Journal of Manufacturing Engineering, June 2015, Vol. 10, Issue. 2, pp 103-111

OVERVIEW OF RAPID PROTOTYPING TECHNOLOGIES: 3D PRINTING

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ABSTRACT

Rapid prototyping is an additive manufacturing. It is a layered manufacturing. It is different from subtractive manufacturing process. In Rapid Prototype manufacturing, the physical object is obtained directly from geometric 3D CAD model with the help of computer by using Catia or Pro/e or Creo software. It is the latest amazing manufacturing and revolutionized manufacturing industry. It is a new manufacturing process in engineering. Rapid prototyping is a unique in manufacturing. It is a new development in manufacturing. It is different from conventional and unconventional machining process. Rapid prototyping is a fast emerging technology in product development. Rapid prototyping is a useful tool. It produces the products at faster rate and at lower cost than conventional manufacturing systems. One of the most exciting innovations is 3D –Printing. It is recently emerged in mechanical engineering at MIT, USA. 3-D printing offers the realistic possibility that anyone, anywhere in the world can produce any object they need on demand. 3D Printing machines have shorter manufacturing time, lower costs and better surface quality of part. The 3D-Printing Technology is fast developing one with tremendous market potential. In this paper over view of composites, 3D-Printing, advantages, disadvantages and its future scope will be discussed.

Keywords: *3D Printing, Rapid Prototyping, Stereo lithography, Selective laser sintering, Fused Deposition Modelling*

1. Introduction

Traditional fabrication methods involve a great deal of effort, expense, and time. Until recently, prototypes had to be constructed by skilled model makers from 2D engineering drawings. This is a time consuming and expensive process. Rapid prototyping and 3-dimensional printing remove some of the time and expense from the process of creating new commercial and industrial objects. But in Rapid prototype manufacturing, a physical object is obtained directly from CAD model due to set of processes. It is an additive and layering manufacturing process instead of removing material. It does not need any cutting tool to manufacture a product. It is different from conventional and unconventional machining process. It is a new development to manufacture the prototypes, parts and tool[1]. Prototypes are made easily and quickly by using new methods. With the advent of new layer manufacturing and CAD/CAM technologies, prototypes may now be rapidly produced from 3D computer models. There are many different rapid prototyping (RP) technologies available. This paper presents an overview of the current technologies and comments on their strengths and weaknesses. Data are given for common process parameters such as layer thickness, system accuracy and speed of operation. Taxonomy is also suggested along with a preliminary guide to process selection based on the end use of the prototype.

2. History

Rapid prototyping is not a new technology. It is started by Professor Herbert Voelker from University of Rochester, in the late 1960s. His efforts resulted in mathematical models and algorithms. His designed tools used today and made rapid prototyping is possible. The first methods for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Then in the mid-80s University of Texas researcher Carl Deckard came up with the idea of printing objects layer by layer. The first commercial rapid prototyping machines using this layering technique were produced in 1987 by 3D Systems and unveiled to the public at the AUTOFACT trade show in Detroit in November of that year. This technique is still in use today. Stereolithography Apparatus (SLA) was developed by Charles W. Hall in 1986. Selective Laser Sintering (SLS) was developed by Carl Deckared and Joseph Beaman of MED. Fused Deposition Modelling (FDM) was developed by S. Scott Crump in the late 1980s and was commercialized in 1990 by Stratasys. Inc. Eden Prairie MN, Ciraud (1972) considered magnetostatic or electrostatic deposition with electron

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beam, laser or plasma for sintered surface cladding. 3D Printing or Additive manufacturing Swainson (1977) Schwerzel (1984) worked on polymerization of a photosensitive polymer at the intersection of two computer controlled laser beams. These were all proposed but it is unknown if working machines were built. Hideo Kodama of Nagoya Municipal Industrial Research Institute was the first to publish an account of a solid model fabricated using a photopolymer rapid prototyping system (1981). Even at that early date the technology was seen as having a place in manufacturing practice. A low resolution, low strength output had value in design verification, mould making, production jigs and other areas. Outputs have steadily advanced toward higher specification uses.

