parts walls are printed on a specific layer, the printer will to start an ironing procedure, wherein a heated nozzle either with negligible extrusion or without any extrusion at all, is passing on the same z-height at a defined pattern to smoothen out the ridges between the individual perimeter lines that form the outer wall of the object.

Figure 1 shows a perspective view of a process wherein a nozzle with an ironing surface is used to move over the top layer of an outer wall of an object. The red line indicates the nozzle path. It is noted that during the displacement of the nozzle along the path, the nozzle does not, or very little, extrude material.

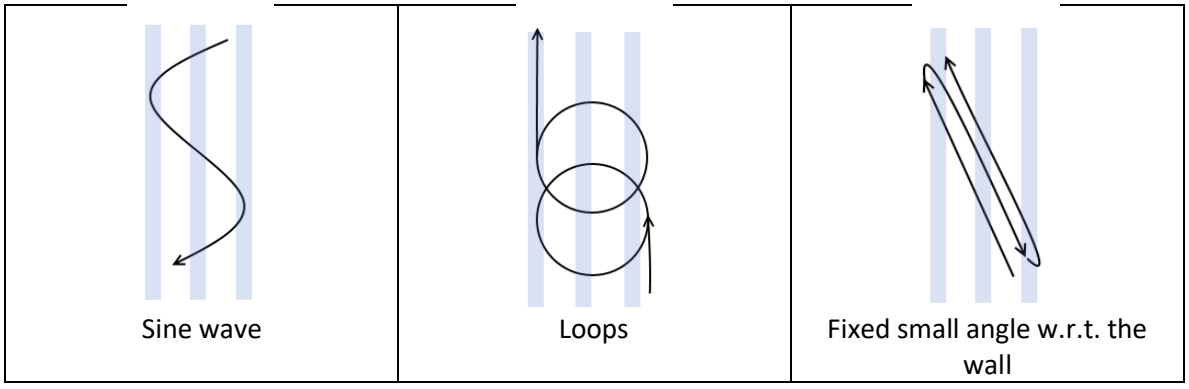
FIG. 1



An additional problem to overcome is that if the ironing is being performed perpendicularly to the walls' direction, it will result in a series of short rapid nozzle moves which bring unnecessary vibration to the printer. Advanced travel planner can overcome the vibration issue, but its use would result in slowing down to unusable level.

We therefore propose several ironing path strategies. Figure 2 shows some examples of the ironing paths to avoid short moves. In Figure 2 the wall direction is vertical, see light blue lines indicating the wall traces. The ironing paths can be applied in one or multiple passes so that the whole surface of a wall can be smoothened.

FIG. 2



The ironing path strategies shown in Figure 2 are just some examples and it is not an exhaustive list. Other strategies are possible for ironing the wall lines. It is noted that the Sine wave example of Figure 2 resembles the example shown in Figure 1.

In case the visuals of a product is critical, the ironing paths can exclude the most outer traces of the wall completely to avoid any heat/extrusion interference on the outside of a product.

Finally, it is noted that instead of a heated nozzle, a separate ironing tool may be used to iron the wall surface.