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3D Printing: The Next Industrial Revolution

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Abstract— This is a in research paper on 3D printing which has become a notable topic in today's world. In this paper, we will look at additive manufacturing or 3d printing. We will firstly define what is actually 3d printing and we will see what is so significant about it. We will delve a bit into history. Then we shall see about the process of 3D printing and the materials used in the manufacture of 3D printed objects. We shall also see the advantages as well as applications of 3D printing as compared to conventional methods of manufacturing as well as disadvantages of it. We shall observe the numerous applications it is being out to use today and effect of 3d printing globally and it's situation in Indian Market.

Keywords—"3d printing, additive manufacturing, revolution, prototypes, material, layers, CAD, CAM"

I. INTRODUCTION.

I'll first explain why I've added the extra phrase 'the next industrial revolution' next to 3D printing. The Industrial revolution is the transition of old manufacturing processes into modern manufacturing processes. The industrial revolution took place from about 1760 to sometime between 1820 and 1840. This transition included going from hand production methods to machines, new chemical manufacturing and iron production processes, the increasing use of steam power, the development of machine tools and rise of factory system. Now coming to the topic, The 3d printing technology have made possible the manufacturing of components, prototypes, food and even structure and many other things by the way of additive manufacturing.

Now, in order to understand additive manufacturing method, we have to understand the method of subtractive manufacturing. Subtractive manufacturing is the method of manufacturing a component out of a block. We start with a metal block and by removing the material we end up having our component. Additive Manufacturing is contrast to this process. In additive manufacturing component is made by adding material in form of layers.

Need of additive manufacturing or 3d printing is arise from limitations of traditional manufacturing methods. There are number of limitations to traditional manufacturing methods which has widely based on human labour and made by hand ideology. However, world of manufacturing has changed and automated processes like machining, casting forming etc are introduced but these are all relatively new, complex processes that require machines, computers and robot technology. However, these technologies all demand subtracting material from a larger block to achieve the end product itself or to produce a tool for casting or moulding processes and this is a serious limitation within the overall manufacturing process. It also requires the expensive tooling, fixtures, and the need for assembly for complex parts. Also, the subtractive manufacturing processes can result in up to 90% of the original block of material being wasted.

3D printing is a technology that encourages and drives innovation with design freedom. It is a tool-less process that reduces prohibitive costs and lead times. Components can be made without assembly requirements with intricate geometry and complex features. It is energy efficient technology.

II. History

The technology for printing physical 3D objects from digital data was first developed by Charles Hull in 1984. He named the technique as Stereo lithography and obtained a patent for the technique in 1986. While Stereo lithography systems had become popular by the end of 1980s, other similar technologies such as Fused Deposition Modelling (FDM) and Selective Laser Sintering (SLS) were introduced. In 1993, Massachusetts Institute of Technology (MIT) patented another technology, named "3 Dimensional Printing techniques", which is similar to the inkjet technology used in 2D Printers. First 3 D Printer was launched in 1998. First 3D colour printer was launched in 2000. Introduced High definition 3D Printing in 2005. HD3DP concept is the result of a combination of print-head technology, materials advancement, firmware, and mechanical design.

III. Principles Of 3D Printing

The main principle of 3D printing is stereolithography, which was introduced by Charles Hull in which means that any 3D object generated using a 3D drawing software is first split into layers and these layers are then successively printed by the machine on top if one another. Step one of 3D printing is the generation of a 3D printable model. This model is generated using a computer aided design software (CAD) or via a 3D scanner. A real life object is scanned to get a 3D model. Then the STL file is generated by converting the design through converting software. You can customize various aspects of the design such as the layer thickness, temperature, and outer finish, etc. Once the STL file is generated, then the object is ready to be printed.

