FDM PRINTER TYPES
B) FDM PRINTERS ACCORDING TO PRINTING MATERIAL

B1) CERAMIC PRINTERS

B1) FDM 3D PRINTER FOR CERAMIC MATERIALS

It is possible to talk about professional three-dimensional printers that can use different types of ceramic materials with various methods. In 2009 Unfold Studio developed the ceramic printer FDM. The printer is limited to a paste extruder, and to vehicles that produce ceramic sludge or porcelain material. The reason for this limitation is that the study aimed to discover the potential of ceramic printers accessible only to personal users.

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As mentioned, these printers use the FDM method. FDM, that is, melt casting, is usually accomplished by melting the plastic loaded into the printer in the thinned state (filament) when it reaches the head and stacking it in layers in a computer-controlled manner. In this method, when plastic material is used, it is necessary to melt with heat; the fluid ceramic material does not need to be heated to bond with each other. The ceramic with sufficient fluidity is stacked on top of each other and left to dry after final shape. In order to turn into the final product, it must be cooked between 900-1300˚C depending on the type of ceramic.

A three-dimensional ceramic printer basically has two differences with a RepRap printer that uses plastic. The first is a printhead suitable for the aforementioned cold production, and the second is the air compressor, which is necessary for pushing the material through the cold production. The extruder, which is designed for melting the material, does not have difficulty in pouring the material with the effect of gravity, while a paste extruder used for ceramic uses a system to push the material in it with air pressure.

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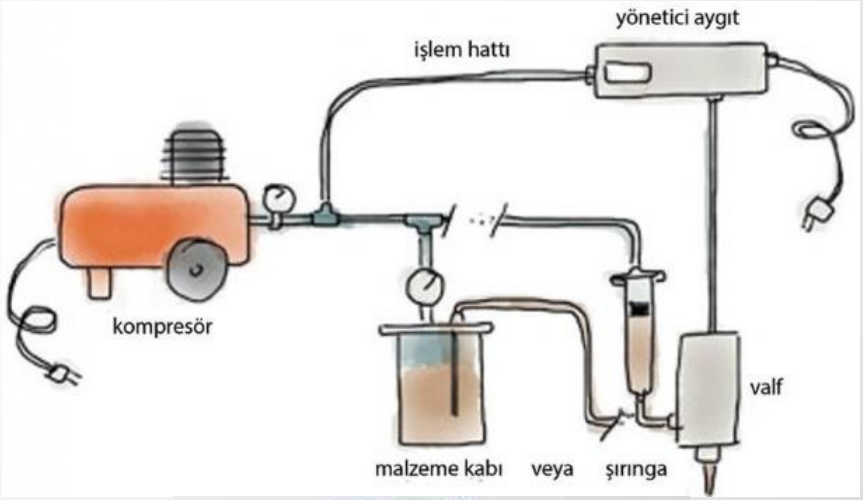
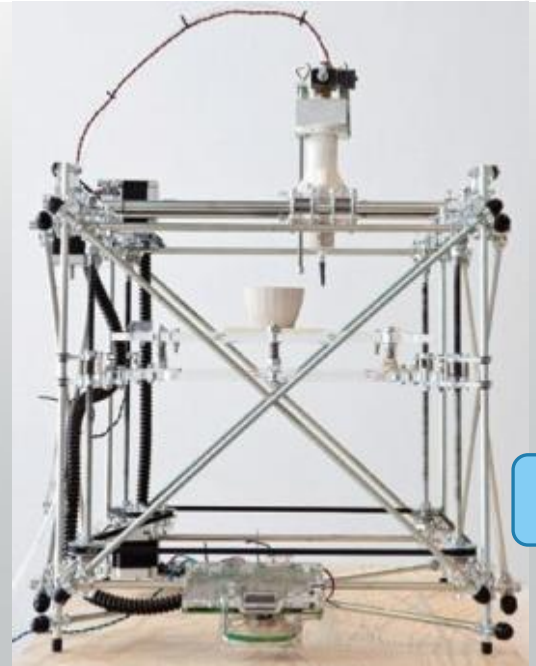
The advantages of the three-dimensional ceramic printer compared to the existing production methods for ceramic can be listed as follows:

1. It allows the production of forms that cannot be produced by existing methods.
2. Compared to molded production, it allows for personalization according to user demands, since it is produced directly on the digital three-dimensional model.
3. It allows for single and unique production as in hand workmanship. However, it takes less time and less labor than manual labor.