3. Basics of Rapid Prototyping Technology

There are several rapid prototyping techniques. But all techniques employ the following five steps:

1. First create a CAD model of the design
2. Convert the CAD model to STL format.
3. Slice the STL into thin cross sectional layers.
4. Construct the model one layer atop another.
5. Clean and finish the model

Principle of RP

Rapid prototyping is unique in the sense that the prototype part is produced by adding material rather than removing material, as in conventional machining process. The RP generates physical object directly from a geometric model of the object. A 3D object is represented as 2D by cutting it into thin slices with the help computer software. Therefore, 2D layer manufacturing generates a 3D object in RP. The produced 2D slices are glued over one another to set the desired 3Dobjects. The steps are as follows:

1. Model the parts by a surface/solid modeler (geometric modeler)

2. Section the parts (slicing) mathematically using software. Generate a series of such parallel cross-sections. For each layer generate appropriate command (process plan) for the RP apparatus. This process is quite analogous to numerical control (NC) tool path generation. In both cases the planning task involve generation of the tool path and associated commands such as rapid, movement of tool, etc.

3. Generate curing/binding path for these pieces.

4. Use RP machine for producing the prototype. Use curing/binding path, generated in the earlier step to decide the solidification or binding a thin sheet of material. Develop a new layer either by deposition of material or selective phase transformation of appropriate material.

5. Generate a new layer using step (3) to (4)

6. Repeat step (5) till complete prototype is developed in a 3D form.

4. Applications of Rapid Prototyping

Rapid prototyping is widely used in the automotive, aerospace, medical and product industry. The applications are limitless. They fall into following categories: Prototyping, rapid tooling and rapid manufacturing.

Prototyping

The primary use of rapid prototyping is to make prototypes for communication and testing. Prototypes improve communication including engineers, find 3D objects easier to understand than 2D drawings. Such understanding leads substantial saving in cost and time. Prototypes are useful for testing of design. It performed for improving the design. Engineers always test prototypes. Testing is easy in prototyping than traditional.

Rapid tooling

With the emergence of RP systems, the concept of Rapid Tooling (RT) has arrived. The challenge and greatest potential for RP lies in providing a direct integrated route to tooling through reduced lead-time and production cost. Even though Rapid Prototype parts may be produced directly in layers, most Rapid Tooling's are produced indirectly. In Rapid Tooling, there are two categories:

1) Soft tooling

2) Bridge tooling.

Soft Tooling is made out of Silicon Rubber Resin and due to its flexibility it is called Soft Tooling (also called Silicon Rubber Mould). Silicon Rubber Mould is used to produce plastic prototype components (out of Polyurethane Resin) and in some cases wax patterns also for further Investment Casting.

Bridge Tooling is an intermediary between Soft Tooling and Hard Tooling, both on count of strength and production. Here the die is produced by spraying low melting alloys over the RP Master and by providing back up materials like Epoxy Resin around it. In comparison to Soft Tooling, this is a longer process and more durable, which can withstand limited injection pressure. Dies produced through this route, die can be used for production of components of commercial plastics (can produce around 3000 pieces) and wax patterns for investment casting. This process may also be used for prototype sheet metal forming.

Rapid Manufacturing

Rapid Manufacturing is an additive fabrication technique for manufacturing solid objects by the sequential delivery of energy and/or material to specified points in space to produce that part. Current practice is to control the manufacturing process by computer using a mathematical model created with the aid of a computer. Rapid Manufacturing done in parallel batch production can provide a large advantage in speed and cost compared to alternative manufacturing techniques such as plastic injection molding or die casting. Rapid Manufacturing may involve custom parts, replacement parts, short run production, or series production.

