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REVIEW ARTICLE

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Uses of 3D printing for production of PPE for COVID 19 like situations: Scope and future

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ABSTRACT

The recent pandemic COVID 19 is taking many nations into its grasp. The medical workers are working as the frontline force in tackling this global epidemic. The virus being very contagious, it is necessary to prevent the spread from an infected person to the medical personnel's. This requires personal protective equipments (PPEs) and face masks in abundance. The ventilators are also not in abundant numbers to accommodate thousands of patients which is very vital for the survival of the infected. The infected countries are facing this crisis and are adopting means of mass production with less labor involved. Therefore, here an attempt is being made to produce 3D printed medical equipment as per requirement. This paper aims at contributing to the production of PPEs, face masks, ventilators, and ventilator splitters by the use of 3D printing techniques.

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3D printing; PPE; virus; COVID 19; pandemic

The pandemic coronavirus now takes hold over the globe. The various countries are implementing travel restrictions, social distancing measures, and work from home policies. The industries, production plants, and distribution chains are being shut down to restrict the spread of the virus through human interaction as these sectors need to employ lot of workers or employees to function. The increase in spread and the infected cases is straining the health systems. Even the more advanced countries are seeing their healthcare systems overloaded and exhausted by COVID-19. The scarcity of personal protective equipment (PPE) is putting up new challenges as the medical personnel's require these protective suits to be safe from infection and in order to be able to treat the infected. In the more severe cases of the respiratory illness, patients may need specialist respirators to take over the role of the lungs. These respirators are in short supply, however, along with medical workers, hospital space and other personal safety equipment required treating the patients. In February, Chinese and US media were reported that Chinese medical professionals often had to source their own PPE, using tape to hold together items meant for single use and, inevitably, becoming ill. In mid-February, China reported that 1,716 medical workers had contracted the virus and six had died. This is the cause of lack of PPE kits. Italy began publishing statistics on doctor deaths on March 11 and since then till end of March, 24 Italian doctors had been named as fatalities from Covid-19. And after 10 days, the fatalities increased to 69. Based on WHO modelling, an estimated 89 million medical masks are required for the COVID-19 response each month. For examination gloves, that figure goes up to 76 million, while international demand for goggles stands at 1.6 million per month [1].

Therefore, 3D printing technology emerges as a vital technique to boost the production of PPEs and other medical protective equipment's. 3D modeling and printing skills can be used to create shapes and sizes as per requirement. The designs can be obtained in lesser time and the modifications are easy to be applied and executed. 3D printing techniques aims at producing PPEs at lesser cost with less manpower while maintaining the social distancing protocol. It is the need of the hour to produce PPEs and face shield in mass quantity so that the medical personnel's can be safe from infection and there is no scarcity [2].

Professional service providers, makers, and designers in the 3D printing community have

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already started to respond to the global crisis by volunteering their respective skills to ease the pressure on supply chains and governments [3].

By the use of 3D design techniques, it is feasible to design and fabricate clear face shields that can be worn over surgical masks to provide another protective barrier for medical workers. Typical face shields are typically manufactured using plastic injection molding, which cranks out high volumes but take months to design and test. While the 3D-printed shields can be turned out within days. The following is a picture of a prototype face shield which is designed using 3D modeling and can be printed to meet the needs in the medical sector [4].

The following images show the design of the face shield designed by the author in Figure 1. Figure 2 shows the printed face shield designed by the author.

In the recent pandemic situation, 3D printing can emerge as a boon in the development of test kits which will be readily available and less expensive. The test kits can be modified as per the requirement. The test kits manufactured by Formlabs is shown in Figure 3 [5].

Moreover, the requirement of ventilators for the COVID 19 positive patients is very vital. With increasing cases, the medical sector is finding it difficult to accommodate such spike in cases with the available ventilators. Therefore, the medical sector immediately required ventilators in large numbers which are readily available and easy to manufacture which requires less manpower. By the use of 3D printing techniques, it is possible to quickly design an adapter that converts breathing machines normally used to treat sleep apnea and other nighttime respiratory conditions into emergency ventilators. 3D printing techniques can be used to fabricate 3D printed splitters so that a single ventilator can be used by multiple patients at the same time. The design can include an air-flow controller and flow meters, allowing clinicians to monitor and regulate air flow for each patient. The air volume controller is a key addition because each incubated patient requires different flow control. A filter designed can also be added to prevent cross-contamination between patients—important because early reports suggest that those exposed to multiple infected people experience worse outcomes [6]. The 3D printed ventilator splitters are shown in Figure 4 [7].

