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Automatic Double Can Crusher Prototype Development

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Abstract

An awareness about recycling among Malaysian keep on increasing as most Malaysian are well educated since kindergarten level. Many activities have been conducted to encourage young children to recycle. Unfortunately, the process of recycling the tin can be difficult to be done by children. Traditional manual crushers required substantial physical effort or expensive pneumatic systems. Therefore, this study is conducted to design and fabricate a prototype of automatic can crusher where this electrically operated solution prioritizes cost-effectiveness and user safety. The process starts with problem identification, followed by concept generation by using morphological chart, then design selection using Pugh chart. The process continues with 3D design model using SolidWorks, fabrication process and testing. The output product is expected to enhance productivity of can recycling and safety, reduce time and efficiency. Experimental results confirm that this product saves significant time and human energy, processing approximately 12 cans per minute. This innovation supports sustainability goals by facilitating easier waste transport and promoting efficient aluminum recycling.

1. Introduction

Nowadays, in Malaysia, aluminum cans are primarily used as a sustainable and lightweight packaging solution for the food and beverage industry [1]. Malaysia is also recognized as one of the top 10 aluminum producing countries in the world in year 2025 [2]. The increasing consumption of canned beverages has led to a significant rise in aluminum has contributed to environmental pollution and efficient waste management [3-5]. Recycling plays a crucial role in reducing this impact [6-8]; however, recycling awareness and participation remain inconsistent among youth demographics [9]. Because the behavioral patterns of younger generation are critical benchmarks for developing effective waste-reduction policies [10], introducing sustainability concepts early through fun, engaging activities are essential for fostering positive lifelong habits. [11]. This early intervention is critical for evaluating and understanding how the younger generation bridges the gap between environmental knowledge and actual practice [12]. A student might intellectually understand that recycling is good, but their socioeconomic reality is whether shaped by their environment, culture, or budget is what ultimately drives their day-to-day behavioral execution [13]. To address these issues, there is a need for an automated, efficient, and user-friendly system capable of handling multiple cans simultaneously and this project proposes the development of an Automatic Double Can Crusher Prototype, designed to crush two cans simultaneously with minimal human effort.

In addition to improving recycling efficiency, the system can also serve as an interactive tool to promote recycling awareness among children in a more engaging and enjoyable way.

Encouraging the youngers to recycle is one of the efforts conducted by schools. Making the recycling process fun, a product that can make the process easier can be very impactful. Traditional methods often rely on manual effort, which is time-consuming and unsuitable for children. It required extra physical strength to crush the cans. With the mechanical compaction, leads to maximizing space and optimizing the storage and logistics of recyclables [14].

Based on the benchmarking process overview, Table 1 provides a comparative overview of existing products that are relevant to the proposed design, serving as a valuable reference for identifying current features, and performance standards in the market that can be improved. Through this comparison, common design trends and gaps or weaknesses in existing products can be recognized. Firstly, the manual can crusher, it relies entirely on human physical power via hand operated lever system to crush the can. Therefore, the capacity of cans is very limited since it processes a single can at a time, and is considered as the slowest option, demanding most physical exertion. Second product is a semi-automatic can crusher. It still relies on manual physical force via a lever but incorporates a gravity-fed wire rack hopper to streamline the loading process. It operates at a medium pace, reduces loading downtime, but continuous manual physical labor is still required. Lastly, the automatic can crusher product is completely independent of human power, utilizing a pneumatically powered piston cylinder to forcefully flatten the cans. This is recognized as the fastest and most efficient process, human effort is minimal which is to activate the automation process.

Table 1 *Comparison of the benchmarking product*

Feature	Manual can crushers [15]	Semi-automatic can crushers [16]	Automatic can crushers [17]
			
Operation mechanism	Requires manual effort	Requires manual effort but more efficient as the cans feed directly	Pneumatically powered to compress cans
Capacity	Compress one can at a time	Up to 10 cans fed but still compress one at a time	Compress one can at a time
Speed & effort	Slowest process; requires physical effort and removing the can after each crush	Medium pace as the can feed automatically, but still requires physical effort	Fastest, users require to switch on the pneumatic – less effort

The scope of this study utilizes 12V AC motor, a crank wheel, and a horizontal position for the crushing mechanism. The power from motor is transmitted to the chain and sprocket that connects the other shaft to move the crusher. This crusher can crush up to two cans at a time.

