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Interlocking Print Patterns

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Title: Interlocking print patterns

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A new method for fastening materials together in additive manufacturing (AM) is proposed. The method can be performed by a software program such as a slicing program for preparing a design for printing. In our research we used an FFF printing technique to validate the new method.

In traditional mass manufacturing, components of mass-produced products are generally manufactured independently by specialized processes and then assembled into a finished product. With many recent advances in AM it became more feasible to manufacture complex products in a single build process based on a digital representation of the product. Rather than building each part separately and then assembling them, AM is very suited for complex products to be manufactured in an integrated manner.

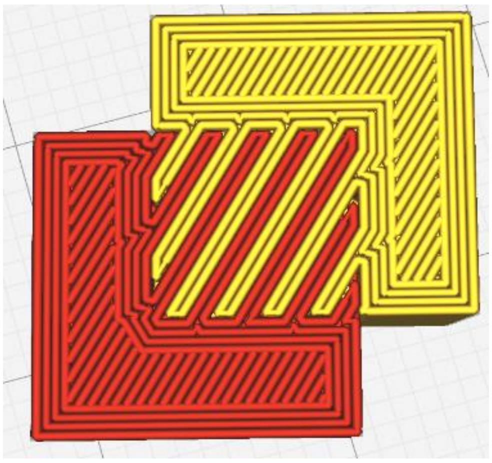
In order to develop systems capable of manufacturing functional products through a largely AM process, many technological obstacles will need to be overcome. Some of these are to develop advanced methods for fastening multiple materials together during a build process, for fixing parts during the build process, for integrating multiple build technologies together, and for improving end-part properties.

Patent publication WO2018/072034 (A1) discloses a method of joining two printed objects, the method comprising bulk depositing of an anchor of a second material in a receptacle in a body of a first material using a print head. The anchors, made of the second material, will be printed in the receptacles, made of the first material, so that it will couple the two printed objects. This requires extrusion moves of the one material to stop inside a region of the other material, and/or extrusion moves which separate off a region of the other material, which leads to an interruption in material extrusion when printing the disjoint regions of the other material.

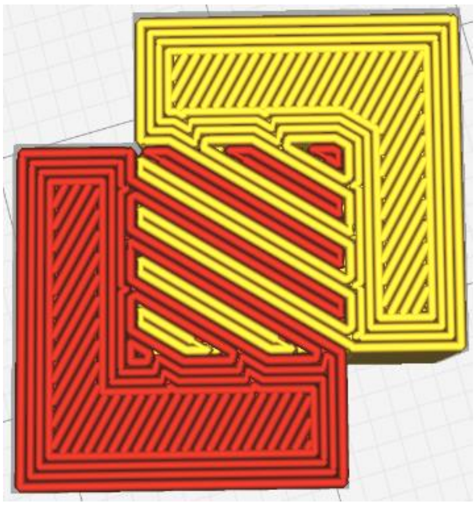
We now propose an improved method wherein an interlocking structure is designed at an interface region between two printed parts. The proposed method introduces few interruptions in the material extrusion flow. We programmed a slicing program to automatically generate an interface between two volumes which can then be printed using a different material (e.g. Nylon and TPU). The interface region was designed in such a way that it ensures the best possible interlocking between the two. The material proportion could be graded from the one material to the other throughout the region, by changing the beam thickness along the beam.

At the next page two cross sections of a simple prototype is shown. The drawings are produced by the slicing program Ultimaker CURA®. The first red object is a box-shaped object and the second (yellow) object is also box shaped but overlaps with the first object. In the overlap or interface region both objects have beam shaped fingers interlaced with each other. Since the beams are connected to the object, the outline of the object can be printed together with the beams without interrupting the flow of extrusion.

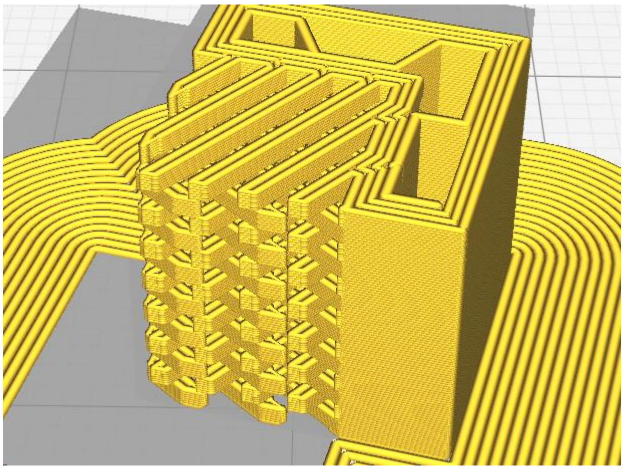
In this example, each object contains straight horizontal beams or fingers which may be e.g. 10 layers high.



The direction of these beams/fingers is rotated every X layers, with X being a preferred number of layers. The rotation angle A can be chosen such that the pattern has rotated a full 180 degrees (to align with the original direction) in N rotations, where N is typically 2 and A is typically 90 degrees.



This weaving of beams causes vertical beams to be formed at the intersections of the same material with the different directions. Such vertical beams can be detected in the picture below which only shows one of the two materials. In this picture the regular changing of orientation of the (yellow) fingers is visible. Also, a brim around the object is shown, which is not subject to the invention.



By letting fingers of one material extend into the other material, and by changing the direction of the fingers every X layers, the two materials are firmly locked in all 3 dimensions.

It is noted that the described method can be used with all sorts of printing materials. Also objects with identical material will me more firmly connected. It is further noted that the examples shown are very simple examples. Other more complex configurations are conceivable where two materials, or even more materials, are coupled using interlocking patterns/structures.