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Development and Testing of A Mini Coin Sorting Machine

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***Abstract*—Mini coin sorter machine is a device used to organise and separate coins into their respective category, either value or coin size. Many users tend to store mixed coins in a single container without properly categorizing them, which causes inconvenience and disorganization. The current project aims to address the problem by providing a practical solution and a low cost for sorting and managing coins systematically and effectively. The study was conducted to design, fabricate, and test a functional machine prototype of the mini coin sorter. The study outlines the concept used and the mechanism involved in the detailed fabrication process, as well as relevant engineering principles and the associated costs. Additionally, an analysis of the machine's operation was conducted to evaluate its performance and highlight the advantages and limitations of the machine. Due to the use of the material and the limitations of the machine, future improvements will be provided to enhance efficiency and durability in future machine development.**

Keywords—Sorter Machine, Coin, Mini, Design and Fabrication.

I. INTRODUCTION

Most banks are equipped with money sorters to handle money efficiently and sort it. The concept of automated money management can be traced back to the 1950s, when a Japanese company, Kokei (Glory), introduced the idea of an automatic coin and banknote counter. [1, 2]. This innovation enabled bank employees to save time and manage their finances more efficiently. While storing paper money is relatively straightforward, coins often pose a challenge [3]. Many people face the problem of losing small change. According to yearly statistics, coin loss happens daily and affects children and adults. We do not realise that even the smallest coins we lose can amount to thousands of ringgits over time.

Sorting is a fundamental method in manufacturing industries that helps everything look neat and be arranged [4]. Depending on the concept requirements and the design of the machine element. Many coin sorter machines have already been invented in the industry, but most are big and not transportable [5]. US 7971699 B2, a coin counter/sorter and coupon/voucher dispensing machine and method, was invented by Vae E. Sun from the United States [6]. An automated cash voucher dispenser that automatically distributes cash vouchers based on the value of the collected coins, manufacturer coupons, and retailer coupons. A hopper tray is filled with coins. Coins pass through a waste management system and into a coin sorting and counting device when the hinged tray is raised. The value and quantity of each denomination are displayed as the coins are tallied. The coins are sorted and then dropped into a holding area. The transaction can now either be approved or rejected. The coins are returned if the transaction is stopped. If the transaction is approved, the user is notified, and the coins drop into a storage area. Based on the patented product published worldwide, this product is utilized by major departments, including banks and other large companies. Each part of this product is closely related to the project, specifically the sorting process within the product itself. This product aims to introduce people to how this concept works [3].

The patent number US10049521B1 describes systems, methods, and devices for managing rejected coins during coin processing, invented by John R. Blake, Curtis W. Hallowell, and Tomasz M. Jagielinski of the United States [7]. Here, systems for handling processed coins, coin-processing equipment, computer-readable storage media, and related information are described. A technique for controlling coins dealt with by a currency processing system is provided. The currency processing system receives a

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batch of coins, which are fed into a coin processing unit equipped with one or more coin-discriminating sensors. It sorts them into genuine fit target coins and rejected coins. Sorting the rejected coins into various groups, each corresponding to a specific category of rejected coins; examining at least one of the rejected groups to see if any real target coins were mistakenly categorised and sorted into that rejected group; and giving credit to a currency user. This product features a solid body and excels at finishing, resulting in a cleaner and more professional appearance. This design is interesting in that it attracts people's attention. This product has high body weight and is commonly used for high management. It can serve as a model for a professional look in producing this product for the final year project.

Malaysian people use 5 cents, 10 cents, 20 cents, and 50 cents for daily buying and selling. The dimensions are 19.3mm diameter for 10 cents, 23.5mm diameter for 20 cents, and 28.2mm diameter for 50 cents, respectively. Based on the given dimension, the hole for the coin to pass through requires some clearance to allow it to pass through smoothly. Additionally, the circular shape has a low likelihood of coins getting stuck. However, if the square shape were applied to the design of the hole on the coin sorter machine, it would increase the likelihood of coins getting stuck in the hole during the sorting process. Based on the literature study, there are three main groups within the target market: small business owners, school or community organizations that deal with coins or donations, such as Local Community Centers, Charity groups running donation drives, and individuals or coin collectors, including hobbyists.

