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Hand-Operated Ramming Tool for Casting Processes

Najibah Ab Latif¹, Muhammad Hazim Md Azli¹, Ainaa Maya Munira Ismail^{1,*} and Nurnida Elmira Othman²

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, Kampus Pasir Gudang, Jalan Purnama, Bandar Seri Alam, 8750 Masai, Johor, Malaysia.

²Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

*Corresponding author: ainaa7609@uitm.edu.my, ORCID: 0009-0007-7606-0682

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Abstract—The production of sand molds for casting is a critical process in modern manufacturing, particularly in industries such as automotive, construction, and machinery. However, existing ramming tools and machines face several inefficiencies, including uneven compaction, high costs, and ergonomic concerns. This study focused on the design and fabrication of a manual ramming machine tailored for small-scale workshops and educational purposes, offering a low-cost and user-friendly solution for efficient mold-making. The proposed manual ramming machine is designed using SolidWorks and incorporates a 2-ton hydraulic jack to ensure uniform sand compaction. Fabrication methods included cutting, welding, and mechanical assembly using durable and recyclable materials. The final prototype is compact, portable, and manually operated, reducing energy consumption and promoting sustainability. Testing confirmed the machine's capability to achieve uniform compression with minimal operator effort, producing high-quality molds in under one minute. The design prioritizes safety and simplicity, making it ideal for students and small-scale manufacturers. Furthermore, the incorporation of recyclable materials and manual operation underscores its environmental benefits. This research highlights the potential of the manual ramming machine to address inefficiencies in current tools, improve accessibility, and enhance the learning experience in casting workshops. Recommendations for future improvements include modular components for easier maintenance and potential automation to reduce manual effort further.

Keywords—Manual, Ramming, Casting, Mechanical.

I. INTRODUCTION

Ramming machines and tools are widely used in sand casting. Ramming machines, including pneumatic and hydraulic types, compact sand in mold efficiently. Uniform density is ensured with hand

tampers and strike-off bars, among other ramming equipment. These tools are necessary for various industrial applications to achieve accurate castings, prevent errors, and create precise mold. The primary objective of using a ramming machine in casting is to ensure that the sand is tightly compacted around the pattern to produce a solid uniform mold or core and to achieve accurate and precise casting dimensions, surface finish, and a solid structure in the final casting product.

The increase in the production of casting and its use in recent years has proven significant for modern industry and the world economy [1]. Castings are mainly used in automobiles, power generation, construction, railways, the cement industry, textile machinery, pumps, compressors and valves, diesel engines, and many other specialized applications. In order to create a product form during the molding process, the manufacturer must ram a sand casting until the density of the sand is solid [2]. The widespread use in the industry showed that ramming machines are important in casting during the molding process. The use of ramming machines is important to ensure regular and consistent sand compaction, which saves time and reduces the need for manual labor, especially for small workshops [2, 3].

Thus, there is a need to develop and design a manual ramming machine for the small-scale casting workshop and workshop for students to make a small casting product. This machine is designed with low-cost, high-quality parts without sacrificing quality in order to provide efficient sand compaction [4, 5]. It is also easy for students in the workshop to conduct and protect users from potential hazards while in use.

The current ramming tools used in the molding process have several inefficiencies [3]. It can be addressed by using the machine product that can give a more force output [6-8]. It also can lead to a longer molding time, higher energy consumption, and uneven mold compactness. This can be addressed by applying high pressure on all surfaces of the sand mold using a mechanical concept [9-12]. Additionally, poorly designed ramming tools pose ergonomic risks, potentially causing hand injuries, and the use of an unwell-maintenance ramming machine can also pose a safety hazard [13].

Therefore, a hand operated ramming tool for casting process was presented in this case. The issue can be solved by using this manual operated with a more friendly and ergonomic design. There are two objectives have been highlighted in this study which are to design and to fabricate the product using the proposed material, specification and design. Furthermore, the high initial cost and maintenance expenses of the ramming machine can be overcome by using low-cost and long-lasting materials that require less servicing and maintenance by introducing this product.

