2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT)
April 09-11. 2021, ISTTS Surabaya, Indonesia

How to the Need for Personal Protective Equipment (PPE) during the current Covid 19 Pandemic: Smart Products Solution

2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT) | 978-1-6654-0514-0/20/$31.00 ©2021 IEEE | DOI: 10.1109/EIConCIT50028.2021.9431851

1st Ari Prasetyo
Department of Mechanical Engineering
Universitas Sebelas Maret
Solo, Indonesia
ari_prasetyo@staff.uns.ac.id

2nd Hamid Abdillah
Department of Mechanical Engineering Education
Universitas Sultan Ageng Tirtayasa
Banten, Indonesia
hamid@untirta.ac.id

3rd Wawan Wawan
Tridilab Indonesia
Yogyakarta, Indonesia
dcombinasi@mail.com

4th Muhammad Nurtanto
Department of Mechanical Engineering Education
Universitas Sultan Ageng Tirtayasa
Banten, Indonesia
mnurtanto23@untirta.ac.id

5th Nur Kholifah
Department of Culinary and Fashion Education,
Yogyakarta State University
Yogyakarta, Indonesia
Nur.kholifah@uny.ac.id

6th Suyitno Suyitno
Department of Automotive Engineering Education
Muhammadiyah University
Purworejo, Indonesia
suyitno@umpwr.ac.id

***Abstract*—Coronavirus disease 2019 (COVID-19) is a new type of disease SARS-CoV-2 and resembles the SARS virus which has now become a pandemic. The level of transmission caused by droplets raises the need for personal protective equipment that can prevent spread. The great need causes the ratio of supply and demand to become unbalanced. This study aims to develop a personal protective product in the form of a face shield that has a good product acceptance rate and an effective manufacturing process. This study uses a 3D printer with the Fused Deposit Material (FDM) system as a means of manufacturing products. First, a product modification process is carried out which is then tested with several parameters. The parameters of the product acceptance level used are fit, space, comfort, weight. Each parameter is measured using a visual analogue scale. The results of product testing were obtained that the fit and weight parameters were in the very good category and the space and comfort parameters were in the good category. The production time required to manufacture a product is 31 minutes and spent 31 grams of the filament.**

***Keywords*—PPE, COVID-19, 3D printer, Face Shield**

I. INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a new type of disease that has now become a pandemic. This disease is caused by infection with SARS-CoV-2 and resembles the SARS virus in form and behaviour [1], [2]. This disease was first recognized in the city of Wuhan, Hubei province, China (China) and to date there are still increasing new cases of transmission worldwide [3].This disease has a high rate of transmission through droplet breaths and mouth movements. The droplet contains a virus that is susceptible to transmission to other people who interact or have sufficient distance from people who have been infected [4]. In response to this, the use of personal protective equipment such as masks and face shields is the main requirement to prevent transmission [5].

The urgency of personal protective equipment to avoid infection has an impact on the level of need and creates scarcity of stocks of personal protective equipment [6]. Unavailability of the need for prevention of transmission will certainly have an impact on the distribution and uncontrolled rates of infection. This in turn has an impact on longer handling and higher rates of infection [7].

This situation then creates an opportunity to fulfil the need for personal protective equipment [8]. Researches on the manufacture of personal protective equipment have sprung up to answer this need. This research is dominated by the use of 3D printers as a modern and fast manufacturing technology [9], [10]. The 3D printer is one of the icons of industrial revolution 4.0 that offers convenience in the design and manufacturing process of products [11]. During the pandemic, many 3D printers were used to manufacture of face shields. These studies also offer a wide variety of shapes and sizes of face shields [12], [13]. However, these studies still have weaknesses in the form of user acceptance and production time.

This study aims to examine the development and quality improvement of face protection products produced using the FDM 3D printer system. The development and improvement of product quality are carried out by engineering the shape and dimensions that are effective and efficient so that they have a good level of acceptance for users, especially users in Indonesia. In addition, the engineering carried out also aims to obtain and short production time.