Based on the aspects mentioned earlier, this project aims to design and fabricate a mini coin sorter that enables users to store coins efficiently and in an organized manner. The "Piggy Bank" acts as the primary collection tank, and once coins are inserted, they move through a sorting section [3]. The machine then sorts the coins neatly and systematically, making it easier to manage savings. With this innovation, we can make saving coins more efficient, fun, and rewarding—starting from home. It is one of the alternatives to immediately remind people to place any coins they find into a piggy bank. This helps prevent loss and promotes consistent saving.

II. METHOD

A. Project Flow

Figure 1 shows the systematic flow chart involved in the project related to the design and fabrication of the mini coin sorter. The flow chart aimed to organise the related process. The project commenced with a comprehensive background study and literature review to identify existing solutions and technologies related to coin sorting. The step is to ensure the project has a strong foundation in basic technical knowledge. The process, which involved identifying the problem statement, was clearly defined, requiring a more accessible and user-friendly mini sorter machine. This stage helps to build a clear objective and scope related to the constraints and expectations of the users.

The conceptual design is developed through hand sketching to illustrate the idea before proper fabrication. As the concept and preparation prototype were completed, the framework and presentation of the progress and improved idea were prepared. The project proposal merged all the feedback to move to the fabrication stage, where the physical machine of the mini coin sorter was constructed. Once the machine was completed, it was tested by running it, and data were collected to evaluate its performance. If the result was unsatisfactory, the modification was carried out until it functioned as expected. This initiative aims to ensure the final product.

Function properly and have reasonable expectations for organising and storing the coins.

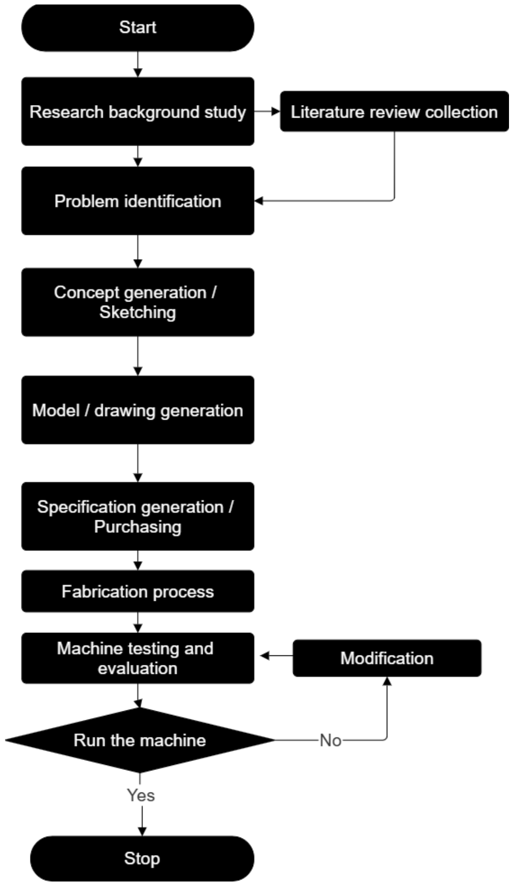

Fig. 1. Work flow of the project.

B. Design Concept

The conceptual design was built based on several scopes. Using each coin's dimensions is the most effective design for producing a small, simple, and working coin sorter product. In Malaysia, we have two eras of coins, old and new. The new one has similar dimensions, ranging from 20 cents to 50 cents. To simplify the product's operation, it is primarily focused on old Malaysian coins, which are currently the primary focus of the work.

The concept design serves as the starting point for the project, providing a vision for the product and initiating the fabrication process. At this point, the design will be made based on the material and the product's shape. The first design, as shown in Fig. 2, shows the design of the mini sorter machine.

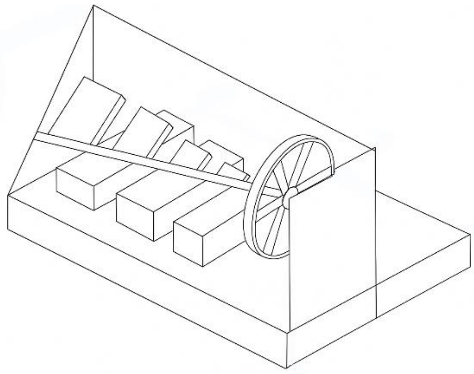

Fig. 2. Concept design 1.

