Journal of Engineering Technology and Applied Physics

Design and Fabrication of An Automated Glass Bottle Cutter for Reuse and Recycling Bottle Glass Products

Alya Amanina binti Mohd Ishak[1], Ainaa Maya Munira Ismail[1], Ahmad Idzwan Yusuf[2], and Ab Aziz bin Mohd Yusof[1, *]
[1] *School of Mechanical Engineering, College of Engineering, Universiti Teknologi MARA, UiTM, Johor Branch, Masai, Malaysia.*
[2]*School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, UiTM, Johor Branch, Masai, Malaysia*.
**Corresponding author*: abaziz86@uitm.edu.my, *ORCiD*: 0000-0002-9700-0714
https://doi.org/10.33093/jetap.2025.7.1.10
Manuscript Received: 3 December 2024, Accepted: 4 February 2025, Published: 15 March 2025

***Abstract* — The glass bottle cutter has a substantial commercialisation potential, as present trends indicate a growing interest in repurposing waste materials. This apparatus enables communities to manufacture new items from discarded glass bottles, including drinking glasses, ashtrays, and vases. Disposal at recycling centres or craft stores is essential for businesses such as restaurants and bars that often produce excess glass waste. Hence, this apparatus is resilient and long-lasting, designed to handle significantly larger amounts more efficiently than manual glass bottle cutters, which require scoring the bottle and alternating between hot and cold water. The main goals of this project are to develop a prototype for a glass bottle-cutting machine and to manufacture the machine according to the designed prototype. The manufacturing process encompasses measuring, cutting, welding, and drilling, with the machine predominantly constructed from metals. It employs a DC motor to facilitate the rotation of the diamond blade, substituting conventional wheel cutters. This design markedly diminishes the necessity for physical labour and enables bottles to be severed in under one minute. The cutter accelerates the procedure, yielding a superior finish with reduced physical exertion. The design and analysis of the prototype have been successful. Potential enhancements may involve the integration of a safety button, applying a coolant to inhibit the dispersion of glass dust, and including a polishing mechanism for smoother edges. These upgrades would boost the machine's efficiency and desirability.**

Keywords—Design, Fabrication, Glass bottle, Cutter, Recycling.

I. INTRODUCTION

Glass bottles are frequently disregarded compared to plastic waste, although posing considerable environmental concerns [1]. The utilisation of glass bottles persists at elevated levels owing to rising consumer demand, especially for items such as soy sauce, juices, and soft beverages. In Malaysia, glass recycling is minimal due to lack of segregation, low public awareness, and economic constraints [2]. Glass waste is particularly problematic because it takes millions of years to degrade naturally, making its proper management crucial. Automatic glass bottle cutters are not readily available in stores or recycling centres [3]. As a result, many people dispose of their glass bottles and domestic waste, which can pose a risk to garbage collectors and contribute to environmental harm [4].

Glass is a non-biodegradable material that does not naturally decompose, contributing to environmental pollution. Small glass fragments have been discovered in the food chain, posing risks to animals and humans when consumed. The issue becomes even more critical when the glass contains toxic substances, as this can lead to serious health problems and negatively impact land and water resources.

The invention of the glass bottle cutter dates back to 1989, when Ephrem J. Gelfman patented a method and apparatus for cutting glass bottles (US3699829A) [5]. His design involved a rotary support structure with rollers that could adjust to cut bottles at different lengths. A cutting edge on one

Published by MMU PRESS. URL: https://journals.mmupress.com/index.php/jetap/index

roller created a circular scoreline as the bottle rotated. Heat was applied along the score line, followed by rapid cooling to clean the bottle, transforming the bottom portion into a useful container. In 1974, James E. Hanson developed another bottle-cutting device (US38445555A [6]), designed to make shallow circumferential cuts around bottles of various sizes and shapes. His hand-operated device used a guide element to engage the bottle's mouth and a tapered, non-rotary glass-cutting tip to score the surface. The device featured a stabilising mechanism that provided stability while cutting, ensuring precision regardless of the bottle's size or angle. 1973 John S. Doyel patented a cutting apparatus for brittle articles like glass bottles (US3744692A) [7]. His apparatus scribed a cut line on the outside of the bottle, then applied force inside it to break it along the line. This design features a base plate for support and a sliding cutting mechanism for precise cuts. Together, these inventions laid the foundation for modern glass bottle-cutting devices.