After the designing step comes the printing part. The converted STL file is fed into the printer and according to the layers we have obtained, the machine starts out laying the plastic out layer by layer. The material need not be plastic but it can be anything ranging from liquid, powder, paper or sheet material. The layers are automatically fused to get the final shape. Its advantage over conventional machining techniques is that it can be used to create almost any geometric shape. The object may take anywhere from several minutes to several hours to complete depending on the size and complexity of n the model and also on the type of machine used. Some additive manufacturing techniques are capable of using multiple materials to construct parts. They can also use multiple colour combinations simultaneously. In case there are projecting parts in the model, supports are used like scaffolding until the overhanging part sufficiently hardens. These supports can be dissolved in water when the model is printed.

IV. Working Of 3D Printers

It all starts with making a virtual design of the object you want to create. This virtual design is for instance a CAD (Computer Aided Design) file. This CAD file is created using a 3D modeling application or with a 3D scanner (to copy an existing object). A 3D scanner can make a 3D digital copy of an object.

A. 3D scanners

3D scanners make use of different technologies to generate a 3D model. Examples are: time-of-flight, structured / modulated light, volumetric scanning and many more. Recently, companies like Microsoft and Google enabled their hardware to perform 3D scanning, for example Microsoft's Kinect. In the near future digitising real objects into 3D models will become as easy as taking a picture. Future versions of smart phones will probably have integrated 3D scanners. Currently, prices of 3D scanners range from expensive professional industrial devices to $30 DIY scanners anyone can make at home.

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B. 3D modelling softwares

3D modelling software also comes in many forms. There's industrial grade software that costs thousands a year per license, but also free open source software, like Blender, for instance.

TABLE I
3D MODELLING SOFTWARES

SolidWorks	Maya	RapidForm	3D Studio Iz
PRO/ENGNEE	SketchU	Alias	FormZ
CATIA	RasMol	RaindropeoMagic	VectorWork
3D Studio Max	Rhino	Inventor	Mimics

When you have a 3D model, the next step is to prepare it in order to make it 3D printable.

C. From 3D model to 3D Printer

You will have to prepare a 3D model before it is ready to be 3D printed. This is what they call slicing. Slicing is dividing a 3D model into hundreds or thousands of horizontal layers and needs to be done with software.

Sometimes a 3D model can be sliced from within a 3D modelling software application. It is also possible that you are forced to use a certain slicing tool for a certain 3D printer. When the 3D model is sliced, you are ready to feed it to your 3D printer. This can be done via USB, SD or wifi. It really depends on what brand and type 3D Printer you have.

When a file is uploaded in a 3D printer, the object is ready to be 3D printed layer by layer. The 3D printer reads every slice (2D image) and creates a three dimensional object.

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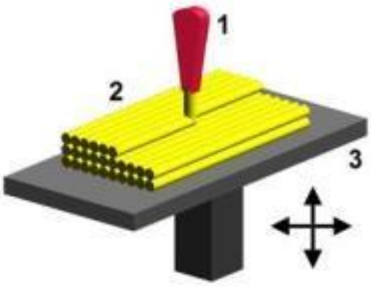
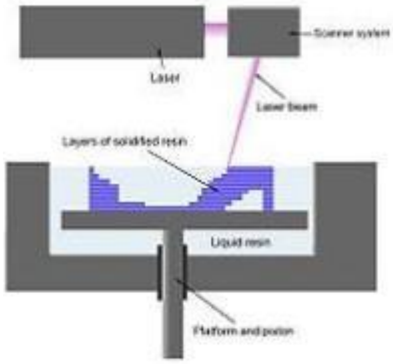
V. Types Of 3D Printing Methods

I. FDM – Fused Deposition Modelling



A plastic filament or metal wire is unwound from a coil and supplies material to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism, directly controlled by a computer-aided manufacturing (CAM) software package. The model or part is produced by extruding small beds of thermoplastic materials to form layers as the material hardens immediately after extrusion from the nozzle. Stepper motors or servomotors are typically employed to move the extrusion head. Advantages of this process are it is cheaper since it uses plastic and Cheap 3D printers have enough resolution in many applications. Disadvantage is that supports leaves marks which has to be removed by sanding .

