

A Review on Impact of Covid-19 (Sars-Cov-2) Pandemic on Additive Manufacturing (3d Printing)

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Abstract- As we know the deadly Coronavirus is spreading very fastly across the world it's almost around 6 months gone but still, there is no vaccine manufacturer for it, the only way to stay protect and safe from it is precautions which may be in the terms of wearing PPE's, masks, hand gloves and maintain social distancing, for affected patients ventilator and other surgical items are needed. The impact of Coronavirus is very deadly so precaution is very necessary, so due to such a high demand of these items and lockdown the manufacturers are unable to deliver it on time, so there is an alternate for it named "Additive Manufacturing " or "3-D Printing " where the process of manufacturing is safe, secure and fast because do to corona impact most of the Industries are shut down. 3-D printing products are accurate and there is no need for post surface finishing and other items can be directly used just after manufacturing, so the demand for 3-D printed products is increased. Harshly affected patients in the COVID-19 pandemic need Ventilators and the caretaking medical staff needed Personal Protective Equipment (PPE Kit). We tried to encounter the problems tackled by the health care organizations in acquiring these gears and the PPE Kits.

Keywords- 3-DprintingAdditiveManufacturing, COVID-19, Face Shield and Masks, Pandemic, PPE Kits, Respirators.

I. INTRODUCTION

The World Health Organisation (WHO) has acknowledged the coronavirus disease 2019 (COVID-19) a pandemic. A worldwide harmonized determination is required to stop the additional spread of the virus. A pandemic is defined as "occurring over a wide geographic area and affecting an exceptionally high proportion of the population." The last pandemic stated in the world was the H1N1 flu pandemic in 2009.

On 31 December 2019, a bunch of cases of pneumonia of unknown cause, in the city of Wuhan, Hubei province in China, was informed to the World Health Organisation. In January 2020, a formerly unknown new virus was recognized, afterward named the 2019 novel coronavirus,

and samples gained from cases and study of the virus genetics showed that this was the reason for the outburst.

This novel coronavirus was named Coronavirus Disease 2019 (COVID-19) by WHO in February 2020. The virus is referred to as SARS-CoV-2 and the associated disease is COVID-19. [1]

Globally, as of 9:37 am CEST, 30 May 2020, there have been 5,796,257 confirmed cases of COVID-19, including 362,483 deaths, reported to WHO. [2]

As WHO declared the Covid-19 a pandemic, WHO also advised nations to implement nationwide Lockdowns to prevent the Community Spread of the Virus. That led to home Quarantine of most of the people and hence no production was done and supply which caused a disruption in the production and supply chain of various essential products for the medical staff and hence the shortage of PPE Kits, Respirators, Ventilators, Masks, Medicines, etc.

The COVID-19 pandemic has suddenly increased the demand for personal protective equipment (PPE) both in India and abroad. Due to this sudden high requirement, the local manufacturers are unable to fulfil the demand because lack of employees, lockdown, and following the social distancing, so there has been a recent increase in popularity of three-dimensional (3D) printing methods for PPE models including face masks, shields, and respirators.

Most of the researchers using 3D printing to create face-wear prototypes are public members who employ desktop fused deposition modelling (FDM) and stereolithography techniques. The quick availability and production of these prototypes have created opportunities in this time of pandemic to fill a large demand in areas with limited PPE. As such, these investigations have been increasingly promoted within various media outlets, and have generated a growing cultural movement within the 3D printing community to experiment with new PPE designs and to openly distribute them through electronic public forums.

Few of these designs appear similar to Standard N95 and N99 masks in shape, size, and use in Apparel. However, the current validation methods employed to ensure the safe use of these prototypes in place of the National Institute for Occupational Safety and Health (NIOSH)-approved PPE are heterogeneous, unregulated, and generally undisclosed. A common disclaimer by media propagators to this lack of objective data for proposed 3D printed prototypes is better than nothing. Although resembling commercially available vetted masks and respirators' in design, these prototypes do not appear to have undergone standardized and reproducible methods of test- and approval.

