



Design of 3-D Printed Strapless COVID-19 Mask

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Abstract— The use of strapped mask for a longer period of time not only had an adverse effect on the health of the people but also were quite expensive and wastes a lot of material in large scale production. The aim of this work is to design and develop a 3-D printed strapless mask which has less hazardous effect on people, is cheap and user-friendly.

Index Terms— 3-D printing, COVID-19, Strapless mask, Pandemic, Health issues, Inexpensive, Comfortable for all size of Faces

1 INTRODUCTION

In March 2020, New York City encountered its first official case of COVID-19 (coronavirus disease 2019). This novel coronavirus, referred to as SARS-COV 2, originated in Wuhan, China in December 2019. Within a short amount of time, hundreds of thousands of cases were diagnosed around the world, causing the World Health Organization to announce it as an official infectious disease pandemic on January 30, 2020.

With the spread of COVID-19 in the country, demand for protective gear such as masks and coveralls has shot up. These products, now made by a handful of manufacturers, are attracting investments because of increasing demand.

According to government sources, the current production of N95 masks in the country is about 75,000 to one lakh pieces a day and coveralls suits 5,000. The production of N95 and other types of similar versions of industrial masks was 10-15 lakh a month and it is now about 25 lakh a month (average). And around the world the face mask market is projected to grow from USD 0.9 billion to USD 21.5 billion.

But investing in this product doesn't seem rightful, where one can only use it up to only three times (shown in a study by National Institute of Health) and spending a lot. Not only is it extortionate but also the cost for manufacturing is also very high. Also, in a study it was shown that the cost of N95 mask used for the protection against COVID-19 in the Indian market is quite high, making it unaffordable for the masses.

People tend to use the same mask for over a long period because of its high cost, belief in one-time-investment and lack

of awareness about how to reuse or dispose it, therefore after sometime it starts losing its tightness and hence due to loose-fitting of such masks, not securing proper cover around the nose and mouth, this may allow COVID-19 virus to enter or leave from the side edges. Furthermore, for prolonged usage of mask with straps had an adverse effect on the physiological and psychological health of a person. And in some cases, have major health issues.

In a recent study it was found that prolonged use of N95 and surgical masks by healthcare professionals during COVID-19 has caused adverse effects such as headaches, rash, acne, skin breakdown, and impaired cognition in the majority of those surveyed.

Wearing masks for a prolonged amount of time causes a host of physiologic and psychologic burdens and can decrease work efficiency. Activity cannot be performed as long or as efficiently while wearing masks as compared to when masks are not worn as the straps continuously irritate the user and sometimes when the straps get loosened it increases the chances of getting affected.

Headaches related to prolonged mask use can be attributed to mechanical factors, hypercapnia, and hypoxemia. Even the tight straps and pressure on superficial facial and cervical nerves are mechanical features causing headaches.

Therefore, we need to find a better solution to overcome all the shortcomings of the strapped COVID-19 mask. Hence, we had designed and developed a prototype which is not only inexpensive, easy to manufacture but also affordable, easily accessible, can be used for a longer period of time, and doesn't have any adverse effect on the user.

2 HISTORY

COVID-19 spreads mainly from person to person through respiratory droplets. Respiratory droplets travel into the air when you cough, sneeze, talk, shout, or sing. These droplets can then land on face or on nose of people who are near you or they might breathe these droplets in. Masks are a simple barrier to help prevent your respiratory droplets from reaching others. Studies show that masks reduce the spray of droplets when worn over the nose and mouth.

Before the awareness for N-95 mask, people were generally using cloth mask or surgical mask. A cloth mask also offers some protection to you too. How well it protects one from breathing in the virus likely depends on the fabrics used and how the mask is made (such as the type of fabric, the number of layers of fabric, and how well the mask fits).

Medical / Surgical masks are single-use masks that are not made of cloth and are not designed to be washed or laundered. They are sold online and through large retail stores. These are not the same as other medical masks. But both the masks were not suitable enough to protect against COVID-19 virus.

Some respirators were designed and tested to meet international standards. These respirators are labelled to tell you what standard they meet. Respirators approved by NIOSH are evaluated by NIOSH against a specific US standard that includes a quality requirement. International standards do not often have quality requirements. The most widely available respirators that meet an international standard are KN95s. Other examples include 1st, DL2, DL3, DS2, DS3, FFP2, FFP3, KN100, KP95, KP100, P2, P3, PFF2, PFF3, R95, and Special.