II. . SLA – Stereolithography



It is also called as SLA process. SLA process makes use of ultraviolent light and polymer liquid. It has a build platform. Underneath the build platform there is a resin tank which contains polymer liquid. The ultraviolent rays traces back and forth path and comes in contact with polymer liquid and solidify the polymer liquid into layers and these layers will combine together to make the final product. Final product is

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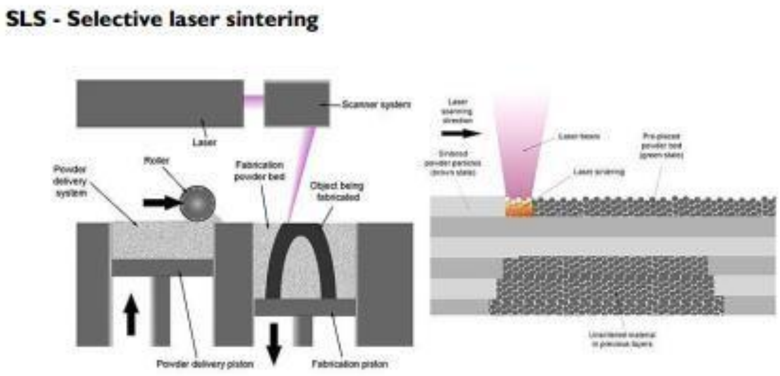
then washed in rubbing alcohol. The final component from printer will have supports on it which is removed after component is made.

Stereolithography is known to produce extreme detail down to four times finer that the human hair. The castabe resins gives children and engineers an inexpensive way to produce parts. The components made out of SLA technique comes out nice and smooth but we can see and feel the ridges on surface.

Stereolithography requires the use of supporting structures which serve to attach the part to the elevator platform, prevent deflection due to gravity and hold the cross sections in place so that they resist lateral pressure from the re-coater blade. Supports are generated automatically during the preparation of 3D Computer Aided Design models for use on the stereolithography machine, although they may be manipulated manually. Supports must be removed from the finished product manually. One of the advantages of stereolithography is its speed; functional parts can be manufactured within a day. The length of time it takes to produce one Particular part depends on the size and complexity of the project and can last from a few hours to more than a day. One stereolithography machines can produce parts with a maximum size of approximately 50×50×60cm (20"×20"×24")and some, such as the Mammoth stereolithography machine (which has a build platform of (210×70×80 cm), are capable of producing single parts of more than 2m in length. Prototypes made by stereolithography are strong enough to be machined and can be used as master patterns for injection moulding, thermoforming, blow moulding, and various metal casting processes.

Although stereolithography can produce a wide variety of shapes, it has often been expensive; the cost of photo-curable resin has long ranged from $80 to $210 per litre, and the cost of stereolithography machines has ranged from $100,000 to more than $500,000. Cheaper SLA 3D printers have been created recently and one can only assume that in the future more will be created that are within the price range of individuals.

III. SLS (Selective Laser Sintering)



The powder is poured into powder bed and made the laser to fall on this powder bed. It uses a high power laser (for example, a carbon dioxide laser) to fuse small particles of plastic, metal, ceramic, or glass powders into a mass that has a desired three-dimensional shape. The laser selectively fuses powdered material by scanning cross-sections generated from a 3-D digital description of the part (for example from a CAD file or scan data) on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one layer thickness, a new layer of material is applied on top, and the process is repeated until the part is completed.

Because finished part density depends on peak laser power, rather than laser duration, a SLS machine typically uses a pulsed laser. The SLS machine preheats the bulk powder material in the powder bed somewhat below its melting point, to make it easier for the laser to raise the temperature of the selected regions the rest of the way to the melting point.

