



The design of a feet-based door opener to prevent the spread of coronavirus disease (Covid-19) through a doorknob

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ABSTRACT

The world is struggling to cope with the ongoing pandemic disaster. The main factor that made this outbreak so troublesome was that it spread very quickly. In addition to droplets when coughing or sneezing, the virus can spread through personal contact indirectly on frequently touched surfaces. One of these objects, which is also widely available in public facilities, is the doorknob. To reduce the intensity of the touch on the doorknob, a door opening system using the foot is very necessary because it does not damage the existing facilities. The use of 3D printing or additive manufacturing has increased during the pandemic because of its ability to make several personal protective types of equipment quickly, inexpensively, and simply. 3D printing is printing solid or 3-dimensional objects from designs that are already available in digital format. This research was conducted using a 3D printer and a simple mechanical system. Hands-free door openers are made for the lever handle type. With a weight of 15 kg, like the weight of a regular footstep, the design can move the handle and open the door. The use of this door opener on a broader scale is expected to suppress the spread of the COVID-19 outbreak.

ABSTRAK

Dunia sedang berjuang untuk menanggulangi bencana pandemi yang sedang terjadi. Faktor utama yang menyebabkan wabah ini begitu merepotkan adalah penyebarannya yang sangat cepat. Selain melalui droplet saat batuk maupun bersin, virus dapat menyebar melalui kontak perorangan yang terjadi secara tidak langsung pada permukaan benda yang sering disentuh. Salah satu benda tersebut, yang juga banyak terdapat di fasilitas umum, adalah gagang pintu. Untuk mengurangi intensitas sentuhan pada gagang pintu, sebuah sistem pembuka pintu menggunakan kaki sangat diperlukan karena tidak merusak fasilitas yang sudah ada. Penggunaan 3D *printing* atau *additive manufacturing* telah meningkat selama pandemi karena kemampuannya untuk membuat beberapa alat pelindung diri dengan cepat, murah, dan sederhana. pencetakan 3D adalah sebuah proses mencetak benda padat atau 3 dimensi dari desain yang sudah tersedia dalam format digital. Penelitian ini dilakukan dengan memanfaatkan 3D *printer* dan sistem mekanis sederhana. Pembuka pintu tanpa menggunakan tangan dibuat untuk tipe pegangan tuas. Dengan bobot 15 kg seperti bobot injakan kaki biasa, desain yang telah dibuat mampu menggerakkan gagang dan membuka pintu. Penggunaan pembuka pintu ini dalam skala yang lebih luas, diharapkan dapat berkontribusi dalam menekan penyebaran wabah COVID-19.

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1. Introduction

A pandemic tragedy hit the world in 2020. Starting with reports of respiratory disease in Wuhan, China, in December 2019, this outbreak has spread to various parts of the world. Compared to the previous endemic diseases, namely SARS and MERS, the current outbreak of Coronavirus Disease 2019 (COVID-19) is much more dangerous because of its rapid transmission [1]. This is indicated by the number of positive cases in Indonesia, around 1,298,608 cases and 111,593,583 cases accumulated globally for one year and two months after the first reported case [2]. In essence, joint efforts are needed to break the chain of transmission of COVID-19.

The mode of transmission of this virus is divided into two, direct and indirect. Direct transmission occurs when a person inhales droplets from a patient's cough or sneeze. In contrast, indirect transmission occurs when a person touches a surface containing the virus from patient droplets [3]. Appeals to minimize the direct transmission rate have been routinely disseminated, starting from the use of masks to reduce the spread of the virus due to coughing and sneezing and guidelines for washing hands with soap and hand sanitizer. However, for the indirect spread of the virus, the recommendations given are still limited to household furniture and public facilities [4].

During the epidemic, 3D printing gained much interest to swiftly and efficiently make tiny to medium-sized objects. The shortage of personal protective equipment, such as mask filters, face shields, and testing devices, can be solved using 3D printing [5 - 6]. This additive manufacturing method was utilized to create various prototypes and one-of-a-kind gadgets to aid in the battle against COVID-19 by stacking a 2D layer with a resolution of up to 50 m. One of the stuff that happens to a lot of indirect hand touch is a doorknob. If counteractions depend solely on disinfection, these efforts will be very ineffective. Therefore, creativity is required to reduce hand contact with these items. Hand-free door movement has been developed [7 - 8]. The concept of "opening the door without hands" emerged at the beginning of this pandemic, and some of these ideas are door openers with secret door handles and hooks [9], [10]. However, the two instruments still have deficiencies, namely that they did not get people to touch the doorknob, and not everyone is disciplined to carry their door hooks. Thus, this study provides a solution in the form of a door opening device using legs without harming or altering the existing doorknob. The device, which is developed independently using a 3D printer, is expected to provide an alternative solution to minimize the prevention of COVID-19 [11 - 15], both on campus and in public facilities.

The system is built to operate perfectly with a mechanical system without using electronic equipment so that it does not rely on the supply of electrical energy. It is not harmed when exposed to water. In addition, the design is designed so that it does not harm the condition of existing doors and can be adapted to all types of doors so that their use can benefit the broader community.

