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Design and Development of Face Shield by 3D Printing for the COVID-19 Epidemics

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Abstract: ***The world is facing problemof pandemic crisis situation with covid-19 virus. In this situation medical persons are seeking a piece of personal protective equipment such as face mask to avoid the infections. The face mask/ shield help to protect from body fluids and droplets, where the patients are treated from cough, other infections.In this concern the present work is focused on the design and development of prototype face shield mask by 3D printing technology using fused deposition modelling (FDM).A preliminary economic design indicated that the presented approach offers a feasible alternative to the current practices.***

Key points: Covid-19, Face mask, Prototype, 3D printing

I. INTRODUCTION

Past from year the epidemic diseases spreading across the world ,such as Typhoid, malaria, Spanish flu, elbola and the current in 2019-2020 is covid-19 disease . Wide protective measures were initiated according to world health organisation (WHO) such as personal hand cleaning, social distancing are essential for all health care.COVID-19 is athreat to the life of medical staff and security personal, working constantly to safeguard our lives facing a shortage of Personal Protective Equipment (PPE), such several research universities and research forms are coming out with some solutions to the shortage, such designing ventilators and face shield using 3D printing technologies.

II. TYPES OF FACE MASK

A. Surgical Mask

The standard surgical mask also known as a fluid-resistant surgical mask (FRSM), is designed to provide a barrier to splashes and droplets impacting on the wearer's nose, mouth and respiratory tract shown in Fig.1. It fits fairly loosely to the user's face. These single-use masks are used for a variety of procedures in community as well as hospital settings. They should be changed when they become moistened or damaged, and should not be undone and dangled round the neck between procedures. It should be worn with eye protection

Fig.1. Surgical Mask used for fluid-resistant surgical mask

B. N95 Respirator

The respirator mask available in the USA as N95 mask and in the UK as an equivalent FFP ('filtering face piece') mask, is used to prevent the user from inhaling small airborne particles in aerosol-generating procedures (AGPs) shown in Fig.2. It must fit tightly to the user's face. There are three categories: FFP1, FFP2 and FFP3. FFP3 provides the highest level of protection. Again, this mask must be worn with eye protection.

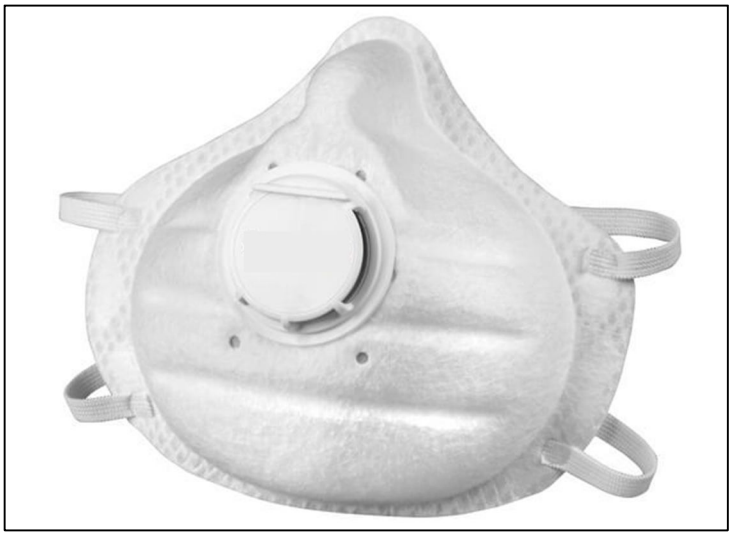

Fig.2. N-95 Mask used for fluid-resistant surgical mask

Additive manufacturing, (AM) or 3D printing of various processes used to make a three-dimensional object in which successive layers of material are laid down under computer control commands. The produce of 3d models is of almost any geometry or different shapes.