Some SLS machines use single-component powder, such as direct metal laser sintering. However, most SLS machines use two-component powders, typically either coated powder or a powder mixture. In single-component powders, the laser melts only the outer surface of the particles (surface melting), fusing the solid non-melted cores to each other and to the previous layer. Compared with other methods of additive manufacturing, SLS can produce parts from a relatively wide range of commercially available powder materials. These include polymers such as nylon (neat, glass-filled, or with other fillers) or polystyrene, metals including steel, titanium alloy mixtures, and composites and green sand. The physical process can be full melting, partial melting, or liquid-phase sintering. Depending on the material, up to 100% density can be achieved with material properties comparable to those from conventional manufacturing methods. In many cases large numbers of parts can be packed within the powder bed, allowing very high productivity.

SLS is performed by machines called SLS systems. SLS technology is in wide use around the world due to its ability to easily make very complex geometries directly from digital CAD data.

1) Benefits-

SLS has many benefits over traditional manufacturing techniques. Speed is the most obvious because no special tooling is required and parts can be built in a matter of hours. Additionally, SLS allows for more rigorous testing of prototypes. Since SLS can use most alloys, prototypes can now be functional hardware made out of the same material as production components. SLS is also one of the few additive manufacturing technologies being used in production. Since the components are built layer by layer, it is possible to design internal features and passages that could not be cast or otherwise machined. Complex geometries assemblies with multiple components can be simplified to fewer parts with a more cost effective assembly. SLS does not require special tooling like castings, so it is convenient for short production runs.

2) Applications

This technology is used to manufacture direct parts for a variety of industries including aerospace, dental, medical and other industries that have small to medium size, highly complex parts and the tooling industry to make direct tooling inserts. With a build envelop of 250 x 250 x 185 mm, and the ability to ‘grow’ multiple parts at one time, SLS is a very cost and time effective technology. The technology is used both for rapid prototyping, as it decreases development time for new products, and production manufacturing as a cost saving method to simplify assemblies and complex geometries.

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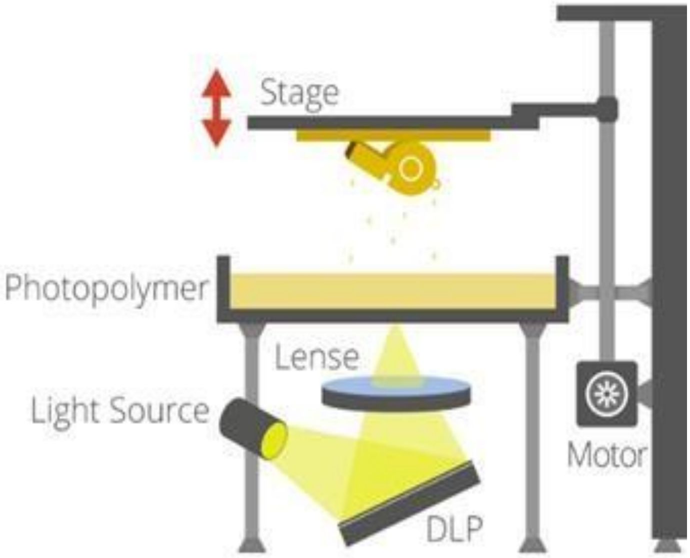
IV. DLP (Digital Light Processing)



DLP or digital light processing is a similar process to stereolithography in that it is a 3D printing process that works with photopolymers. The major difference is the light source. DLP uses a more conventional light source, such as an arc lamp, with a liquid crystal display panel or a deformable mirror device (DMD), which is applied to the entire surface of the vat of photopolymer resin in a single pass, generally making it faster than SL. Also like SL, DLP produces highly accurate parts with excellent resolution, but its similarities also include the same requirements for support structures and post- curing. However, one advantage of DLP over SL is that only a shallow vat of resin is required to facilitate the process, which generally results in less waste and lower running costs.