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Neil Gershenfeld has worked with the Massachusetts Institute of Technology for digital production technologies, especially 3D printers. When Gershenfeld in the face of intense interest by artists, designers and students for the digital production laboratory project FabLab, he emphasized that the separation of education, industry and art, once together, was a wrong move. In this context, it is possible to evaluate the personalization of digital production technologies as an indicator of the effort to put people back in the center of machine-based production.

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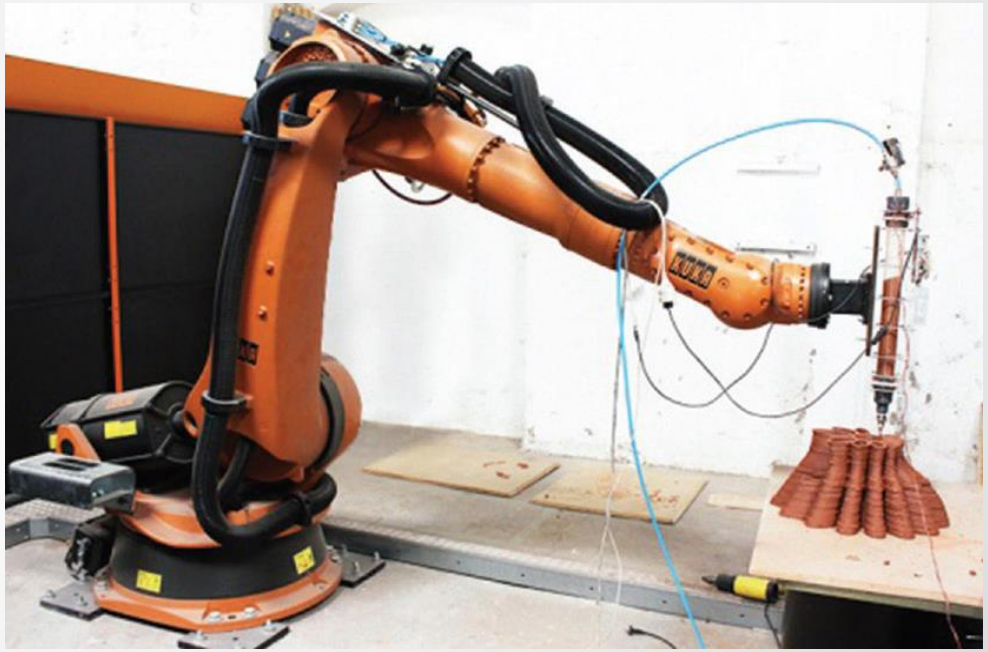