II. HOW COVID-19 IMPACT THE SCENARIO OF ADDITIVE MANUFACTURING

To understand the impact let's see some study on it which is done by different authors from across worldwide.

The author Sapoval M [3], conducted a study to report the clinical assessment of 3D printed face shield to protect interventional radiologists from the transmission of Covid-19 Virus. In this, the face shield is made ofPVC sheet. And then they tested the sheet in 31 interventional courses of action like visual comfort, tolerances, ability to do usual work, etc. They used a Likert Scale for evaluation of face shield. After all the tests were done, they concluded that the 3D printed face shield can be well accepted in various procedures and it can become optional protection for interventional radiologists.

The author Karthikeyan Iyengar [4], has done a literature review on the shortage of ventilators in the entire world during the global pandemic of Covid-19. He read all about the possible keywords related to this and concluded that as due to COVID-19the cases of respiratory illness will increase rapidly and health care systems and the governments will face the tough challenge of acquiring ventilators to support the patients. All the supply chain processes like manufacturing, storage, delivery, etc. Face a lot of problems. So Out of the Box application of Additive manufacturing like 3D printing can help us in preparing us for such pandemics.

The author Alborz Shokrani [5] discusses and points out how our manufacturing sector and supply chain is hit by the Quarantine Conditions arising due to global pandemic Covid-19. And due to which there is a huge demand for medical and personal protective articles. To tackle the problem, he also suggested that nations should now rely on their domestic mass manufacturers rather than on the low-cost economic countries. He also presented a design of a simple medical face shield that can be easily produced with almost no

equipment and expertise. In the paper, he broadly explains how the face shields can be easily manufactured in the country without any Assembly Line or a Factory. He also discusses a few difficulties and also provides the resolution to that.



The author Erickson MM [6] talks about the challenges faced by the medical staff while taking care of Covid-19 patients. A high risk of getting infected while taking care of infected patients. The medical staffs have been suggested to at least wear an N95 mask but that also doesn't guarantee safety. So, a Powered Air Purifying Respirator (PAPR) gives superior safety. So, putting considers all these points he designs an "arthroplasty helmets" which can be used as protective gear for medical staff special for the surgeons who were wearing the mask, led lights, face shield, and helmet this helmet replace them all. A HEPA filter is used inside this helmet in which the air keeps on flowing inside and then outside to maintain a positive breathing environment for the person wearing it.

The author Leonardo Cavallo [7] talks about the lack of breathing devices during the Covid-19 pandemic, and how he made the dental expert volunteer to back the process of creating printed plastic valves, by adjusting the dental digital workflow and altering masks in emergency CPAP (continuous positive airways pressure) devices. To supply full technical notes to volunteered dental experts curious about printing Charlotte and Dave connectors to breathing devices. The author introduces an alternate use of the dental (CAD/CAM) machinery, and reports on the manufacture of a 3D printed assembly samples appropriate for linking to face masks, This call for action was spoken to dentists and dental research laboratories who are willing to make accessible their knowledge, services, and equipment for the advantage of patients, even means outside dentistry.

The author Stephanie Ishack [8] discusses the inadequate supply of N95 Masks, Respirators, Face Shields, Testing Kits, PPE (Personal Protective Equipment), Ventilators, and its valves and how 3D printing can help undertake these deficiencies. The author talks about how we can print customized N95 masks using the FDM 3D printer which will help seal the mask by properly fitting on the face of the user and also how we can print transparent face shields with high optical clarity. She also talks about 3D printing test

swabs which will help in increasing the number of tests per day. She also tells that 3D printing techniques such as fused filament, inkjet, extrusion, and powder extrusion can be used to manufacture 3D printed Pills. She also suggests that we should use 3D printing to print Personal Protective Gears to protect ourselves from the virus.

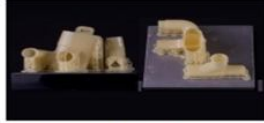


Figure 4. Printed valves external and internal vision.