Fused Deposition Modelling (FDM) was developed by Stratasys in this process, a plastic or wax material was extruded through a nozzle that traces the parts cross sectional geometry in layer by layer. The build material is usually supplied in filament form, but some setups utilize plastic pellets fed from a hopper instead. The nozzle contains resistive heaters that keep the plastic at a temperature just above its melting point so that it flows easily through the nozzle and forms the layer. The plastic hardens immediately after flowing from the nozzle and bonds to the layer below. Once a layer is built, the platform lowers, and the extrusion nozzle deposits another layer. The layer thickness and vertical dimensional accuracy is determined by the extruder die diameter, which ranges from 0.013 to 0.005 inches. In the X-Y plane, 0.001 inch resolution is achievable. A range of materials are available including ABS, polyamide, polycarbonate, polyethylene, polypropylene, and investment casting wax.

3D printing that run on Fused Deposition modelling Technology build parts layer-bylayer

The process is simple: ¬

1) *Pre-processing:* With 3-D CAD Model file -preparation software slices are built and positions and calculates a path procedure program to extrude thermoplastic called Polylactic acid (PLA) with necessary support material.
2) *Fabrication:* The FDP -3D printer heats the thermoplastic to a semi-liquid state and deposits it in ultra-fine beads along the extrusion path in which programme is executed by commands.
3) *Post-processing:* The excess supported isremoved or dissolves it in solution water and the final part is ready to use.

FDM is an prominent form of rapid prototyping, used in rapid manufacturing and it facilitates iterative testing. The benefits of FDM technology is clean, simple-to-use and office-friendly. Supported production-grade thermoplastics are mechanically and environmentally with Stable, Complex geometries and cavities that would otherwise be problematic become practical with FDM technology.

The present study involves a prototype design and development of face shield using 3d modelling and 3d printing that can be adopted in case need at low price . We found a free design in literature papers to print but it was not up to the mark in terms of safety. There is a gap found in between the head and the frame of shield such could allow virus into the vicinity of ENT(Eyes, noise,Teath) shown in figure 2 on left hand side. So we modified this industrial design to benchmark its safety features, such made an addition change on both side of frame, by adding a structure to fill the gap between head and frame to make it skin-fit adjustable aerofoils shown in figure on right hand side.

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III. EXPERIMENTAL METHODOLOGY

A. Design Stage (CAD model)

CAD model have been developed to provide an ad-hoc solution to this pandemic of COVID-19, such to do that design, it should be safe and handy. Such used open CAD software for modelling face shield frame and to then convert it to stereolithography (STL) format to make compatible for slicing software shown in Fig 3

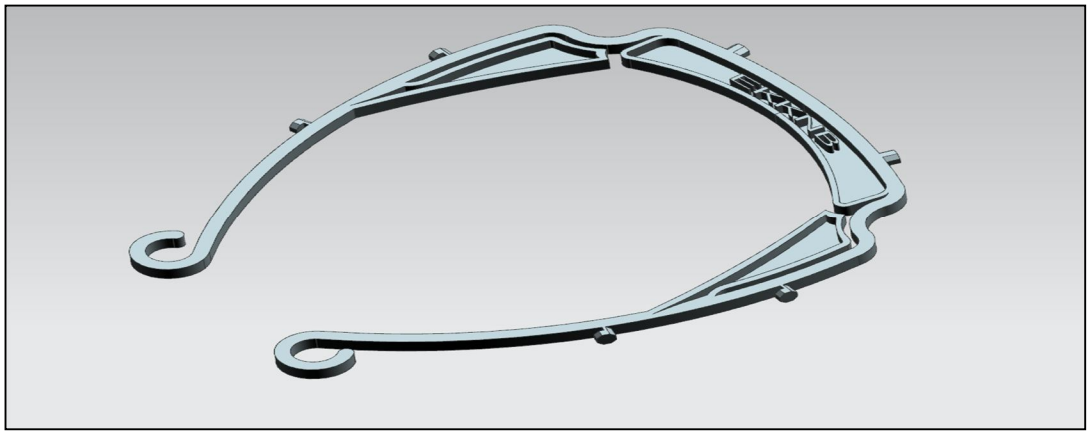

Fig.3: Design of final model.

