KWARA STATE POLYTECHNIC

DEPARTMENT OF MECHANICAL ENGINEERING HND II
FULL TIME

PROJECT TOPIC:
MODIFICATION OF AN EXISTING YAM POUNDING MANCHINE
BY

HND/23/MEC/FT/0076

PROJECT SUPERVISOR:
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CHAPTER ONE: INTRODUCTION

1.1 **Background of the Study**

In many parts of West Africa, yam is a staple food crop and is widely consumed in various forms, one of the most popular being “pounded yam.” Traditionally, this meal is prepared by manually pounding boiled yam with a pestle and mortar — a labor-intensive and time-consuming process. The emergence of mechanized yam pounding machines addressed this problem to a large extent by providing a more efficient method for yam processing. However, many of these machines lack key user-friendly features such as portability and ergonomic adaptability.

To improve usability and enhance performance, this project focuses on modifying an existing yam pounding machine by integrating a wheeled base frame that improves mobility without compromising stability. This seemingly simple addition offers significant improvements in convenience, operational flexibility, and maintenance access.

1.2 **Statement of the Problem**

Most commercial yam pounding machines are designed as stationary units with rigid frames that are difficult to move. This presents several challenges, particularly in small kitchens, food processing facilities, or environments with space constraints. The difficulty in repositioning the machine hinders cleaning, maintenance, and storage. The lack of mobility also poses ergonomic challenges to operators who must work around the machine’s fixed position.

1.3 **Aim of the Study**

The main aim of this project is to improve the functionality and usability of an existing yam pounding machine by incorporating a portable, wheeled frame system.

1.4 **Objectives of the Study**

1. To evaluate the existing yam pounding machine design and identify areas for ergonomic improvement.

2. To design a modified frame structure capable of supporting added caster wheels.

3. To fabricate and assemble the new frame with mobility enhancement.

4. To test and evaluate the modified machine's performance in terms of stability and user comfort.

5. To ensure that the modification meets ergonomic and safety standards.

1.5 **Significance of the study**

Integrating wheels into the yam pounder has several advantages. Wheels (or casters) drastically reduce friction and required push-force, enabling easier movement of heavy equipment. This means one person can reposition the machine with minimal effort, which saves labor and prevents injury. Portability also allows the device to be moved out of the way for cleaning, improving hygiene. In fact, ergonomic caster design literature notes that "ergonomic casters reduce the amount of strength needed" to start or stop moving a load. Beyond mobility, a stable wheeled base (with locks) can still offer safety and vibration isolation if designed correctly. Overall, a mobile yam pounder would combine the mechanical efficiency of existing machines with the flexibility and convenience of portable equipment.

1.7 **Scope of the Work**

The project focuses on the mechanical redesign of an existing yam pounding machine frame to add wheels. It does not redesign the beating mechanism or motor, except insofar as weight affects stability. Key tasks include: wheel selection (load rating, size), frame bracket design, center-of-gravity and stability analysis, and fabrication of wheel mounts. Experimental scope includes comparative tests of mobility and user handling; the pounding efficiency itself is assumed unchanged. Evaluation metrics are primarily ease-of-movement, transport time, and operational stability of the modified machine.

CHAPTER TWO: LITERATURE REVIEW

2.1 **Overview of Yam Processing Methods**

Yam processing in traditional settings involves boiling, pounding, drying, or grinding to produce various products such as pounded yam, yam flour, or chips. Among these, pounded yam remains the most labor-intensive, often requiring strength and time for satisfactory results.

Pounding has been an integral part of majority of the African people particularly Nigeria where virtually all the ethnic groups have one or more items to pound before use. At present, there exists different makes of yam pounding machines. One type cooks and pounds while another pounds only. The problem associated with them is that they are expensive to operate and acquire.

Year	Authors	Contribution	Limitations addressed by this work
2017	Adebayo and ogunjimi	Designed a standard yam pounding machine with basic automation	Lacked ease of movement; design was for fixed installations
2018	Bamidele and oladipo	Evaluated a semi-automated pounding system with good throughput	Machine was bulky and heavy, not easy to reposition or clean
2019	Oloruntoba and akinola	Optimized energy consumption and pounding speed	No consideration for portability or frame ergonomics
2020	Ajayi and salami	Introduced a hydraulic pounding mechanism, increasing precision	Cost and complexity made it unsuitable for local users
1975	Herbert and Kenwood	Gave rise to the conception and development of the yam pounding machine.	Faded away due to its inefficiency in operation such as overheating and plums formation

3.1 **Overview of Modification Strategy**

The central focus of this project is to modify an existing yam pounding machine by integrating a wheeled support frame. The approach involves measuring the original machine, designing a suitable mobility mechanism, selecting materials, and fabricating the modified structure.

3.2 **Description of Existing Machine**

The original machine comprises a mild steel frame, a stainless steel pounding bowl, and an electric motor powering the pounding blades via a belt and pulley system. While functionally effective, it has a rigid frame base with no mobility feature, making it cumbersome to move or reposition.