VI. Materials Used In 3D Printers

1) Plastic material

ABS –Most common material used in 3D printer is ABS (Acrylonitrile Butadiene Styrene). It is a part of polymer family. It is used in personal or household 3D printing, which is done primarily by FDM 3D printers. It is lightweight, has good impact strength, abrasion resistance and affordable. The melting temperature of ABS family is 200 degree Celsius which makes it ideal for use in relatively safe machines that are easy to operate. It's physical properties such as tensile strength and stiffness and heat deflection temperature are advantages. It also has good surface quality and flame retardation

PLA – PLA (polylactic acid) is commonly used for FDM process . It is a bioplastic which is made from agricultural products like cornstarch or sugarcane. Due to this the PLA is more environmental friendly than the ABS. Another advantage of PLA is that it does not emit toxic fumes when heated. It comes in variety of solid and translucent colors and it is easier to print than ABS.

PVA –PVA (polyvinyl Alcohol) is soft and biodegradable polymer that is highly sensitive to moisture.PVA dissolves when it is exposed to water which makes it very useful support structure for material for 3D printing. When printing extremely complex shapes or parts with enclosed cavities, PLA support can be used and easily

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removed by dissolving in warm water. It is moisture sensitive so airtight containers are required for storage and it is expensive.

PC –PC (polycarbonate) is a high strength material used for tough environment and engineering applications. It has extremely high heat deflection and high impact resistance. It also has high glass transition temperature of 150 degree Celsius that means it can be used in high temperature applications. It is highly hygroscopic means it will absorb moisture from air which will have impact on it's performance and strength so it is required to keep in air tight and moisture free containers

2) Chocolate-

Material engineers have devised a way to use chocolate in 3D printers to obtain some delicious treats. With the help of computer-aided manufacturing systems found in 3D printers innovative designs can be developed with this delicious material.

3) Bio-Ink-

Biomedical professionals such as Anthony Atala are researching the use of materials such as bio-ink. Bio-ink comprises stem cells and cells from a patient, which can be laid down, layer by layer to form a tissue. Human organs such as blood vessels, bladders and kidney portions have been replicated using this technology.

4) Bone Material-

A research team headed by Dr Sushmita Bose from Washington State University printed a bone-like material comprising silicon, calcium phosphate and zinc. This bone-like material was integrated with a section of undeveloped human bone cells. In about a week, growth of new bone was seen along the structure. This new material dissolved eventually and did not harm the patient.

5) Hot Glue-

A common hot glue gun was hooked up by designers to their CAM system and although hot glue may not be significant, the results if any obtained by hobbyists will truly be fascinating.

6) Full Colour Sandstone-

It is basically a gypsum powder material which is available in variety of colours by which we can make realistic creations with help of laser sintering. This material enables the production of 3D printed creations with almost any colour. Fine designs for action figures; architecture and character models are becoming highly popular with this material. It is even possible to print the human face on sandstone through 3D printing and the results are not that bad.

7) Glass-

Glass can be used in two different ways- the first way of using glass powder and in second way glass is melted and then with help of nozzle it is extruded. In second method, the upper chamber in printer is heated to about 1900 degree Fahrenheit which serves as a Kiln to keep glass pliable. Then molten glass flows through heat resistance alumina-zircon- silicon nozzle and print the CAD model. The lower chamber is insulated it allows the glass component to cool slowly so it doesn't fracture. In first method, Ground up glass powder is spread layer by layer, bonded with adhesive spray then baked resulting in 3D printed glass product.

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8) Medication-

Engineers and doctors are working together to create 3D-printed medication. Medication need not be always purchased from pharmacies, the days are not far away when they can be printed!

9) Skin-

Similar to bio-ink, 3D printers can help in skin regeneration. This could bring about a change in how patients receive treatment. If this technology truly develops, the potential for regenerative medical application will be tremendous.

10) Ceramics-

Ceramics are a relatively new group of materials that can be used for 3D printing with various levels of success. By using ceramics powder and laser sintering machine the component is made. After printing, the ceramic parts need to undergo the same processes as any ceramic part made using traditional methods of production namely firing and glazing in which heating of component is done in order to improve certain property.