2. Research Methodology

Research began with the study of literature and the preparation of tools and materials. In addition, the design considers how much force is required to pull the door handle, what components will increase the working force, and the material properties of 3D printing that will be achieved. The operation of this door opening device is more of a trial and error in which the design ideas that have been made will be printed and tested to structural strength, user experience, and ergonomics. The tools and materials needed during the research activities are a 3D printing and printing machine, commonly referred to as a filament that uses polyacid (PLA) in this research, followed by a design evaluation door, as well as other supporting materials such as nuts, rulers, drills, and screwdrivers. The system is built to operate perfectly with a mechanical system without using electronic equipment so that it does not rely on the supply of electrical energy. It is not harmed when exposed to water. In addition, the design is designed so that it does not harm the condition of existing doors and can be adapted to all types of doors so that their use can benefit the broader community.

3. Results and Discussion

3.1. Design Process

Three designs, which are design A, design B, and design C, have been made in this study to compare which one is the most effortless and most functional design. Design A used the change of force of the gearbox system. The mechanical system hopes to transform a slight movement into a sufficient force by using the gear ratio. The process is applied to the foot pedal, which does not require a large rotation angle but is sufficient to generate a pulling force on the door handle.

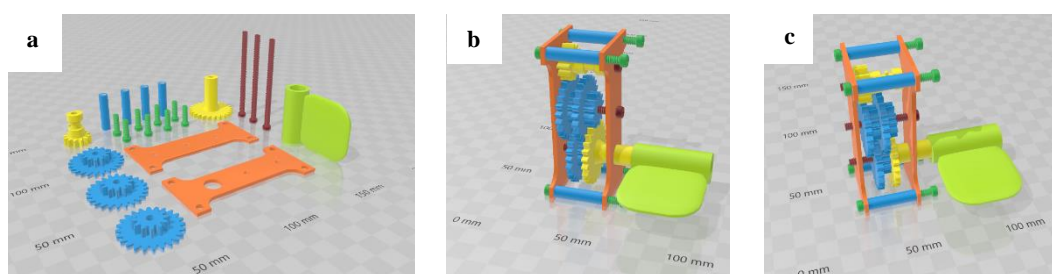


Figure 1. Design A: The gearbox system. a) Constituent components, b) and c) Configuration of components once installed

Furthermore, design B and C is to make a pedal connected to the door handle. This system is like the pedal on a sewing machine or a car foot brake where when the pedal is pressed, it pulls the door handle and opens the door. The difficulty with this technique is determining how thick and lengthy the structure has to be to sustain the foot's impact. Another consideration is also about how to attach and connect the pedals to the door.

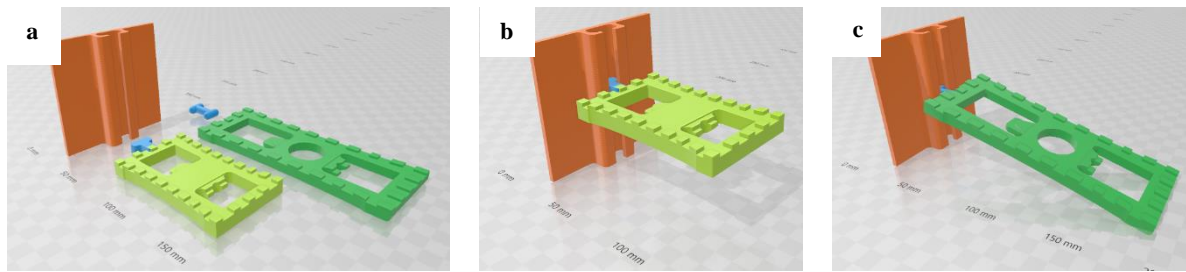


Figure 2. The pedal. a) Component design, b) Short pedal without hinge (Design B), c) Long pedal with hinge (Design C)

After converting the design into STL format, the files were converted again into slice or layer format. Here, the creality slicer software was used to prepare the final format, which is gcode. The software also is used to set some parameters that will be explained later.

3.2. Printing Process

The 3D printing machine used in this research is Creality Ender 3 Pro© with PLA-based filament from eSUN. It is best to know the mechanical properties of the filament before printing the design. This study aims to determine how much load the designed structure can withstand and its safety factor. Table 1 shows the parameters of the filaments used in this experiment.

Table 1. The Properties of PLA filament

Parameter	Value
Hot-end temperature	: 205-225 °C
Bed temperature	: 60-80 °C
Density	: 1.24 g/cm ³
Tensile strength	: 65 MPa
Strain	: 12%
Bending resistance	: 75 MPa
Flow index	: 4 g/10 min

Table 2. The parameter setting of 3D printing machine

Parameter	Value
Layer height	: 0.1 mm
Shell thickness	: 2 mm
Bottom/top thickness	: 1-2 mm
Fill density	: 20 %
Print speed	: 50 µm/s
Printing temperature	: 200 °C
Bed temperature	: 60 °C
Filament diameter	: 1.75 mm
Filament flow	: 100 %
Nozzle size	: 0.4 mm

The first thing to do to operate the 3D machine is to insert the filament into the conduit tube. After that process, start the engine and make some adjustments to the height of the bed. The flatness and spacing of the bed with the hot-end nozzle are essential to maintain the printout quality. Then, enter the prepared gcode file, and the design is ready to print. In addition, special adjustments in temperature need to be made depending on the complexity and dimensions of the design. This process may require several iterations. To design a sufficiently small surface area, about 9 cm², a bed temperature of about 40°C is required. For a larger surface area, a temperature of about 60°C is required. The 3D printing settings used in this experiment are summarized in Table 2.

