EMERGING USE OF NONCONVENTIONAL TECHNOLOGIES DURING THE GLOBAL PANDEMIC

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ABSTRACT: At the begining of the pandemic outbreak, medical supplies and medical devices were runing out in many countries resulting in great life loss. Major fields of science teamed up to help fighting this cause, engineers, health care personel, creators and inventors around the world tried to give aid in such a problematic field. Panic buying and rising demands disrupted the flow of the and the gobal supply chain in many countries resulting the need of an innovative, quick and easy solutions to be applied. Nonconvetional technologies are a well seen presence on the global market and with their help, on a global scale, many lives were saved and also huge steps towards evolution were done.
KEYWORDS: Nonconvetional, Pandemic, COVID-19, PPE, Global scale

1. INTRODUCTION

As for today, the global pandemic resembling COVID-19 is still going strong on a worldwide scale. In the last one and a half year this global pandemic brought huge issues to the entire medical systems accross the world, in many cases being almost succumbed due to the disease outbreaks and increased contagion.

COVID 19 represents an respiratory disease known for its high infectiousness caused by the Severe Acute Respiratory Syndrome Coronavirus 2 – SARS COV 2. Due to this characteristic it brings high health concerns on a global scale. In may cases, symptoms are mild to medium, in many cases being related to respiratory issues but in other cases, neurological, nervous system and many other manifestations can be presents leading to other issues, including Long COVID and also death. It has been recognized as the most devastating pandemic of the modern era and also one of the most deadly in the human history with a death toll rising up to millions.

In the absence of effective treatment and limited supply of COVID-19 vaccine, people must adhere to recommended preventive measures, as shown in [1].

The infection especially spread via droplets produced by an infected person coughs, sneezes or respires. Those droplets are too heavy to hold the air and rapidly fall on floors or surfaces. When you are close to someone who has corona virus or contacts a contaminated surface then your eyes, nose or mouth, you will become infected by breathing in the virus. Each patient/individual requires a separate mask and other personal protective equipment (PPE).[1,2]

3D printing is playing and an important role in providing essential protective equipment and items to hospitals and the wider communities, such as visors, facemasks and ventilator components.

As presented in [3], 3D printing and rapid prototyping represents a technique that can reproduce in a short amount of time a model of part designed in a computer aided design (CAD) program using data from it and manufacturing it layer by layer using a 3D printer as a part of additive layer manufacturing. On the current market we can find a large variety of printers, each one having its own pro and cons.

FDM printers are most popular in modern-day to print Personal protective equipment‟s and contributing about 60% in the overall production of PPE. FDM is a manufacturing process that uses layers of material being melt and deposited on layers. This process uses mainly thermoplastic materials to produce prototypes and 3D models, as presented in Figure 1. The commonly used materials are PLA (polylactic acid) & ABS (acrylonitrile butadiene styrene) widely used to print the component.

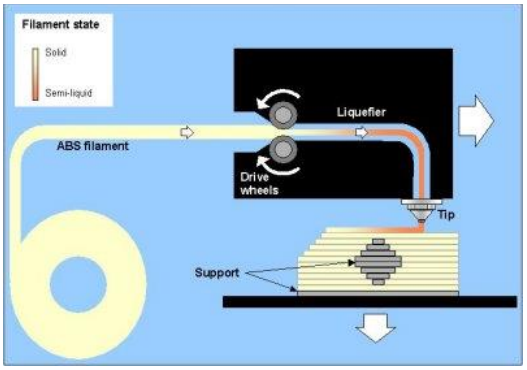

Figure 1. – FDM work principle

The use of 3D printers in medical fields is being more and more noticeable. The large variety of materials and infinite ways to optimize them are being a great reform for human services. This pandemic is fulminant in the entire world and is

imposing new healthcare challenges. Medical and auxiliary staff rely on PPE, known as Personal Protective Equipment to put a barrier between them and the infection.

This kind of equipment refer mainly to tools, safety googles, oxygen valves, nasal swabs, face shields, face masks, respiratory masks, pill dispensers, medical devices, surgical tools and many more.

