SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage: https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

A Study on Adjustable Height Stand for Temperature Scanner

Mohammad Shahrul Nizam Amin Nuddin[1], Norazlianie Sazali[2,3,*], Ahmad Shahir Jamaludin[3], Kumaran Kadirgama[4], Devarajan Ramasamy[4], Wan Sharuzi Wan Harun[4]

1 Faculty of Electrical and Electronics Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
2 Centre for Research in Advanced Fluid and Processes (CARIFF), Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
3 Faculty of Manufacturing and Mechatronics Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
4 Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia

ARTICLE INFO

Article history:
Received 20 April 2023
Received in revised form 17 July 2023
Accepted 23 July 2023
Available online 9 August 2023

Keywords:
Temperature scanner; ultrasonic sensor; adjustable stand

ABSTRACT

This research project aimed to transform a common temperature scanner stand into a user-friendly adjustable stand holder temperature scanner. The temperature scanner automatically adjusts its height according to the user's height, reducing the risk of contact infection by using an ultrasonic sensor to detect the user in front of the scanner. The experiment involved measuring the time taken for the thermometer to move from the starting position to the maximum height of different individuals with varying heights. A frame capture application on a smartphone was used to record the motion and time, capturing data at a rate of 33 frames per second for accuracy. The tests were conducted using a constant motor speed of 100 revolutions per minute. The results showed that the duration of waiting time for the adjustable stand holder temperature scanner was valid for individuals with heights ranging from 100 cm to 180 cm. The constructed adjustable stand successfully served its purpose and demonstrated functionality and reliability in real-life testing. To improve the accuracy and expand the capabilities of the adjustable stand holder temperature scanner, future work are needed such as utilizing smart system programs to cater to user preferences, implementing material modifications to reduce vibrations, and introducing additional features to indicate a person's height and weight.

1. Introduction

Since the outbreak of the Coronavirus disease 2019 (COVID-19) in the country on January 25, 2020, the Ministry of Health of Malaysia confirmed the first positive COVID-19 case [1,2]. Even though most people have been vaccinated, the virus continues to spread widely as the vaccine does not completely prevent all infections [2]. Today, the Ministry of Health announced that COVID-19 will be considered endemic, and Malaysians need to accept the fact that it will always be present in the community. Therefore, society must learn to live with the virus [3]. One term that has become widely used is the standard operating procedure (SOP).

* *Corresponding author.*
E-mail address: azlianie@ump.edu.my

https://doi.org/10.37934/araset.31.3.115125

The Ministry of Malaysia has announced procedures for communities to follow according to the SOP in order to control the spread of the disease. One of the initial SOPs announced by the government is the implementation of temperature scanners at all premises across the country to detect the main symptom, which is fever with a body temperature of 37.5 degrees Celsius or above [4]. This step involves measuring people's body temperature in crowded places, and any customers with a high temperature are not allowed to enter the premises [4]. Temperature scanners are crucial in reducing the spread of the infection as they can detect individuals who may be infected and prevent them from entering [5,6].

Many inventors have created various designs of temperature scanners and stands to ensure that all premises can utilize them. However, most stand models have a fixed height. This inspired me to develop the idea of an innovative temperature stand with automatic adjustable height. This project utilizes an infrared sensor that detects a person's presence and commands a DC motor to move the stand upward until the infrared sensor no longer detects the person's maximum height. The movement automatically stops, allowing the temperature scanner to scan the forehead. When no one is in front of the stand, the infrared sensor does not detect anyone and commands the DC motor to return to the normal position. This stand offers modern features to attract users [5,6].

The issue with the positioning of the temperature scanner is that it is not strategically placed due to the varying height levels of the community. Having a fixed height for the temperature scanner is not suitable, as it does not account for different heights of individuals. Mounting the temperature scanner on a stand also poses challenges, as the stand's height remains fixed. This impractical setup makes it difficult to measure the body temperature of people of different heights, especially children. Consequently, short or tall individuals may face difficulties in obtaining accurate thermometer readings due to the forehead's position not being perpendicular to the thermometer [7]. To address this problem, businesses and public sectors should consider alternative methods, such as using an infrared thermometer gun to measure the temperature of shorter or taller individuals. This may require hiring someone to hold the thermometer scanner and measure people's body temperature before they enter the premises.