11) Paper-

'Mcor technology' have introduced a 3D printer which uses paper for making realistic products. It is recyclable and it's speed is four times the industrial printers. We can recycle the waste plus the printer uses water based resins and inks that means no toxic fumes are released. It prints half an inch an hour which is more than other printers but it is not the fastest printer. 3D printed models made with paper are safe, environment friendly, easily recyclable and require no post-processing.

VII. 3D PRINTING OF WOOD

It is now possible to 3Dprint wooden objects using a standard material extrusion 3Dprinter.To achieve this a 3D printing enthusiast called Kai Parthy has created a 3mm filament material called 'LAYWOO-3D'. This is a composite of wood fibres and a polymer binder, and can be melted and extruded to print wooden objects using any thermoplastic extrusion 3Dprinter, including consumer models that costless than$1,000. Once printed, objects created in LAYWOO-3D feel and smell like wood. They can also be sanded and otherwise worked on like any object made of a wood composite, such as medium density fibre board (MDF).

One of the really clever things about LAYWOO-3D is that its final colour is dependent on the temperature of the print head used to melt and extrude it. In practice, this means that LAYWOO-3D can be output as either a dark or a light wood, anywhere in-between. In fact, with appropriate temperature control, it is even possible to 3Dprint wooden objects with 'treerings' or subtle colour gradients. If this were not enough, unlike thermoplastic build materials, LAYWOO-3D does not wrap or shrink during printout.

VIII. 3D PRINTING OF CONCRETE

Concrete is initially mixed into a viscous form that is poured in particular shapes through nozzle before it sets. Concrete does not need to be heated to make it melt in print head. It is forced through a motion controlled nozzle in its naturally pre-set state to form layers that then solidifies.

We can build castle and other concrete structure or even houses out of combination of 3D printing technology and concrete .

The first experiment to create a concrete 3D printer took place at University of Southern California in 2004. At the time the technique was called as 'contour crafting', and was used to make 3D printed wall.

While an earlier version of the printer was based on a 3- axis gantry, the most recent model has its nozzle mounted on a 7-axis robotic arm to further enhance print quality, speed and potential object size. Already the Loughborough team have 3D printed a one tone reinforced concrete architectural piece to demonstrate the viability of their technology

One of the benefits of 3D concrete printing could be the fabrication of complex curves and designs that are hard if not impossible to manufacture with traditional building techniques. While at present all walls and floors cast in concrete have to be solid (as they are created by pouring concrete into some kind of mould or shuttering), 3Dprinting will relax this constraint. Parts of buildings will therefore be able to be crafted with internal air pockets to improve insulation and to reduce materials usage. Ducts for utilities like power and water will also be able to be 3D printed directly into a concrete wall as it is being made.

IX. Capacity Of 3D Printers

2D printers have a maximum ‘print area’ while 3D printer has ‘build size’ or ‘build volume’ that determines the largest object they can print.

The size of the printing volume depends on the chosen material which in turn determines the type of printer used. The maximum size also depends on the chosen finishing process (e.g. colouring, polishing etc.)

For consumer thermoplastic extrusion printers, build volume typically starts at around (125x125x125) mm or about (5x5x5) inches. The largest build volume available on an industrial thermoplastic extrusion machine is 914x610x914 mm (36x24x36inches). A build volume of this size can be used not just to make large objects, but also to manufacture many smaller objects side-by-side in a Single print. Example: following table summarise the size limitations for each material on Sculpeto printer.

TABLE II
SIZE LIMITATIONS FOR EACH MATERIAL ON SCULPETO PRINTER

	White/ Unpolished	Coloured	Polished
Plastic	(677x368x565)mm	(180x220x220)mm	(11x8x7)mm
Silver/Brass	(60x80x100)mm Maximum size	(2.4x2.4x0.8)mm Minimum size	

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Resin	(290x190x147)mm Maximum size		
Alumide	(300x300x500)mm Minimum size		
Ceramics	(250x350x200)mm Maximum size	(6x6x6)mm Minimum size	
Multicoloured	(254x381x203)mm Maximum size		

X. ADVANTAGES

1) Ability to customize products-

We can customize anything with help of 3D printing and promote the artistic ideas. We can make any object we want with help of blueprints.