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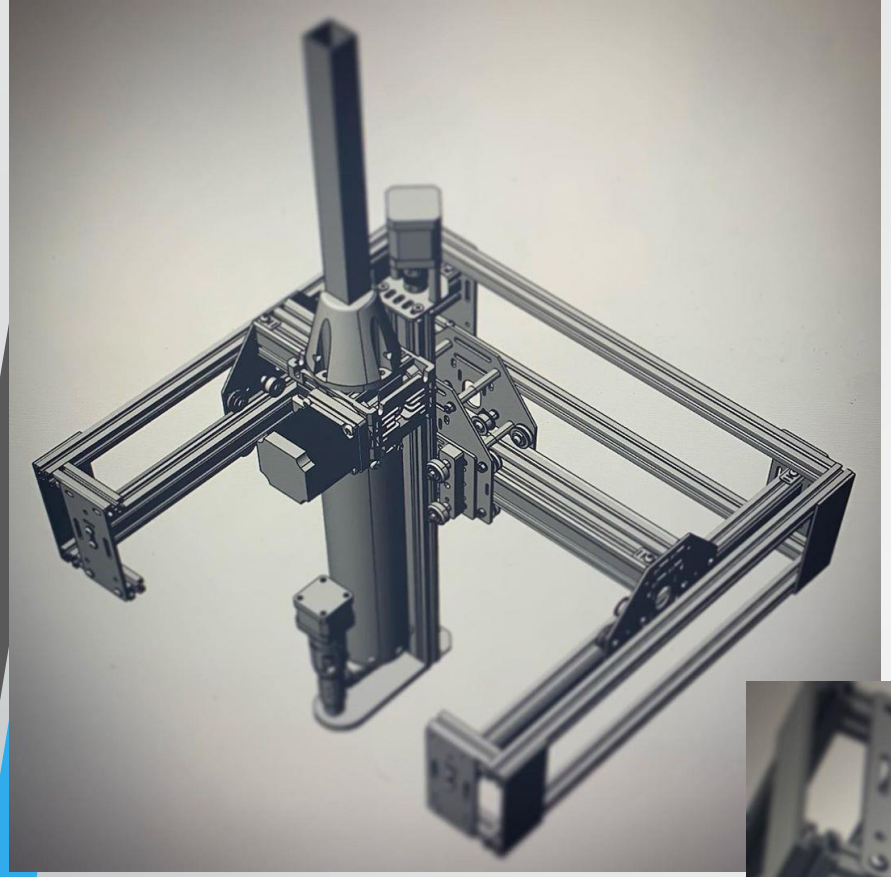
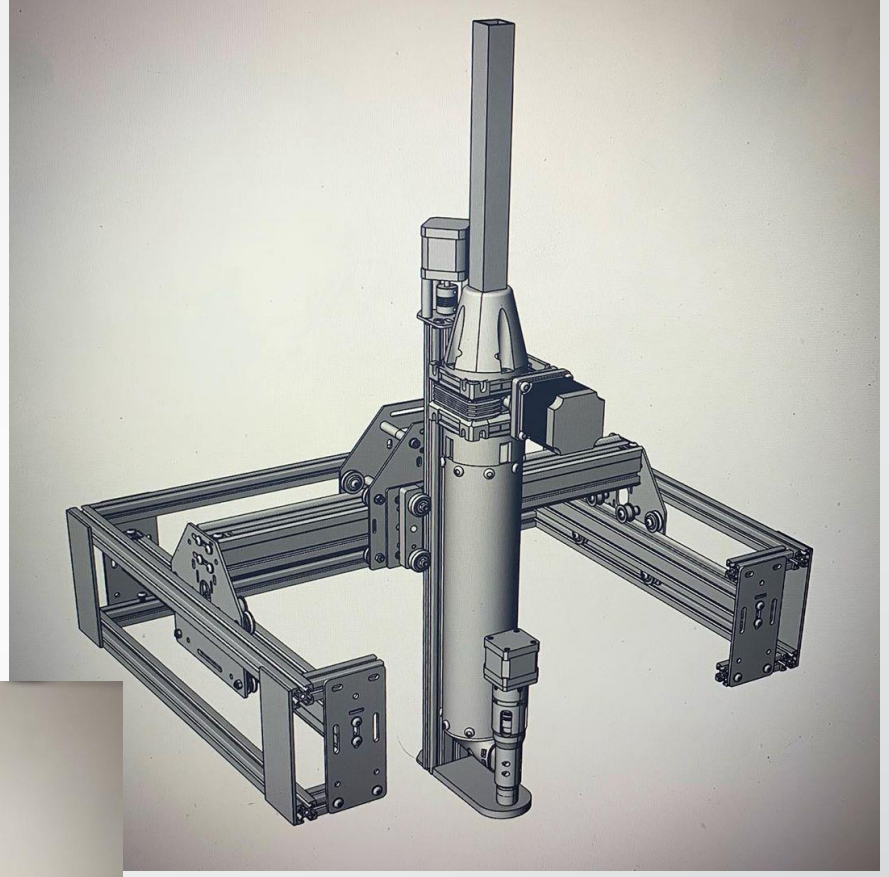
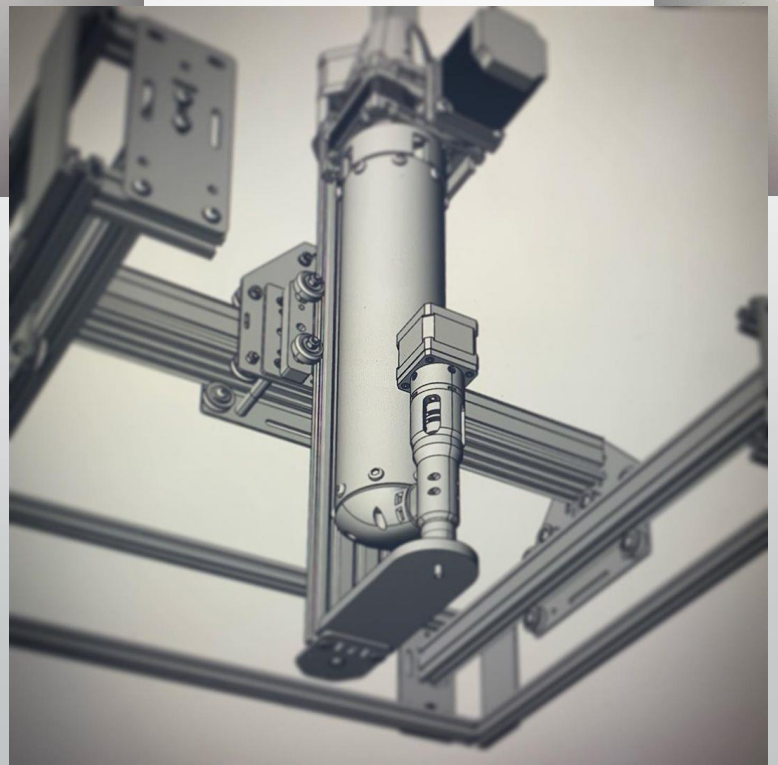
Moving away from manual labor, the machines that break the relationship between production and human beings approach human beings and allow individual production in a manner similar to craft production. in this context, the 3D printers seem to be moving in order to regain the advantages of personal production.