Rapid Manufacturing for large products with layer-based manufacturing from metals, plastics, or composite materials is well known for several industrial applications in the military (MPH-Optomec) and aerospace (Boeing) sectors. Small products and microsystem applications are known in medical (Siemens) as well as consumer electronics, diagnostics and sensor technologies (microTEC). Batch production of very small parts by rapid manufacturing techniques like RMPD offer cost and time advantages. Increasingly, rapid manufacturing is being applied to automotive, motor sports, jewelry, dentistry, orthodontics, medicine and collectibles.

Additive Manufacturing is the process of making a product by adding layers in a relatively efficient way, such that there is little waste or reduction of materials [3]. Two examples are inkjet printing and aerosol jet printing of electronic circuits. In comparison to photolithography where the manufacturer must remove much of the material that is deposited to create a given layer of the product, inkjet and aerosol jet printing only use material where it is needed with little or no waste.

In this technique, a solid model of the component to be fabricated is made either by 3D imaging system or by designer using computer-aided design (CAD) software or by math data as an output of numerical analysis. Thus obtained model is sliced into thin layers along the vertical axis. The thin layers are converted into corresponding numerical controlled (NC) code and are sent to Laser Rapid Manufacturing (LRM) station in suitable format. LRM station employs a laser beam as a heat source to melt a thin layer on the surface of the substrate/deposited material and fed material to deposit a new layer as per shape and dimensions defined in NC code. A number of such layers deposited one over another and it results in three-dimensional (3D) components directly from the solid model.

Benefits

LRM eliminates many manufacturing steps such as materials-machine planning, man-machine interaction, intermittent quality checks, assembly and related human errors etc. Therefore, LRM offers many advantages over conventional subtractive techniques, such as reduced production time, better process control and capability to form functionally graded parts. It is also an attractive candidate for refurbishing applications because of low heat input, limited dilution with minimal distortion and capability of adding finer near-net shaped features to the components.

Future Developments of RP Technology

The future of rapid prototyping used for “printing” 3D models of engineering parts direct from designs on a computer screen depends on being able to turn out real components made of real materials instead of plastic look-alikes. Instant one-step manufacturing is the goal. Rapid prototyping is a new name for a group of techniques that have largely been developed during the last ten years. They involve producing parts by adding layers of material on top of each other to build a complete model. The research involved on these techniques is mainly being undertaken in North America, Europe and Japan, with many new advances occurring each year. There is still much scope for work in developing new rapid prototyping techniques and applications for the parts produced from them. The impact of these techniques on manufacturing is only just being recognized, but during the next few years academia and industry will accept them as a valuable addition.

5. 3D Printing

It is known as additive manufacturing (AM) or direct digital manufacturing (DDM). It is a leaner and greener technology. 3-D printing was originally developed for rapid prototyping purposes, making one or two physical samples. It allowed designers to identify and correct design flaws quickly and cheaply, thereby speeding up the product development process and minimizing commercial risks. It is different from traditional “subtractive” manufacturing processes where materials are cut away to produce a desired form. It minimizes the waste and it uses required amount of material to make the part. 3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file [4]. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the entire object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object.

3D Printing working

It all starts with making a virtual design of the object you want to create. This virtual design is made in a CAD (Computer Aided Design) file using a 3D modeling program (for the creation of a totally new object) or with the use of a 3D scanner (to copy an existing object). This scanner makes a 3D digital copy of an object and puts it into a 3D modeling program.

To prepare the digital file created in a 3D modeling program for printing, the software slices the final model into hundreds or thousands of horizontal layers. When this prepared file is uploaded in the 3D printer, the printer creates the object layer by layer. The 3D printer reads every slice (or 2D image) and proceeds to create the object blending each layer together with no sign of the layering visible, resulting in one three dimensional object.

Methods and technologies of 3D Printing

Not all 3D printers use the same technology to realize their objects. There are several ways to do it and all those available as of 2012 were additive, differing mainly in the way layers are build to create the final object. Some methods use melting or softening material to produce the layers. Selective laser sintering (SLS) and fused deposition modeling (FDM) are the most common technologies using this way of printing. Another method of printing is to lay liquid materials that are cured with different technologies. The most common technology using this method is called stereo lithography analysis (SLA).