II. METHODOLOGY

A. Process Flow

The development process commenced with a comprehensive literature review to examine existing technologies and identify research gap, as illustrated in Fig. 1 subsequently, multiple design concepts were generated and evaluated, leading to the selection of the most feasible solution. Detailed design plans were developed during the prototype design phase, followed by engineering analysis. Based on the plans, the prototype was fabricated and subjected to performance testing.

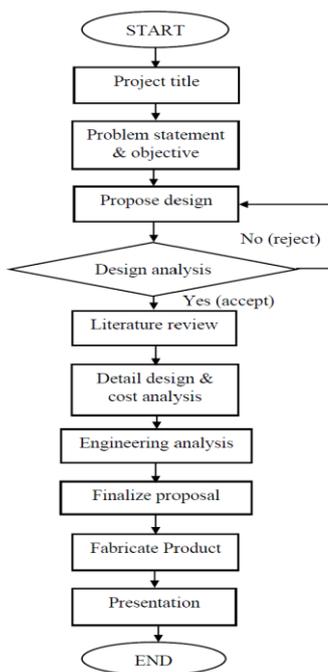


Fig. 1. Process flowchart.

B. The Concept Design

The concept design (CD) has been presented into 3 which are used to evaluate the final prototype. It is important to finalize included the materials, components and standard parts of the design. Figure 2 shows feature a concept design 1 until concept design 3 (CD1-CD3) to optimize the functionality of the ramming tool and was tabulated in Table I. This smart design was chosen because it is more practical and easier to handle. CD2 has been chosen because it gave more ergonomic and mechanical compared to another. The frame, ramming head, strike bar, mold box and stand was denoted in Fig. 3.

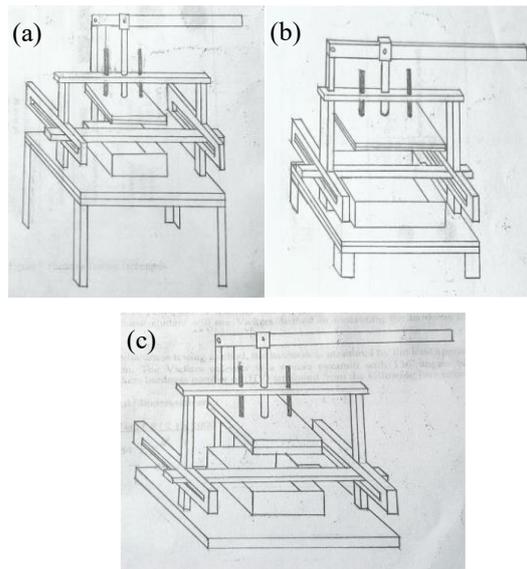


Fig. 2. Concept design (a) CD1, (b) CD2 and (c) CD3.

Table I. Final fabricated prototype view.

No	Name of part	Reason	CD1	CD2	CD3
A	Frame	More capable of withstanding mechanical stresses and loads	/		/
		Enough strength and ease to welding		/	
B	Ramming head	More flexibility and can absorb shock and impact effectively	/	/	
		Can give an impact and use by recycled material		/	/
C	Mold box	Cheap material	/	/	/
D	Strike bar track	To reduce friction and support the strike bar's movement	/		
		To provide a low-friction surface for the strike bar to slide against.			/
		To provide guided and controlled linear motion for the strike bar		/	

E	Stand	Can operate the machine on floor without table	/		
		To operate the machine on the table			/
		To get more stable on any floor condition.		/	

C. Fabrication Process and Materials Descriptions

The fabrication processes and material descriptions have been discussed in Table I. Mild steel was selected as a main body material because of the low cost, availability and high durability. Table II presents fabrication processes which correlated to this product development which are including cutting, drilling and joining of the related parts [9].

Table II. Fabrication process and materials descriptions.