II. RESEARCH METHODS

This research is an applied research that examines the use of FDM 3D printers for face shield improvement and manufacture. Fig. 1 is the flow of activities carried out in this study. Activities start from the beginning of making product designs to analysing the products produced.

A. Tools and materials

The tool used in this research is a 3D printer ender 3pro with a FDM system with a production capacity of 220x220x250 mm for making face shield frames. The raw material for the 3D printer filament used is Polylactic acid (PLA) with a diameter of 1.75 mm. PLA is a biodegradable thermoplastic aliphatic polyester material with a molecular structure ($C_3H_4O_2$). PLA is made from renewable sources such as corn flour, tapioca or sugar cane [14].

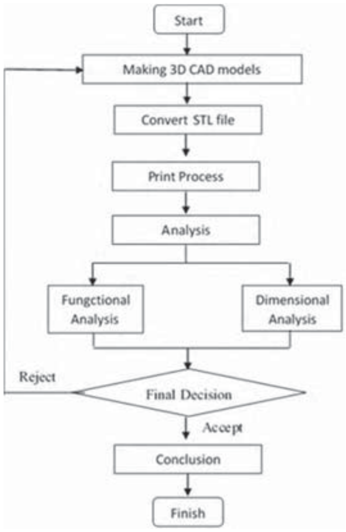

Fig. 1. Research flowchart

B. Data analysis

The data in this study consisted of 2 data, namely product dimension data and product functional data. Product dimension data aims to obtain the accuracy of the resulting product dimensions. Product dimensions are made based on the anthropometry of the average Indonesian human head. The basic anthropometric measurements used are the width of the head and the distance between the eyes. [15]. The product is designed based on the anthropology of the Indonesian head shape, based on the circumference of the face of the head. It was obtained that the average head circumference of 157 mm was used as a turning point (middle value). This value is the value between the diameters of the front head circumference, namely 130-190 mm. Furthermore, from the rotary point the design is designed and the following formulations are obtained:

$$E = \text{average head width} / 2 \quad (1)$$

$$D = 34 \text{ (based on RC 2)} \quad (2)$$

$$A = \text{distance between eyes} + D \quad (3)$$

$$B = (\text{head width} + D - A) / 2 \quad (4)$$

$$C = (\text{head width} + D - A) / 2 \quad (5)$$

$$F \text{ and } G = \text{intervals for fixing rubber ties} \quad (6)$$

This data is obtained by measuring the parts of the product (Fig. 2) using a precision measuring instrument (digital callipers). Measurements in one part, were carried out 3 times with different measuring points. This treatment aims to see the size distribution in that section [16] . This is also used as an illustration of the resulting geometric shape, if the measurement results at the 3 points have the same, then the section has a good general shape. Product functional data is carried out by conducting product use trials. The product was tested on 30 Indonesians. The parameters in the functional analysis are (1) contact between the frame and the user's head (fit) (2) free space / distance between the face and the product for breathing and the addition of other PPE such as glasses and masks (space), (3) the comfort of using products such as pressure on the head and the product position slip during use (Comfort), (4) additional load on the head during use of the face shield (weight). These parameters were measured using a visual analogue scale (VAS) with a rating range from 0 mm = "not accepted" to 100 mm = "very acceptable"[17].

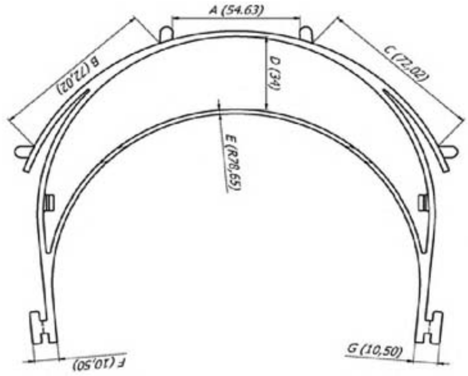

Fig. 2. Location for collecting dimensional data

The data obtained from the product dimensions and product functional experiments were analyzed using quantitative descriptive statistics. Descriptive statistics include the arrangement, depiction and description of data [18]. Descriptive analysis is presented in the form of: (a) the frequency distribution of each variable, (b) a measure of central tendency (mean, median, mode), and (c) a measure of dispersion (spread), namely standard deviation and variance. The results of the data processing are then interpreted by Table I. Decision making is carried out after the functional analysis of the product has been completed. A product is declared to accept if it gets a "good" rating from users.