Alternatively, single slider crank mechanisms convert rotary motion into reciprocating motion, utilizing electric motors instead of pneumatic air. Motorized automatic can crushers effectively reduce the can volume with lower maintenance costs, greater safety, and less floor space [18]. Other than that, the automated compactors able to eliminate manual labor while ensuring the material is crush consistently [19].

Therefore, this study is conducted to design and fabricate an automatic double can crusher to improve safety among users as well as to encourage younger generation to recycle.

2. Methodology

2.1 Process Flow

The flowchart shown in Fig. 1 presents a systematic approach to the design and development of the proposed product, start with problem identification and end with the fabricated prototype product. Initially, the process starts with identifying a problem from current existing product, followed by concept generation by using morphological chart, where three ideas were generated. Next, design selection stage involves evaluating these concepts and choosing the most suitable one based on specific criteria using Pugh chart. Once selected, the 3D modelling design was enabled using SolidWorks before the physical fabrication process conducted. Then, after fabrication, the prototype product undergoes testing to assess its functionality and performance.

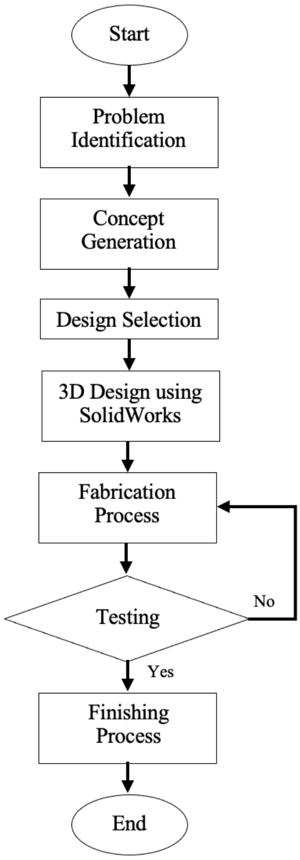
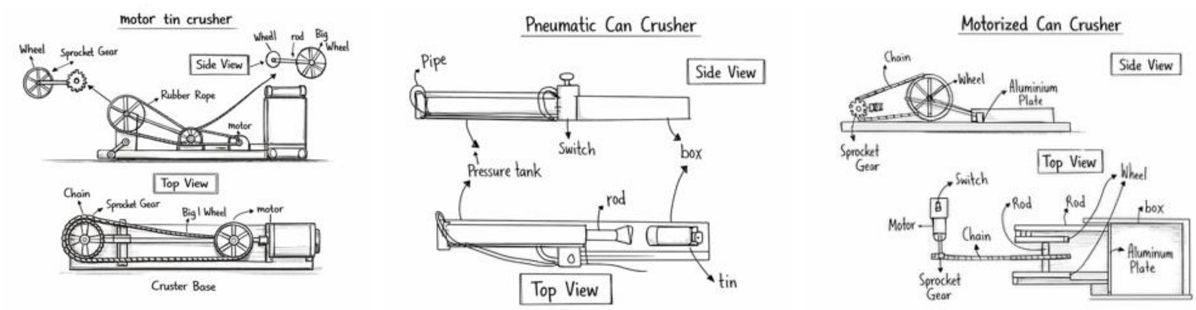


Fig. 1 *Process flowchart*

2.2 The Concept Design

The concept stage plays a crucial role in transforming the identified problem into practical and innovative solution ideas. In this study, three design concepts were generated using morphological chart, a structured method that facilitates the exploration of multiple design combinations by breaking down the product into its key functions and components. Fig. 2 shows a concept design 1 to concept design 3.



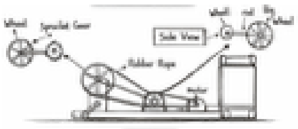
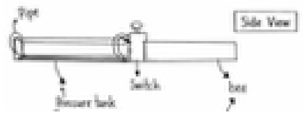
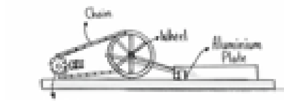
(a) **(b)** **(c)**

Fig. 2 *Three concept design (a) Concept 1; (b) Concept 2; (c) Concept 3*

2.3 Concept Design Evaluation

This stage evaluates these three-concept design based on a set of predefined criteria such as functionality, cost, safety, comfort level, easy to store, easy to handle, and durability. This evaluation ensures that the selected concept not only meets the project requirements but also practical for fabrication and application. Design 3 provide various mechanical configurations, including slider-crank and lever mechanisms, which have been extensively reviewed to determine their mechanical advantage in volume-reduction tasks [20]. Through this process, concept design 3 is the most suitable concept as it obtained the highest score as shown in the Table 2 below.