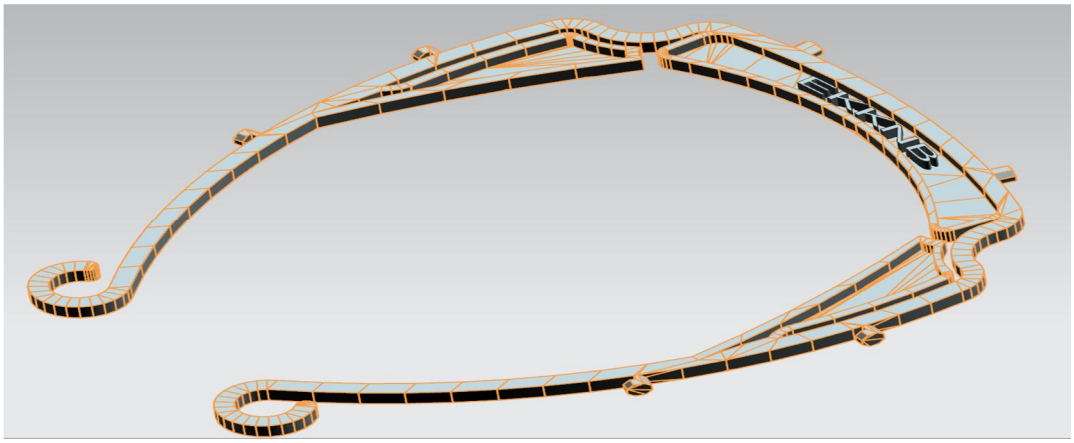

Fig.4: STL meshing of CAD model

The designed file is saved as .STL format (Stereo Lithography) shown in fig.4..This file format is supported by many software packages; it is widely used for rapid prototyping, 3D printing and computer-aided manufacturing. An STL file describes a raw unstructured triangulated surface by the unit normal and vertices (ordered by the right-hand rule) of the triangles using a three dimensional Cartesian coordinate system.

B. Materials Required

Material used for this project should have good mechanical properties along with bio-disposable (eco friendly) in nature so we prefer Poly Lactic Acid (PLA).

C. Machine Specifications

1) *ENDER 3*- FDM 3D printer
2) *Built Volume:* 220x220x250 mm^3
3) *Extruder Temp:* 0-280° C
4) *Bed Temp:* 0-90° C
5) *Layer height:* 0.1-0.4mm.
6) *Material use:* PLA, ABS, PETG, etc.

D. Machine Input Parameters

1) Extruder Temp: 200° C
2) Bed Temp: 55° C
3) Layer Height: 0.3 mm.
4) Print Speed: 50mm/sec
5) Material Use: PLA

E. Experimental Producer of 3D Printing

1) Slicing of STL model in layers to be printed, using a open source slicer cura 15.04.6.

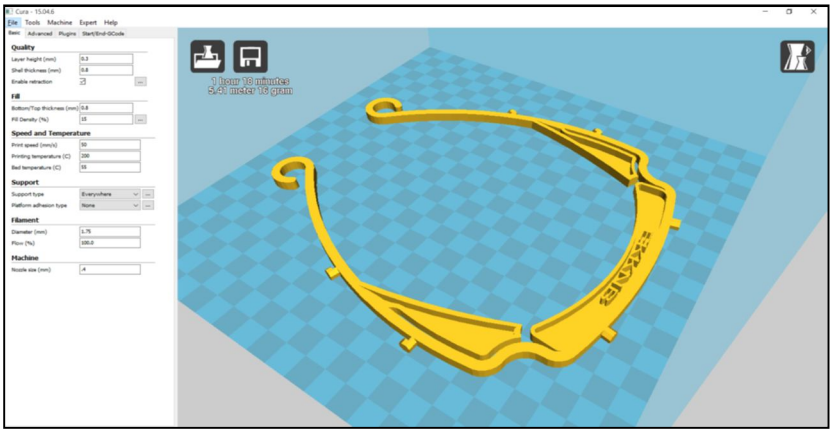

Fig.5: STL model imported to Cura 15.04.6 slicer.

2) Setting up input Parameters and slice the Model.