Based on the design in Fig. 2, it has more disadvantages. This design lacks an edge on the body product and is at high risk of injury from the sharp part. Additionally, there is not enough space for container movement. Lastly, the circular plate was challenging to produce and inefficient.

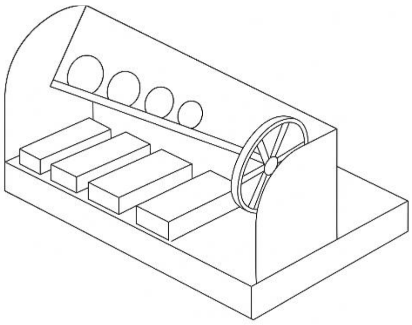

Fig. 3. Concept design 2.

Figure 3 shows the design concept 2. This design was improved from the original by adding an edge to the corner and making it safer. Additionally, the container placement space is improving compared to before. However, the disadvantages of this concept were that the holes in the sorting system would make it less likely for a coin to pass through.

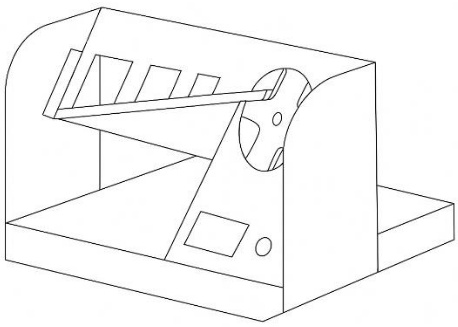

Fig. 4. Concept design 3.

The third design concept is shown in Fig. 4. The concept was chosen as the best design because it assembled the best elements, improving upon the previous design's idea while incorporating a better safety factor on the edge, making it more ergonomic. Additionally, the systematic placement of the container, motor, and micro-USB charging board ensured an electrical input. Additionally, this design features a rocker switch button, enhancing its appearance with an on-off toggle. From the final design, it looks great, simple, and confident, as an efficient product that can be produced in the future.

C. Engineering Calculation

Engineering calculation is the systematic process of using mathematical and scientific principles to analyse the final design [8]. Based on the results, the limitations of the structure under the applied load were identified. With engineering calculations, the related problem can be analyzed using relevant data and the safety factor for the project.

Figure 5 illustrates the force acting on the storage boxes, which are a critical component of the product. A calculation was carried out to investigate the stress and deformation on the part. Approximately 1 kg of coins is expected to be placed in the box, which is later transferred to the machine structure. Figure 6 illustrates the part's cross-section as a force acting in a free-body diagram for better understanding. Following the step-by-step process, the engineering calculation is carried out.

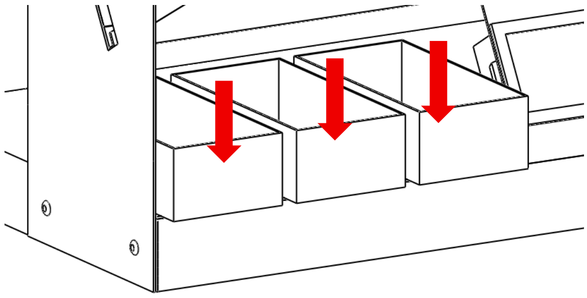

Fig. 5. Loading acts on the critical part.

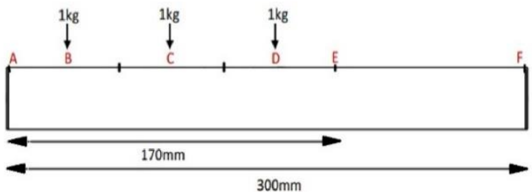

Fig. 6. Free body diagram of the critical part.

Assume 1 kg of coins is in each box for each designed category.

Step 1: Find the total load on the critical part.

Total mass: 1 kg × 3 = 3 kg

Total load: W = mg

W = (3 kg) (9.81 m/s^2)

W = 29.43 N

Totally about 29.43 N force acting on the main structure from the sorted coin.

Step 2: A cross-section of the critical part and the free body diagram of the acting force.