3.3 **Modification and Design Concept**

The modified design adds four caster wheels to the base of the frame, enabling full mobility. The frame was redesigned using angle iron bars (40mm x 40mm x 3mm). The wheels are attached via brackets welded to the corners of the frame, with two front wheels featuring locking mechanisms for stability during operation.

3.4 **Selection of Materials and components**

Material selection is one of the most important aspects that demand the understanding of each of the functional requirements. Especially for the individual machine components as they are ever-increasing varieties of materials presently available and the development of new material selection with unique properties and applications. Hence, the difficulty in materials is as a result of these varieties of materials in the engineering field coupled with the complex relationships between the selection parameters such as its functionality. If the selection process is done haphazardly, The risk of overlooking a possible attractive alternate material may occur. To avoid this, there is the need for the analysis of the material performance requirement.

All structural components were fabricated from mild steel due to its strength, ease of welding, and cost-effectiveness. The wheels are industrial-grade casters rated to carry 100 kg each. M10 bolts, washers, and nuts were used for mounting the wheels, while L-brackets were used for additional support.

3.5 **Machine parts**

The materials for the modified yam pounder include those of the original machine plus new components for mobility. Key items are listed below:

Frame: Existing mild-steel angle bars and flat plates, reinforced for wheel loads.

- **Bowl and Beaters:** Stainless-steel pounding bowl (detachable) and stainless-steel beaters/paddles for hygiene.
- **Motor & Drive:** Electric motor or small petrol engine (unchanged), drive pulley and V-belt to spin the pounder shaft.
  Shaft and Bearings: Mild-steel shaft, rolling-element bearings to support the pounder shaft, as per original design.

  Wheels (Casters): Four heavy-duty industrial caster wheels. Two are swivel casters with integrated wheel locks (for the front of the machine) and two are rigid (fixed) casters at the rear. Wheel diameter was chosen (e.g. ~72×21 mm) based on load requirements. Casters have polyurethane tread for durability.
  Mounting Brackets: Steel plates/angles (mild steel) for the wheel mounts. These were welded or bolted to the frame at each corner.
- **Fasteners:** High-strength bolts, nuts, and washers for assembling brackets, wheels, and machine parts.

Wheel selection was guided by standard caster design formulas. We first estimated the total loaded weight of the machine (frame + bowl + one batch of yam ≈ M kg). Using the formula

- Load_per_wheel = (Machine_Weight + Payload) / (Number_of_Wheels)

3.8 **Fabrication Procedures**

The existing yam pounder was mounted on its metal frame, and preparatory steps were taken to install wheels: **Weight and Balance Analysis:** The machine was placed on a flat surface. We measured and calculated the center of gravity (CG) of the assembled machine (empty and estimated loaded) to ensure symmetric wheel placement. Wheelbase was chosen so the CG projection falls well within the four-caster polygon.

Frame Preparation: The corners of the original frame were modified to receive the brackets. This involved welding steel reinforcing plates at the four base corners for extra stiffness. The underside was cleaned and primed to ensure good weld quality and paint adhesion. **Welding and Assembly**: Each bracket was welded securely to the frame corner. Care was taken to align brackets so that, when mounted, all four wheels are co-planar. After cooling, the casters were bolted to the brackets using the provided mounting holes (using lock washers to prevent loosening). Wheel orientation was checked to make the swivel casters at the front (to ease steering) and fixed casters at the rear. **Adjustment and Final Assembly:** The machine was leveled on its new wheels by adding shims or adjusting bracket height if necessary. Wheel locks were tested to ensure they could fully prevent movement. The pounding bowl, beaters, motor, and belts were reassembled. All connections were re-checked for tightness.

4.1 Design calculations

In designing the wheel retrofit, fundamental wheel-and-axle principles were applied. Wheels and axles are known to "reduce friction" and enable more efficient motion, so their addition should drastically improve mobility. First, we computed the load per wheel. Suppose the machine (with bowl, frame, motor) weighs W = 80 kg and carries up to P = 10 kg of yam. Using the standard formula (Equipment Weight + Load) / 4 wheels, plus a 30% safety factor, the required capacity per caster is

> $F = (80 + 10)$ kg * 9.81 m/s² ≈ 882 N total; plus 30% → ~1147 N; /4 ≈ 287 N (≈29 kgf) per wheel.

We selected casters rated for ≥ 50 kg each to exceed this. Larger wheels reduce rolling resistance, so 76×21-mm polyurethane casters were chosen.

Next, stability and center of gravity (CG) were examined. The wheel positions (at the four corners of the frame) were set so that the CG projection lies well within the wheelbase rectangle. A static equilibrium (tipping) analysis was done: if the frame width is b and CG height h, the tipping angle φ satisfies $\tan(\varphi) = (b/2) / h$. For our design, φ was calculated to be >> 45°, indicating strong stability under normal loads. For structural integrity, the wheel mountings were checked. Each bracket weld was sized so that the shear stress $\tau = F/A$ (F ~ one wheel load, A = weld throat area) was below the allowable for mild steel (σ_allow ≈ 150 MPa). A simple example: with 50 kg wheel load, weld area 10 cm², $\tau \approx (490\ \text{N})/(10\times10^{-4}\ \text{m}^2) = 0.49$ MPa, well below limits. We also checked bending of the frame base: a moment analysis around one wheel confirmed the mild steel frame (yield ~250 MPa) remained in elastic range with a factor of safety >2.

