

Fleximatter

The 3D Printing Industry Today

Additive Manufacturing, or 3D Printing, has exploded as an industry in the last decade, rapidly becoming a staple of rapid prototyping. Since its commercial inception in the nineties, the price of printing machines and printed products has decreased by two orders of magnitude, but it is still a technology better used for prototyping than production for most industries.

Today there are four main types of additive manufacturing, each with its own strengths and weaknesses.

	Stereolithography (SLA)	Selective Laser Sintering (SLS)	Polyjet™	Fused Deposition Modelling™ (FDM) / Fused Filament Fabrication (FFF)
Description	Starting with a vat of fluid resin, ultraviolet lasers trace the shape of the part, partially curing the resin layer by layer. The whole part is then further cured in a UV oven.	Fine powder particles of metal, glass, ceramic, or nylon are deposited in a thin layer before being sintered together at high temperatures using a laser.	Droplets of photopolymer are deposited in a layer then instantly cured by UV light. Layers are deposited until the part is complete. A trademark of Stratasys.	Thermoplastic filament is forced at high temperatures through an extruder, depositing one layer at a time. FDM is trademarked by Stratasys, FFF is a non-trademarked synonym.
Machine Price (USD)	\$3000-\$8000 for hobbyist machines, ~\$100 000 - \$500 000 for professional machines	~\$800 000	~\$300 000 - \$650 000	\$1000-\$5000 for hobbyist machines, \$20 000 - \$50 000 for professional machines
Material Price (USD)	\$60-\$120 a litre	Varies hugely by material	\$300-\$600/kg	\$40-100/kg
Strengths	Very fine resolution and tight tolerances, smooth finish, water resistant, large build volume	Large range of materials, higher temperature and chemical resistant materials, high strength parts	Best resolution, high tolerances, multi-material capability, multi-color capability, range of materials adapted for purposes (temp resistance, toughness, chemical resistance), fast	Lower material prices, strongest and most functional materials, fast, dimensionally stable parts. Some machines can use multiple heads to use more than one material.
Weaknesses	Uses hazardous chemicals, No mixed material capability, limited color capability, can require support structures, post processing for support structures,	High running costs, poor surface finish, post processing required, extremely high machine prices, hazardous materials	High machine prices high operating cost, humidity light and temperature can distort parts	Poor surface finish (ridge marks), strength anisotropy in Z axis, layer adhesion issues, lower tolerances, lowest resolution

	high prices, brittle parts			
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Challenges Facing the Industry

As the industry stands today, strength is sacrificed for savings and vice versa. Each technology has its strengths and weaknesses but no one option can yet tackle all or even most of the industry challenges at once.

- **MATERIAL PRICES**

The Polyjet™ and SLS materials require a large initial investment , although the leftover powders can be reused. SLA, while having lower material prices, uses hazardous materials which add containment and disposal costs to the total. FDM™/FFF have the lowest material prices at this moment in time, but the filament creation process still ensures a mark-up from the raw materials. The current extruder or jet technology is not compatible with using materials in a less processed form.

- **BUILD SPEEDS**

Printing focusing on high resolution uses fine nozzles and low extrusion levels, of the order of 40-80g per hour. While fine for prototyping, these speeds are not suited to production levels of manufacture, especially if operating and electricity expenses add more to the overall price.

- **MATERIAL STRENGTH**

FDM/FFF technologies have made great strides in improving material strength, and can produce dimensionally stable parts with almost production level qualities. The other technologies lag behind. One major concern is strength anisotropy throughout the part – the strength in the Z-direction can be 30-50% less than the strength in the X-Y plane.

- **MULTIPLE MATERIALS**

Polyjet printing has successfully combined more than one material in the same build, and while the finished result is visually stunning and excellent for prototypes, the functional properties and dimensional stability of the parts – and the high price – disqualifies it as an option for production runs.

FDM/FFF and SLA can use filaments and powders made from composites (e.g. Glass-Filled Nylon), but the material must be prepared and processed prior to the manufacturing process.

- **MACHINE PRICES/BUILD VOLUME**

Professional standard machine prices are extremely high, and while large build volume machines exist for each category the initial investment is far out of reach for many businesses. New desktop and hobbyist level

machines are constantly being developed, but their reduced price comes with a tiny build area. Reducing costs by printing in batches is not an option.

The Fleximatter Solution

Fleximatter is a FPF™ machine - fused pellet fabrication as opposed to fused filament fabrication - developed to tackle these industry challenges, and can drastically reduce both initial and operating costs while increasing build area and speed.

- **INNOVATIVE EXTRUDER DESIGN & CONTINUOUS EXTRUSION ALGORITHMS**

The patented extruder system works with the material being transported through the barrel with a central extruder screw to a nozzle. A valve in the extruder can completely open or close the nozzle, and a moving central section controls the amount of material extruded. The extruder barrel is heated to ensure correct material temperature.

This extruder design and the algorithms controlling it mean extrusion volumes of 1 kg/hour and higher can be reached. For comparison, a part that takes 10 hours to complete with the next fastest FDM/FFF process would take only 1 using Fleximatter. Operating costs such as electricity are reduced while production volume increases.

- **MATERIALS**

This extruder not only reduces the build time; it allows for raw materials to be used almost without reprocessing. Thermoplastics can be used directly in pellet form at a cost of only \$3/kg (for ABS), orders of magnitude cheaper than any of the available technologies.

Fleximatter is capable of working with a large range of thermoplastic materials. The entire ABS family has been tested and is the main testing material, but many other materials have resulted in successful prints. Polypropylene, Nylon, polycarbonate and thermoplastic rubber have all printed successfully. ABS-PC blends and glass fibre filled plastics have also produced functional parts.

- **EXTRUSION PLANE AND LAYER ADHESION**

Layer adhesion and Z-direction strength is too often a weakness of FFF/FDM printers. With Fleximatter, the layer adhesion strength is increased due to several processes:

- The increased build speed (10x that of FDM/FFF machines) means the previous layer has less time to fully solidify before the next layer is deposited
- The temperature of the deposited material is higher, making the join contact area smoother and requiring less post-processing to remove ridges or join-marks.
- A larger amount of material is deposited making a larger contact area and thus stronger bond between layers.

The strong adhesion between layers as well as patented algorithms for optimizing printing developed by Fleximatter means overhangs of up to 90 degrees (horizontal parts) can be printed without the use of

support structures, compared to the maximum recommended unsupported overhang of 45 for other FDM/FFF processes.¹

Fleximatter parts can produce larger and longer unsupported parts before needing to use support structures or 'rafts', giving cleaner surface finishes, and reducing the need and expense of post-processing.

- **PROPRIETARY MACHINE DESIGN**

Using accessible materials such as steel sheet, laser cut and CNC bended according to a proprietary design, the final machine cost is estimated at \$5,000-\$10,000. The available build volume is 900x800x600mm, comparable to large professional machines (1000 x800 x 800mm) at a fraction of the price. The final machine cost is nearing desktop machine levels, with a typical build area of 200x200x200mm. The structure of the machine is easily customizable and increasing build areas by 10-20% should be possible.

In conclusion, due to the patented extrusion technology and algorithms, the build speed and material costs can be optimized to prepare 3D printing for production, while the reduced price of the machine make production accessible to more businesses.

¹[Source:](#) Cockrell School of Engineering, University of Texas: Tips for Designing 3D printed parts