To mitigate this issue, a proactive approach is necessary to address the problem of height limitations with the thermometer stand. Implementing an adjustable height feature for the temperature stand can effectively tackle this issue. Furthermore, the automatic system used in the adjustable height temperature scanner ensures convenience and ease of use. By standing in front of the adjustable height stand, the thermometer will move upward until it reaches the person's forehead, where it will then scan their temperature. In summary, this invention offers an automatic adjustable height stand for the temperature scanner, which is user-friendly and convenient to use.

1.1 Problem Position of Thermometer

The problems associated with the position of the temperature scanner that are not strategic due to the various height levels of the community which is it is not suitable to just stick with one level of height. Due to the design of the temperature scanner which can be attached to the wall at one height only and can be mounted on stand temperature scanner. While the design and function of the stand temperature scanner is only to stand and hold the temperature scanner at the height set by the owner.

As the decades passed, the thermometry instrument evolved into a variety of shapes, ranging from the bulky mercury thermometer to the digital thermometer. Researchers have been working on inventing and upgrading temperature sensors, particularly for monitoring core body temperature, until recently [6]. Electronic thermometers are a popular alternative to mercury thermometers among healthcare professionals. The essential idea of their operation is based on the creation of a detector that can detect infrared radiation (heat energy) released by the human body. Radiation energy is converted into measurable temperature units using these thermometers.

Thermometers are classified as contact or non-contact depending on whether the item of measurement contacts the temperature sensor or not. Contact thermometers measure temperature by passing heat through a metallic element to a thermocouple, a resistance temperature detector (RTD), or a thermistor. Alternatively referred to an infrared thermometer, a digital infrared non-contact infrared thermometer or also called as forehead thermometer is a device that affordable and effective for measuring a person from a distance [7,8]. K3 IR Thermometer also a device that can measure body temperature with equipped a smart feature. This type of thermometer also in category non-contact infrared thermometer frequently used for fever screening. An intelligent temperature measuring machine can be installed in the main entrances of crowded places.

Temperature Scanner with face recognition is based on the Linux system and includes application for face recognition and temperature measuring. Face recognition camera module with infrared temperature detector built-in, capable of managing staff access and detecting temperature. To check the person’s body temperature, he or she stands in front of the camera. There is no requirement for human interaction.

The temperature scanner with stand is not practical to measure body temperature of different heights of people especially for children. This may lead some problems to short or tall people to scan their forehead temperature that will cause the thermometer’s reading not too accurate due to position of forehead not perpendicular with thermometer [6]. Therefore, business, and public sectors should have other ways to measure temperature for short or high people by using infrared thermometer gun temperature. Thus, this situation requires someone to be hired for holding the thermometer scanner to measure people’s body temperature before entering the premises. To prevent this problem, a proactive step must be taken to counter the problem about height for the thermometer stand.

Adjustable height for temperature stand can be implemented to tackle the problem. In addition, the adjustable height for temperature scanner operates by using automatic system so that they can use the scanner without any problem. By standing in front adjustable height stand for temperature, the thermometer will move upward until temperature scanner stop at person’s forehead and temperature scanner will scan that person’s temperature. In short, this invention offers an automatic adjustable height stand for temperature scanner that is easy to use and convenient for users.

