3D PRINTING AND ITS ROLE DURING THE COVID PANDEMIC

Mohammed Zainul Arefeen¹, Hussam Bin Mehare¹, Mohammad Hassan Murtaza¹, & Mustafa Shamsi²

¹Department of Mechanical Engineering, Zakir Husain College of Engineering and Technology, Aligarh Muslim University, Aligarh, India
²Department of Mechanical Engineering, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi, India

hussambm9909@gmail.com

Abstract. The current COVID-19 pandemic took the entire world by surprise, making us realize how far we had been lagging behind in the development of new technologies which makes the entire fabrication process more efficient and faster. During the pandemic, worldwide there was a shortage of basic medical equipments PPE kits, masks, syringes, ventilator pipes & masks, etc. All we needed at that time was a faster and more cost-efficient fabrication technology which would have kept pace with the growing demands of these basic equipments as the situation went from bad to worse. 3D-Printing, we believe is the future of the manufacturing and fabrication sector as it's faster compared to our current technology and much more efficient when seen from an economic and an environmental point of view. In this paper, we have talked about how the COVID-19 pandemic wreaked havoc worldwide on their healthcare systems with thousands of people dying every day due to the lack of basic medical equipments. All these challenges could have been met head-on if the abilities of 3D Printing were exploited on a larger scale. We have tried to offer a brief insight into how 3D Printing can change our lives for the better and make it a lot easier once 3D Printing reaches its full potential.

1. INTRODUCTION:

1.1 COVID-19

The COVID-19 or the coronavirus disease is a malady that causes utmost respiratory disorders in the human body. This virus got the name “Corona” from the spikes, shaped like a crown on the surface of the virus. This disease was first spotted on the 8th of December 2019 in Wuhan, China, and was named “2019 Novel Coronavirus”[1-2]. The Coronavirus pandemic offered enormous difficulties to the public health, scientific and medical sectors just like the two other coronavirus breakouts SARS (2002-2004) and MERS (Middle East respiratory syndrome, 2012 – present) [1]. Due to the global spread of SARS-CoV-2, WHO declared a pandemic on March 11, 2020. This virus has had a great impact throughout the world; more than 200 million individuals have been infected by this, killing
around 5 million people as of October 2021 [3]. Figure 1 gives a visual representation of the confirmed COVID-19 cases and deaths all around the world[4].

SARS-CoV-2 can spread from human to human through the medium of air threatening every single human on the planet. The rate of transmission of this virus is way too high than in previous outbreaks [5]. Due to these complications, it’s endorsed that people must wear masks, surgical or non–surgical; they should also wear face shields, gloves, goggles, gowns, and N95 masks at public places where maintaining physical distance is arduous. Doing this will prevent physical contact between people who are infected, with or without symptoms; which will help in slowing the communication of this virus from person to person. This virus led to economic and social unhappiness. The healthcare systems worldwide were under tremendous pressure due to extreme shortages of beds in the hospitals; personal protection equipment (PPE) and also medical equipment because of the increasing number of patients in the hospitals globally [6].

This pandemic is a “wicked dilemma”, comprising many competing issues that appear to contradict one another [7], like saving lives of people are prioritized second, and conserving livelihood is prioritized first. Although, crucial actions to limit this pandemic have begun; through creative and inventive majors, which led to the astounding methods of producing some useful essentials and one of the methods is 3D printing. Amid COVID-19, 3D printing has proven to be helpful through its ability to perform competitive tasks during emergency situations. It replaces a few conventional techniques that are implemented during public health emergencies, by acting more productively; reducing the time that was utilized in drafting, manufacturing, packaging, and transporting the product [8].
1.2 3D-Printing

3D printing is a process of manufacturing three-dimensional objects using materials viz. plastic, metal, carbon, etc. These objects are generated with the help of supporting materials -- that are applied layer by layer on a base. 3D printing for medical applications used to be aspiring. However, through hard work, dedication, and investing money and time 3D printing was made physical. Nowadays, medical and pharmaceutical firms exploit 3D printing technology in developing better-specialized medications, by manufacturing medical implants quickly and changing the way doctors and surgeons use to perform surgeries. As 3D printing or additive manufacturing has provided an easy and rapid way of prototyping 3D structures from different types of materials, it has attained huge attention. This approach of 3D printing is prominent for its way of flexibility, waste reduction, mass customization, constructability, and architectural manufacturing [9-11].

3D printing provides a flexible way of manufacturing, by designing on software like CAD; and straight away manufacturing products like face masks, ventilator components, and even nasal swabs for testing covid, rather than waiting for the components and medical items to be produced in a mass amount by third party manufacturers, who will dispatch the product - to the hospitals. Outsourcing these digital designs of 3D printed models for COVID-19 has improved the efficiency of the products.