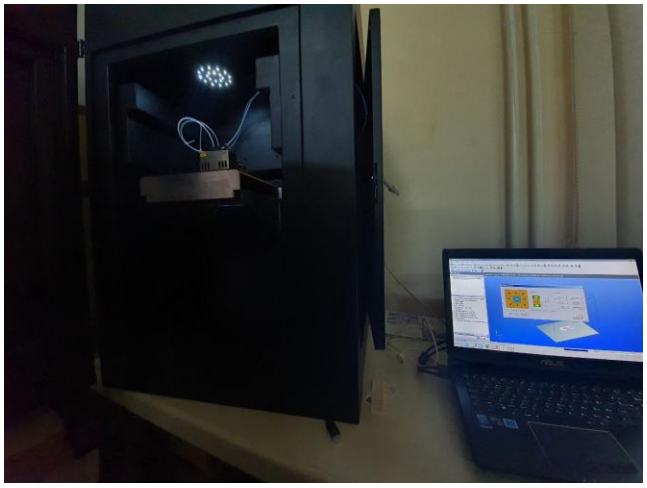

Figure 2. – Rapid prototyping system

2. PRINTING PROCESS

Like any other manufacturing methods, rapid prototyping has its own structure presented in Figure 3. The main elements consist of the 3D model that was designed in a computer aided environment.

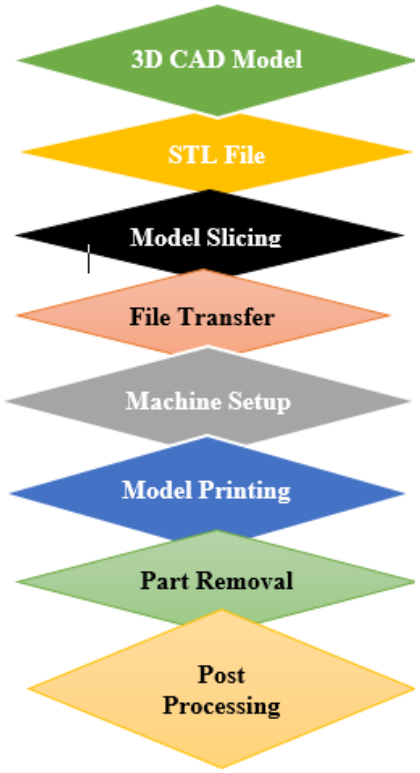

Figure 3. – Steps of model printing

After processing through computer aided programs, the 3D model is “sliced” and a simulation can be done to estimate the manufacturing time and material usage. Presented in Figure 4. we can see the 3D model being positioned in the virtual 3D printer, resembling the scaled dimensions that will be reproduced following the printing.

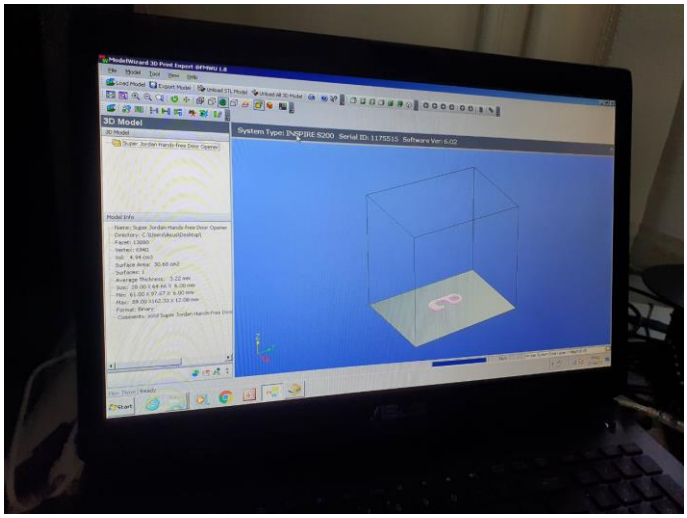

Figure 4. – 3D model placed in the virtual 3D printer

After the machine parametrization, the printing can begin. 3D printing is known to be a very efficient and quality oriented manufacturing method resulting that further more refining can be done. This types of refining are being done on the 3D model in a computer aided environment, in many cases, modification being necessary due to analyses or simulation methods that would indicate information about the behaviour of the product.

Finite Element Method is very commonly used to simulate the previously mentioned behaviour under different situation of the desired products that are being reproduced as a virtual 3D model, thus resulting an infinite circle of optimization of the desired products. This circle can be seen in Figure 5. and in being used as the main principle of the continuous optimization of any system or product.