2. Methodology

An adjustable height stand for a temperature scanner was created through a mechanical and electrical process. The main structure of this project was built from hollow mild steel material, which was measured and cut using a grinder machine. All parts were assembled using metal inert gas (MIG) welding. Next, the complete structure was covered with spray paint to prevent rust [9]. The transmission of motion for the thermometer is achieved through a belt and pulley system, which is powered by a stepper motor. The main component for the system to move automatically is an ultrasonic sensor, which is placed above the thermometer. The power source for this project is AC current, providing a constant flow of electricity. The microcontroller used in this system is Arduino UNO, which integrates the electronic components of the project. Testing and functionality of the product in real-life scenarios involve different individuals with various heights. The aim of the experiment is to collect data on the time taken for the thermometer to move from the initial detection of a person until it stops. This data is crucial in considering the RPM (rotations per minute) for the stepper motor. Before the design process began, various client requirements, such as design, price, and investment characteristics, were studied [9]. From the study, it was found that the height of the adjustable stand was insufficient, causing problems for taller individuals.

Additionally, the stand could only be adjusted to a fixed height and could not be changed while in use, making it non-ergonomic. After reviewing literature, it was concluded that an adjustable height stand for the temperature scanner should be developed by incorporating technological advancements and improving ergonomics [10,11]. Several designs were generated through brainstorming to implement a new conceptual product. The market target for this product is to provide a solution to the identified problems with existing adjustable stand temperature scanners. The aim is to create a useful and preferable product that reduces human effort and addresses the issues of current products [12,13]. After comparing various mechanisms and assessing their feasibility, the market target was determined, with a focus on luxury premises. The following steps involve identifying the problems with the adjustable stand and understanding the challenges faced by users.

2.1 Measurement System and Test Sample

A product concept is an approximate description of the technology, working principles, and form of the product. There is a concise description of how the product will satisfy the customer needs. A concept is usually expressed as a sketch or as a rough three-dimensional model and is often accompanied by a brief textual description. Based on research of the adjustable stand, several types of product concept were generated from the brainstorming to implement into a new concept product. Figure 1(a) below shows the full design of adjustable height stand for temperature scanner in SolidWorks while for Figure 1(b) shows fabricated smart adjustable stand.

Fig. 1. (a) 3D design Smart Adjustable stand (b) Fabricated Smart Adjustable stand

The artistic diagram below is a layout of the system of the adjustable height stand for temperature scanner. The layout shows the estimate arrangement of the wire being used and their connection for each component electronic to another component electronic. Figure 2 depicts the overall circuit diagram of adjustable stand, which consists of a NEMA17 Stepper Motor Bipolar with Cable to rotate in clockwise and counterclockwise, Ultrasonic sensor, Stepper Motor Driver (A4988) where it used to transform pulse signal into angular displacement signal, and Arduino UNO R3. Figure 3 shows complete flowchart of the fabrication.