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Verbruggen from the Unfold Studio team spoke of a similarity due to a glitch in his three-dimensional ceramic printer. The flowability of the ceramic material transferred to the printer head changes during production. Due to this change, the amount of air pressure used to propel the material must also be continuously adjusted. Verbruggen, who discusses various proposals for this, says that otherwise they have to constantly check and adjust the air pressure, which is more like a craft than a three-dimensional writing action.

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- Unfold Studio has pioneered the development of other three-dimensional ceramic printers that will be mentioned in 2009, where it shares the construction process as an open source. The printer of Unfold Studio is of the Cartesian type; that is, it has a linear moving structure on the x, y, z axes.
- Artist Jonathan Keep set out by taking Unfold Studio as his model and used a delta type structure in his printer, which has the same production logic and similar skills.
- The artist Olivier Van Herpt, on the other hand, produced a three-dimensional printer with a very large working area using the delta type.
- On the other hand, FabClay, developed by students of the Institute for Advanced Architecture of Catalonia (IAAC) in Barcelona, has been integrated into an industrial robot with a paste extruder suitable for ceramic, using a similar method and system as the other printers mentioned here.

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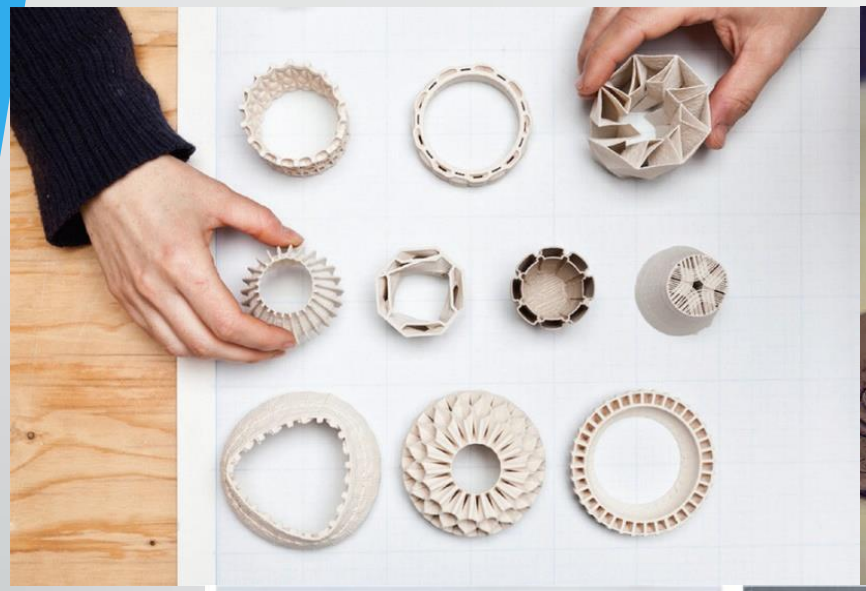
PRINT EXAMPLES PRODUCED BY WITH 3D CERAMIC PRINTERS