III. RESULTS AND DISCUSSION

A. CAD modelling

CAD modelling [19] is the face shield frame design process can be seen in Fig. 3. CAD modelling is done using Solid works software. The frame design adopted from one of the popular open-source face shields designs RC2 developed [20]. RC2 in Fig. 4 was chosen because it is a face protection product that has the best level of user acceptance. Modifications were made to reduce the filament weight needed to make one frame and adjust to the face type of Indonesian people. After the design process is complete, it is followed by the conversion process to STL format as input for slicing and 3D printer setup.

TABLE I. DATA INTERPRETATION

Range			Category
0	s/d	20	Very less
21	s/d	40	Less
41	s/d	60	Enough
61	s/d	80	Good
81	s/d	100	Very good

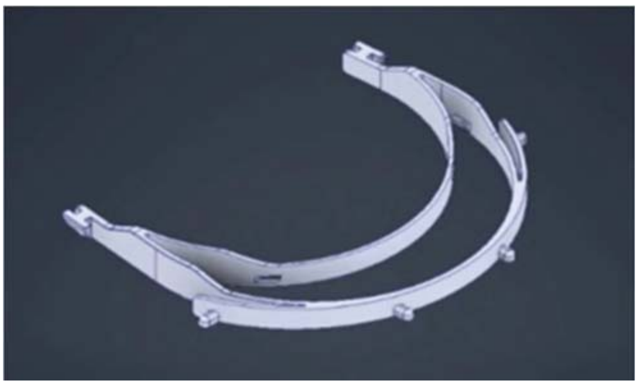

Fig. 3. Modified 3D CAD Modeling

Fig. 4. RC2 face shield designs

B. Print Process

The print process begins with slicing the STL design file. STL file creation is done using high-resolution quality. This aims to obtain a good geometric shape and accuracy of STL files [21]. The resulting STL file output has a size of 4.1 MB or the equivalent of 11.5 megapixels. The STL file that was ready was then sliced. The slicing process was carried out using simplify 3D software (Fig. 5). This slicing process aims to produce G Code, which will then be inputted to the 3D printing device. After the slicing process is complete, the next process is to set the print parameters (Fig. 6) of the 3D printer that will be used. In this study, the print parameters that are regulated are on file and layer (0.2mm) with an estimated print time of 46 minutes. The frame product (Fig. 7) is finished with a print process about 31 minutes. This print time is faster than the estimation made by the slicer software. The time difference between estimation and reality is 15 minutes. This is obtained because the print process is done Overclocking the print speed of 160%. This overclocking facility is the default for the 3D printer used, result frame product presented in Table II.