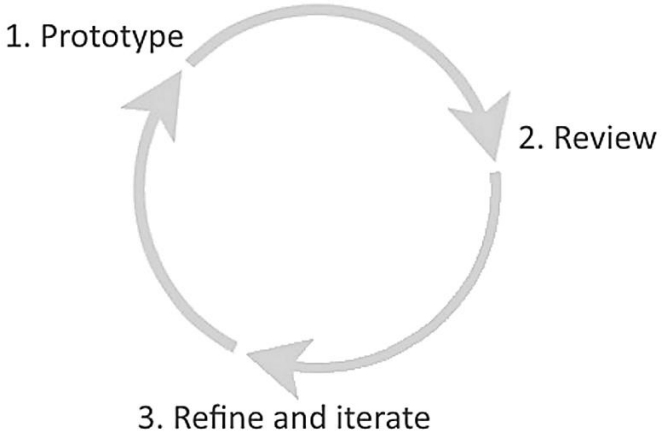

Figure 5. – Continuous optimization circle resulting thus an ongoing constant optimization for desired parts

3. EMERGING USES OF RAPID PROTOTYPING

Rapid Prototyping machines represents an innovative technology that is being used more and more in medical fields and being increasingly popular in the current pandemic. Rapid Prototyping is structured on many levels of methods or manufacturing processes, fused deposition of material being widely used due to its efficiency, good cost-quality ratios and many ways of optimizations.

With the help of rapid prototyping, any kind of objects or models can be reproduced in a short amount of time. Being also in a crisis, this kind of technologies are bringing healthcare services to another level of efficiency and satisfaction of the people.FDM printers are most popular in modern day to print personal protective equipment and contributing about 60% in the overall production of PPE.[4]

Another form of personal protective equipment that is becoming increasingly popular in the public is face shields and masks with visors. They consist of a band that goes around the head which is attached to a that provides a barrier for the face from the surroundings. At the beginning of the pandemic, face shields were mostly used amongst individuals in manufacturing industries but now there are a necessity for the healthcare workers.

Figure 6. – Face shield used by medical staff

With such a large range of issues involving the traditional manufacturing of PPE, this is where 3D printing comes into play, offering numerous advantages. 3D printing is notorious for offering high customizability in its products; this technology's ability to manufacture complex and highly personalized equipment is unmatched. Face masks can be customized in order to fit the exact parameters of one's face through 3D scanning technology. Using this technology, chin arc, jawline, face length, nose length, and nose protrusion measurements can all be taken accurately and virtually instantaneously. Although this individualized approach does have its downsides as it requires more time and thus is less efficient to manufacture, it targets issues of personalization that are clearly not met by the conventional mass manufacturing means. [4]

Prusa research is a leading company that manufactures fused deposition modeling 3D printers and had a very rapid response to this global crisis. The shortage of materials and personal protective equipment represented the foundation for many projects developed by this company. Tens of thousands of face shields, masks, protective equipment were donated and also the projects and designs are available online, based as an open source project to be used by everybody on this world and also to be optimized regarding the situations. Also, the design is meeting the European Union Norms – EN166:2001 that defines the standards for Class 3 Protective Equipment.

Figure 7. – Prusa protective face shield

In the current global crisis and the current wave of infections the need of protective equipment is high and production capacities decrease significantly in countries that rely mainly on human resource such as China or India. To try to accomplish higher production levels its imperative for many companies to find different production capabilities and try to solve the current shortages.

While using 3D printing can help increase some characteristics, in some cases, with underdeveloped machines, time can represent a distress factor. In this case, it has been highly recommended to use the main optimization characteristics that help to reduce manufacturing time by optimizing to exact dimensions and to use more efficient materials such as ABS or PLA. [5]

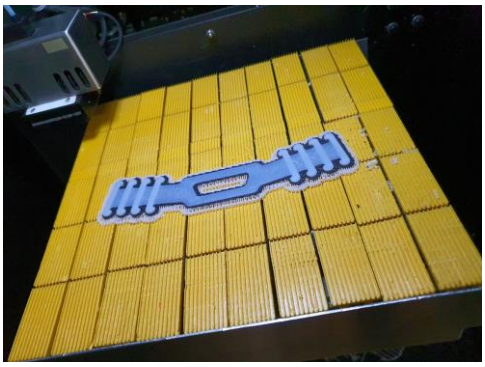

Figure 8. – Face mask buckle

Many healthcare workers were facing severe discomfort due to wearing mask continuously for hours resulting thus a 3D model of buckle to be used with the masks, presented in Figure 8.