Three dimensional printing (3d printing)

It was developed at the mechanical engineering department of the Massachusetts institute of technology (MIT) at USA. The technology is quite similar to the selective laser sintering (SLS) process. The 3D model of the product is sliced into layers of 2D cross-sections. Ink-jet type of computer printer is used in this method. For a given 2D cross-section, a layer of powder is spread over a piston type of arrangements, which moves down wards in the cylinder. An ink-jet printer, which is driven by a stepper motor and a xy positioning device, is used here. This is controlled by a central computer. The printing injects binder material droplets over the powder bed (which is laid on the piston head). The droplets are injected only over those portions where solidification is needed in the 2D-CAD-generated slice. After this, the piston moves slightly down in the cylinder. Next layer of powder is spread over this. Again the printer moves in the predefined X-Y path to spread binder (glue) material. The process is repeated till entire thickness of job (i.e z-coordinate) is complete. Excess powder, which is not glued, is removed. The glued job, which is bound is further heat treated for about 2 hours at 120^0C (for ceramic powder) to improve the layer-bonding. For binding the use of amorphous or colloidal silicon carbide has been used. At MIT, HP ink-jet printer has been used. The process has been used to fabricate high temperature resistant ceramic molds and ceramic composites. Layer thickness is up to 175 micro meter, part size up to 12’’x12’’x24’’ has been developed so far. The speed of the process is about 2 seconds per layer of about 100 micro meters.

Advantages of RP

Rapid prototyping offers many advantages to its users. These are:

1. It offers direct manufacturing from CAD (computer aided design) files and sketches.
2. It is paperless manufacturing.
3. Very fast development of functional parts is possible. Therefore, it offers tremendous potential in new product development.
4. For conventional metal casting, master part is needed for moulds. RP provides a quicker way to manufacture these. For plastic parts also, RP is a useful process. In the investment casting, wax may be used as material to be deposited in RP.
5. RP may be used to test the suitability of a functional part during early development of a product. Initial defects in design may be detected and rectified.
6. Before, any product is commercialized few pieces are tested for performance and customer’s acceptability. If this is done after procuring high cost dedicated machines, there are risks in the event of product failure. Few pieces made by RP may be used for the test and specimens.
7. It is very useful and effective tool for the physical visualization of design.
8. RP can be used to test the assemblies for the intended functions and interface with related elements.
9. RP is used to develop parts (as prototypes) which may be used for initial testing, such as photo elastic tests. Polymers, which are very common material used in RP, are highly suited for the photo elastic tests of material.
10. RP parts can be used as a template for copy-milling machine.
11. It reduces lead time to produce prototype component.
12. It offers greater capability to compute mass properties of components and assemblies.

Limitations of RP

1. It is still in developing stage. Only few proprietary plastic materials are being used in RP.
2. It is fast emerging technology for other materials such as metal and alloys.
2. P does not offer good surface finish.
3. It does not give good dimensional accuracy.
4. It is not a perfect process
5. Part volume is limited.
6. Machines for RP are very costly and it is difficult for small and medium size firm to afford. However, with emerging technologies, the cost is expected to fall in future.