All supporting pins are removed, and the external surfaces of the plastic devices are finished using conventional dental methods, with rotating burs and brushes (Figure 5).

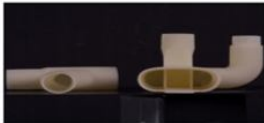


Figure 5. Finishing.

The last step is cleaning with a broad-spectrum disinfectant hydroalcoholic solution (Bactisan Spray, Amedica). Finally, the valves, stored in sterilization tubing to avoid contamination, are ready for delivery, since correct adaptation to the mask is ensured. (Figures 6-8).

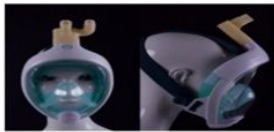


Figure 6. Insertion of "Charlotte" valve to the mask.

The author Mohd Javaid [9], discusses the application of industry 4.0 in fighting the Covid-19 pandemic. He says Industry 4.0 is known as the fourth Industrial Revolution, which has the potential to fulfil customized requirements during the COVID-19 crisis. This revolution was started with the bids of advanced engineering and digital information knowledge. Industry 4.0 can achieve the necessities of customized face masks, gloves, and collect information for healthcare systems for proper regulation and treatment of COVID-19 patients. He has discussed ten major technologies of Industry 4.0 which will help to solve the problems of this virus. This consists of various engineering and digital information skills to gather, handover, stock, analyse, and properly monitor information systems. Digital technologies provide an advanced method for the proper separation of the infected patient to decrease the high risk of mortality, speeding up the drug production, treatment process, and care.

The author William Clifton [10], debates the challenges and solutions regarding 3-D printed PPEs used extensively during this time of the Covid-19 Pandemic. The recent decline in available (PPE) due to the (COVID-19) pandemic has given rise to a host of (3-D) printed prototypes for the face mask of these models has been made open access and publicly available for printing and use, and have been promoted by various media outlets. Although these desktop

3D printing measures have provided a possible venue for success in providing homemade and cost-effective PPE to health care workers, the rapid spreading of these prototypes can overcome on demand. Although these methods have not been accepted Or suggested by authoritative organizations as viable production approaches to address the PPE shortage, many organization said these products can be used in an emergency, a concerted effort within the 3D printing community to adhere to scientific methodology and organized research efforts has the potential to provide a solution to this critical issue.

The author Warwick J. McKibbin [11], has discussed the impact of the Covid-19 pandemic on the Economy of different countries. In this, they have shown some primary estimates of the cost of the Covid-19 breakout fewer than 7 distinctive scenarios in which disease can evolve. They also suggest in short term, central banks and treasuries should make sure that the economies should continue while the outbreak continues. In long term, all major countries should take part actively in defending against this pandemic. There needs to be an immense investment in public health and the development of the poorest in different countries. Politicians should not ignore the importance of policies that suggest that public health has an important role in improvising the quality of life and is also the driver of economic rise.

The author Esther K. Choo [12], discusses the problem of shortage of medication during the Covid-19 global pandemic. They also suggest a few ways to boost the medication supply and also how to sway the cost of medication. For Example, to boost the medication supply they recommend that the FDA should set in motion a 24-hour turnaround for accepting the import of generic drugs that are in shortage from reputed manufacturers of other countries and to sway the cost of medication they suggested to use the NETFLIX model (which is currently being used in the state of Louisiana for Hepatitis C) in which they get fixed sum of money for an unlimited supply of medicine. They also say that the problem of medication shortage is invisible nowadays but can be fatal in dealing with the pandemic itself and also for other patients who have other diseases. They urge us to tackle this problem quickly and effectively before it is too late to do anything.

The author Nick Vordos [13], converses on the role of social media and Additive Manufacturing (3D printing) in tackling the lack of (PPE Kit) for medical staff during Covid-19 pandemic. The authors talk about how he used the Literature Review and Social Media Listening Software to reach the deduction that 7 Billion users searched for Covid-19 related keywords across Twitter and Facebook and these

platforms were used for PPE Design circulation. The author also advises that at the times like these, Social Media and 3D printing collectively can be the means to challenge emergency circumstances like the COVID-19 epidemic.