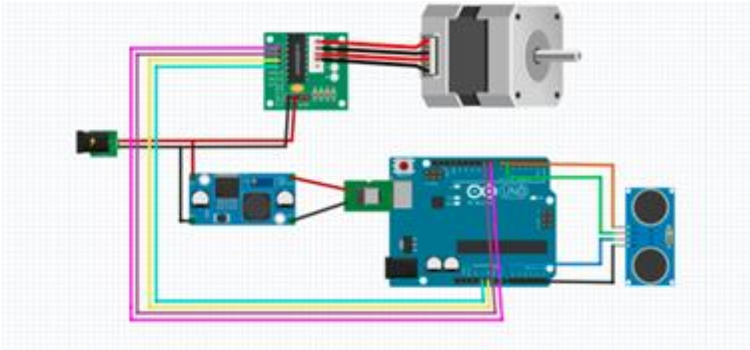

Fig. 2. Circuit diagram of adjustable stand

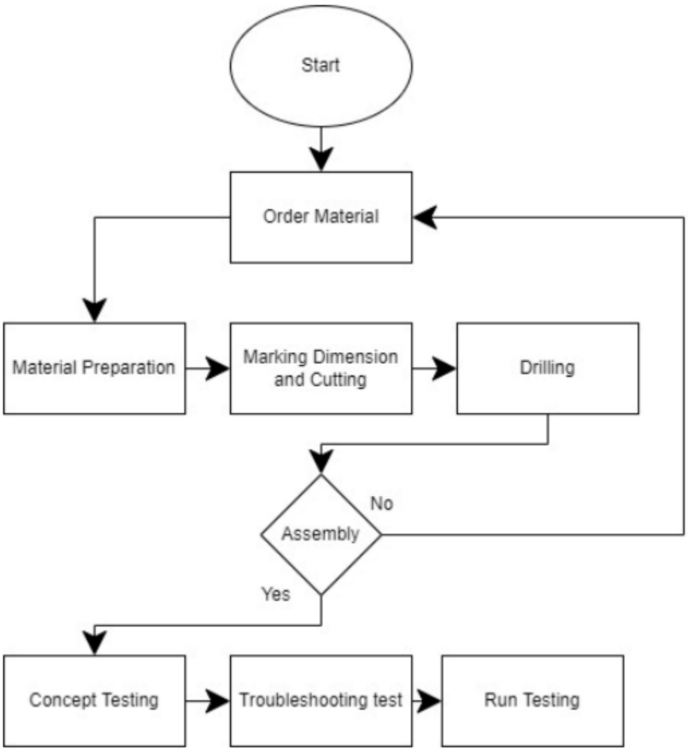

Fig. 3. Fabrication process flowchart

2.2 Speed and Time

To ensure the improvement of project a movement of thermometer will be calculated by distance from origin and the time taken from start until thermometer stop. Frame Capture is application that use the camera as the medium to play the video and can display digit of frames per second (FPS) which is easier than stopwatch. A benefit that can obtain from these applications is it can read the fps based on the quality camera of smartphone. The data that have been taken from this application is time by unit second and will be calculated by formula to get the speed. This application also a platform to edit and capture the image from video playback for the better view to someone.

$$d = v \times t \quad (1)$$

The formula that has been used to calculate distance as shown in the equation above where *d*, *v*, and *t* are displacement, velocity, and time respectively. This formula can be used for measuring the speed of thermometer move at origin until the end of the process. The time will be taken by apps frame capture and will be calculate into the formula to get speed between each distance thermometer move and each time taken. For example, if the person has 180 cm tall, the thermometer at origin which is 100 cm must move upward until reach 180 cm, so the movement from 100 cm to 180 cm will be taken by using frame capture application to get the time by millisecond and will be calculate into formula speed to get how fast the thermometer will be reach 180 cm.

2.3 Structure Fabrication

In a way to fabricate the temperature scanner few steps need to be done. Figure 4 below shows steps to fabricate the temperature scanner. Firstly, hollow mild steel square was measured and have been cut into the required measurement using cutter. Then, the hollow mild steel that had been cut were assembled into the desired design by MIG welding. Next, weld grinding is an important step in many metals' fabrication processes after the weld process to remove and clean the excess weld metal to get smooth finisher of frame product.

After weld and grind the frame, assembled process are well doing with alignment the body structure using aluminum spirit level for balance standing structure. Base of the project was created with design required that can be balance the body of project. The base has the same process, but it meets difficulties to get the same design as the design drawing. After frame and base of structure project has been made. The assemble of the part will be done through drilling process. It because the adjustable height stand product can be detachable and more portable that meet customer requirements.

The chosen material which is hollow mild steel for this project will rust because of the material itself, of course there will not run out from rust. Spray painting are used to covered surface of structure project and it will be like new after welding, grinding, and drilling process [14-16]. After the thermometer holder was designed in SOLIDWORK, the next step is to create the thermometer holder by using 3D printing. The material that has been chosen to create the product is stereolithography (SLA) [17-20]. After all of assembly and painting have been done, the structure must be covered by Aluminum Composite Panel (ACP).

Cutting process of the ACP use traditional method because of the ACP is a quite soft material that can be cut with paper cutting knife. Next, part by part ACP that has been cut will be attach with the structure project by using screw. So, drilling process needed to be installed for each piece of ACP to the structure adjustable height stand. Finally, the 50% of project adjustable height stand for temperature scanner was done completely.