Selective Laser Sintering (SLS)

Selective laser sintering is a challenging additive fabrication (AF). SLS offers the freedom to quickly build complex parts. SLS part are more durable and provide better functionality over other rapid prototyping technologies. When you compare SLS technology to Stereo lithography analysis (SLA), SLS differs in that the material is a powder rather than a photo curable liquid resin cured by UV light. This means your SLS parts will remain stable over time instead of degrading and becoming brittle from light absorption as SLA parts do. Complex parts with interior components, channels, and other features can be built without trapping material inside and altering the surface from support removal. Conversely, SLA parts are built in a vat of liquid and parts do require a support structure to facilitate the build. Internal features are often hard to build and post process as the support structures must be removed. When SLS is compared to Fused Deposition Modeling (FDM), they both have good durability and can work very well as functional prototypes or end-use parts. However, the FDM process has its limitations of strength in certain build directions as fused "walls" can be strong in one direction but extremely brittle in another. Additionally, the SLS process is faster, more affordable and can build smaller features that are crisper and more accurate than FDM. SLS materials have evolved over the years and they can be used for different applications. If strength, durability and functionality are required, we can offer black or white Duraform™ EX, Duraform PA and GF. These three materials are the majority of the SLS business for APP and provide an excellent solution for many applications including aerospace, automotive, and consumer products. Duraform EX has proven to be the best direct AF material to produce snap-fits and living hinges – that actually work for many cycles! If a customer has the need to build a part that requires a low durometer to simulate rubber hoses, gaskets or seals, then Duraform Flex is a perfect fit. SLS Cast Form Wax allows for the production of investment casting patterns direct from 3D CAD data without tooling. SLS continues to be one of my favorite AF technologies because of the diverse materials offered and wide array of applications. It is a challenging technology that continues to deliver strong, functional parts from production like materials for a wide array of customers.

Laminated Object Manufacturing

Laminated Object Manufacturing (LOM) machine works by actually cutting the slices of the object out of a sheet of paper foil and then bonding them together. The foil comes off the material supply roll and the laser then cuts around the outline of the layer. It also hatches the foil around the edge so that this can be easily broken away when all of the layers have been bonded together. After the laser has cut out the top layer, a heated roller moves over the top of the foil to bond the layer to rest of the object. A sensor is used to measure the thickness of the foil as this can vary and the machine will automatically adjust the dimensions of the layer being cut to account for any variation the result is a part that looks like laminated wood. The further development of the concept of layering manufacturing has resulted in creation of systems utilizing metal sheets as a building material.

Some of the uses of rapid prototyping are

1. Check the feasibility of new design concepts.
2. Conduct market tests/evaluation
3. Assess the fit of complex mechanisms.

Table.1 Summary of RP Technologies

System	Max. build size (mm)	Accuracy (mm)	Compa-rative cost	Compa-rative build time	Materials	Advantages	Disadvantages
Stereo lithography	508x 508x 600	0.1-0.2	1	1	Liquid photo sensitive resins.	High accuracy, medium range of material large build size	High cost, Process, support structure needed, post cure required
Selective laser sintering	380x 330x 420	0.1-0.2	1	1	Nylon based materials elastomer, rapid steel, cast form, sand form.	Large range of material, good accuracy, large builds size.	High cost process poor surface finish
Fused Deposition Modelling	254x 254x 254	0.1-0.2	0.3	1	ABS, elastomer and wax.	Good accuracy, functional materials, medium range of materials,office friendly.	Support structures needed

4. Promote concurrent product development.
5. Make many exact copies simultaneously.
6. Make moulds for wax cores in castings.
7. Use as a master for silicon and epoxy moulds.

A comparative evaluation of these processes is given in table.1

3D Printing

3D printing technology is immensely popular, and is making rapid advancements. 3D printing technology was introduced in the 90s and since then, several advances have been made. 3D printing can print 3D objects of widths smaller than the diameter of a strand of human hair, and with greater precision. 3D printing employs layered printing to create tangible objects using digital 3D models. In other words, if you possess the blueprint (CAD file) of an object, say a cup, a toy car, or the Eiffel Tower, you can print it in three dimensions. This means you can 'print' a miniature replica of the famous monument in Paris, or a real cup that you can use to enjoy your favorite coffee! The raw materials used for 3D printing, include plastics, wood, paper, resin, and glass. Now, imagine seeing your imaginations come to life, with you doing nothing but creating the design using 3-dimensional design software. Isn't it amazing? Well, it's almost too good to be true.