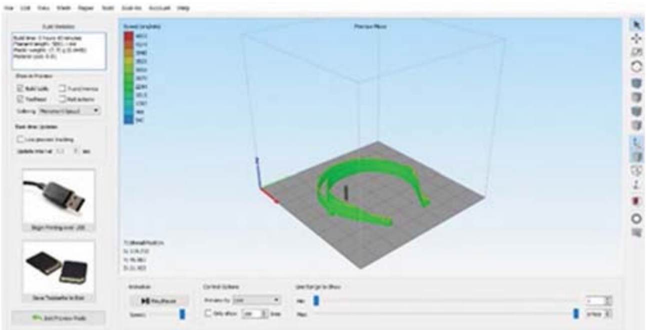

Fig. 5. 3D CAD slicing process

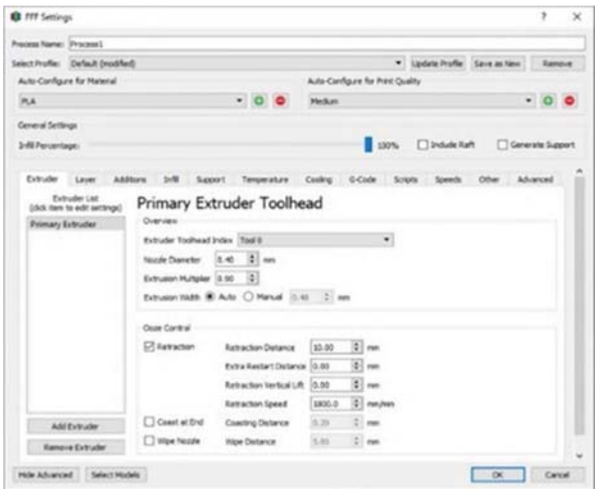

Fig. 6. Print parameter settings

TABLE II. RESULT OF PRODUCT MODIFICATION

Name	RC2	Modified
Filament Weight	42 g	31 g
Print Time	3 h 17 min	31 min

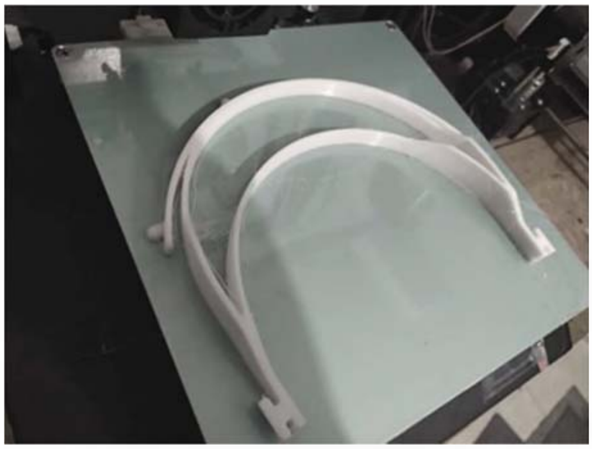

Fig. 7. Results of face shield frame products

Fig. 8. Final Product

The use of filaments for products that have been modified is 31 grams. This result is 26% more effective than the previous product (RC2). After the print process is complete, proceed with conducting measurements to produce the final face shield product (Fig. 8).

C. Assembly

The assembly process is carried out by joining the frames, rubber ties and protective mica. The dimensions of the protective mica frame used are 240 x 240 mm with a thickness of 0.4mm. The assembly process is carried out using the guidelines created by the team [22].

D. Product Dimension Analysis

Product dimension analysis is carried out to see the size achievement between the design and the product produced. Measurements are carried out in the parts listed in Fig. 2. Table III displays the measurement results of the face shield frames made with the FDM 3D printer. The measurement results show a deviation of 0.03 to 0.06. The biggest deviation occurs in parts A, B and C which are part of the product with a circular profile. The largest dimensional deviation occurs in sections A, B and C show an accuracy of 0.18mm to 0.2mm. Meanwhile, in sections D, E, F and G, it is <0.1 mm.

TABLE III. RESULT OF PRODUCT DIMENSIONS

Location	Mean	S.Dev	Guide	Gap
A	54,43	0,06	54,63	-0,20
B	72,22	0,06	72,02	0,20
C	72,20	0,06	72,02	0,18
D	33,94	0,05	34,00	-0,06
E	78,88	0,05	78,65	0,23
F	10,42	0,02	10,50	-0,08
G	10,43	0,03	10,50	-0,07

The largest dimensional and dimensional deviation occurs on the part of the product which has a circular profile. This is in accordance with findings which states that the largest deviation of product dimensions occurs in the circular profile. In the aspect of accuracy, the dimensional accuracy obtained from the product is ± 0.2mm. This accuracy is in line with the findings of previous research which states that the accuracy of 3D printing products is ± 0.2mm [23].

E. *Functional Analysis*

Functional analysis is carried out to examine the function and performance of the product being made. The functional analysis for this face shield product was carried out by testing the use of the product (Fig. 9) which was then evaluated using a questionnaire. The evaluation results are shown in Fig. 10. The fit parameter obtains an average score of 82 with a deviation of 5.7. This shows that the contact between the face shield frame and the head is in the very good category. This means that the shape and dimensions of the frame that are made are acceptable and in accordance with the circumference of the user's head.