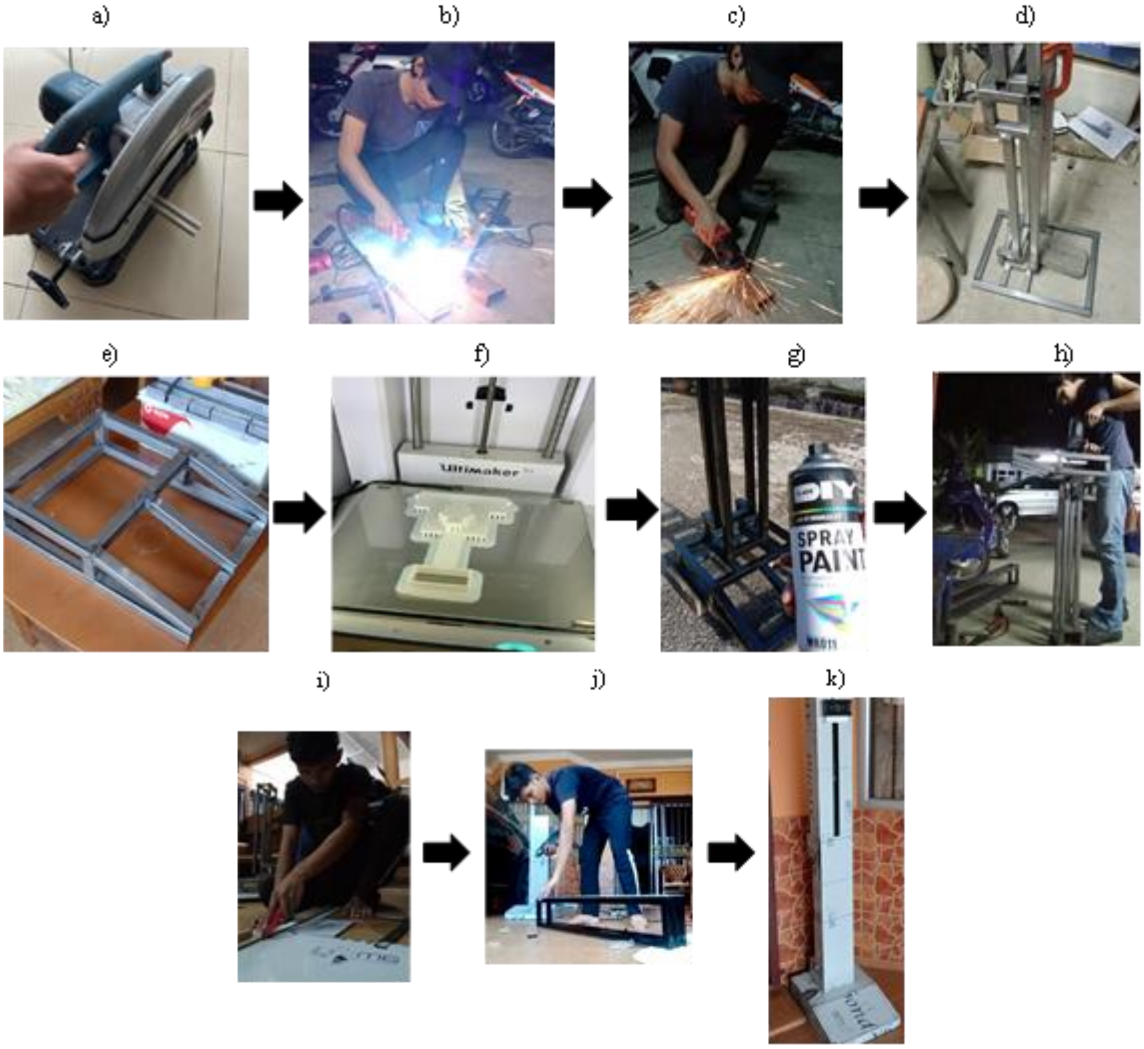

Fig. 4. Steps to fabricate the temperature scanner

2.4 Experiment Setup

Figure 5 below shows the sketch setup of experiment for measure time taken of moving thermometer from beginning until reach limit height person with any height by using Frame Capture application and calculate into velocity formula. The Smartphone will be place toward the adjustable height stand to capture the motion and time by 33 fps to get accurate time. The person height will be setup with different person to get different value height. In addition, each experiment with different height person will record and play back to get time at beginning thermometer start moving until stop. Lastly, all the tests will be using constant speed of the motor which is 100 revolution per minute.