The author Cristian Wesemann [14], said about the impact of COVID-19, He and his team said that Coronavirus is spreading very fast across the world and it is very difficult for the front-line healthcare workers for taking care of the patients because they can easily get affected by patient's aerosol. Furthermore, for the eyes and mouth, such as face shields, allow for additional protection when working with aerosols. 3-D printing enables the easy and rapid production of lightweight plastic frameworks based on open-source data. So finally, they concluded that 3-D printed PPE's and other essential equipment for fighting against COVID-19 be a good option.

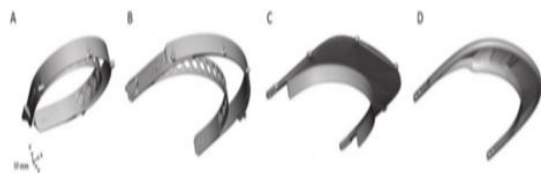


Figure 1. Open-source standard tessellation language (STL) datasets of (A) RC1, (B) RC2, (C) Budmen V3, and (D) Easy 3D Face Shields.

III. IMPACT AND NECESSITY OF ADDITIVE MANUFACTURING AT THIS TIME OF PANDEMIC

While it is easy to manufacture essential items through 3-D printing, most of the industries are still not using this and they all are in their traditional way. Products are highly precise and effective which are manufacturer by 3-D printing so it is a study about the different steps taken by some of the industry, experts, and researchers on how we can apply this 3-D printing for effective manufacturing.

This study also shows some of the unique products and design which can play a very effective role to win the battle against Covid-19.

By Additive Manufacturing we were able to produce PPE Kits, Face Shield, Masks, Respirators, Testing Swab, etc. Because there was a shortage of all these things because of disruption in the global supply chain due to Quarantine and all other reasons like lockdown in cities to prevent community spread of Covid-19.

Though Health Care Authorities doesn't approve the use of these printed safety devices because they are not inspected or vetted that they provide protection.

IV. INFERENCES

- The 3-D printed PPE'S can be a better alternative than traditional manufacturing.
- We can create a wide range of variations in the product according to our requirements.
- Mask, face shield, and other devices made from 3D printing stand on qualifying parameters which are set by the different organization responsible for health and drug department.
- At this time of the pandemic, 3-D printed equipment is very necessary because the product is manufacturing safely with less human intervention.

V. PROPOSED WORK

As we know Coronavirus is spreading very fastly across the world and there is no vaccine available. So, only precautions are the Personal Protective Equipment, of which we are facing shortage due to nationwide lockdown. So, an option we have is to switch toward 3-D printed essential protective items like Masks, PPE, Face Shield, etc.

The government and Public Health Department should legalize the production of Personal Protective Equipment (PPEs). So, more of these types of devices can come into the market and can reduce the Demand Surge.

Where we can see such large variations and uniqueness in the products which play an effective role nowadays like.

- 3-D printed ventilator nozzles which can give ventilation support to 4 patients with the use of single Ventilator. This saves money (which was used to buy new ventilators, can now be used for other purposes) and more importantly the invaluable lives of patients as well.
- A helmet which was used at the time of surgery by a surgeon can now be modified by attaching 3D printed attachments so that the medical staff taking care of Covid-19 patients will not get affected by the virus.

VI. CONCLUSION

By Additive Manufacturing we were able to produce PPE Kits, Face Shield, Masks, Respirators, Testing Swab, etc. Because there was a shortage of all these things because of

disruption in the global supply chain due to Quarantine and all other reasons like lockdown in cities to prevent community spread of Covid-19.

Though Health Care Authorities doesn't approve the use of these printed safety devices because they are not inspected or vetted that they provide protection or not.

After reading many papers and doing the analysis of all the papers, we reached to a conclusion that Additive Manufacturing is having a positive impact on overcoming the Covid-19 pandemic. By Additive Manufacturing we were able to produce PPE Kits, Face Shield, Masks, Respirators, Testing Swab, etc. Because there was a shortage of all these things because of disruption in the global supply chain due to Quarantine and all other reasons like lockdown in cities to prevent community spread of Covid-19.