By leveraging the benefits of recycling, particularly glass products, it is estimated that recycling one tonne of glass can save 0.67 tonnes of carbon dioxide emissions. In 2022, global carbon dioxide emissions from glass processing furnaces reached 95 million metric tonnes due to the extremely high temperatures required for production [8].

Pursuing cost-effective cutting tools while maintaining high process efficiency is a key driver in cutting technology advancements. Cutting tools differ in energy consumption, speed, material defects, temperature effects, and the quality of surfaces and edges obtained. The conventional method of glass cutting, using a wheel cutter or diamond point tool, has been used for decades due to its low cost and available expertise [7, 9]. In this method, the glass surface is marked and scribed, followed by immersing the glass in hot and cold water to separate the cut [10]. However, insufficient immersion time can cause fractures. The process often results in irregular cuts, poor surface finishes, and significant material deformation.

This study aims to develop a glass cutter that automatically cuts glass bottles into functional items such as drinking glass, lamps, or ashtrays. This could reduce the environmental effect and minimise harm to the environment. The machine was designed for extensive domestic use, and recycling facilities were used to produce valuable items from recycled glass bottles. This glass cutter offers convenient, easy-to-use, and improved safety aspects, with the ability to repurpose waste glass. Eventually, it will contribute to environmental sustainability and water-reducing efforts.

II.Materials and Methods

A. *The Flow of The Work Progress*

The development process starts with a literature review to understand existing technologies and identify gaps, as shown in Fig. 1. Concept generation follows, where multiple design ideas are evaluated, and the most promising ones are selected. This leads to prototype design, where detailed plans are created. The prototype is then fabricated based on these plans. After Fabrication, the prototype undergoes testing to ensure it meets performance standards. If testing reveals issues, the prototype is inspected, and necessary repairs or rework are performed. The process is iterative, with adjustments made until the prototype meets all required specifications and functions.

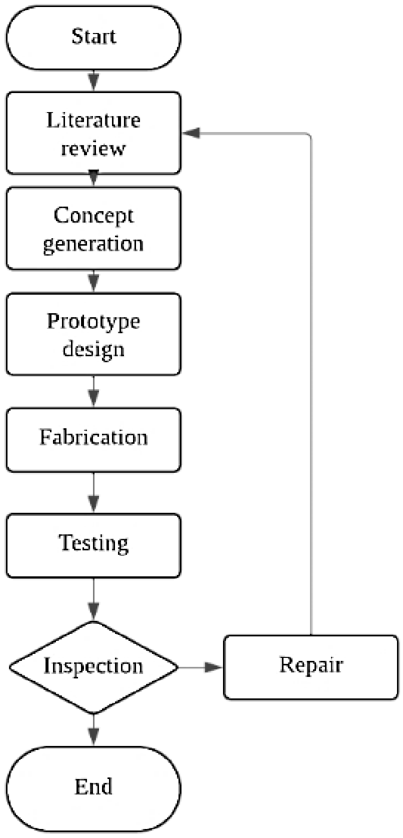
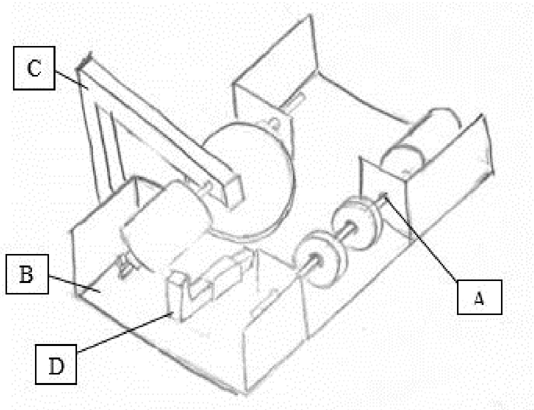


Fig. 1. Flow chart of the overall process.