No	Machining Process	Description
1	Cutting	A Mild Steel Plate was cut from (30cm x 40cm) into two parts (30cm x 30cm) base and (30cm x 3.8cm) Horizontal Frame using angle grinder
2		A Pine Wood from (12.3cm x 30cm) was cut into two pieces of (4cm x 17.4cm) and two pieces of (4cm x 15cm) using table saw.
3		A 2 inch of Mild Steel Angle, from 1ft was cut into four equal pieces to serve as Stands.
4		A ¾ inch of Mild Steel Hollow, from 5ft was cut into two pieces of 30 cm, four pieces of 5cm, and two pieces of 21cm as a Vertical Frame.
5		A 6 mm Mild Steel Rod, from 2ft was cut into two 30cm pieces to serve as Strike Bar Tracks.
6		A 1 inch of Mild Steel Angle from 1ft was cut into 8 pieces of 1.5cm as a Bracket.
7	Drilling	A Mild Steel Flat Bar was drilled to insert the M4 screw and spring hook.
8		A Hydraulic Jack was drilled using a 7mm drill bit
9	Joining	Join the Stand with a Base at every corner of the plate to produce the Lower Part. Use 40 Volt current
10		Join the Bracket to the Horizontal Frame and (15cm x 15cm) Mild Steel Plate as a Ramming Head
11		Join the Vertical Frame with the Horizontal Frame to produce the Upper Part, middle part and lower part.

III. RESULTS AND DISCUSSIONS

A. Final Fabricated Prototype

Figure 3 shows solidwork drawing of the operated ramming tool casting process. It has been design based on following dimension as shown in Fig. 3. Final prototype and the fabricated product views has been reported in Table III.

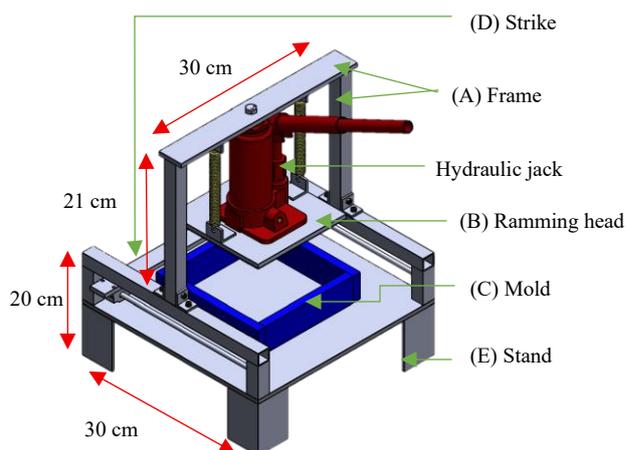


Fig. 3. SolidWork drawing of hand operated ramming tool.

Table III. Final fabricated prototype view.

View	Description
<p>Fig. 4. Top view.</p>	The top view of the prototypes showcases its compact and symmetrical design. The hydraulic jack is positioned in the center of the frame, securely attached, and aligned for optimal force application.
<p>Fig. 5. Front view.</p>	The front view of the prototype highlights its functional and structural components. The two vertical springs are mounted symmetrically on either side, attached to the frame and pressing plat, providing a retraction mechanism to return the plat to its original position after compression.
<p>Fig. 6. Side view.</p>	The side view of the prototype provides a clear perspective on its structural alignment. The reinforced legs are symmetrically positioned to distribute weight evenly and maintain balance during operation.
<p>Fig. 7. Isometric view.</p>	

The completeness of the prototype reflects a thorough development process, beginning with the first design, which compares with the final design to evaluate and address limitations. The modification

was made to enhance functionality, durability, and usability. The final prototype includes specifications such as a 2-ton hydraulic jack for force application. These enhancements were discussed in detail, highlighting how each change contributed to achieving a more efficient, user-friendly, and practical solution for small-scale molding tasks as shown in Fig. 8.