3D printing is the latest craze in the technology. In fact businesses see a huge potential in this technology. For those that are not familiar with this innovative idea, the idea is the same as paper printing. You need to have your 3D design, input it into the machine and the machine will create a prototype of the design. The prototype is built layer by layer according to the design using either particle or liquid raw material. However, just like other technologies, 3D printing can have its pros and cons. Let us now look at the pros and cons of using 3D printing.

Pros of 3D printing

The pros of using 3D printing would include making processes finish faster. In a design company for example, the usual process would be first come up with the design of the new product. Once the design has been approved, they send the design to a third party company to make the prototypes. The prototypes would be sent to the company for final checking and modifications. Overall, this would take weeks. With the help of 3D printing, this process would be shortened because once the company has the design they can just make the prototype on their own.

The next advantage would deal with safety issues. Most of the time making the prototype is done manually. Whatever the machine can’t do, this is done manually. This is to ensure that all the details of the design have been included and also to ensure the quality of the prototype being produced. Aside from the longer time spent in manual work, injury is also a big possibility especially to the person making the prototype. There are companies who make prototypes using big machines but the operation of these machines requires personnel. They are still prone to danger. Using the 3D printer would significantly reduce the level of danger to those who are making the prototypes.

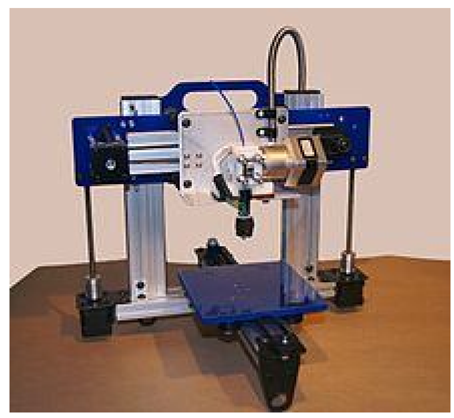

Fig.1 an ORDbot Quantum 3D printer

Cons of 3D printing

One of the disadvantages of using 3D printing is the possible manufacturing of dangerous weapons. As we all know, anyone can get almost anything from the internet – including designs of dangerous weapons. If these design fall into the wrong hands especially those that have 3D printer, they could make dangerous weapons easily. Aside from that, 3D printing could also be used for counterfeiting. Designs of different objects can easily be duplicated and sold as counterfeits by unsuspecting customers.

Lastly, mass production of 3D printers could replace cheap labor. This could be advantageous for manufacturing companies because they can save cost in the long run. However, many people would lose jobs especially those that are working in the prototyping industry. Most of the workers in this industry know only this skill and they might have a hard time shifting to other industry. Before mass producing 3D printing, the pros and cons should be reviewed by experts. They should see to it that the technology helps the entire population and not only a small sector of the society.

Merits and Demerits of 3D Printing

In spite of the huge hype surrounding 3D printing and how it's on its way to revolutionize the way we manufacture products, it has its own share of disadvantages. Here we shall look at both sides of the coin.

Merits

Manufacture of Customized Products: With 3D printing technology, manufacturing became easier. Now, anyone can manufacture any product using 3D printer and with desired raw material.

Rapid Prototyping: 3D printing technology can manufacture component in a short time.

Improved Life Quality & Welfare: 3D printing has the potential to increase the quality of life and welfare since any essential parts or models can easily be created for the use of education, medical & health, military, automotive, lifestyle and a variety of other purposes.

Eco-friendly: 3D printing is also considered environment friendly since it produces less waste compared to other techniques.

Ability to customize products: Customization is the norm when it comes to 3D printing. With the desired raw material, a 3D printer, and the required blueprint, one can "manufacture" any object, with the specifications and design of any choice.

Rapid production of prototypes: 3D printing enables quick production of prototypes or small-scale versions of the real object. This helps researchers and engineers plan the actual object and catch any design flaws that may affect quality and functionality.

