19AST202 AIRCRAFT PRODUCTION TECHNOLOGY

ADDITIVE MANUFACTURING IN AEROSPACE

Material Extrusion- ***Fused-deposition modeling*** (FDM)

MATERIAL EXTRUSION This AM process technology is an adaptation of plastic extrusion to form the layers in rapid prototyping and additive manufacturing. The starting materials are wax and thermoplastics such as ABS (acrylonitrile–butadiene–styrene) and PAL (polylactic acid). ***Fused-deposition modeling*** (FDM) is one of the material extrusion processes; it extrudes a filament of wax and/or thermoplastic polymer onto the existing part surface from a work head to complete each new layer. The work head is controlled in the *x*–*y* plane during each layer and then moved up by a distance equal to one layer in the *z*-direction. The starting material is a solid filament with typical diameter = 1.25 mm (0.050 in) fed from a spool into the work head, which heats the material to about 0.5°C (~1°F) above its melting point before extruding it onto the part surface. The extrudate is solidified and cold-welded to the cooler part surface in about 0.1 sec. If a support structure is needed, that material is usually extruded by a second extrusion head using a different material that can be readily separated from the main part. The part is fabricated from the base up, using a layer-by-layer procedure similar to other RP systems. A disadvantage of FDM is its relatively slow speed, because the deposited material is applied in a moving-spot scanning mode, and the work head cannot be moved with the high speed of a laser spot. Also, the use of an extruder, with its circular nozzle orifice, makes it difficult to form sharp corners.

FDM was developed by Stratasys Inc., which sold its first machine in 1990. The starting data consist of a CAD geometric model that is processed by Stratasys's software to slice the model into layers and generate any support structures required during the build process. The slice (layer) thickness is typically set from 0.25 to 0.33 mm (0.01−0.013 in), but for finer details, layer thickness can be set to a minimum of 0.076 mm (0.003 in) [5]. Up to about 400 mm of filament length can be deposited per second by the extrusion head. Starting materials are wax

and several polymers that are nontoxic, allowing the FDM machine to be set up in an office environment. A collection of plastic parts made by fused-deposition modeling is shown in Figure, and the FDM machine that made these parts is shown in Figure .