Distance A to B: (0.17m / 3) ÷ 2 = 0.283 m

Moment at point A: $M = \sum M_A = 0$

$0 = [(-9.81N) \times (0.283m)] + [(-9.81N) \times (0.85m) + [(-9.81N) \times (1.42m)]$

$0 = -24.99$ Nm

Force at y-axis, $\sum F_{y1} = 0$

$0 = F_A + (-9.81N) + (-9.81N) + (9.81N)$

$F_A = 29.43$ N

Step 3: The allowable stress is applied to the structure

Assume the safety factor of Aluminium alloy = 1.5

Area of critical part, A = length × width

A = 300mm × 30mm = 0.009 m^2

Normal stress, $\sigma = F/A$

$\sigma = 29.43N / 0.009m^2$

$\sigma = 3270$ Nm^{-2}

Factor of Safety = $normal\ stress, \sigma\ (Nm^{-2})$ / $alloable\ stress$

$Allowable\ stress = 3270Nm^{-2} / 1.5$

$= 2180$ Nm^{-2}

Based on the calculation above, the calculation result shows the machine can handle a 29.43 N load from the coin container at the critical part of the machine. Based on the result, this machine is expected to work correctly and deliver the function without issues.

The machine was set at a 1.5 safety factor as calculated. This safety factor is incorporated into the design to ensure that functionality and cost are balanced. The machine is expected to withstand a stress of 2180 N/mm² in normal conditions and up to 3279 N/mm².

D. Fabrication Process

Fabrication is a process of determining the engineering design and incorporating it into the physical product. In this project, the common fabrication technique used was shear cutting and bending, as the primary material, aluminium plate, was selected during the design process.

The fabrication process started with a machine-based structure. The 1mm aluminium plate needs to be measured for dimensions, and the plate was cut using a manual foot sheet metal shearing machine and a sheet metal hand cutter as in Fig. 7 [9]. A sheet metal bending machine was used to bend the material according to the design [10, 11]. This machine can help to bend the material precisely. A standing drill press was used to create a hole, which was prepared for riveting after all parts were completed and ready for assembly.

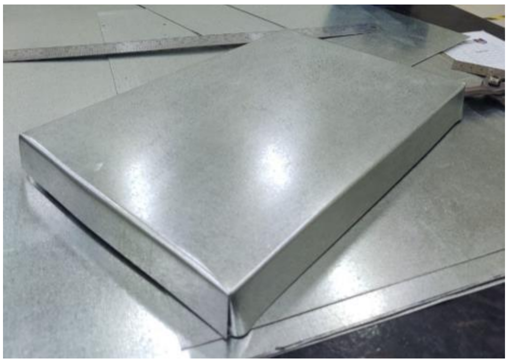

Fig. 7. Fabricated base on the machine using 1mm aluminium plate.

The pillar structure is a central component that holds all the other parts together. The structure consists of two components: the left and right pillars. To fabricate this part, a 1mm aluminium plate was measured using a steel ruler and scriber to get the dimensions. After all dimensions were decided and marked, the raw material was cut using a manual foot sheet metal shearing machine to make the small pieces. After obtaining the small piece, a sheet metal hand cutter was used to create a curve in the part.

The important part of the sorting section needs to be fabricated with accurate dimensions, using a steel ruler and scriber, to ensure the precise size of the hole for sorting the coin. Using a manual foot sheet metal shearing machine, cut the original size of the plate into small pieces. Then, continue using a sheet metal hand cutter for the small areas. The hole for attaching the DC motor needs to be fabricated using a floor-standing drill press with M16 drill bits. The rocker switch hole also requires the use of M16 drill bits.

The container in Fig. 8 was fabricated using a manual foot sheet metal shearing machine and a sheet metal bending machine. The dimensions of this part need to be carefully produced to ensure it fits the container area. To make it look straighter and follow the design, a container slot must be fabricated using a 1mm aluminium plate and a standing drill press for the rivet hole.

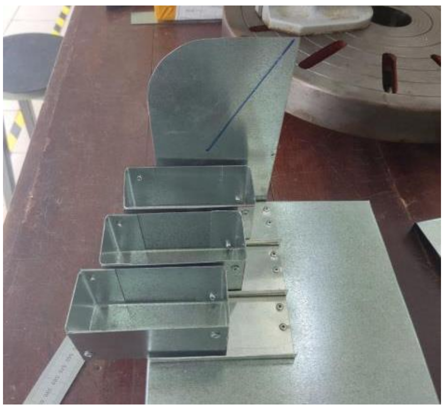

Fig. 8. Container part for the coin sorting machine.

