3-D Printing

Paper-GS III – S&T

Three-dimensional printing (3-D printing), also known as Additive manufacturing (AM) is a process of joining materials to make objects from 3D model data, usually layer upon layer. It is basically a process of making three dimensional solid objects from a digital file.

This is opposite of ‘Subtractive Manufacturing’ which works on removal of material to create a desired object. It is similar to a man who cuts a stone to create a sculpture. The first working 3-D printer was created in 1984 by Charles W. Hull of 3-D Systems Corp. The machine was named Sterolithography Apparatus.

Process of 3D Printing:

- 3D printing starts by making a virtual design of the object to be created. Virtual design can be made using a 3D modelling program such as CAD (Computer Aided Design) or 3D scanners.
- The 3D digital copy is then put into a 3D modelling program. The model is then sliced into hundreds or thousands of horizontal layers in preparation for printing.
- This prepared file is thus uploaded in the 3D printer which reads each slice in 2D format and then proceeds to create the object layer by layer and the resulting object has no sign of layering visible, but a 3 dimensional structure.

Applications of 3D Printing:

1. Defence and Aerospace: At present, AM technology in the aerospace and defence sector is broadly used for prototyping, repair of small parts and component manufacturing. Examples: The UK Royal Air Force and Navy use AM for repairing spare parts.

2. Health:

   - Hearing aids have been made using 3D printing technology.
   - Bio printers: Organ printing or body part printing is being printed and some parts being used as implants of actual body parts. Example: Titanium pelvic, plastic tracheal splint, titanium jaws
   - Tissue engineering: Tissue engineering made remarkable progress with printing of 3D blood vessels. This was achieved 3D bio-printing technology and biomaterials through vascularisation of hydrogel constructs.
   - Dentistry: Dental Implants are being made on a commercial level using 3D printing technology
   - Prosthetics: 3D printing is being used to make surrogate body parts
   - Artificial organ: Additive manufacturing of stem cells has also led to various possibilities in printing artificial organs, although most of the work is still in the experimental stage

3. Manufacturing: 3D printing can be used to manufacture varied forms of products- from car or plane parts to sport goods, toys etc. Customised products are able to be manufactured as customers can edit the digital design file and send to the manufacturer for productions.
4. Domestic Usage: 3D printers can be used in the home to make small objects such as ornamental objects, small toys etc.

5. Architecture, housing: The technology can be used for a variety of housing projects with application in custom luxury designer homes, large scale development projects, to temporary housing projects. It could also enable engineers to design and build stiffer and safer geometries for houses. Further, can also help engineers to rebuild and restore old heritage designs quickly yet accurately.

6. Food: 3D printing enables fast automated and repeatable processes, freedom in design, as well as allowing large and easy variability of the cooking process which can be customized.

7. Education: Affordable 3D printers in schools may be used for a variety of applications which can aid students with learning better.

Advantages of 3D printing:

1. Low cost: 3D printing is cheaper than traditional method of manufacturing. Cost of producing or manufacturing products using 3D printing technology is equal for small-scale and mass manufacturing. For example: China was able to construct 10 one storey houses at less than $5000 per house

2. Less Time: Printing of the 3D object can be done directly, differing from the traditional manufacturing where different components had to be joined to form the final product.

3. Efficiency: Generating prototypes with 3D printers is much easier and faster with 3D printing technology.

4. Increased Productivity: It enables quick production with a high number of prototypes or a small-scale version of the real object

5. Flexibility: Different materials can be used in the 3D models. This makes it very easy to create construction models or prototypes for a wide variety of projects within many industries.

6. Customization: Every item can be customized to meet a user’s specific needs without impacting the manufacturing costs.

7. Quality assurance: the technology builds robust products with superior functionality

8. Employment opportunities: The widespread use of 3D printing technology will increase the demand for engineers who are needed to design and build these printers and design blueprints of products.

9. Reduced wastage: AM process produces less waste in comparison with other traditional manufacturing techniques

Disadvantages of 3D Printing:

1. Limited size: The size of objects created with 3D printers is currently limited

2. Limited Raw Materials: With 3D printing being an additive method (layer after layer), the materials available suited for it are limited- ceramics, resin, plastics, etc.