B. *Concept Design*

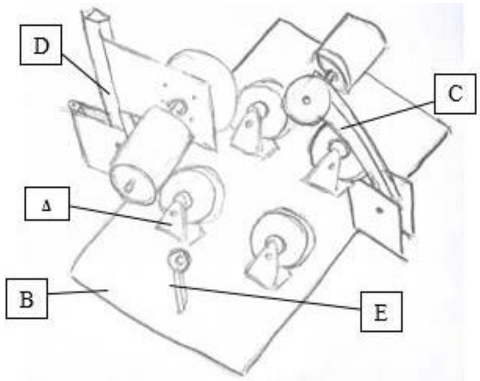
This section presents three concept designs which will be used to evaluate the final model of the prototype. Important parts such as material, components and standard parts were considered correctly.

Concept 1, shown in Fig. 2, features a complex design to optimise the functionality of the glass bottle cutter. The more straightforward tyre holder design was chosen to reduce production time. The base wall is designed high to prevent glass dust from spreading, making cleanup easier after cutting. The bottle top holder is also adjustable, allowing users to cut the bottle to their desired length. This combination of features balances efficiency and ease of use.



Label	Function	Reason
A	Tyre holder	Easy to build
B	Base frame	Prevent the glass pieces from scattering.
C	Blade holder	Simple design
D	Bottle top holder	Adjustable

Fig. 2. Concept design 1.

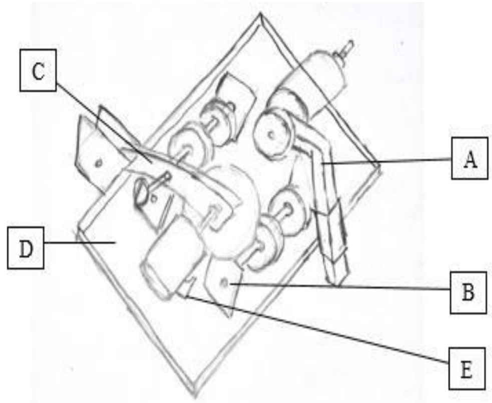


Label	Function	Reason
A	Tyre holder	Low cost
B	Base frame	Simple design
C	Bottle belt	Smoothen the rotation of the glass bottle
D	Blade holder	Adjustable
E	Bottle top holder	Secure in place

Fig. 3. Concept design 2.

On the other hand, Concept 2, as shown in Fig. 3, features a simple design with a base frame made from rectangular sheet metal, reducing production costs and time. The adjustable blade holder allows for cutting small glass bottles without manual effort. A small RPM DC motor is attached to the bottle belt, ensuring smooth, moderate rotation. The blade holder includes a height adjuster, enabling users to set the cutting height as needed. This design incorporates a basic, cost-effective tyre, and the bottle top holder is securely fixed and immovable, enhancing stability during the cutting process.

Besides Concept 3, as shown in Fig. 4, the base frame is constructed from rectangular sheet metal with a low profile. This design minimises spillage of the working fluid, keeping the workspace clean. The blade holder requires user manual handling during the cutting process. The movable bottle belt accommodates various bottle diameters, enhancing versatility. The tyre holder is easy to install and contributes to the product's straightforward design. Additionally, the bottle top holder is simple and cost-effective, further streamlining the overall design of the cutter.



Label	Function	Reason
A	Bottle belt	To hold the bottle in place
B	Tyre holder	Neat
C	Blade holder	Controllable
D	Base frame	Prevent messy workspace
E	Bottle top holder	Simple

Fig. 4. Concept design 3.

III. FINAL PROTORTPE DESIGN

The final design integrates all activities based on the preliminary design and includes preparing detailed construction plans and performance specifications. The overall design was developed using SOLIDWORKS 2017, a 3D CAD software tool that allows for the creation of 3D parts, drawings, and assembly models [8]. The design process involves several steps: creating each part with precise dimensions, assembling these parts using the software's mate system, and generating detailed drawings. Figure 5 shows the final prototype of the model based on the design concept evaluation.

The growing concern over environmental issues and the emphasis on sustainability have driven efforts to enhance recycling technologies, particularly for glass bottle waste. Traditionally, glass bottles could be manually cut for small-scale operations; however, this method poses significant safety risks and lacks precision. Therefore, an automated system is needed to improve manual methods and provide a more practical and efficient solution. Table I compares manual methods, fully automated systems, and the current prototype.