Some notes need to be added to the use of this 3D printing machine after several experiments. If the printed design has a large horizontal surface area (approximately 8x10 cm²), the printed result will be deformed due to the shrinkage that occurs during the polymer cooling process. The solution to overcome this problem is to rotate the design and print from parts that have a small surface area or increase the printing mat's temperature. In addition, a prolonged printing process can cause the machine to overheat and the filament line to become clogged, which can disrupt the process and take time to repair. If the design size is too large, it must be broken down into several components.

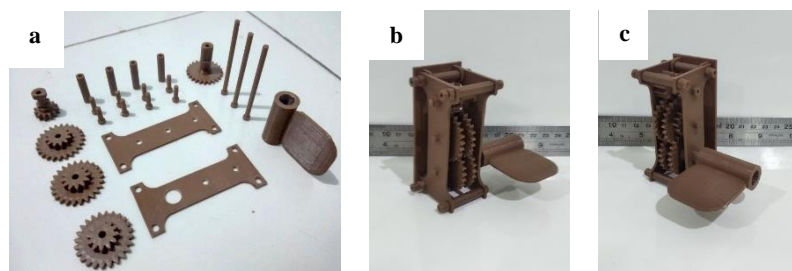


Figure 3. Printing result of the design A: a) Components, b) and c) Components that have been assembled



Figure 4. Printing result of the pedal design: a) Short pedal without hinge (Design B), b) and c) Long pedal with hinges (Design C)

3.3. Trial Process

The assembled components are checked after performing the molding process to see if they can be used or not. Once attached to the doorknob, each design is weighted 1 kg, 5 kg, 10 kg, and 15 kg. Design A's initial challenge was the orientation of the gear shaft mold parallel to the torsional load. This aspect causes the starting shaft to fracture. Thus, the repression is carried out in different directions so that the load is perpendicular to the resulting printed thread. It is clear that this shaft change increases the strength of the structure and does not fracture. However, the tuned gearbox does not pull the handle out, and the gears cannot transfer excess power. It happened because the lever was too short, and the frame was not sturdy enough. The current gearbox system still cannot be used as a door opener after this test. Design B is sturdier and thicker than design A, but the design is too short, and the hook is stiff. During this time, the pedal could not shift towards him when he stepped on the foot. Design C can surpass the test and open the door smoothly. The design and structure can withstand the maximum load given in the test. The long pedal does not have an unmounted hook configuration, and the way it attaches to the doorknob is terrible. The straps often come off and need to be readjusted. This experiment still needs much improvement. Additional designs for other types of doorknobs, such as swivel and push or pull handles, are essential to extending this concept. Suitable bearings can also be added to increase the design life and prevent failure due to friction and excessive forces. The final configuration of design C that has been installed on the door is shown in Figure 5. The summary of the load test can be seen in Table 3. The link in the Appendix shows how to use this tool to open and close the door.

Table 3 The summary of the load test result

Type	Load test result			
	1 kg	5 kg	10 kg	15 kg
Design A	The doorknob did not move	The doorknob moved a quarter	The gear loose	The shaft broken
Design B	The doorknob did not move	The doorknob moved a half	The pedal hardly moved; the door did not open yet	The pedal hardly moved; the door opened
Design C	The doorknob did not move	The doorknob moved a half	The doorknob moved; the door did not open yet	The door opened smoothly

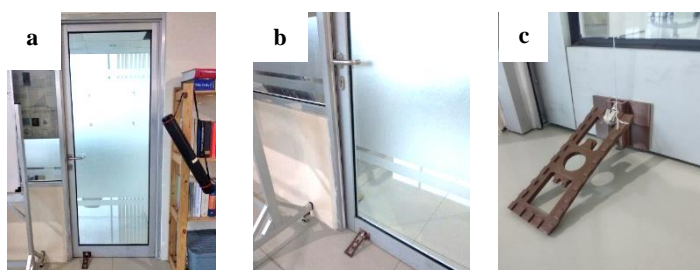


Figure 5. Installation of the two door opening system designs: a) Front view, b) Side view, c) Close view

4. Conclusions

The conclusion drawn from this process is that 3D printing, like any evolving manufacturing process, is well suited for designing and manufacturing lab-scale components. The trial was carried out several times to obtain the appropriate printing parameters and to obtain printouts that suit the needs and are economical. In this study, the design and planning process has been printed correctly, and the function can use the design results to open the door without using hands and not damage the door.

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Appendix

STL files and video about how this door opener work can be accessed in this link: <http://bit.ly/feetdooropener>

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