The motor blade part was made from ABS material using 3D printing [12, 13]. The part was planned to be fabricated using the same material as the other parts, a 1mm aluminium plate. However, the thickness of the plate is not suitable, and the method used causes its surface to become sharp, which reduces the smoothness of the rotation during the coin sorting process.

After all parts have been fabricated, prepare the hole for the riveting process. All the parts must then be assembled using rivets as the primary means of joining. The M4 screw is used to join the DC motor to the sorting section of the body [14]. Once all assemblies have been completed, this project utilizes WD-40 to remove the marking from the part that was previously marked with a permanent marker. Using this technique, the project product will look clean and ready to be presented.

III. RESULT AND DISCUSSION

Figure 9 shows the full dimensions of the machine design. The machine has dimensions of 300 mm (length) × 200 mm (width) × 221 mm (height), as modelled using the SolidWorks software package [15]. Meanwhile, Fig. 10 displays the physical prototype of the machine, as designed.

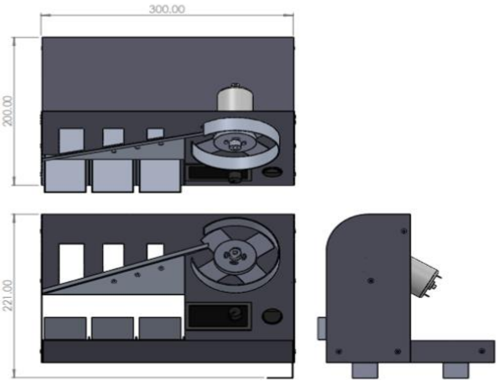

Fig. 9. Orthographic drawing of the machine with dimensions.

Generally, the machine operates as soon as the coin is inserted into the rotational hopper. The coin was transferred into the slanting coin pathway. The pathway was positioned at a certain angle to ensure the coin rolls smoothly due to the gravitational effect. The coin was separated according to the segregator along the pathway. The coin then falls into the collection tray based on its size.

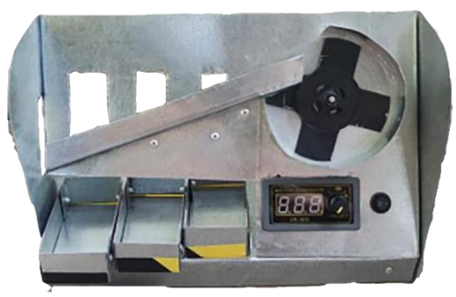

Fig. 10. Physical prototype of the coin sorting machine.

The on-off switch was placed in front of the machine to ensure it can be easily turned off. The rotational speed can be adjusted using a voltage regulator, which is displayed on the screen.

Based on the current physical prototype, as shown in Figs. 9 and 10, the prototype measures 300 mm × 200 mm × 221 mm. This machine is equipped with an electrical motor, a sorting slot, and a rotating part. The total weight of the machine was 2.6 kg.

E. Machine Testing

Machine operation starts with a feed bowl equipped with a rotating feed or hopper that is turnable. This part measures the coins one by one and guides them to run across the bank with a fixed slot sized to a specific diameter. Coins then slid into the slot, which attaches to the guide rail or channel, allowing only one coin to proceed at a time. Coins slide along this straight channel, which keeps the coins properly aligned.

The slot bank is placed at the side of the channel, arranged in series based on the coin size. The opening diameter is set as a fall through which starts with the smallest coins, of 5-cent coin size, before enlarging up to the size of a 50-cent coin. Containers were placed under the slot bank to collect the sorted coins into separate bins. Generally, the machine was operated at a low rotational speed to ensure smooth operation without errors in sorting.

Several tests are done to see the effectiveness and performance of the machine. Table I presents the results of the testing conducted to evaluate machine performance.

Table I. Testing and evaluation.

Operation	Category	Result
Lifting the coin at the entrance.	10 cents, 20 cents, and 50 cents.	Able to lift all coins except for the 10 Cent has some errors.
Coin slightly at the Coin Slot part.	10 cents, 20 cents, and 50 cents.	Able to slide smoothly.
Coin through every hole to be Sort them into their category.	10 cents, 10 cents, and 50 cents.	Able to go through to each other Category, but does not follow the line.

Based on the current prototype, several improvements can be made to the machine to include both prior and current versions of the Malaysian coins. The first improvement is an adjustable sorting channel that fits all types of coins, regardless of thickness or diameter. Additionally, by integrating advanced sensors, such as infrared or optical sensors for edge detection, more accurate sorting decisions can be made. Additionally, the thickness sensor could be integrated into the machine to measure the thickness of the coin [3, 4, 16].