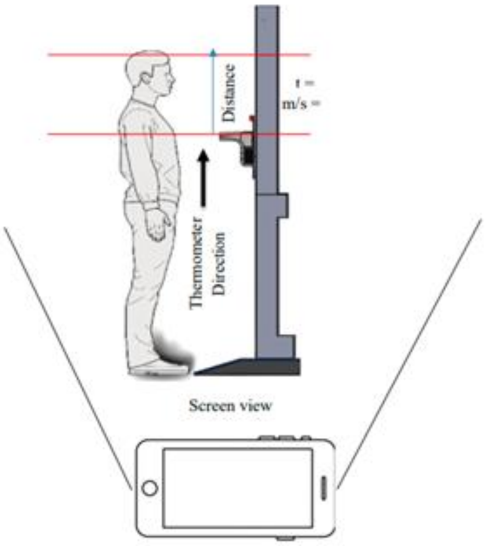

Fig. 5. Sketch of experiment setup

3. Results

The aim of this study successfully accomplished by testing the functionality product in variety of height. The testing product use a different people which is in range of 153 cm and 170 cm. The ultrasonic sensor has good functionalities by scanning the existence of people in front of the adjustable height stand. The thermometer holder moves upwards and downward smoothly without any problem. Based on the coding, speed stepper motor was set at 100 rpm and the distance for ultrasonic sensor sense at distance between 30 cm. Delay after the thermometer completely move upwards is about 10s. After 10s, the thermometer will go downward until the origin to stop functioning. Figure 6(a) shows the beginning test product for height 170 cm while Figure 6(b) shows the height for 153 cm that the person stands in front product and ultrasonic will sense and give signal to Arduino to trigger the stepper motor to rotate the pulley and move the belting that attach with holder thermometer.

Figure 6(c) and Figure 6(d) shows the middle test product for height 170 cm and 153 cm respectively. At this section, the thermometer holder stops, and the person can scan their temperature on duration 10s before the thermometer will move downward. After 10 s, the thermometer will move downward and stopped at the origin. For the person height of 170 cm, the time taken for starting is 8.333 s while the end of thermometer holder stops scanning the person's forehead temperature at 11.967 s. Next, for a person who height 153 cm the time taken for starting thermometer move upwards is 6.100 s while the end of thermometer holder stop scanning the person's forehead temperature is 9.167 s.

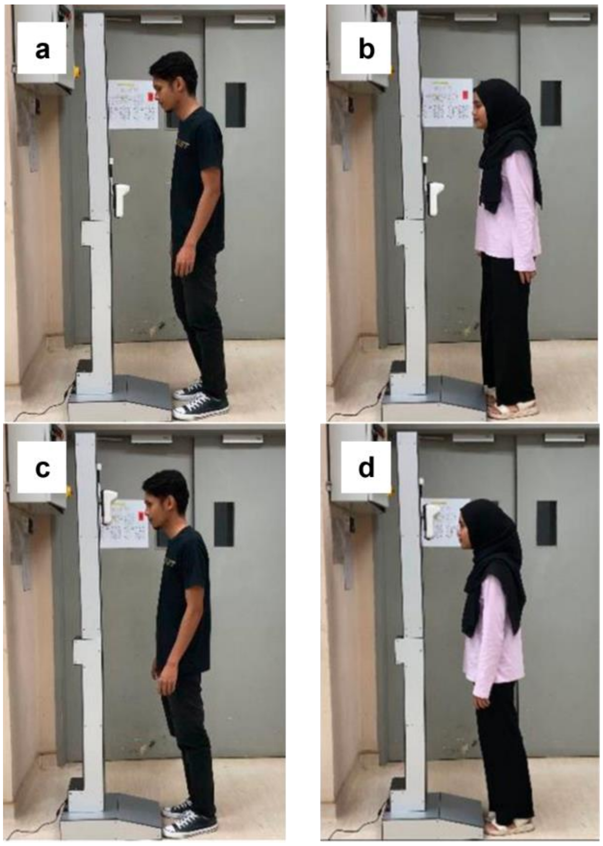

Fig. 6. (a,b) Beginning test product for height 170cm and 153cm and (c,d) Middle test product for height 170cm and 153cm, respectively