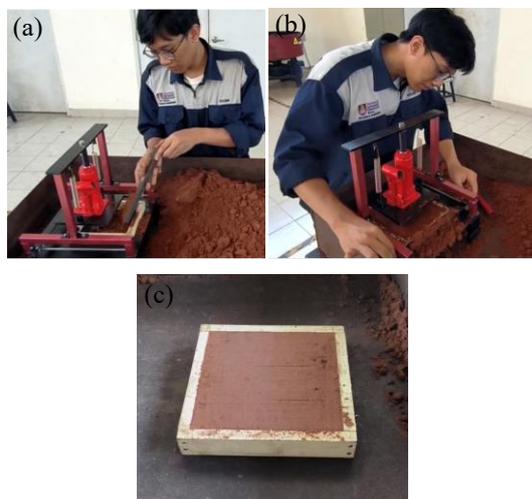


Fig.8. Casting process of sand (a) pour sand into the mold, (b) flatten the sand using strike bar and (c) sand after casting.

B. Product Specification, Performance, Safety and Availability

Table IV shows product specification and Table V presents its performance and safety feature of the ramming tools. It is important for properly documenting machine requirement to fulfil and match customer need by providing high value added of the product.

Table IV. Final prototype specification.

Specification	Value
Height	36 cm
Width	30 cm
Length	30 cm
Weight	8 kg
Hydraulic jack capacity	2 ton
Performance metrics	Less than 1 minute per mold

Table V. Performance and safety.

Item	Actual prototype	Current prototype
Performance	Fast and require high level of user skill.	Moderately efficient offering faster performance
Safety	High risk due to mechanical hazard like can trap hand and finger leading to serious injured	Low risk because the speed of ramming head can controlled by hydraulic jack manually.

The fabricated prototypes offer both advantages and disadvantages, which must be considered alongside the sustainability requirements. Ensuring that these prototypes meet the necessary criteria for performance, durability, and environmental impact is important in determining their overall practical and readiness for efficient, long-term use in real-world applications.

In terms of cost effectiveness, the prototype is significantly more affordable than an industry ramming machine, making it accessible for small-scale users and educational institutions. It is also more compact and lightweight design allows easy transportation and storage, unlike heavy industrial presses that are stationary. This manual operation eliminates the need for electrical power, relying entirely on the operator’s input for functionality. It is also has some disadvantages which are limited force capacity. Using a 2-ton hydraulic jack, the press is suitable only for lightweight applications and cannot handle heavy-duty industrial tasks. It is also restricted of scalability meaning that the prototype’s design is not scalable for longer or more demanding industrial applications, limiting its versatility and market scope. In terms of sustainability and environmental impact, the manual operation eliminates the need for electricity, reducing carbon emissions and making it environmentally friendly in terms of energy usage. It is also made of recyclable materials. The prototype is made of metal and wood, which are recyclable or reusable, contributing to sustainability and minimizing waste. This product also has long service life. The robust construction ensures durability, reducing the need for frequent replacement and lowering the overall environmental footprint.

IV. CONCLUSION

The manual ramming machine prototype successfully fulfils primary objectives. First, it demonstrates an innovative design for a manual ramming machine using SolidWorks, incorporating essential features like a 2-ton hydraulic jack, spring, and a strike bar with bearings. These components work synergistically to ensure efficient and uniform compression of sand molds. Second, the fabrication of the prototype as a proof of concept confirms its practicality, ease of operation, and ability to meet the requirements of small-scale workshops and educational settings. The compact and ergonomic design offers a safe and user-friendly alternative to traditional ramming tools.

The findings highlight the prototype’s significant contributions to improving the casting process. Particularly for students and small-scale users. It offers an affordable, environmentally friendly, and portable solution while maintaining consistent mold quality. The incorporation of recyclable materials and manual operation underscores its sustainability, ensuring minimal environmental impact and long service life. This project not only addresses existing inefficiencies in ramming tools but also promoting accessibility, safety, and eco-conscious manufacturing practices in small-scale casting processes.

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Najibah Ab Latif: Project of 3 in 1 Cart Ladder

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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