There are four denominations of coins currently in circulation: 5-cent, 10-cent, 20-cent, and 50-cent coins. Each of the coin value have two sizes, which refer to the old and new designs: 5 cents, with an average diameter of 17.78 mm, a weight of 1.72 g, and a thickness of 1.12 mm. 10 cents with an average diameter of 18.80 mm, a weight of 2.98 g, and a thickness of 1.5 mm. 20 cents with an average diameter of 22 mm, a weight of 4.18 g, and 50 cents with an average diameter of 25 mm, a weight of 5.66 g. Machine enhancement was performed to improve this process, which involved designing a bank slot that fit the average diameter size, typically a design used in sorters. This sorting bank acts as a measurement zone, important to allow the specific size of the coins to pass through [4].

F. Advantages and Limitations

Every machine has its limitations, and based on that information, some improvements can be made in the future to improve its functionality. The first advantage of using the motor is that it enables the blade to lift the coin, which is then delivered to the coin pathway and sorting section to separate the coins by size. All coins can be transferred smoothly to the sorting section. Additionally, without interference from the machine, the coin can be easily sorted into its respective category.

The limitation: There is some error with the 10-cent coin: the clearance between the coin and the motor blade is minimal, so it cannot touch the coin lot surface while intercepting. In a particular situation, the coin will stick due to the friction generated by the surface. Some errors do not follow the lineup. Expecting a result, the first hole is for 10 cents, and so on, but the result is that the first hole is for 50 cents, the second for 10 cents, and the third for 20 cents.

G. Bill of Materials

Cost calculation is compulsory when producing the project product. This section presents the total cost required to complete the machine in Table II. Generally, the cost is considered low-budget, as it involves fabricating the physical machine for no more than RM200.00. The highest cost was incurred for the machine structure, which utilized an aluminium plate.

Table II. List of cost calculation.

Item	Detail	Quantity	Price/pcs	Total
Aluminium plate	1.0mm, A4	7 pcs	RM10.00	RM70.00
Electrical wire	1m length	1 pcs	RM0.50	RM0.50
DC motor	6000rpm speed	1 pcs	RM31.90	RM31.90
Switch	Single pole single throw	1 pcs	RM2.50	RM2.50
Screw	M4	2 pcs	RM0.50	RM1.00
Rivet	M4	31 pcs	RM0.15	RM4.65
Micro USB	Charging board	1 pcs	RM5.50	RM5.50
Plastic ABS	3D printing part	1 part	-	
			Total	RM116.05

IV. CONCLUSION

A mini coin sorter machine is a small and handy device that helps organise and sort coins by size and value. It's like a little robot, but without any sensors on the machine. The machine sorts the coins using each coin's dimensions as a sorting concept. Insert the coin, and it will be lifted to the sorting section and sorted neatly. In addition, all machines have their advantages and limitations. Therefore, this will enhance our skills and knowledge, enabling us to improve further in the future. Ultimately, this machine is well-suited for light-duty use and is suitable for all ages, particularly at home. Besides, it can give the vision and motivation to the new generation about the mechanism of a specific machine.

To cope with advanced technology and further upgrade the sorting machine, several improvements of the current work are suggested. Implementation of the advanced sensing technology, such as optical sensors,, inductive metal sensors, to differentiate coin materials and weight sensors to distinguish the material. By implementing the sensors, the sorting process can enable high-speed classification with lower mis-sorting error. Additionally, it is suggested to introduce smart counting and digital display using an Arduino microcontroller to enhance the sorting process and improve error detection.

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AUTHOR CONTRIBUTIONS

Ikhwan Hafiz Bin Hayaroni: Design and Fabrication Process and Original Draft.
Mohd Fahmi bin Md Salleh: Preparation, Review & Editing, Manuscript Refinement and Writing
Muhammad Amir bin Mat Shah: Validation, Visualization, Testing, Data Analysis,
Ab Aziz bin Mohd Yusof: Conceptualization, Supervision, Resources, and Review.

CONFLICT OF INTERESTS

No conflict of interests was disclosed.

ETHICS STATEMENTS

Our publication ethics follow The Committee of Publication Ethics (COPE) guideline. https://publicationethics.org/

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