In the space parameter get an average score of 75 with a deviation of 3.5. This shows that the available free space is in the good category. The existence of good free space allows users to add other PPE without friction with the face shield [24]. This means that users can use additional PPE such as masks, glasses etc., to meet the standard health protocol for handling COVID 19. The comfort parameter has a mean score of 66 with a deviation of 4.1. A score of 66 shows that the user's comfort against binding and slip pressure is in the good category. This can still be improved by replacing the rubber band with a more elastic type of material. The binding material which is more elastic can reduce the pressure on the user's head when using the face shield [25], [26]. The weight parameter obtained an average score of 89 with a deviation of 2.2. This shows that the weight of the face shield product is in the very good category. This means that the face shield product has a light weight so that it does not place a significant burden on the user's head.

Fig. 9. Product functional testing

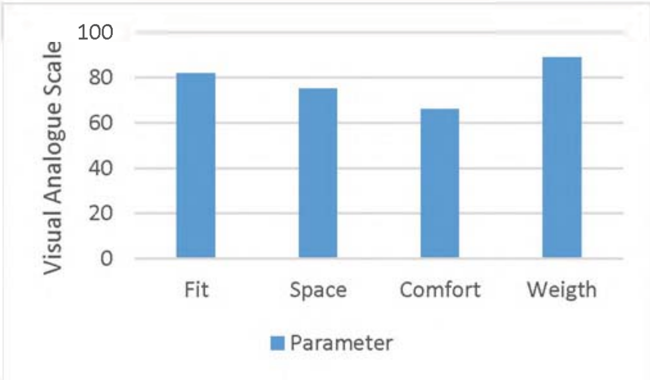

Fig. 10. Rod digram of product parameter analysis

CONCLUSIONS

The conclusion of this study is that the development products made have met the majority of user needs such as fit, space, weight and production time. However, the comfort parameter still requires further development to increase the level of product acceptance. In addition, product modification succeeded in reducing filament usage to 31 grams with a production time of 31 minutes. Face shield products developed are stated to be accepted by users from Indonesia with an average functional rating of the product in the good category.

REFERENCES

[1] F. Isbaniah and A. D. Susanto, "Pneumonia Corona Virus Infection Disease -19 (COVID-19)," *J Indon Med Assoc*, vol. 70, no. 4, pp. 87–94, 2020.

[2] R. R. Aliyyah *et al.*, "The perceptions of primary school teachers of online learning during the COVID-19 pandemic period: A case study in Indonesia," *J. Ethn. Cult. Stud.*, vol. 7, no. 2, pp. 90–109, 2020.

[3] S. P. Adhikari *et al.*, "Epidemiology, causes, clinical manifestation and diagnosis, prevention and control of coronavirus disease (COVID-19) during the early outbreak period: a scoping review," *Infect. Dis. poverty*, vol. 9, no. 1, pp. 1–12, 2020.

[4] X. Liu and S. Zhang, "COVID-19: Face masks and human-to-human transmission," *Influenza Other Respi. Viruses*, vol. 14, no. 4, pp. 472–473, 2020.

[5] R. Soetikno *et al.*, "Considerations in performing endoscopy during the COVID-19 pandemic," *Gastrointest. Endosc.*, vol. 92, no. 1, pp. 176–183, 2020.

[6] C. Ma, Y. Zhang, H. Zhang, L. Wu, and L. Yang, "Manufacturing of Herringbone Gear Model by 3D Printing Assisted Investment Casting," in *IOP Conference Series: Earth and Environmental Science*, 2019, vol. 332, no. 4, p. 42045.

[7] L. Garg, E. Chukwu, N. Nasser, C. Chakraborty, and G. Garg, "Anonymity preserving IoT-based COVID-19 and other infectious disease contact tracing model," *IEEE Access*, vol. 8, pp. 159402–159414, 2020.

[8] C. Chakraborty and A. N. Abougreen, "Intelligent Internet of Things and Advanced Machine Learning Techniques for COVID-19." 2021.