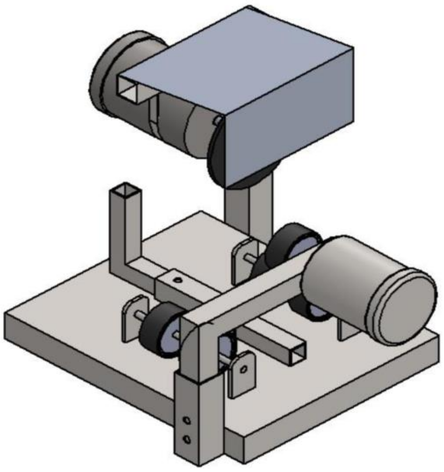


Fig. 5. Final prototype model.

Table I. Comparison between manual, fully automated and current prototype.

Item	Manual	Fully Automated	Current prototype
Efficiency	Less efficient and requires a high level of user skill.	Fast and capable of high-speed operations.	Moderately efficient, offering faster performance than the manual method.
Safety	High risk due to exposure to sharp edges.	There is minimal risk as operations are fully automated.	Improved safety by reducing direct user contact with glass.
Cost-effectiveness	It is low-cost, as only basic tools are required.	High cost due to advanced machinery and systems.	Moderate cost, covering design and fabrication materials.

IV. ENGINEERING ANALYSIS

Engineering analysis serves as the internal guide for a project by breaking down an object, system, or issue into its fundamental elements to understand their relationships with each other and external factors. For the glass bottle cutter machine, the focus is on stress simulation analysis to ensure durability and performance.

The material selected for this analysis is plain carbon steel, which contains up to 2.1% carbon. This type of steel typically does not have a specified minimum content for other alloying elements. However, it often includes small amounts of manganese, silicon, and copper—generally less than 1.65%, 0.6%, and 0.6%, respectively. Key material properties for this iron-carbon alloy include a Young's modulus of approximately 210 GPa and a Poisson's ratio of around 0.3. Despite its relatively low strength and softness, carbon steel is highly ductile, making it well-suited for machining, welding, and cost-effective production methods.

Stress simulation in the SolidWorks software package helps optimise product design early in the process, reducing the need for numerous prototypes. Integrating simulations into the design workflow ensures that parts are capable of withstanding applied stresses, preventing wasted time and resources on designs that may fail [11]. This approach leads to a shorter and more cost-efficient design cycle.

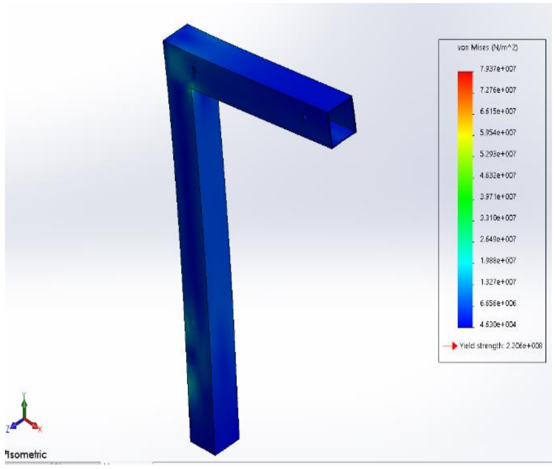


Fig. 6. Finite element analysis of the critical part.

In structural analysis, as shown in Fig. 6, key factors include von Mises stress, displacement, and safety factors. Von Mises stress represents the maximum stress a material can handle before it undergoes permanent deformation, making it a crucial indicator for ensuring the durability and reliability of the design. Figure 6 shows the blade holder, made from plain carbon steel, selected for analysis as it bears the highest load compared to other parts. A load of 72 N was applied, and the maximum von Mises stress recorded was 7.94×10^7 N/m^2. The yield strength of the material is 2.21×10^8 N/m^2, which is significantly higher than the von Mises stress. This indicates that the structure can withstand the applied load without any risk of failure or fracture, ensuring the durability and reliability of the blade holder.