Table 2 *Pugh chart*

Concept Design				
Criteria	Weight	Concept design 1	Concept design 2	Concept design 3
Functionality	2	+	+	+
Safety	2	0	-	+
Cost	2	-	+	-
Comfort level	1	-	+	+
Easy to store	1	0	-	0
Easy to handle	1	0	+	+
Durability	1	+	0	+
+		2	4	5
0		3	1	1
-		2	2	1
Total net		0	2	4

2.4 Fabrication Process

The fabrication process was conducted as tabulated in Table 3 below.

Table 3 *Fabrication process*

Process	Description
Measuring 	The sheet metal is measured and marked before going through cutting process
Cutting 	Cut the hollow steel as measured using hacksaw machine to divide a large piece of raw material into smaller sizes following the dimension

Drilling 	Focus on creating a hole, allowing for placements of bolts, screw or even wiring
Milling 	Milling process is to remove a layer on the surface to make it smooth and flat
Grinding 	Grinding is used for precision and smoothness. It is used to achieve very tight tolerances or a specific surface texture
Welding 	Welding is one of the joining processes that melted two parts and fused together into single piece

3. Results and Discussion

3.1 Final Fabricated Prototype

Fig. 3 shows a 3D design of selected concept design. It has been designed using SolidWorks software. This design consists of few parts where the rotational power from the motor will transmit into linear motion to crush the tins. Attached to the side of the sprocket, is a mechanical linkage arm that functions like a crank; as the wheel rotates, it transforms the continuous circular motion into a back-and-forth sweeping action. This process will continuously move, and the user needs to manually put the aluminum tins within that time.

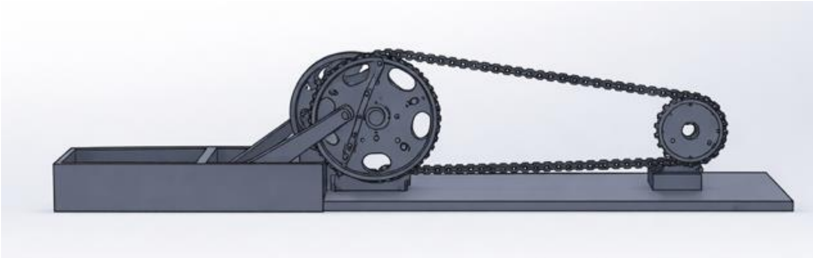


Fig. 3 *3D design*

While Fig. 4 shows the final prototype and the fabricated product. From the 3D CAD design, produce the fabricated product. Function as an automated mechanical aluminum can crusher. There is a 12V motor that drives a small sprocket that mounted in the middle of house bearing, transferring mechanical power to the chain that rotates the wheel with attached linkage arm. The linkage arm will move the steel slider that will directly crush the tins. The crush tins will then drop into the collection area.

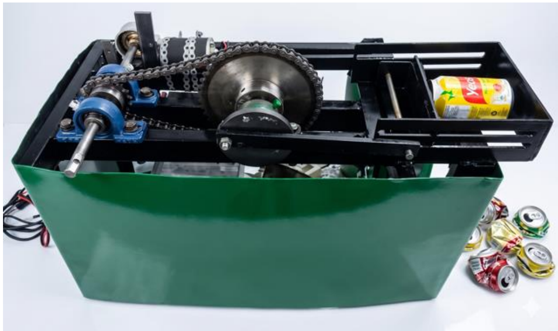


Fig. 4 *Final fabricated prototype*

3.2 Product Specification

Table 4 shows the product specification, operational details, pricing, and overall pros and cons of the automated can crusher machine. The detail breakdown of each section includes the physical structure where the dimension of the prototype is 900mm x 180mm x 160mm. The structural chassis is constructed from square hollow steel as this material provides high rigidity and strength-to-weight ratio, ensuring the product can withstand the repetitive compressive forces needed to crush the aluminum cans without bending or warping. In terms of power supply, power source of 14.5V AC battery is used with daily usage roughly about 1 hour. For the market price, it is estimated around RM350 which is affordable and consider cheaper as compared to current product. Lastly, the advantages of the product are; time saving, as this product crush cans faster than manual foot-stomping or hand-pressing. Other than that, it is also safe for all as the mechanical moving parts are guarded, removing the risk of pinched fingers or sharp metal cuts. One of the disadvantages is that the users need to load the cans manually.