Low cost of production : Although the initial cost of setting up a 3D printing facility may be high, the overall savings in the form of labor costs, time saved, and equal effort for small-scale and mass manufacturing ensures that the cost of production is relatively low.

No storage cost: Since 3D printers can "print" products as and when needed, and does not cost more than mass manufacturing, no expense on storage of goods is required.

Increased employment opportunities:

Widespread use of 3D printing technology will increase the demand for designers and technicians to operate 3D printers and create blueprints for products.

Quick availability of organs: The long and often traumatic wait for an organ donor could come to an end with advances in bioprinting or manufacture of 3D printed organs. Research is on to create bioprinters that can create living organs along with the structural lattice for the organ using the patient's own cells and tissues.

Disadvantages of 3D printing

Violation of copyrights: Technology such as this can be misused resulting in the rise of many ethical concerns. As any desired object can be printed, an owner of a 3D printer can print objects that are protected by copyrights. By cutting off the availability of 3D printer design of the protected work can help to protect the copyrights. However, it is nearly impossible to remove the availability of all the existing design files on the internet.

Harm authenticity: 3D printing will also give rise to copyright infringement increasing the amount of counterfeit products that will damage the authenticity and demand for many brands. As a result, many businesses producing a unique product may suffer from the growth of 3D printing.

Printing Weapons: Another major disadvantage is the ability to print dangerous objects such as plastic guns, knives, or any other object that could be used as a weapon. This transformation technology will make it easier for criminals and terrorists to bring weapons in public places such as an airport with ease and without the possibility of detection.

Scan & Fraud

3D printers can be used to scan and print I.D. and credit cards, car keys, as well as a multiplicity of other private belongings.

1. Intellectual property issues: The ease with which replicas can be created using 3D technology raises issues over intellectual property rights. The availability of blueprints online free of cost may change with for-profit organizations wanting to generate profits from this new technology.

2. Unchecked production of dangerous items: Liberator, the world's first 3D printed functional gun, showed how easy it was to produce one's own weapons, provided one had access to the design and a 3D printer. Governments will need to devise ways and means to check this dangerous tendency.

3. Limitations of size: 3D printing technology is currently limited by size constraints. Very large objects are still not feasible when built using 3D printers.

4. Limitations of raw material: At present, 3D printers can work with approximately 100 different raw materials. This is insignificant when compared with the enormous range of raw materials used in traditional manufacturing. More research is required to devise methods to enable 3D printed products to be more durable and robust.

5. Cost of printers: The cost of buying a 3D printer still does not make its purchase by the average householder feasible. Also, different 3D printers are required in order to print different types of objects. Also, printers that can manufacture in color are costlier than those that print monochrome objects.

3D printing becomes industrial strength. Once reserved for prototypes and toys, 3D printing will become industrial strength. You will take a flight on an airliner that includes 3D-printed components, making it lighter and more fuel efficient. In fact, there are aircrafts that already contain some 3D-printed components. The technology will also start to be adopted for the direct manufacture of specialist components in industries like defense and automotive. Overall, the number of 3D printed parts in planes, cars and even appliances will increase without you knowing.

3D printing starts saving lives. 3D-printed medical implants will improve the quality of life of someone close to you. Because 3D printing allows products to be custom-matched to an exact body shape, it is being used today for making better titanium bone implants, prosthetic limbs and orthodontic devices. Experiments in printing soft tissue are underway, and may soon allow printed veins and arteries to be used in operations. Today's research into medical applications of 3D printing covers nano-medicine, pharmaceuticals and even printing of organs. Taken to the extreme, 3D printing could one day enable custom medicines and reduce if not eliminate the organ donor shortage.

Customization becomes the norm. You will buy a product, customized to your exact specifications, which is 3D-printed and delivered to your doorstep. Innovative companies will use 3D printing technologies to give themselves a competitive advantage by offering customization at the same price as their competitor's standard products. At first this may range from novelty items like custom smart phone cases or ergonomic improvements to standard tools, but it will rapidly expand to new markets. The leaders will adjust their sales, distribution and marketing channels to take advantage of their capability to provide customization direct to the customer. Customization will also play a big role in healthcare devices such as 3D-printed hearing aids and artificial limbs.