NIOSH approves many types of filtering facepiece respirators. The most widely available are N95, but other types (N99, N100, P95, P99, P100, R95, R99, and R100) offer the same or better protection as an N95.

When supplies are available, individuals may choose to use a basic disposable N95 respirator for personal use, instead of a mask, in some situations.

The digital versatility and quick prototyping of 3D printing empowered a swift mobilization of the technology and hence a rapid response to emergencies. Even during severe disruptions in supply chains, critical parts was manufactured on-demand by any decentralized 3D-printing facility in the world by leveraging designs shared online. Moreover, the additive nature of 3D printing enables product customization and complex designs. The broad spectrum of 3D-printing applications in the fight against COVID-19

3 includes personal protective equipment (PPE), medical and testing devices, personal accessories, visualization aids and emergency dwellings. 3-D printing had broadened the scope even in this pandemic and encouraged many to provide a better solution.

Many industries and institutions had proposed and manufactured different masks. Also many organisations had also promoted the idea of additive manufacturing by running different events like, The Fit-to-Face Mask Design Challenge organized by America Makes in collaboration with the Department of Veterans, VHA Innovation Ecosystem and Challenge America launched their 2nd COVID-19 Maker Challenge and so on.

The designs so far were having straps or straps extender with it. Though it looks negligible issue but it can have a long-time effect on one. Therefore, in May 2020, Avery Dennison Medical had partnered with Global Safety First (GSF) to helped to bring an innovative mask technology to the healthcare market. The NIOSH-Certified Strapless N95 face masks use a special air-purifying filter media and a hypoallergenic medical adhesive at the perimeter of the mask to filter more than 95% of particles. The mask utilizes a strapless innovative design that provides a complete perimeter seal with security and protection.

However, this innovative idea wasn't applied in the 3-D printable masks so far.

3 METHODOLOGY

Since, the designs which had been manufactured so far were easily worn off after few washes and the straps gets loosened after some time of application. So, we came up with a solution of designing a 3-D printable mask which will be strapless and will be having a N-95 filter.

We will make it strapless by applying hypoallergenic medical adhesive at the perimeter of the mask which will create a vacuum region hence will not allow any virus to enter and N95 filter at the front. The design is made in such a way that it will be skin friendly, breathable and easily accessible for the user. It is a one-time investment, the 3-D printed material will not be worn out and can be use for a longer period of time, also the N-filter will be easily replaceable. The only thing that is required to change at a certain interval will be the hypoallergenic tape, which is available at a very low cost.

4 DESIGN

The isometric view shows the placement of N-95 filter, hypoallergic tape in Figure 1.