2. Benefits of 3D Printing in Medical Applications

3D printing has been beneficial in the healthcare field offering additional applications every year saving and improving the lives of patients in a way that was never imagined. It has been useful in a broad range including healthcare settings. 3D printing is not only possible for cardiothoracic surgery, cardiology, gastroenterology, neurosurgery, oral ophthalmology, otolaryngology but also possible in other healthcare fields due to the benefits which this technology provides vastly. Applications of 3D printing in the medical field and healthcare are as follows.

The substantial benefit which 3D printing provides in healthcare and medical applications is that 3D printing provides feasibility to produce custom-made products and equipment. For instance, 3D printed custom prosthetics and implants provide amazing value for both the patient as well as the physicians. Also, made-to-order fixtures and jigs can be produced by 3D printing to use in operating rooms. In terms of required time for surgery and recovery of the patient, custom-made fixtures, implants, and surgical tools can possess a positive impact produced by 3D printing.

A key benefit of 3D printing is that it provides the production of items cheaply compared to traditional methods. Although these methods of manufacturing things traditionally are less expensive when production is at a large scale. 3D printing however is becoming more competitive for manufacturing products at small-scale production.
The manufacturing cost can be reduced in 3D printing by reducing the usage of resources that are not necessary. For instance, a pharmaceutical tablet of 10mg weight can be fabricated by customizing according to the requirement as 5 tablets of 1mg. Some medications can also be easily printed in the form of dosage, which will be more cost-effective for the patients to get delivered.

2.1. Personal Protective Equipment - PPE

Compared to other byzantine devices like valves and ventilators, these PPE (Personal protective equipment) were produced/printed in abundance due to their low tolerance requirement geometrically, relative simplicity, and lower risk of classification within the FDA during the pandemic [12].

During the COVID-19 pandemic, PPE kits were in shortage and this was mainly needed by the doctors to keep their bodies away from COVID exposure while they treat their patients. Complete PPE kits usually consist of gloves, gowns, shoe covers, head covers, respirators, eye protection, and goggles.

2.2. Face Shields

Face shields were considered a class A medical device by FDA, as they constitute most of the work among PPE [12]. These face shields were considered as an alternative by WHO to the medical mask during shortages. They protect the user’s face from direct contamination through sprays and splashes, as they are clear plastic sheets with a head-worn frame to protect the face of the user [13-14].

The medical staff faced critical challenges while interacting with the patients, one of the major problems was a shortage of face shields. Extra variations on personal protective equipment to be included, Equipment designed by Prusa provided in a protective face shield. These types of devices provide a reusable printable headpiece in which a separate transparent plastic sheet can be attached to assemble a face shield that can protect the mouth, nose, and eyes of a person. Using Fused Deposition Modeling [FDM] face shield can be printed as it provides an improved and simple geometrical printable material. This method of using 3D printers to create face shields has completely changed the era of 3D printers [15]. Figure-2 below shows 3D Printed Face Shields[16].

2.3. Face Masks

On account of the shortage of masks globally, designers are trying to achieve this demand in a different way. Adapting scuba and snorkel masks using them in a different manner, great conversion has been planned[17-18] In this conversion, a filter can be held to a face mask rapidly being smaller in size, by
using a 3D printer at a very low cost. But it requires access to filter paper and mask by the person who is using it, to fit it inside the holder. Secondly, these masks are reusable just like the face shields, which could be easily used again by disinfecting them. To combat the COVID-19 pandemic, retrofitting equipment like face masks to PPE kits is one of the best ways to comprehend designers’ creativity and also benefit society globally [19]. Figure-3 shows a 3D Printed N95 mask[20].

2.4. 3D Printed Medical Accessories

Mechanical Ventilators are one of the most essential components supporting the patients that might be struggling in breathing. Severe respiratory complications experienced by patients are treated by getting incubated in IMV (Invasive Mechanical Ventilation) procedure [19]. During the pandemic, emergency valves like ventilator valves being the key components are 3D printed which are used to assist the breathing of the patients. The patients are supplied with oxygen through these ventilator valves, which are attached to the patient’s mask. [20]

3. Conclusion

COVID-19 had caused almost every country to go into lockdown at some point of the pandemic, this move had really rocked the world supply chains of important medical parts and equipment such as masks, face shields, PPE kits, etc. as there were difficulties in catering to the ever-growing demands caused by the pandemic. It will not be unfair to assume the fact that many lives could have been saved if adequate supplies were present at their disposal. The gap between supply and demand was exploited and it was made clear to the world the shortcomings of the current manufacturing techniques which take quite some time to produce bulk orders, especially for critically important medical parts and equipments. 3D Printing can provide consumers with mass customization and offer on-demand manufacturing and these characteristics of 3D Printing make it a better fabrication technique when the world is suffering from a pandemic. Also, it’s almost a completely computerized process that does not need human interaction at each step of the process makes it another good choice to be used during the pandemic. This review paper has talked about a few of the parts which were developed using 3D Printing during the current pandemic. But it also must be kept into consideration that the current 3D Printing still is in its dormant stage and it will take a few more years to be able to reach its capacity and this technology might be the solution to improvise the world supply chains.
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