Table 1 below shows data collected through Frame Capture application for height 170 cm and 153 cm.

Table 1
Data for time taken

Height, h_2 (cm)	Distance from origin, h_2 - h_1 (cm)	Starting time, t_1 (s)	End time, t_2 (s)	Duration from t_1 to t_2, t_2- t_1 (s)
170	70	8.333	11.967	3.634
153	53	6.100	9.167	3.067

The result shows the relationship between different of height person against time taken from starting until end. The difference of duration for height 170 and 153 cm is 0.567s which is negligible due to slightly differences of waiting time. Hence, the duration of waiting time for this product is valid for various height within the range 100 cm to 180 cm.

4. Conclusions

Finally, the adjustable height stand for temperature scanner has been successfully constructed to assist the hospitalities and luxury places. This adjustable height stand can accomplish the goal. Based on fabrication, it demonstrates that the chosen mechanism successfully operates an automatic thermometer scan forehead people. It has been demonstrated that functionality based on testing this product in real life and reliability about the durability of this product. Few limitations have been found throughout this experiment where the prototype only can operate at one speed. Furthermore, the distance only reaches about 100 cm until 180 cm. Not only that, but the design was also too big and lastly the prototype only can be used when there is an electric current The development of the project still must carry forward to improve the accuracy of the result. During concept generation, several factors are not considered in the design analysis and the further work strongly recommended where application of future technology such as camera thermometer and digital display according to the user's desired with the help of smart system program. Moreover, material modification can be done by making a flexible coupling to decrease vibration of the pulley and belt. Lastly, additional features need to apply to indicates a person's height and weight.

Acknowledgement
This research was funded by a grant from Ministry of Higher Education Malaysia and Universiti Malaysia Pahang (Grant number FRGS/1/2022/TK10/UMP/02/57) and RDU 223307.

References
[1] Shah, Ain Umaira Md, Syafiqah Nur Azrie Safri, Rathedevi Thevadas, Nor Kamariah Noordin, Azmawani Abd Rahman, Zamberi Sekawi, Aini Ideris, and Mohamed Thariq Hameed Sultan. "COVID-19 outbreak in Malaysia: Actions taken by the Malaysian government." *International Journal of Infectious Diseases* 97 (2020): 108-116. https://doi.org/10.1016/j.ijid.2020.05.093

[2] Branswell, Helen. "The world needs Covid-19 vaccines. It may also be overestimating their power." *STAT News* (2020).

[3] Bernama. 2021. "Malaysia to Move to COVID-19 Endemic in October - Khairy." *Astro Awani*, 2021.

[4] Sensors.nl. 2020. "Pass Management Vertical Module of Temperature Measurement & Face Recognition." 2020.

[5] Peprah, Kwakye, and Leigh-Ann Topfer. 2020. "Infrared Temperature Devices for Infectious Disease Screening During Outbreaks: Overview of an ECRI Evidence Assessment." https://www.cadth.ca/sites/default/files/covid-19/ha0004-non-contact-ir-temperature-screening-final.pdf.