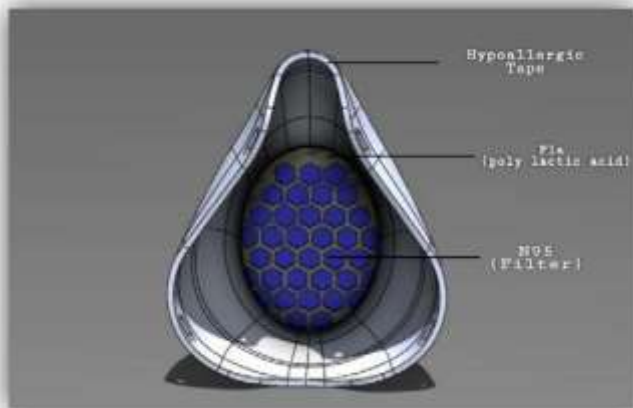


Figure 1 :Isometric View

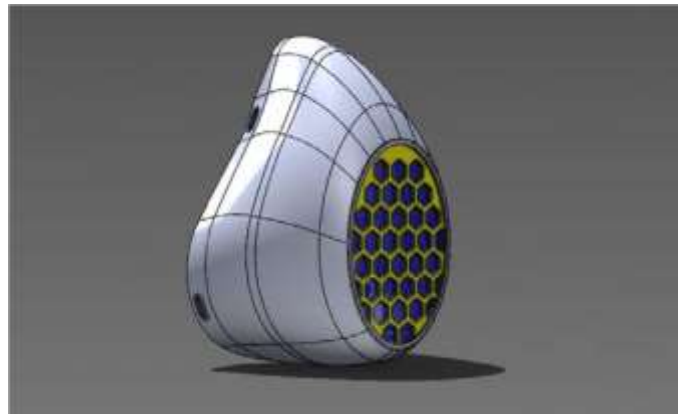


Figure 4: Side view

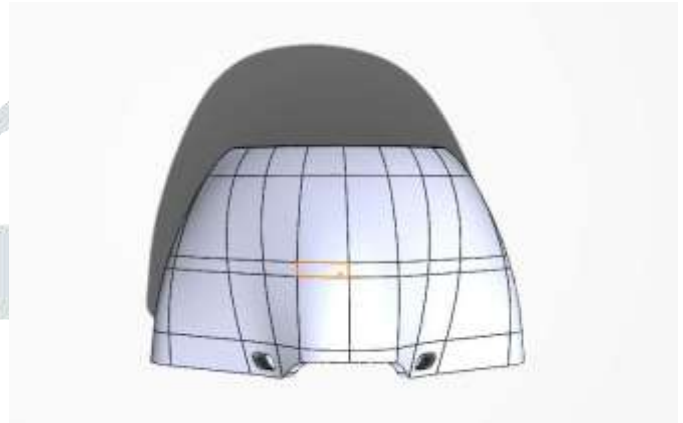


Figure 5: Top view

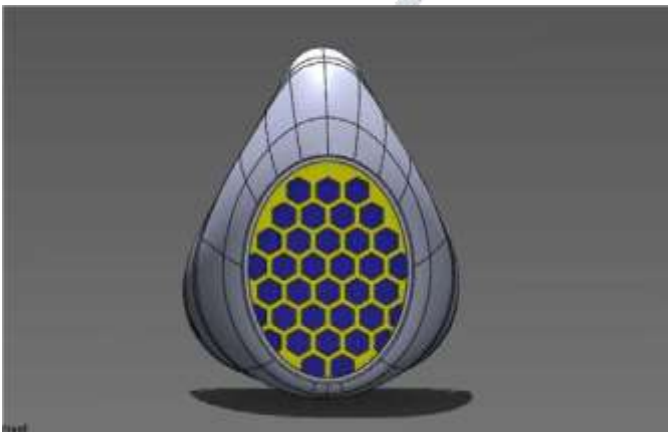


Figure 2: Front view

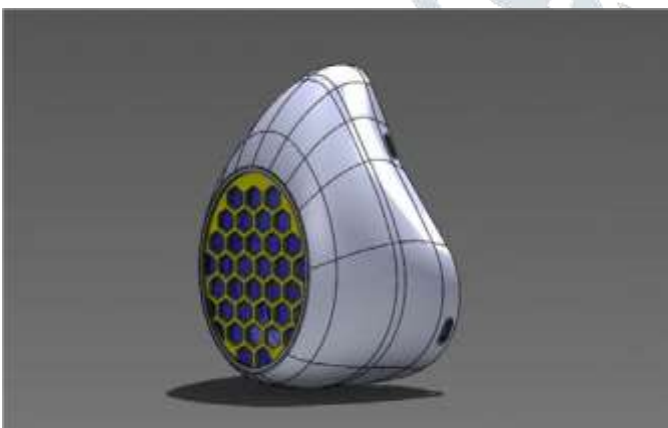


Figure 3: Side view

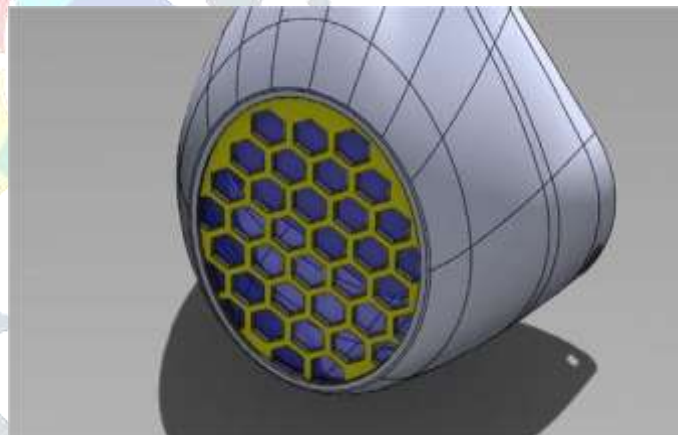


Figure 6

5 MATERIAL USED

The mask is divided into three regions: -

- Outer case
- Inner case
- Outer perimeter

The *outer case* will be made up of PLA (Polylactic Acid) which is a biodegradable (under the correct conditions)

thermoplastic, derived from renewable resources such as corn starch or sugarcane. It is one of the most popular bioplastics, used for many applications ranging from plastic cups to medical implants.