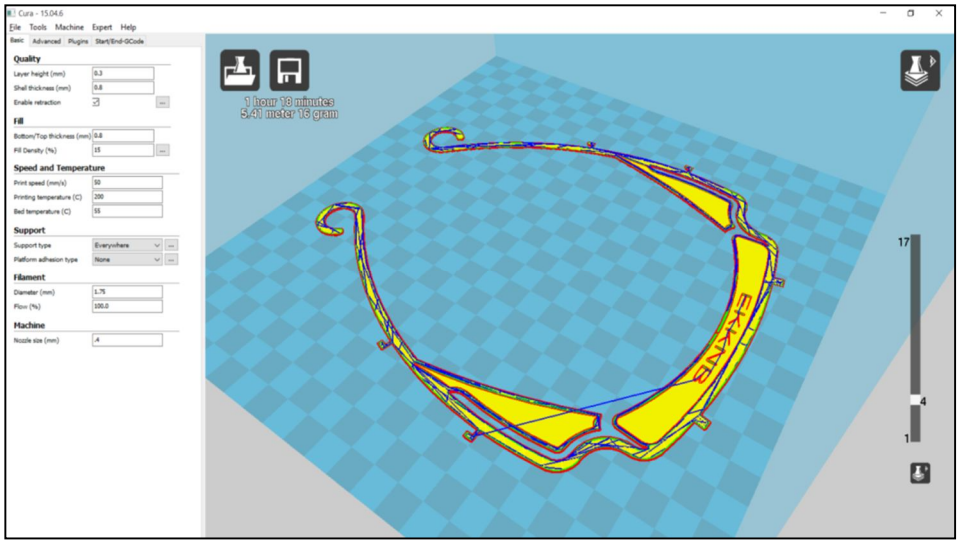

Fig.6: sliced model layer no.4

3) Save G-code file to the memory card and insert card in slot provide on 3d printer.
4) Switch ON printer and prepare it for printing , run Preheat PLA command given in menu to start heating up extruder and bed for preferred printing conditions of specific material. Printing PLA at temperature of extruder and bed are 190-220° C and 50-60° C respectively.
5) Spay adhesive to make bed sticky to hold print.
6) In the mean time printer reached printing temperature give print command form the card.
7) Remove the printed part carefully to avoid damage.

F. Final Printing

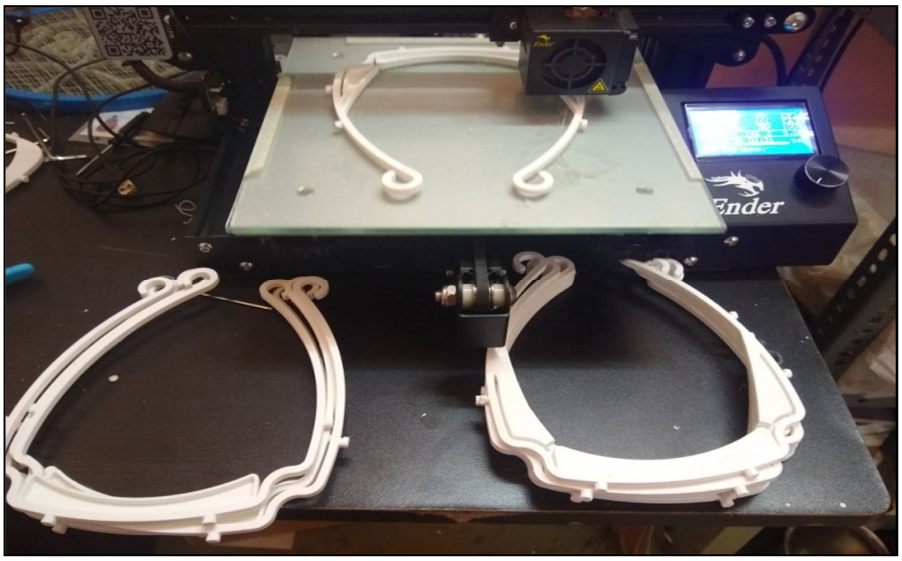

Fig.7: 3D printed frames, free source frame on left hand side and modified designed frame on left hand side.

Fig.8. Final Assembly of Face Mask Shield

IV. CONCLUSIONS

The purpose behind this research was to develop a low cost face Shield Mask by 3D Printer by using Fused Deposition Process with PLA materials which are easily available and cost effective for the Covid-19. We have been successful in reducing the cost to a considerable extent i.e about 10-15 %. The parts made in 3D design and 3D Printer software are successfully imported the product obtained has the same dimension given during the design stage of the product i.e an accuracy close to 99.99%. The Face Shield mask was successfully fabricate the 3D printer according to its virtual design proposed at reduced cost.