V. FABRICATION PROCESS

Fabrication of the automated glass bottle cutter involves combining standardised parts through cutting and welding to shape raw materials into the final product. Figure 7 shows the fabricated part of the prototype. The 25 mm and 32 mm square hollow steel are measured, cut using a cut-off saw, and welded with gas metal arc welding. Holes are drilled using a bench drill, and bolts and nuts are attached to the 32 mm steel. A caster wheel is mounted to the motor (see Fig. 7). Steel plate and rod are measured, cut with an angle grinder, and drilled. Caster wheels are attached to the rod, welded to a sheet plate, and greased for smooth rotation. Finally, the bar and sheet plates are cut and welded using arc welding to complete the automated glass bottle cutter prototype.

Fig. 7. Fabrication of the prototype.

VI. FABRICATION PROCESS

A. *Testing Working Product Capability*

Several tests were carried out to assess the machine's performance. A list of operations was tested as in Table I, with each operation having expected and actual results. The tests included various glass bottle diameters to evaluate cutting efficiency.

Table II below outlines the operations, expected outcomes, and actual results. The machine successfully performed all tasks without issues, demonstrating its effectiveness in cutting glass bottles as intended.

Table II. List of operations for the automated glass bottle cutter.

Operations	Bottle diameter	Results
Cut a soy sauce glass bottle	70 mm	Able to cut through.
Cut a Vsoy glass bottle	50 mm	Able to cut through.
Polished a glass bottle	50 mm	Able to smooth the cut surface

B. *Product Specifications and Capabilities*

A product specification is important for properly documenting the machine's requirements for fulfilling its design and providing necessary information about the features and functionalities. To match customer needs, developing a product development specification and highlighting its capabilities is important for providing high value added to the product.

The prototype was constructed from plain carbon steel, AISI 1013, with final dimensions of 305 mm × 250 mm × 230 mm and a weight of 25 kg. It operates on a power output of 1.51 kW and 20 W, with a 240 V/220 V voltage requirement. The motor can achieve speeds of 5500 RPM and 1440 RPM, accommodating a maximum tool diameter of 100 mm. The cutting tool used is a diamond blade, capable of handling a maximum cutting diameter of 120 mm. The estimated cost of the prototype is RM 215.30. This design enables efficient and precise cutting of glass bottles, making it suitable for household and small-scale commercial applications.

The machine was designed to ensure high-quality cutting results by meeting specific requirements. It accommodates bottles with diameters of 3 cm to 10 cm and lengths up to 35 cm, with a cutting time of 30-60 seconds per bottle, depending on material and thickness. Adjustable features such as customisable cutting ranges were incorporated to handle different bottle sizes and shapes, as shown in Fig. 8. Speed control was a critical requirement, with two ranges: lower speed (3000 RPM) for thinner and delicate materials to prevent cracking and higher speed (5000 RPM) for thicker glass to achieve smooth and precise cuts. A 100-watt electric motor was selected for small-volume production, offering a cost-effective solution for light-duty operations.

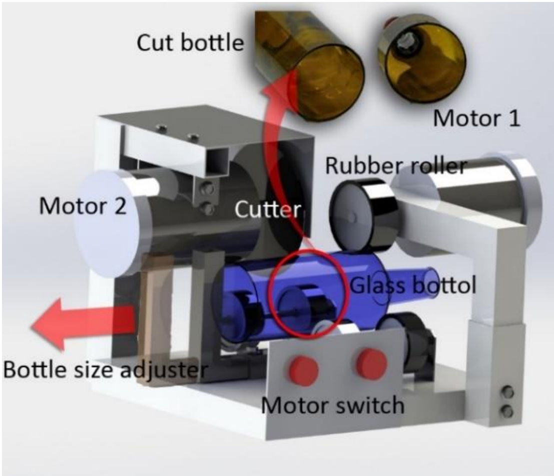


Fig. 8. Machine specification and cutting product for the glass bottle.

VII. DISCUSSION

The currently designed and fabricated cutter prototype presents a solution for efficiently managing the glass bottle while fulfilling practical and environmental requirements. The design, suitable for various bottle sizes, was versatile and provided a solution for various user interests. The machine was designed with user-friendly user features, allowing quick adjustments and easy operation. Besides that, the machine also provided a cutting process with minimum effort.

The machine is constructed from steel, ensuring high durability and suitability for prolonged, intensive use. During operation, it requires minimal effort, making it energy-efficient. Users can modify the blade position and adjust the bottle holder for precise alignment to accommodate bottles of different sizes and shapes.