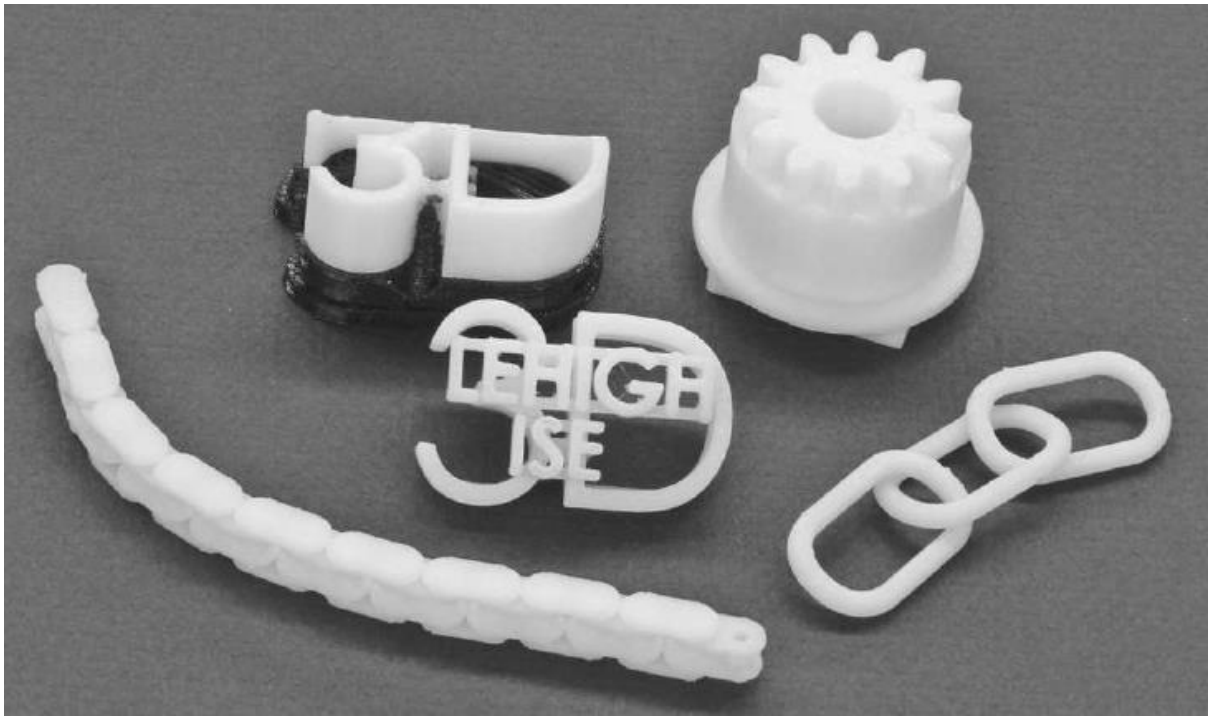
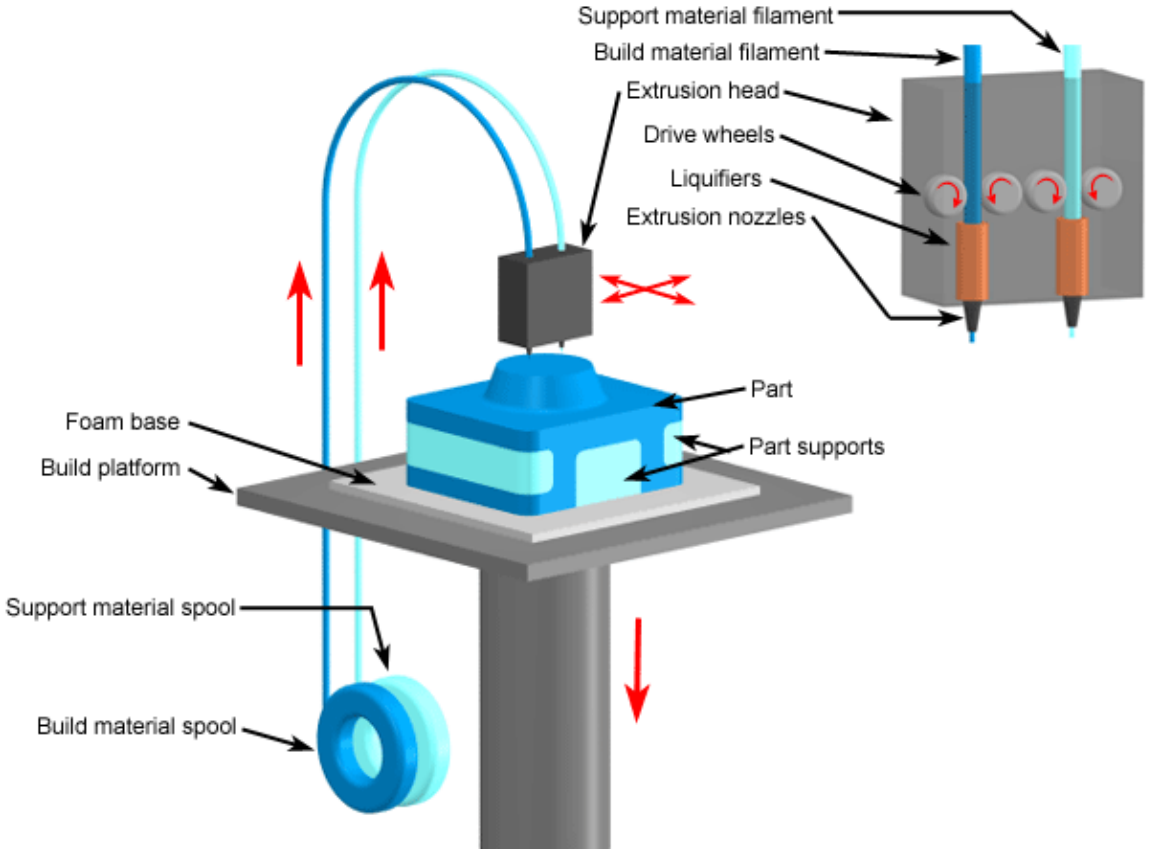


Figure Collection of parts produced by fused-deposition modeling.

Figure Fused deposition modelling machine.



Fused Deposition Modeling (FDM)

Fused Deposition Modeling (FDM) was developed by Stratasys in Eden Prairie, Minnesota. In this process, a plastic or wax material is extruded through a nozzle that traces the part's cross sectional geometry layer by layer. The build material is usually supplied in filament form, but some setups utilize plastic pellets fed from a hopper instead. The nozzle contains resistive heaters that keep the plastic at a temperature just above its melting point so that it flows easily through the nozzle and forms the layer. The plastic hardens immediately after flowing from the nozzle and bonds to the layer below. Once a layer is built, the platform lowers, and the extrusion nozzle deposits another layer. The layer thickness and vertical dimensional accuracy is determined by the extruder die diameter, which ranges from 0.013 to 0.005 inches. In the X-Y plane, 0.001 inch resolution is achievable. A range of materials are available including ABS, polyamide, polycarbonate, polyethylene, polypropylene, and investment casting wax.