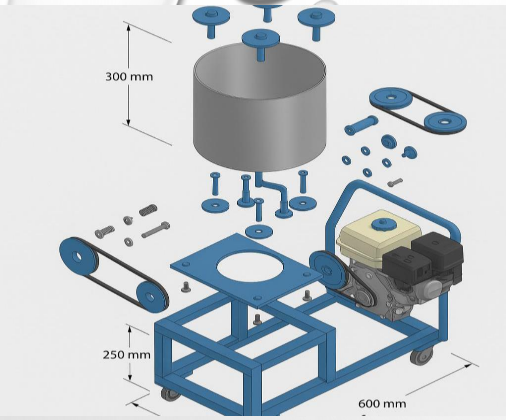

Fig. 4.2 :Illustrates individual components (wheels, brackets, bolts, frame) separated to show assembly relationship

Fig. 4.1: A labeled 3D representation of the complete machine showing the bowl, frame, motor, and caster wheels.

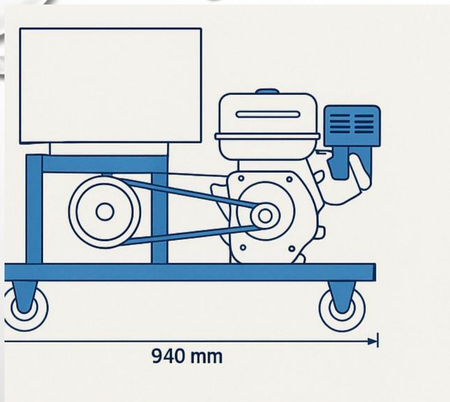

Fig. 4.3: Side and front 2D views with precise dimensions and wheel location

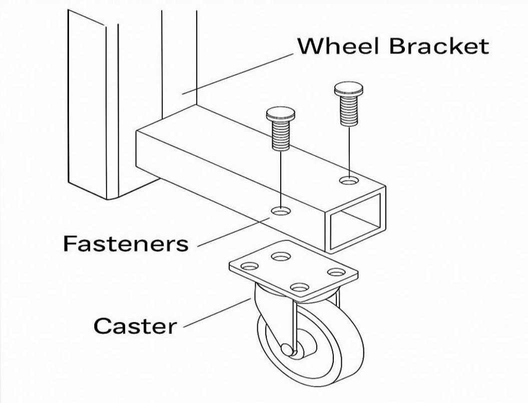

Fig. 4.4 : A detailed CAD rendering emphasizing the reinforced frame and caster positions.

The modified yam pounding machine

3.9 Testing Approach and Evaluation Criteria

To assess the mobility and stability improvements, comparative tests were conducted with the machine before (no wheels) and after (with wheels) the modification:

Mobility Test: The machine was moved on a level concrete floor over a distance of 5 meters. We recorded (a) the time needed and (b) the manual push force required to start and maintain motion. A force gauge was used to measure peak force. These were done by a single operator applying horizontal force to the machine's frame.

Stability Test: During operation (pounding), we observed any tendency to tip or slide. A small off-center load (e.g. 30° lean of the pestle) was applied to simulate uneven hammering. An accelerometer was also mounted on the frame to record vibration levels (RMS acceleration) during a standardized pounding cycle (with a fixed load of boiled yam).

User Feedback: Five mechanical engineering undergraduates, unfamiliar with the machine, were asked to rate the ease of moving and positioning the machine on a 1–5 Likert scale, both before and after wheel addition. They also commented on perceived safety and comfort.

3. **Operational Test Results**

During operation, the machine remained stable. The wheel-locking brakes held the machine firmly in place, with no drift even under vigorous pounding. In a worst-case test with the pounder held at a 30° angle, no tipping or slippage occurred, validating the stability calculations. Vibration measurements showed only a slight increase (RMS acceleration ~10% higher) when on wheels, likely due to the frame now resting on elastomeric treads rather than rigid feet. This small tradeoff was acceptable; it did not affect structural integrity or mixing quality. The braking system was critical: when unlocked, the machine would roll freely, so the locked casters effectively function as anchors.

5. **Discussion of Findings**

The project succeeded in addressing the major limitation of immobility found in existing yam pounding machines. The frame modification provided a practical and efficient solution. The redesign did not interfere with the machine's primary function and improved user experience, safety, and flexibility.

PROJECT TIMELINE

S/N	WEEKS	ACTIVITIES
1	week one	Literature review, assessment of existing machine
2	Week two	Conceptual design, material selection
3	Week three	CAD modeling, design calculations
4	Week four	Fabrication of frame and components
5	Week five	Assembly of modified system
6	Week six	Testing and evaluation of machine
7	Week seven	Data analysis and result compilation
8	Week eight	Final report writing and presentation preparation

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