For daily use, many people started to use different objects to not come in touch with surfaces that were in contact with numerous persons. It has been demonstrated at the beginning of the pandemic that commonly touched surfaces can be the source of disease transmission, being contaminated by an infected person.

This type of object were door openers and pointers to help the users to touch the door handles indirectly. Designers and creators has designed numerous types of door openers that can be fixed in door handles and many convenient sized multipurpose door hooks.

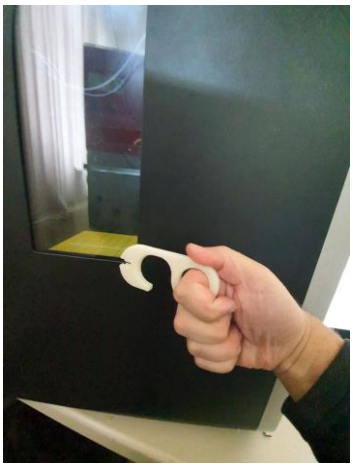

Figure 9. – Door Hook

4. FURTHER INNOVATIONS

As the pandemic in going strong there are many researches going on related to bioactive plastic materials, or coatings and nano-coatings being able to form a barrier againt bacterias and viruses.

These surface-attached bacteria Are highly resistant to usual and conventional antimicrobial agents and can make their way to chronic infections. During the pandemic, U.S. Food and Drug Administration and European Medicines Agency have considered rapid prototyped medical devices as veridical alternatives to conventional devices due to large manufacturing shortages.[4]

Biofilm quantification, surface topography, digital optical microscopy, and 3D projections were employed to better understand the bacterial attachment to 3D printed surfaces. We found that biofilm formation depends on surface structure, hydrophobicity, and that there was a wide range of antimicrobial properties among the tested polymers. A recent paper in The New England Journal of Medicine[6] suggested that copper was more efficient than polymers, polypropylene and stainless steel in reducing the COVID-19 virus viability.[4,5,6]

Figure 10. – Antimicrobial Polylactic Acid (PLA) filament that incorporates copper nanoparticles within a polymer matrix. It has been approved by the United States Food and Drug Administration to be used from surgical devices to orthotics.

Specifically, the authors reported that after exposure to a copper surface, there was no viable COVID-19 virus detected after 4 hours. Stainless Steel, however, showed no viability after 72 hours. Polypropylene and polymers were the worst, viruses being detected even after 72 hours. Thus, standard polymers and polypropylene are having the potential problem of promoting COVID-19 virus viability for up to 3 days, while copper surfaces reduce viral viability to only 4 hours.

The FDA-registered 3D-printing filament material is made from PLA and facilitates “multiple recycling options including the production of new antimicrobial medical devices. The end cycle of this filament can classify as a renewable resource facilitated by semi-biodegradation after the service life of the device and decreased antimicrobial properties," according to the research presented in [7, 8, 9].

5. CONCLUSIONS

3D printing has been present into many personal protective equipment domains and it is still going strong with further more innovations. Although, in terms of high speed production it has to take some time for enhancements, the precision and accuracy of rapid prototyping are significant enough to be used on

a large scale and on a daily basis. Also viewing from a research point of view, the advanced materials and processes are contributing to a very efficient improvements of further applications.

Being a very precise manufacturing methods, many companies are taking into account the investment into 3D technologies, here being included the rapid prototyping machines and also the reserve engineering devices that can be used to optimize further products.

Our main goal was to try optimize different personal protective equipment and parts. The main feature of 3D printing and rapid prototyping consists in being able to make adjustments of the desired parts by making different setting on the 3D printer. With different densities of the workpiece we achieved different material structures resulting different material elasticity and different fits. These aspects are very important if we take into consideration the long and gruelling hours that medical professional are required to wear. With the help of the printer parametrization unit presented in the first images different densities can be achieved being a great way to improve the customization for each person.

The pandemic is still going strong in some parts of the world, at the moment the focus being in the Eastern Europe, where the pandemic wave started to take big proportions, pressure being put on the medical systems in various countries.

Engineers, healthcare workers, designers and simple people that are trying to help in this outbreak are focusing to help the suppressed medical systems by trying to reproduce medical equipment and medical devices via 3D printing to try to support in way or another the fight against the rapid growing cases.

The future consist of many rapid prototyping devices that will be used in many fields resulting thus a nonconventional technology that will start to be a more and more used manufacturing method, redefining the fine boundary between conventional and nonconventional.

6. ACKNOWLEDGMENTS

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