Pioneering applications of Additive Manufacturing like 3-D printer technology may help to guarantee the accessibility of ventilators to the patients and ready us for such upcoming epidemiologic outbreaks.

Though Health Care Authorities doesn't approve the use of these printed safety devices because they are not inspected or vetted that they provide protection or not. Then also these products are being used and as the saying goes "Something Is Better Than Nothing".

REFERENCES

- [1] Merriam Webster Dictionary. Pandemic. Available from: <https://www.merriam-webster.com/dictionary/pandemic>
- [2] Physiopedia, "Corona virus Disease (COVID-19)", 2020. [Online]. Available: [https://www.physio-pedia.com/Coronavirus_Disease_\(COVID-19\)](https://www.physio-pedia.com/Coronavirus_Disease_(COVID-19)). [Last Accessed: 30 May, 2020].
- [3] World Health Organization, "WHO Coronavirus Disease (COVID-19) Dashboard", 2020. [Online]. Available: <https://covid19.who.int/>. [Last Accessed: 30 May, 2020].
- [4] Sapoval M, et al, "3D-printed face protective shield in interventional radiology: Evaluation of an immediate solution in the era of COVID-19 pandemic", *Diagnostic and Interventional Imaging*, vol. 101, no. 6, pp. 413-415, 2020.
- [5] Karthikeyan Iyengar, et al. "Challenges and solutions in meeting up the urgent requirement of ventilators for COVID-19 patients", *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, vol. 14, no. 4, pp. 499-501, 2020.
- [6] Alborz Shokrani, et al. "Exploration of alternative supply chains and distributed manufacturing in response to COVID-19; a case study of medical face shields", *Materials and Design*, vol. 192, 2020.
- [7] Erickson MM, Richardson ES, Hernandez NM, Bobbert II DW, Gall K, Fearis P, "Helmet Modification to PPE with 3D Printing During the COVID-19 Pandemic at Duke University Medical Center: A Novel Technique", *The Journal of Arthroplasty*, pp. 1-5, 2020.
- [8] Leonardo Cavallo, et al. "3D Printing beyond Dentistry during COVID 19 Epidemic: A Technical Note for Producing Connectors to Breathing Devices", *Prosthesis*, vol. 2, no. 2, pp. 46-52, 2020.
- [9] Stephanie Ishack, Shari R. Lipner, "Applications of 3D Printing Technology to Address COVID-19 Related Supply Shortages", *The American Journal of Medicine*, 2020.
- [10] Mohd Javaid, et al. "Industry 4.0 technologies and their applications in fighting COVID-19 pandemic", *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, vol. 14, no.4, pp. 419-422, 2020.
- [11] William Clifton, et al. "Considerations and Cautions for Three-Dimensional Printed Personal Protective Equipment in the COVID-19 Crisis", *3D Printing and Additive Manufacturing*, vol. 00, no. 00, 2020.
- [12] McKibbin, Warwick J., and Fernando, Roshen, "The Global Macroeconomic Impacts of COVID-19: Seven Scenarios", CAMA, 2020.
- [13] Esther K. Choo and S. Vincent Rajkumar, "Medication Shortages during the COVID-19 Crisis "What We Must Do", in *MAYO CLINIC Proceedings*, vol. 95, no.6, pp. 1112-1115, 2020.
- [14] Nick Vordos, et al. "How Social Media and 3D Printing Tackles the PPE Shortage during Covid-19 Pandemic", *COVID-19 SARS-CoV-2 preprints from medRxiv and bioRxiv*, DOI: <https://doi.org/10.1101/2020.04.27.20081372>, 2020.
- [15] Wesemann C, Pieralli S, Fretwurst T, Nold J, Nelson K, Schmelzeisen R, et al. "3-D Printed Protective Equipment during COVID-19 Pandemic", *Materials*, vol. 13, no. 8, 2020.