Şekil 8. Unfold Studio'nun tasarlayıp ürettiği bir ürün [15].
Figure 8. An object designed and produced by Unfold Studio [15].

Şekil 9. Unfold Studio'nun tasarlayıp ürettiği sürahi ve bardaklar [16].
Figure 9. Pitcher and cups designed and produced by Unfold Studio [16]

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Şekil 10. Jonathan Keep'in matematik işlemi tabanlı formları [17].
Figure 10. Jonathan Keep's mathematical process based forms [17]

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https://www.asme.org/topics-resources/content/3d-printing-houses

ARCHITECTURAL FORMS

The FabClay project aims to explore 3D printed architecture with ceramics and to produce architectural structures. In the project, it is seen that forms, which rise mostly on the vertical axis, have a pattern that can stand structurally when seen from the top and form an architectural volume.

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https://singularityhub.com/2018/03/18/this-3d-printed-house-goes-up-in-a-day-for-under-10000/

https://m.all3dp.com/3d-printed-pedestrian-bridge/

A Pedestrian Bridge in Madrid produced with 3D Printer

https://www.youtube.com/watch?v=n2szk5MItRA

https://www.huhmagazine.co.uk/the-worlds-largest-3d-printed-concrete-bridge-is-complete/

Anju Bridge produced with 3D printer in China

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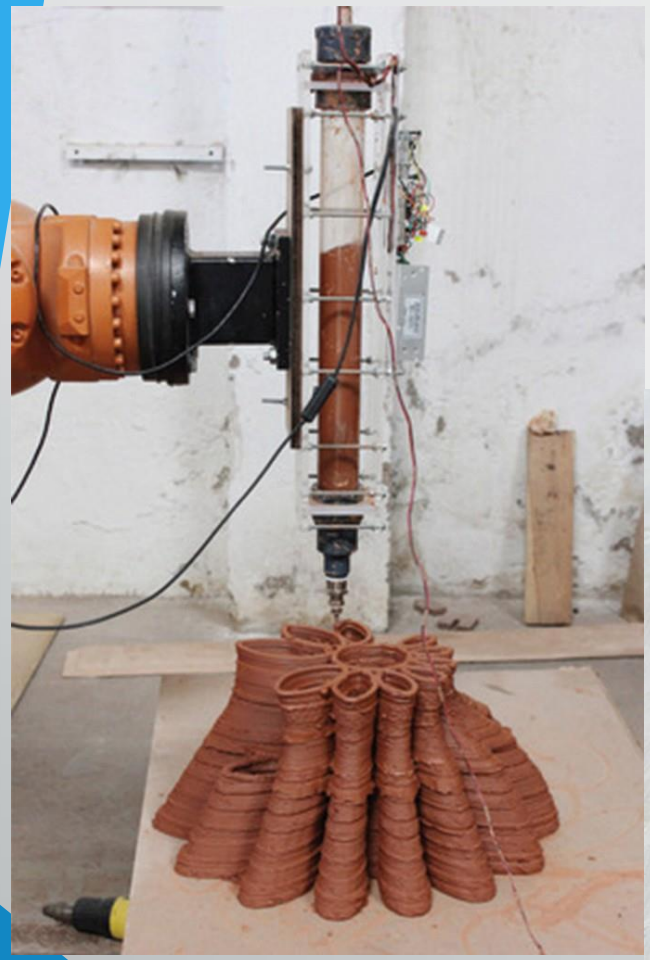
STUDIO UNDER AND COLOR CERAMIC PRINTING



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The lighting elements of Studio Under, based in Israel, are also examples of end-user products for ceramic three-dimensional printing. The team, which mixed colors with the material to be used in printing, managed to make color ceramic printing by using different colored material for different layers during printing.

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