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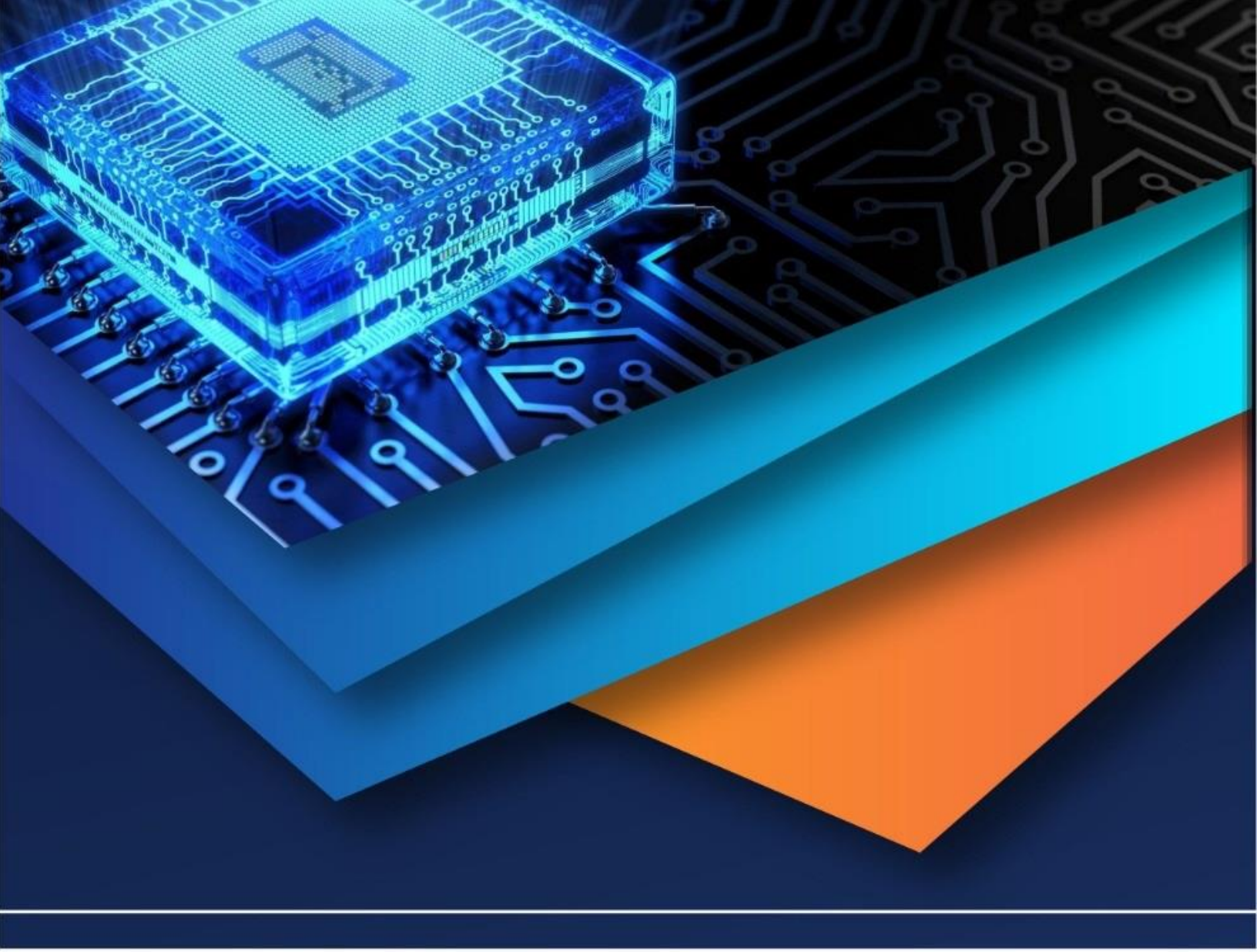

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