2) 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.

3) Low cost of production-

Cost is lowered in case of 3D printers. The initial cost of setting up 3D printer may be high but other costs are low. It has low operating cost as most desktop 3D printer uses the same amount of power as laptop or computers. It also lowers the material cost as well as labour cost as most of the printer requires only one person. Also, the cost of tooling, jigs and fixture as well as assembly and inventory is reduced.

4) No inventory 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.

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5) 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

6) . Quick availability of organs

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

XI. Disadvantages

1) 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. Anyone can access to the design of any kind and a 3D printer. Governments will need to devise ways and means to check this dangerous tendency.

2) Limitations of size

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

3) 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.

4) 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 colour are costlier than those that print monochrome objects.

5) Production of Unnecessary Stuff

Another possible disadvantage of 3D printing is that people would print stuff on a whim, and this would result in a huge number of unnecessary stuff being produced. Add to that, the difficulty we already face in recycling stuff, and you have a serious problem here

6) Copyright Issues

As this technology becomes more widespread, it will be easier for people to print out different products. In fact printing out copyrighted products to build fake items and misusing them will be easier. It will be difficult to distinguish the fake ones from the copyrighted ones, thereby causing a huge problem.

7) Decrease in Manufacturing Jobs

3D printing will decrease the manufacturing jobs as people can easily create their own products if they like. This will impact the economies of the third world countries, which depend on low skill jobs.

XII. Applications

Scientists have successfully been able to print ears, skin, kidney, blood vessels and bones using 3D printers. Instead on typical plastic, a gel-like substance made of cells is used. For bones, a ceramic powder is used instead. In the future, every patient will have their own matching set of skin for a graft, a bone fragment or an organ.

Already, 3D printers are capable of printing prosthetic limbs for people with disabilities. The biggest challenge is the challenge of printing a fully beating human heart that works just as well as a natural one. Bio-engineers at the Cardiovascular Innovation Institute at the University of Louisville have printed a coronary artery some small blood vessels of the heart muscle and are hoping to soon print a functioning heart

In the future, we may live in houses that have been 3D printed. A researcher at University of Southern California claims to have designed an enormous 3D printer that is capable of printing a whole house in just a day. This conceptual model uses concrete as its base element in order to replicate computer programs. In order to ensure that the house is compatible with plumbing and electrical apparatuses, it uses a layered fabrication tech called "Contour Craft". A printed house could have far-reaching implications for low-income housing, disaster recovery applications such as creating models of plastic that can serve as a sample or a prototype of a larger-scale version of itself.

NASA has been developing technologies to print wood from printers by using 3D bio printing technology. The printer will lay out living cells in specific manner upon a gel. This get stimulates the cells to start excreting wood. Application is that astronauts could bring wood to space without actually carrying it.

Modern Meadow, a company that combines the traditional farming and modern cutting-edge 3D printing technologies, is a company that believes we can sustainably 3D print food. According to the company, traditional slaughtering of animals to obtain animal by-products such as meat or leather is unsustainable and that we might be better off trying to 3D print our meat.

The company also thinks that there will be a high demand for that sort of meat in the future. Though it may sound like something farfetched, the company has patented techniques to make it happen to print meat. This technology, according to their own description, achieves it as follows: In this technology, conveniently prepared multicellular aggregates (the bio-ink particles) are delivered into a biocompatible support structure according to a design template (compatible with the shape of the desired biological ISSN 2348-1196 (print) International Journal of Computer Science and Information Technology Research ISSN 2348-120X (online) Vol. 2, Issue 2, pp: (378-380), Month: April-June 2014, Available at: www.researchpublish.com Page | 380 Research Publish Journals construct) by a computer-controlled delivery device (the bio-printer).More research is still needed to make it happen but the company evidently has the brains and research to figure it out.