The glass bottle offers various advantages to fulfil customer requirements, especially for the bottle with a diameter ranging from 60 mm to 100 mm and height limited to 100 mm to 200 mm. The specification enables users to cut several types of bottles in different diameters, including beverage, ketchup, and soy sauce containers. The machine fabricated with steel offers intensive utilisation and durability for a long time. The glass functions with the minimum effort necessary to save energy during the operation. For the different bottle sizes and shapes, the user must modify the blade position and adjust the bottle holder to position the bottle accurately.

The product has significant potential in the hospitality and recycling industries due to its ability to reduce waste and repurpose glass bottles by reducing disposal costs and promoting sustainability. In hospitality, for example, the machine allows related industries such as hotels and restaurants to upcycle the potential glass bottle into a decoration or candle holder, enhancing product aesthetics. Besides, reduce the waste volume sent to the recycling plant or area. In addition, encouraging the circular economy related to converting glass into functional items

VIII. CONCLUSION

The designed glass bottle cutter machine aims to tackle issues related to glass wasters, especially bottles. The product is multifunctional for domestic use, especially in households and recycling facilities, and it has a safe design and function to cut bottles. Besides that, cutting bottles requires safety measures due to glass dust. The durability and robustness are assured by its economical construction from standard carbon steel, which is properly maintained. The pairing of cutting and polishing features diminishes user fatigue and enhances efficiency. This glass bottle cutter machine enhances sustainability by transforming glass trash into valuable products, thus promoting waste reduction and raising awareness of the importance of recycling for environmental conservation.

ACKNOWLEDGEMENT

All the authors would like to express their special appreciation to Universiti Teknologi Mara, Pasir Gudang Campus, for the support and opportunities provided during the study. We are also deeply thankful to the contributors for their assistance and help in all aspects, from proposal preparation to the fabrication of the prototype and manuscript writing.

REFERENCES

[1] J. G. Guerrero, J. R. Reséndiz, H. R. Reséndiz, J. M. Álvarez-Alvarado and O. R. Abreo, "Sustainable Glass Recycling Culture-based on Semi-automatic Glass Bottle Cutter Prototype," S*ustainability*, vol. 13, no. 11, pp. 6405, 2021.

[2] Y. C. Moh and L. Abd Manaf, "Overview of Household Solid Waste Recycling Policy Status and Challenges in Malaysia," *Resourc., Conserv. and Recycl.*, vol. 82, pp. 50-61, 2014.

[3] 丁丁, "Glass Bottle Cutter," China Patent Appl. CN201921141079.4U, 2019. [Online Available: https://patents.google.com/patent/CN211311313U/en?oq=CN211311313U]

[4] K. Odum, M. C. Castillo, J. Das and B. Linke, "Sustainability Analysis of Grinding with Power Tools," *Procedia CIRP*, vol. 14, pp. 570-574, 2014.

[5] E. J. Gelfman, "Method and Apparatus for Cutting Glass Bottles and The Like," Worldwide Applications, 1989. [Online Available: https://patents.google.com/patent/US3699829A/en?oq=US3699829A]

[6] J. Hanson, "Bottle Cutter," United States, 1973. [Online Available: https://patents.google.com/patent/US3845555A/en?oq=US3845555A]

[7] J. Doyel, "Bottle Ccutter," United States, 1972. [Online Available: https://patents.google.com/patent/US3744692A/en?oq=US3744692A]

[8] M. Jaganmohan, "Emissions from Glass Production Worldwide and in Europe in 2022," [Online Available: https://www.statista.com/, 2025]

[9] B. Ciałkowska and M. Wiśniewska, "Cutting with Diamond Saw Blades Non-Metallic Materials," *Mechanik*, vol. 90, no. 4, pp. 306-308, 2017.

[10] E. Prakash, K. Sadashivappa, V. Joseph and M. Singaperumal, "Nonconventional Cutting of Plate Glass Using Hot Air Jet: Experimental Studies," *Mechatron.*, vol. 11, no. 6, pp. 595-615, 2001.

[11] A. Reyes, *Beginner's Guide to SOLIDWORKS 2020-Level I*. SDC Publications, 2019.