Distributive Manufacturing of Clinical Needs during COVID– 19

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Abstract

World Health Organization has recommended Personal Protective Equipment (PPE) to prevent and control spread of Covid – 19 pandemic, which includes gloves, face mask, face shield, head cover and rubber boots. Medical practitioners are recommending use of Aerosol Box and Isolation Testing Stations to ensure safety of both the care givers and the patients. During the tough times of Lock Down announced by majority of the affected nations, distributive manufacturing of clinical needs of health care professionals by efficiently employing the locally available facility and without involving extensive transportation is extremely beneficial. Here, the article focuses on 3D printing technique which is useful in producing the protective equipment quickly and enhances the medical infrastructure of hospitals handling Covid – 19 pandemic.

Keywords: 3D Printer, Face Shield, Aerosol Box, Testing Station, Distributive Manufacturing.

1. INTRODUCTION

Manufacturing is the production of products and services for consumers using various resources like machines, labour, chemicals, and tools. In general it refers to wide range of activities ranging from generation of resources to high tech manufacturing which is mostly applied to Industry design, where the raw materials are transformed into finished goods on a large scale.These finished goods may be further sold to other manufacturing norms for further production of complex products. The steps through which raw materials are transformed into final product is known as manufacturing process or manufacturing engineering. The initial process begins by drawing out the layout of product design and material specifications and the required tools for the process. The end product is the result of this process. As the technology advanced the machines became equipped with wireless technology and sensors, connected to a single system which can control the entire production with the help of software algorithms. This led to automation which include internet of things (IOT), industrial internet of things (IIOT). Software technologies like Cloud computing, Machine Learning, Deep learning and Artificial intelligence let to the creation of smart industries which achieve greater performance and efficiency.

1.1 Distributive Manufacturing

Distributive manufacturing also known as de-centralized manufacturing where the enterprises use a network of geographically dispersed manufacturing facility that work in harmony with each other and have a common vision[1]. As products become more localized and personalized, the demand for smaller production increases. This means companies can specialize in designing and delivering products locally, creating a real connection between the company and the customer. Today an individual can create products including clothing, electronics and many more which could not be accomplished years back. With the access to advanced digital fabrication tools and technology like 3D printing and CNC machines many entrepreneurs are emerging. Distributive manufacturing is different from traditional manufacturing in a manner that the raw materials and the methods of fabrication are distributive. It has changed the current

manufacturing trends and has taken the manufacturing capability and efficiency to the next level. The main moto behind distributive manufacturing is to replace most of the supply chain with digital information[3]. For example, to manufacture a table, instead of starting from scratch and fabricating it into table in a single factory, the digital design for the table are distributive among the local manufacturers. These parts can later be assembled at a warehouse where it is converted into finished products. Distributive manufacturing is more efficient in utilizing its resources and human capital which lowers the entry barrier to the industry which is increasing the number of start-ups. A lot of capital is saved by sending the digital information rather than the product itself by saving the transportation cost.

2. 3D-PRINTING

3D printing, commonly referred to as additive manufacturing, and rapid prototyping is a process by which 3D solid objects of any shape or geometry can be created from a digital file[2]. The creation is achieved by laying down successive layers of a specific material until the entire object is created. Each of these layers represents a thinly sliced horizontal cross-section of the eventual object, in contrast to traditional subtractive manufacturing methods which relies upon the removal of material to create the product.

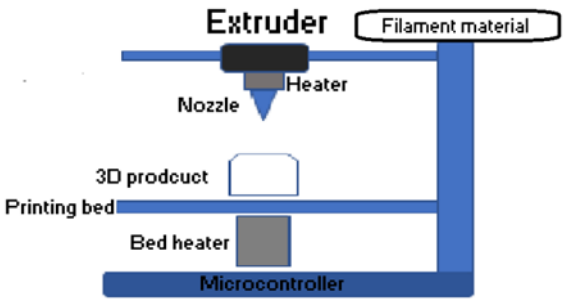

Figure 1. 3D Printer

The components involved in a regular 3D printer are as shown in Figure 1. Print Bed is the flat surface where the 3D models are layered during printing. Heated Print bed ensures the warmth of the print section of the print and therefore helping the prevention of warping during layering process.

Extruder is the part that thrusts out and feeds the printer filament into the 'hot-end'. The extruders push the filament through a tube into the hot-end.

Hot-end deposits molten material. The quality of the print is dependent upon smaller nozzle size by compromising with the longer time taken for stacking up the thin layers. Filament is the input material which is formulated as a 3D solid object by the printer. Like an inkjet inject ink, a 3D printer emits melted filament.

The process of transforming a digital file into solid object is quite long and complicated. The 3D printing begins with designing a CAD (Computer Aided Design) file of the object being printed. Along the way, software slices the design into hundreds, or more likely thousands, of 6 horizontal layers. Once this digital file is loaded into the printer hardware, the printer prints each layer on top of one another until the entire file is executed.

The motors used in the 3D printer are the stepper motors that converts digital pulses into mechanical shaft rotation. The 3d printer is equipped with 3 stepper motors for moving in the X, Y, Z direction of the printer head and 1 stepper motor for the moving the plate/bed.

The microprocessors like the AM335x containing a processing unit and a graphics accelerator is utilised in most of the 3D printers. The AM335x microprocessors are enhanced with image, graphics processing, and industrial interface options.