The N95 masks which come equipped with respiratory filters is made up of electrostatic non-woven polypropylene fiber. But these masks make it quite difficult to breathe while engaging in tiresome activities. Owing to this problem, some N95 masks come with an exhalation valve which can be opened to make breathing easier wearing those masks. These valves can be 3D printed in lesser time and can be equipped in the N95 masks so that it is read-

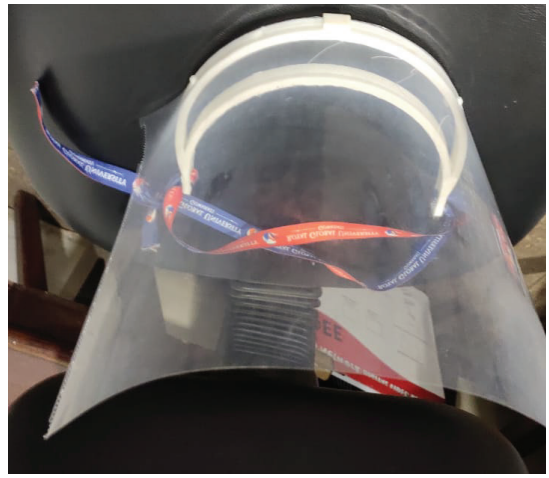

Figure 2. 3D Printed face shield (by original author).

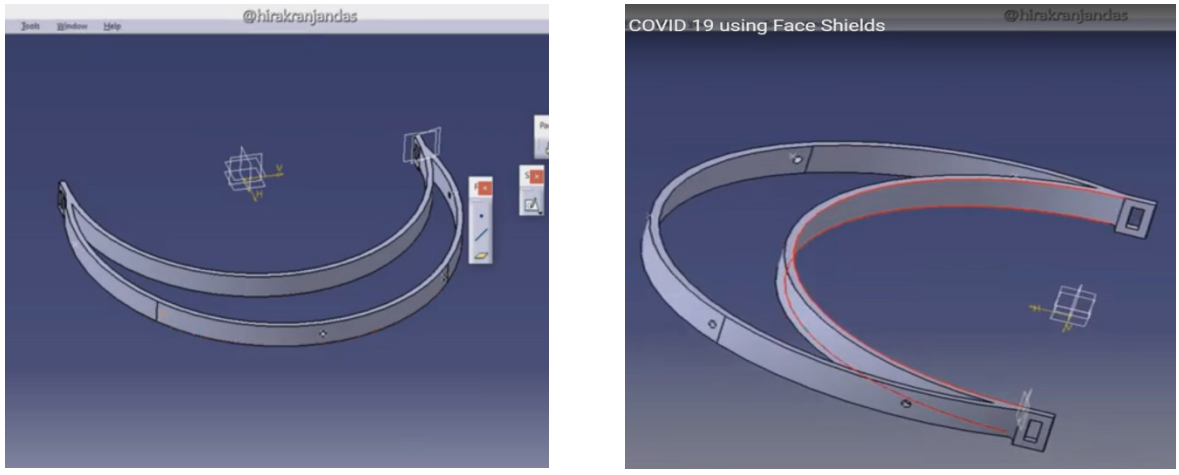

Figure 1. 3D design of face shield (by original author).

ily available and less expensive. The design of N95 exhalation filter as designed by the author is shown in Figure 5 [8].

In medical science, life supporting equipment's are machines that push oxygenated, humidified, and warmed air into the lungs. These machines monitor the amount of oxygenated air being supplied to the patient's lungs as per the requirement. 3D printing can be used to fabricate the nozzles and the regulating devices with more size variations as per requirement. The gas accumulators can be designed and manufactured with less labor and can be extensively used. The inspiratory flow regulator can be equipped with sensors and used for regulation. This is actually a solenoid valve that sits in front of the gas supply and 3D printed valves can assure that these are of perfect size and less chance of getting contaminated unlike metal surfaces [6].

While 3D printing is considered to be the ultimate solution for the scarcity of PPEs and other medical equipment's, there are certain drawbacks which sometimes come at a cost to the quality. The machines are high end and can cost up to millions of dollars to purchase, and the products produced by many 3D printers are inferior to those made through traditional manufacturing. The material selection for 3D printing is quite limited as it doesn't have many options. The most popular material use for 3D printers is plastic filament. While this plastic is high quality and relatively inexpensive, its byproduct ends up in landfills. This on the contrary effects our environment and this adds to the prevalent environmental hazards. In order for widespread 3D printing to work in the industry, the byproduct must be reused. The 3D printers which are used for small scale production and rapid prototyping such as the desktop 3D printers release potentially harmful nanosized particles in

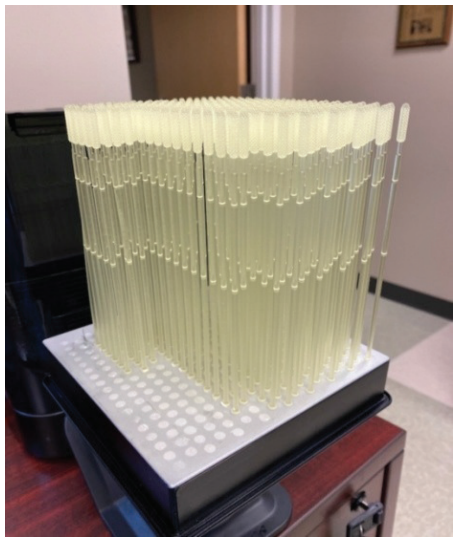

Figure 3. Formlabs testing kit. [5]

Figure 4. 3D printing industry images of ventilator splitters [7]. (Source: 3D printing industry images).