NASA is concentrating on 3D printing food so that astronauts can print food in space. We already can print chocolate confectioneries and desserts from a special printer invented recently called Chocedge. Also, Hershey and 3D Systems have partnered to presumably create all kinds of printable food items.

Speaking of astronauts, by far the most ambitious of 3D printed future is where we set up entire moon base by printing out construction blocks to be used to construct base. Researchers have concluded that in absence of plastic we can use freely available moon soil to print out building blocks to form lunar habitat for humans.

Researchers at the European Space Agency have been able to create a 1.5 tonne building block make of synthetic lunar soil. The result was a sturdy yet light material that the astronauts can assemble themselves. It should be noted that, so far, these technologies have been tested only on Earth. The real test will occur whenever the ESA decides that it is ready for space launch

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XIII. GLOBAL EFFECTS ON MANUFACTURING

3D printing is already having an effect on the way that products are manufactured –the nature of the technology permits new ways of thinking in terms of the social, economic, environmental and security implications of the manufacturing process with universally favourable results.

3D printing has the potential to bring production closer to the end user or the consumer, thereby reducing the current supply chain restrictions. The customization value of 3D printing and the ability to produce small production batches on demand is a way to engage consumers and reduce or negate inventories and stock piling

Shipping spare parts and products from one part of the world to the other could potentially become eliminated, as the spare parts might possibly be 3D printed on site. This could have a major impact on how businesses large and small, the military and consumers operate and interact on a global scale in the future.

The ultimate aim for many is for consumers to operate their own 3D printer at home, or within their community, whereby digital designs of any (customizable) product are available for download via the internet, and can be sent to the printer, which is loaded with the correct material(s).

The wider adoption of 3D printing would likely cause reinvention of a number of already invented products, and, of course, an even bigger number of completely new products.

Today previously impossible shapes and geometries can be created with a 3D printer, but the journey has really only just begun. 3D printing is believed by many to have very great potential to inject growth into innovation and bring back local manufacturing.

The use of 3D printing technology has potential effects on the global economy, if adopted worldwide. The shift of production and distribution from the current model to a localized production based on-demand, on site, customized production model could potentially reduce the imbalance between export and import countries. 3D printing would have the potential to create new industries and completely new professions, such as those related to the production of 3D printers. There is an opportunity for professional services around 3D printing, ranging from new forms of products designers, printer operators, material suppliers all the way to intellectual property legal disputes and settlements. Piracy is a current concern related to 3D printing for many IP holders, the effect of 3D printing on the developing world is a double edged sword. One example of the positive effect is lowered manufacturing cost through recycled and other local materials, but the loss of manufacturing jobs could hit many developing countries severely, which would take time to overcome.

XIV. THE 3D PRINTING INDUSTRY IN INDIA

The 3D printing industry of India is likely to grow big in the coming years. For example, the Indian 3D printing industry is set to reach $79 million by 2022. India is also being considered a key player in terms of large scale adoption of additive manufacturing in the Asia Pacific (APAC) region. It has also been pegged to become a major beneficiary of the additive manufacturing industry of the APAC region. The additive manufacturing industry in the APAC region is estimated to reach $5.56 billion by 2025.

India is an attractive hub for foreign investments in the 3D printing technology. Several foreign firms operating in the 3D printing industry have set up or are looking to establish or expand their bases in the country. In fact, some have already established their base in India. Some of the major foreign players that have established their base in India include Stratasys – one of the largest 3D printing companies in the world. The other foreign players in the country include the UK-based Renishaw Plc and EOS. A global leader in the field of industrial 3D printing, EOS has recently announced its expansion plans in India.

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XV. Conclusions

The version of this template is V2. Most of the formatting instructions in this document have been compiled by Causal Productions from the IEEE LaTeX style files. Causal Productions offers both A4 templates and US Letter templates for LaTeX and Microsoft Word. The LaTeX templates depend on the official IEEEtran.cls and IEEEtran.bst files, whereas the Microsoft Word templates are self-contained. Causal Productions has used its best efforts to ensure that the templates have the same appearance.

Acknowledgement

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