[6] Sullivan, Stacey JL, Jean E. Rinaldi, Prasanna Hariharan, Jon P. Casamento, Seungchul Baek, Nathanael Seay, Oleg Vesnovsky, and LD Timmie Topoleski. "Clinical evaluation of non-contact infrared thermometers." *Scientific Reports* 11, no. 1 (2021): 22079. https://doi.org/10.1038/s41598-021-99300-1

[7] Kroemer K 2008 Fitting the Human Introduction to Ergonomics (Boca Raton: CRC Press)

[8] McCormick E and Sanders M 2001 Human Factors in Engineering and Design (New York: McGraw Hill)

[9] Sazali, N., W. N. W. Salleh, A. F. Ismail, N. H. Ismail, N. Yusof, F. Aziz, J. Jaafar, and K. Kadirgama. "Influence of intermediate layers in tubular carbon membrane for gas separation performance." *International Journal of Hydrogen Energy* 44, no. 37 (2019): 20914-20923. https://doi.org/10.1016/j.ijhydene.2018.06.148

[10] MacLeod, Dan. *The ergonomics kit for general industry*. CRC Press, 2006. https://doi.org/10.1201/9781420006308

[11] Pheasant, Stephen. "Bodyspace Anthropometry." *Ergonomics and Design.* 177 (1988). https://doi.org/10.1201/9781482272420

[12] Ibrahim, Haziqatulhanis, Norazlianie Sazali, Ahmad Syahiman Mohd Shah, Mohamad Shaiful Abdul Karim, Farhana Aziz, and Wan Norharyati Wan Salleh. "A review on factors affecting heat transfer efficiency of nanofluids for application in plate heat exchanger." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 60, no. 1 (2019): 144-154.

[13] Shafie, Siti Nur Alwani, Wen Xuan Liew, Nik Abdul Hadi Md Nordin, Muhammad Roil Bilad, Norazlianie Sazali, Zulfan Adi Putra, and Mohd Dzul Hakim Wirzal. "CO 2-Philic [EMIM][Tf 2 N] Modified Silica in Mixed Matrix Membrane for High Performance CO2/CH4 Separation." *Advances in Polymer Technology* 2019 (2019). https://doi.org/10.1155/2019/2924961

[14] Qin, Yi, Akhtar Razul Razali, Mei Zhou, Jie Zhao, Colin Harrison, and Wan Adlan Wan Nawang. "Dynamic Characteristics of a Micro-Sheet-Forming Machine System." *Key Engineering Materials* 504 (2012): 599-604. https://doi.org/10.4028/www.scientific.net/KEM.504-506.599

[15] Zhao, Jie, Andrew Brockett, Akhtar Razali, Yi Qin, Colin Harrison, and Yanling Ma. "Micro-sheet-forming and case studies." *Steel Research International* 81, no. 9 (2010): 1185-1188.

[16] Bowling, R. Allen. "A theoretical review of particle adhesion." *Particles on Surfaces 1: Detection, Adhesion, and Removal* (1988): 129-142. https://doi.org/10.1007/978-1-4615-9531-1_10

[17] Hwang, Jaewon, Taeshik Yoon, Sung Hwan Jin, Jinsup Lee, Taek-Soo Kim, Soon Hyung Hong, and Seokwoo Jeon. "Enhanced mechanical properties of graphene/copper nanocomposites using a molecular-level mixing process." *Advanced materials* 25, no. 46 (2013): 6724-6729. https://doi.org/10.1002/adma.201302495

[18] Kottasamy, Arvind, Mahendran Samykano, Kumaran Kadirgama, Devarajan Ramasamy, Md Mustafizur Rahman, and Adarsh Kumar Pandey. "Optimization of impact energy of copper-polylactic acid (cu-pla) composite using response surface methodology for fdm 3d printing." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 84, no. 1 (2021): 78-90. https://doi.org/10.37934/arfmts.84.1.7890
[19] Kumaresan, Rajan, Mahendran Samykano, Kumaran Kadirgama, Devarajan Ramasamy, Ngui Wai Keng, and Adarsh Kumar Pandey. "3D printing technology for thermal application: a brief review." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 83, no. 2 (2021): 84-97. https://doi.org/10.37934/arfmts.83.2.8497
[20] Srivatsan, T. S., and T. S. Sudarshan, eds. "Additive manufacturing: innovations, advances, and applications." (2015). https://doi.org/10.1201/b19360