Table 4 *Prototype specification*

Specification type	Details
Dimension	900 mm x 180 mm x 160 mm
Frame	Square hollow steel
Power source	14.5V AC Battery
Daily usage	1 hour
Voltage	Maximum 12V
Current	Maximum 14A
Max cans	2 cans
Market price	RM350.00
Advantages	Save time
	Safe for all
	Mechanical energy
Disadvantages	Manually load cans

Table 5 presents the fundamental structural and electrical components of the automated can crusher machine, mapping each individual part to its primary function. Here is an in-depth explanation of each component; body frame is used to support load of shaft and gear. It is made from square hollow steel which acts as the rigid backbone of the entire machine. It absorbs and counteracts the mechanical stress generated during operation. Next, cover crusher is used to hold force from cans and crusher. This refers to the slotted rectangular housing mechanism at the loading end of the machine. When the mechanical arm presses forward to flatten an aluminum can, it absorbs the crushing impact, so the cans collapse cleanly instead of slipping out. Next, motors are used to produce rotation power and torque where it is the prime mover of the entire system. It converts electrical energy into kinetic mechanical energy. The motor is powered up by the battery. Continuing with crusher, the moving mechanical arm that connected to the slider plate that applies compressive stress to the aluminum cans to flatten them. Next part was bearing which is used to support rotating body and to reduce friction. Bearing is critical because steel rotating shafts moving under high loads create immense friction. By utilizing internal rolling elements, they allow the drive shafts to rotate with minimal resistance. Next, shaft and sprocket that is used to transmit rotary motion, while chain is used to connect two sprockets. It ensures positive, non-slip power transmission across a physical distance, allowing the design to remain elongated while successfully transferring torque over from the motor to the crank.

Table 5 *Function of each part*

Part	Function
Body frame	To support load of shaft and gear
Cover crusher	To hold force from cans and crusher
Motor	To produce rotation power and torque
Battery	To produce electrical energy
Crusher	To crush the cans
Bearing	To support rotating body, reduce friction
Shaft	To transmit rotary motion
Sprocket	To transmit rotary motion between shaft
Chain	To connect two sprockets
Crank	To convert circular motion to linear
Connecting rod	To connect crank and crusher
Switch	To turn on and off the can crusher

Both tables of specification and parts function provide a comprehensive overview of the prototype product that highlight its technical characteristics and role of each component to ensure smooth operation.

4. Conclusion

The development of automatic can crusher demonstrates a practical and effective solution to address the limitations of conventional crushing machines, particularly for educational and small-scale applications. Through a structured design process that included problem identification, concept generation using morphological chart, concept evaluation with a Pugh chart, and detailed design development, a suitable and functional concept was successfully selected and fabricated. The integration of key mechanical components such as the motor, chain drive system, sprockets and crushing mechanism ensures efficient operation while maintaining simplicity and safety for users.

Furthermore, benchmarking and specification analysis helped guide the design toward improved performance, cost-effectiveness, and ease of fabrication. The testing phase confirmed that the machine can perform its intended function, with opportunities for further refinement identified during the evaluation process.

Overall, the project highlights the importance of systematic engineering design approach in producing a compact, affordable, and user-friendly machine. It also provides valuable hand-on learning experience and serves as a foundation for future improvements and potential real-world applications.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Adib Farhan Badrol Isa, Nurul Hanna Mas'aud;* ***data collection:*** *Adib Farhan Badrol Isa, Nurul Hanna Mas'aud;* ***analysis and interpretation of results:*** *Nur Aini Sabrin Manssor, Nurrul Amilin Zainal Abidin;* ***draft manuscript preparation:*** *Adib Farhan Badrol Isa, Nurul Hanna Mas'aud, Norjasween Abdul Malik. All authors reviewed the results and approved the final version of the manuscript.*

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