Why PLA?

PLA

<p>PROS</p> <ul style="list-style-type: none"> - Can be printed on a cold surface - More environmental-friendly - Shinier and smoother appearance - Smells sweet when being print -) - No harmful fumes during printing - Higher 3d printer speed - More detail 	<p>CONS</p> <ul style="list-style-type: none"> - Can deform because of heat (like a cassette in a car) - Less sturdy (than ABS)
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ABS

<p>PROS</p> <ul style="list-style-type: none"> - Very sturdy and hard - Suitable for machine or car parts - Higher melting point - Longer lifespan 	<p>CONS</p> <ul style="list-style-type: none"> - Made out of oil, so more damaging to the environment - Deforms when not being print on a heated surface - Hot plastic fumes when printing - Therefore, you need ventilation - More difficult to print - Not suitable for using with food
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Table 1

Hence, PLA is recyclable, compostable and when is incinerated, it emits fewer toxic fumes than oil-based plastics. In case of biomedical use, PLA degrades into nontoxic acid. Therefore, it would be suitable for one to wear it for a longer period as there will be no side effects on skin. It is also cheap and can be easily printed.

The *inner case* i.e., the filter case will be of N-95 mask's material, which can be easily replaced after certain uses. We are using N-95 because it is sanctioned and certified by NIOSH.

The *outer perimeter* will be comprising of a hypoallergenic adhesive medical tape which is latex-free and free of 90 to percent of allergens. Hypoallergenic tape has been tested and proven not to cause skin reactions. It is lightweight and allows the skin to breathe efficiently.

6 FABRICATION

Based on the design the model is fabricated and the details of components, cost and the materials based on research are in table

NOTE: - This cost estimation is based on market value and is for only 1 mask.

Sr.NO.	Components	Material	Cost
1	Outer case	PLA	Rs-15
2	Inner case (Filter)	N95	Rs-30
3	Outer perimeter	Hypoallergenic Tape	Rs-15
	Total		Rs-60

The proposed model cost of Rs 60 is affordable for masses.

7 CONCLUSIONS

The COVID-19 pandemic has led to a dramatic loss of human life worldwide and presents an unprecedented challenge to public health, food systems and the world of work. The economic and social disruption caused by the pandemic is devastating, tens of millions of people are at risk of falling into extreme poverty, while the number of undernourished people, currently estimated at nearly 690 million, could increase by up to 132 million by the end of the year.

Therefore, in such case we need a better solution which is eco-friendly, available to all, is innovative and don't have adverse effects.

8 FUTURE SCOPE

This mask is available for all size of faces and since it is cheap, durable and can be used for a longer period of time, hence it is kind of one-time investment. We can add new features as per the need of an individual.

There is flexibility and product is easy to understand and use.

The different components of product are completely reusable and reduces the environmental impacts arising from waste treatment and disposal.

9 ACKNOWLEDGEMENTS

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10 REFERENCES

- 1) <https://www.nature.com/articles/s41578-020-002343>
- 2) <https://elblogdelplastico.blogs.upv.es/2015/01/31/pla-vs-abs-plastic-the-pros-and-cons/>
- 3) <https://bellmedical.com/strapless-n95-facemask>
- 4) <https://medical.averydennison.com/en/home/product/s/personal-protective-equipment/N95mask.html>
- 5) <https://clinmedjournals.org/articles/jide/journal-of-infectious-diseases-and-epidemiology-jide-6-130.php?jid=jide>
- 6) <https://blogs.cdc.gov/niosh-scienceblog/2020/08/04/skin-irritation-respirators/>
- 7) https://www.researchgate.net/figure/N95-filteringfacepiece-respirator-with-top-strap-high-on-theocciput-a-and-with-the_fig4_258921576
- 8) <https://insidefirstaid.com/first-aid-kit/medical-tape-buy-the-right-kind>
- 9) <https://www.frontiersin.org/articles/10.3389/fpubh.2>

- [020.606635/full](#)
- 10) <https://www.healthline.com/health/coronavirusmask#types-of-masks>
- 11) <https://www.cdc.gov/coronavirus/2019-ncov/preventgetting-sick/cloth-face-cover-guidance.html>
- 12) <https://www.fda.gov/emergency-preparedness-andresponse/coronavirus-disease-2019-covid-19/3dprinting-fdas-rapid-response-covid-19>