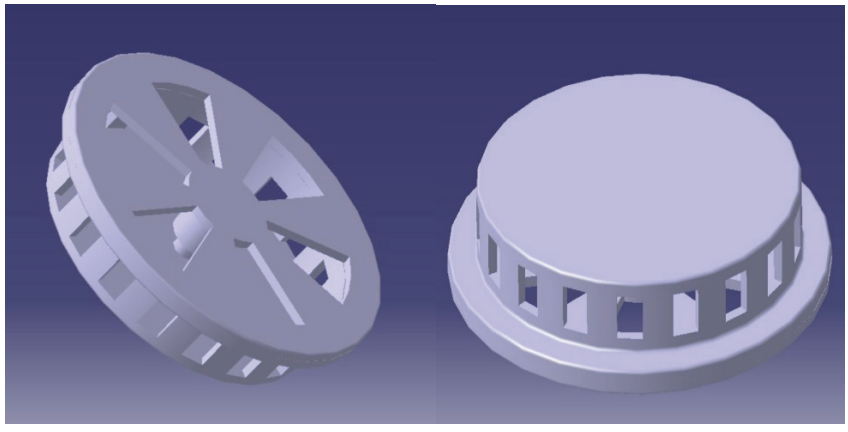

Figure 5. N95 mask exhalation filter design (by original author).

indoor air. In order to use these printers for industry purposes there should be proper exhaust filtration additions [8].

Moreover, the cost of production is higher using 3D printing techniques and requires more time than the traditional methods of production which will make it less affordable for mass purchase. The 3D printing industries face the scarcity when it comes to skilled personnels for the designing, operation and execution of the printing procedures.

Injection moulding is one of the alternatives of 3D printing which fits in the present pandemic situation. It requires 50%–90% less electrical energy than the 3D printing machineries. By the use of injection moulding, the products can be fabricated at a rate of more than one at a time. The range of materials available for injection moulding is broader. The objects made through injection molding consist of a single poured layer, which adds strength to the shape because there are no fissures or points of weakness. Furthermore, injection molding can handle pure varieties of dense materials like concrete that have to be diluted or otherwise modified for 3D printing filaments.

The materials which will be used for 3D printing is being planned to recycle the waste plastic materials and then use for further printing. This will help in keeping the environment pollution in check. With advancement of 3D printing technologies, the bioprinting of various organs can be made possible for test operations and cloning the anatomical model of an organ or a patient to check the fatalities and thereby perform the pre operation simulation in order to avoid failures and deaths to certain extent.

References

[1] Raphael T. Opinion hospitals losing fight against coronavirus due to PPE shortage, 2020. Available via https://www.livemint.com/opinion/online-views/hospitals-losing-the-fight-against-coronavirus-due-to-ppe-shortage-11585914434045.html

[2] OanhHa, K. Startups Are 3D-printing scarce ventilator and virus test kit parts, 2020. Available via https://www.bloombergquint.com/business-week/the-3d-printing-community-is-the-pandemic-s-unlikely-hero (Accessed 11 April 2020).

[3] 3D Printing Industry. How is the 3D printing community responding to COVID-19? 2020. Available via https://3dprintingindustry.com/news/3d-printing-community-responds-to-covid-19-and-coronavirus-resources-169143/ (Accessed 12 April 2020).

[4] Das H. How combat COVID 19 using face shields, 2020. Available via https://youtu.be/LklRMS-48mJQ

[5] Fig III Formlabs testing kit, Plastic Today Staff. Formlabs is 3D printing more than 100,000 COVID19 Test Swabs Daily, 2020. Available via https://www.plasticstoday.com/medical/formlabs-3d-printing-more-100000-covid-19-test-swabs-daily/38291431262722 (Accessed 12 April 2020).

[6] NIH 3D Print Exchange. COVID 19 supply chain response. Available via https://3dprint.nih.gov/collections/covid-19-response

[7] Fig IV 3D printing industry images of ventilator splitters, 3D Printing Industry. How is the 3D printing community responding to COVID-19?, 2020. Available via https://3dprintingindustry.com/news/3d-printing-community-responds-to-covid-19-and-coronavirus-resources-169143/ (Accessed 12 April 2020).

[8] Das H. Fig V—N95 mask exhalation filter design, 2020. Designed by original author.

[9] Plastic Today Staff. Formlabs is 3D printing more than 100,000 COVID19 test swabs daily, 2020. Available via https://www.plasticstoday.com/medical/formlabs-3d-printing-more-100000-covid-19-test-swabs-daily/38291431262722 (Accessed 12 April 2020).