[9] H. Abdillah and U. Ulikaryani, "Hybrid Manufacturing and Rapid Prototyping in Metal Casting Industry: A Review," in *Proceedings of the 2nd International Conference of Science and Technology for the Internet of Things, ICSTI 2019*, 2020, doi: 10.4108/eai.20-9-2019.2290957.

[10] C. Chakraborty, A. Banerjee, L. Garg, and J. J. Rodrigues, "Internet of Medical Things for Smart Healthcare." Springer.

[11] H. Sofyan, M. Nurtanto, Z. Arifin, and P. Sudira, "Vocational Teachers Readiness in Face of the Industrial Revolution 4.0: Vocational Teachers Perceptions in Yogyakarta-Indonesia," in *Journal of Physics: Conference Series*, 2020, vol. 1700, p. 12082, doi: 10.1088/1742-6596/1700/1/012082.

[12] D. Amin, N. Nguyen, S. M. Roser, and S. Abramowicz, "3D Printing of Face Shields During COVID-19 Pandemic: A Technical Note," *J. Oral Maxillofac. Surg.*, vol. 78, no. 8, pp. 1275–1278, 2020.

[13] J. Neijhoft *et al.*, "Manufacturing and supply of face shields in hospital operation in case of unclear and confirmed COVID-19 infection status of patients," *Eur. J. Trauma Emerg. Surg.*, vol. 46, pp. 743–745, 2020.

[14] H. Abdillah, M. Munadi, and N. W. Supriyadi, "Comparison Of 3d Printer and Wood Casting Pattern," *J. Elektro dan Mesin Terap.*, vol. 6, no. 2, pp. 70–80, 2020.

[15] "Rekap Data Antropometri Indonesia," *Antropometri Indonesia*. .

[16] H. Abdillah and M. Munadi, "Three dimensional stereolithography printer application for casting pattern development," *Int. J. Emerg. Trends Eng. Res.*, vol. 8, no. 6, pp. 2643–2649, 2020, doi: 10.30534/ijeter/2020/69862020.

[17] N. Crichton, "Visual analogue scale (VAS)," *J Clin Nurs*, vol. 10, no. 5, p. 706, 2001.

[18] G. Glass and K. Hopkins, "Statistical methods in education and psychology," *Psyccritiques*, vol. 41, no. 12, pp. 12–24, 1996.

[19] M. Nurtanto, H. Sofyan, and P. Pardjono, "E-Learning Based AutoCAD 3D Interactive Multimedia on Vocational Education (VE) Learning," *J. Eng. Educ. Transform.*, vol. 34, no. 1, pp. 21–27, 2020.

[20] C. Wesemann *et al.*, "3-d printed protective equipment during covid-19 pandemic," *Materials (Basel).*, vol. 13, no. 8, p. 1997, 2020.

[21] M. Munadi and H. Abdillah, "Pengaruh Resolusi 3D CAD STL Pada Kualitas Geometri dan Dimensi (G&D) Produk Pola Cor 3D Printer," *Infotekmesin*, vol. 11, no. 2, pp. 130–136, Aug. 2020, doi: 10.35970/infotekmesin.v11i2.225.

[22] Team Covid Assistance, "Cast Face Shield Process & User Manual," *COVID-19 Research*. 2020.

[23] H. Abdillah and U. Ulikaryani, "Aplikasi 3D Printer Fused Deposite Material (FDM) pada Pembuatan Pola Cor," *SINTEK J. J. Ilm. Tek. Mesin*, vol. 13, no. 2, p. 110, 2019, doi: 10.24853/sintek.13.2.110-115.

[24] E. Livingston, A. Desai, and M. Berkwits, "Sourcing personal protective equipment during the COVID-19 pandemic," *Jama*, vol. 323, no. 19, pp. 1912–1914, 2020.

[25] A. Bukauskas *et al.*, "Curved-crease origami face shields for infection control," *PLoS One*, vol. 16, no. 2, p. e0245737, 2021.

[26] M. H. Chua *et al.*, "Face masks in the new COVID-19 normal: materials, testing, and perspectives," *Research*, vol. 2020. 2020.