Many processes or techniques have been developed for creating a physical 3D object from digital designs. The classification is based on the type of materials used and the process followed in layering the materials. Few methods melt or soften the material to produce the layers and the object subsequently, whereas other methods are inclined towards curing liquid materials into desired shape and size by employing various technologies. As a result, it can be seen that 3D printing is closer to reality than ever, with ever increasing technologies and needs, this

particular field is being popularised in many applications. With faster production and accessible features of 3D printing, every household, industry or an organisation can now bring their ideas and designs into real word quickly. Many applications of 3D printing have already proven its capabilities and will soon revolutionize the field of product manufacturing.

3. DISTRIBUTIVE MANUFACTURING OF 3D PRINTED PRODUCTS

3D printed products are the most customizable products for the consumers. It has the ability to print anything with also the choice of the material being used for the same. With the advances in technology the 3D printers became less expensive and affordable to quite a lot of people. And also easy to use user friendly software.

With this being said, people can manufacture any product or parts of a product which allows the individual parts to be manufactured faster and can be later integrated to form the actual product. During a situation like global pandemic the 3D printing comes to the rescue. It relieves pressure of manufacturing on the manufacturing industries to some extent. Anyone who has a 3D printer can take up the initiative to go the hospitals and enquire regarding the equipment required and the specifications of the same.

With these specifications provided anyone can come up with the design and print a prototype. The prototype can be then presented to the officials at the hospital who will scrutinize the product. If the product meets the required specifications then the printing of the same in large numbers can be initialized. Also the printing process is quite slow hence the quantity of the products printed is less. This turns our sight towards the online 3D printing communities or hubs. Hubs are the online forums where anyone can post their project(design) or any problems related to the same.

The qualified design file can be uploaded to such forums and the people who own a 3D printer can print them using the same file. This helps to increase the quantity of products printed significantly. These printed products can be collected at a common drive through place. Drive through place is a location where people can drive by in their cars and drop the products. Or the products can be collected from them by other means. Thus the printing process is distributive geographically among various individuals who contribute as a whole.

A few products which are currently being printed during the global pandemic[4] are as follows:

1. Masks - Masks with a proper particle filtering specification can be 3D printed
2. Face shields
3. Ventilator valves - Ventilators provide oxygen to single patient. Using the 3D printed valve, the ventilator can provide oxygen up to 4 patients
4. Aerosols
5. Testing chambers
6. Swabs - The shafts of the swabs can be 3D printed
7. Sanitizer holders - These can be placed at the doors of the wards in the hospital and also in essential stores
8. Door handles - These are specially designed door handles which allows you to open the door with the help of your fore arm

Figure 2. Face shield and Face Mask (Courtesy: PupilMesh Pvt. Ltd.)

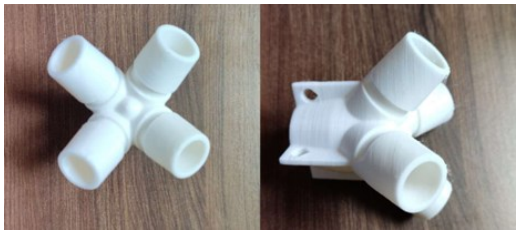

Figure 3. Ventilator Valves (Courtesy: PupilMesh Pvt. Ltd.)

4. APPLICATIONS OF 3D PRINTED PRODUCTS FOR CLINICAL PURPOSES

Standard protection precautions employed by health care professionals are face masks and face shields as shown in Figure 2. Face masks are used in non-pharmaceutical interventions to prevent viral transmission during Covid – 19 pandemics. Face shields are designed to protect the entire face from infection. Typically used materials for face masks are polycarbonate, with its excellent impact resistance, chemical resistance, heat resistance and optical quality, or Cellulose Acetate, with good chemical resistance, normal impact resistance and optical quality. Sheets of 0.8mm thickness and 6mm nominal diameter are used. Special valves are designed to increase the usage of ventilators. Since ventilator is a crucial part of treating Covid – 19 patients, more ventilators are needed. Hence, instead of using one ventilator for one patient, ventilator valves, as shown in Figure 3, can be used so that one ventilator can be used for more number of patients.

Figure 4. Aerosol Box(Courtesy: PupilMeshPvt. Ltd.)

Figure 5. Testing chamber (Courtesy: PupilMeshPvt. Ltd.)

For adequate protection, Aerosol Box is used to improve the barrier of protection. It consists of a transparent cube which incorporates two circular ports through which the medical practitioner will perform the procedure, as shown in Figure 4. Isolation testing stations, as shown in Figure 5, are built and tested for utilization in hospitals to ensure that the clinician and the patient maintain physical distancing to ensure better safety conditions for all the stake holders. Thus, 3D printing offers a platform based manufacturing with very high flexibility with respect to product design as well as manufacturing technology. Joint development of manufacturing systems along with products seamlessly is made possible by using pre-defined platforms. Michaelis et al[5] illustrate this concept of 'Integration with Product Platforms' using the example of a robotized manufacturing station. They have compared the existing dedicated welding station with a modular configurable station that can accommodate different manufacturing techniques as well as used to for creating new products. The conditions for co-development process with the two manufacturing stations.

5. CONCLUSION

Distributive manufacturing is a blessing in the disturbed times of Covid – 19 pandemic spread in the world. Localized and personalized manufacturing is extremely beneficial to cater to the personal protection of medical staff volunteers, patients and public, in general. Face masks, face shields, ventilator valves, Aerosol Box and Isolation Testing Station are some of the safety measures which can be produced using 3D printing with ease. These can be provided to the hospitals and health care professionals and medical infrastructure can be enhanced. There is scope for co-development of product and manufacturing process by employing pre-defined platform. This is particularly useful in times of pandemic like Covid-19.

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