3. Effect on employment: Jobs in manufacturing will be rendered obsolete which will have a negative impact on developing economies.

4. Concerns over copyright infringements: There is concern over counterfeit printing of...
copyrighted or patented products. Anyone who gets a hold of a blueprint will be able to counterfeit products easily.

5. **Production of dangerous items**: There are concerns over deterring or controlling people from 3D printing potentially dangerous items. Example: International regimes such as the Nuclear Suppliers Group, Missile Technology Control Regime and the Wassenaar Agreement that control technology have been concerned about proliferation of high-performance 3-D printers, which have the capability to print parts for missile or nuclear weapon.

6. **Cyber security concerns**: Studies have shown that the 3-D printer connected to online network is vulnerable to cyberattacks.

7. **Ethical concerns associated with use of 3D technology in healthcare**:

   **Justice in access to healthcare**: One major concern about the development of personalised medicine is that it might increase cost of treatment and widen the disparity between rich and poor in terms of access to healthcare.

   **Testing for safety and efficacy**: second concern is how it is to tested that the treatment is safe and effective before it is offered as a clinical treatment.

### 3D Printing in India

- The government has launched several initiatives such as ‘Make in India’, ‘Digital India’ and ‘Skill India’ to improve investment opportunities and to enhance manufacturing capabilities in the country. Given the government’s interest in boosting manufacturing, major manufacturers have established 3-D printing assembly lines and distribution centres in partnership with foreign technological firms.

- A PwC report titled ‘The Global Industry 4.0’ in 2016 shows that in India, 27% of industries have either already invested or will be investing in AM technology within the next five years.

### Opportunities for India:

1. Owing to the well-established Indian software industry and plans to increase connectivity are well under way as part of ‘Digital India’, 3D Printing could lead to the creation of manufacturing facilities in small towns and foster industrial development outside of major cities.

2. Traditional small and medium enterprises can benefit by switching to 3D printing technology which is cost-effective and efficient.

3. The technology can be used to boost manufacturing in the aviation and automotive industry. It can enhance production times as well as product performance in terms of strength, weight and environmental impact.

### Challenges for India:

1. **Lack of domestic manufacturers of 3D printer**: Though, there has been some attempts in producing 3D printers domestically they are not of industrial grade and industries largely depend on imports.

2. **High cost of imports**: There is a lack of clarity relating to the import of 3-D printers that
attract close to 30–40% customs duty, over and above the shipping cost. The huge cost associated with importing industrial grade 3-D printers is too much for the medium and small-scale industries in India.

3. **Employment:** 3D printing carries dangerous implications for employment scenario in developing nations such as India as it decreases reliance on assembly workers. It may lead to the creation of software-based design platforms in the West that distribute work orders to small manufacturing facilities, whether located in developed or developing countries, but ultimately transfer value creation towards software and design and away from physical manufacturing.

4. **Awareness:** Due to lack of awareness many business entities do not opt for design-prototyping-manufacturing assistance which largely reduces the reach of 3D printing.

5. **Research:** Research involving AM and its allied technologies in India is inadequate for competing in the global arena. Lack of a centralised approach to AM has been constraining Indian institutions from undertaking intense research on AM-related technologies.

**International best practice:**

China had launched the first national plan for 3-D printing, called “Additive Manufacturing Industry Promotion Plan 2015–2016”. Later, a new additive manufacturing Action Plan (2017-2020) for the further development of the technology in the country was launched. The Plan focuses on strengthening research and development, as well as accelerating applications of 3D printing and its adoption in industry.

**Conclusion**

It is important to create an environment that is conducive for industry to form collaborations with foreign firms to co-create the technology. Training and skilling is another important aspect which requires considerable attention. There is huge scope under the ‘Skill India’ initiative to reach out to the many technical institutes in the country to sensitisie them regarding the opportunities in 3D printing.

There is a need for strong support from the government and business houses for AM-related studies and R&D for the growth of the technology in India. Research in India with regard to AM technology needs to be significantly scaled up if it is to emerge as a competitive player in this field.