Product innovation is faster. Everything from new car models to better home appliances will be designed more rapidly, bringing innovation to you faster. Because rapid prototyping using 3D printers reduces the time to turn a concept into a production-ready design, it allows designers to focus on the function of products. Although the use of 3D printing for rapid prototyping is not new, the rapidly decreasing cost, improved design software and increasing range of printable materials means designers will have more access to printers, allowing them to innovate faster by 3D printing an object early in the design phase, modifying it, re-printing it, and so on. The result will be better products, designed faster.

New companies develop innovative business models built on 3D printing. You will invest in a 3D printing company's IPO. Start-up companies will flourish as a generation of innovators, hackers and "makers" take advantage of the capabilities of 3D printing to create new products or deliver services to the burgeoning 3D printer market. Some enterprises will fail, and there may be a boom-bust cycle, but 3D printing will spawn new and creative business models.

3D print shops open at the mall. 3D print shops will begin to appear, at first servicing local markets with high-quality 3D printing services. Initially designed to service rapid-prototyping and other niche capabilities, these shops will branch into the consumer marketplace. As retailers begin to "ship the design, not the product," the local 3D print shop will one day be where you pick up your customized, locally manufactured products, just like you pick up your printed photos from the local Walmart today.

Heated debates on who owns the rights emerge. As manufacturers and designers start to grapple with the prospect of their copyrighted designs being replicated easily on 3D printers, there will be high-profile test cases over the intellectual property of physical object designs. Just like file-sharing sites shook the music industry because they made it easy to copy and share music, the ability to easily copy, share, modify and print 3D objects will ignite a new wave of intellectual property issues.

New products with magical properties will tantalize us. New products – that can only be created on 3D printers – will combine new materials, nano scale and printed electronics to exhibit features that seem magical compared to today's manufactured products. These printed products will be desirable and have distinct competitive advantage. The secret sauce is that 3D printing can control material as it is printed, right down to the molecules and atoms. As today's research is perfected into tomorrow's commercially available printers, expect exciting and desirable new products with amazing capabilities.

New machines grace the factory floor. Expect to see 3D printing machines appearing in factories. Already some niche components are produced more economically on 3D printers, but this is only on a small scale. Many manufacturers will begin experimenting with 3D printing for applications outside of prototyping. As the capabilities of 3D printers develop and manufacturers gain experience in integrating them into production lines and supply chains, expect hybrid manufacturing processes that incorporate some 3D-printed components. This will be further fueled by consumers desiring products that require 3D printers for their manufacture.

"Look what I made!" Your children will bring home 3D printed projects from school. Digital literacy – including Web and app development, electronics, collaboration and 3D design – will be supported by 3D printers in schools. A number of middle schools and high schools already have 3D printers. As 3D printing costs continue to fall, more schools will sign on. Digital literacy will be about things as well as bits.

6. Conclusion

Rapid prototyping is a fast emerging technology in product development by using CAD model with the help of computer. Rapid prototyping is a useful tool. It produces the products at faster rate and at lower cost than conventional manufacturing systems. In present market there is tremendous pressure on new developments at faster rates and at lower costs. Hence the utility of RPT is also really tremendous. With this, the prototype may be quickly developed from 3D – CAD drawing. The fabricated parts may be analysed for features, colour look etc. It uses generative principle of rapid prototyping to produce parts of any geometry. These processes are used for production of complex shapes. They can produce both positives (parts) and negatives (dies and molds). The final conclusion of differences between mentioned methods is better for 3D printing because of shorten time, lower costs and better surface quality of part. On the other hand there are higher purchase costs of machine. The RP Technology is fast developing one with tremendous market potential.

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