

Design and Fabrication of an Eco-Friendly Bagasse Disposable Bowl Making Machine

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Abstract

The growing demand for disposable food containers has led to extensive use of plastic and thermocol products, resulting in significant environmental pollution. Sugarcane bagasse, a fibrous residue obtained after juice extraction, offers a sustainable alternative for the production of biodegradable tableware. This research presents the design and development of a manually operated screw press machine for manufacturing eco-friendly bowls using sugarcane bagasse.

The proposed machine incorporates a mild steel frame, threaded screw mechanism, guide rods, and a die assembly to apply the required forming pressure. Processed bagasse fibers mixed with a natural starch-based binder are compressed within the die cavity to obtain the desired bowl shape. The developed system aims to convert agricultural waste into value-added products while minimizing manufacturing cost.

Performance evaluation of the produced bowls was carried out through water absorption, oil resistance, heat resistance, and biodegradability tests. Experimental observations indicate that the manufactured bowls possess adequate strength for food-serving applications and exhibit natural decomposition under environmental conditions. The machine is simple in construction, economical to operate, and suitable for small-scale production.

The study demonstrates the potential of utilizing sugarcane bagasse as an alternative raw material for disposable food containers and contributes towards sustainable waste management and reduction of plastic pollution.

Keywords: Sugarcane Bagasse, Biodegradable Bowls, Screw Press Machine, Sustainable Manufacturing, Agricultural Waste Utilization, Eco-Friendly Products.

1. INTRODUCTION

The increasing use of disposable food containers and packaging materials has led to a significant rise in environmental pollution. Plastic and thermocol products are commonly used due to their low cost and convenience; however, their non-biodegradable nature causes serious environmental problems. These materials accumulate in landfills, pollute water bodies, and adversely affect ecosystems and human health. Therefore, there is a growing demand for sustainable and biodegradable alternatives to replace conventional disposable products.

Sugarcane bagasse is a fibrous residue obtained after the extraction of juice from sugarcane. India is one of the largest producers of sugarcane, generating a substantial quantity of bagasse every year. Although a portion of bagasse is used as fuel in sugar industries, a significant amount remains underutilized. Improper disposal or open burning of bagasse contributes to environmental pollution. Converting this agricultural waste into useful products can provide both environmental and economic benefits.

Bagasse possesses several favorable properties such as biodegradability, renewability, lightweight structure, and good mechanical strength. These characteristics make it a suitable raw material for manufacturing eco-friendly disposable products including plates, bowls, trays, and food packaging containers. The utilization of bagasse helps reduce

dependence on plastic products while promoting sustainable waste management practices.

The present work focuses on the design and development of a manually operated bagasse bowl-making machine. The machine consists of a mild steel frame, lead screw mechanism, hand wheel, guide rods, die assembly, and heating arrangement. The lead screw mechanism generates the required compressive force to shape the bagasse mixture into bowls, while the heating system improves bonding and dimensional stability of the final product. A natural starch-based binder is used to enhance the strength and durability of the manufactured bowls.

The primary objective of this research is to utilize sugarcane bagasse for the production of biodegradable disposable bowls and to develop a low-cost manufacturing machine suitable for small-scale industries. The developed machine aims to provide an economical, environmentally friendly, and sustainable alternative to conventional plastic and thermocol products.

The successful implementation of this technology can contribute to waste utilization, pollution reduction, rural employment generation, and the promotion of green manufacturing practices. Thus, the project supports the development of sustainable products while addressing environmental challenges associated with plastic waste.

2. PROBLEM STATEMENT

The extensive use of plastic and thermocol disposable bowls in food packaging and serving applications has become a major environmental concern. These materials are non-biodegradable and remain in the environment for long periods, causing land pollution, water contamination, and waste management problems. The increasing accumulation of plastic waste poses serious threats to ecosystems, wildlife, and human health.

At the same time, sugar industries generate large quantities of bagasse as a by-product during sugarcane processing. Although a portion of bagasse is used as fuel, a considerable amount remains underutilized or is disposed of through open burning, resulting in air pollution and wastage of valuable biomass resources.

Therefore, there is a need to develop an economical and environmentally friendly solution that can effectively utilize sugarcane bagasse for manufacturing biodegradable disposable products. The development of a low-cost bagasse bowl-making machine can help convert agricultural waste into useful products, reduce plastic dependency, and promote sustainable manufacturing practices.

3. OBJECTIVES

Primary Objective:

To design and develop a manually operated bagasse bowl-making machine for manufacturing biodegradable disposable bowls.

Specific Objectives:

- To utilize sugarcane bagasse as a raw material for bowl production.
- To reduce environmental pollution caused by plastic and thermocol products.
- To develop a low-cost and easy-to-operate machine.
- To evaluate the strength, water resistance, oil resistance, and biodegradability of the manufactured bowls.
- To promote sustainable waste utilization and eco-friendly product development.

4. LITERATURE REVIEW

The growing environmental concerns associated with plastic waste have encouraged researchers to investigate biodegradable materials and sustainable manufacturing techniques. Agricultural residues such as sugarcane bagasse, rice husk, wheat straw, and banana fibers have been widely studied for the production of eco-friendly disposable

products.

Several researchers have reported that sugarcane bagasse possesses excellent characteristics such as biodegradability, low density, good strength, and easy availability. These properties make it a suitable raw material for manufacturing disposable plates, bowls, trays, and food packaging products. The utilization of bagasse not only reduces environmental pollution but also adds value to agricultural waste.

Studies on biodegradable tableware have shown that natural binders such as starch, tapioca flour, and corn flour can significantly improve the bonding strength of bagasse fibers. The use of these binders enhances the structural integrity, water resistance, and durability of the final product.

Researchers have also developed various forming methods including hydraulic pressing, hot pressing, compression molding, and screw press mechanisms for shaping biodegradable products. Among these methods, screw press systems are preferred for small-scale production because of their simple construction, low manufacturing cost, and ease of operation.

Previous studies have concluded that bagasse-based products can effectively replace conventional plastic and thermocol products in food-serving applications. However, there is still a need for economical and compact machines that can be adopted by small-scale industries and rural entrepreneurs.

Based on the literature survey, it is observed that sugarcane bagasse has significant potential as a sustainable raw material for biodegradable bowl manufacturing. Therefore, the present work focuses on the design and development of a manually operated bagasse bowl-making machine that can convert agricultural waste into value-added eco-friendly products.

5. METHODOLOGY

The methodology adopted in this research involves the collection and processing of sugarcane bagasse, preparation of the binder, design and fabrication of the bowl-making machine, and manufacturing of biodegradable bowls. The complete procedure is carried out in a systematic manner to ensure the production of quality eco-friendly products.

5.1 Collection of Bagasse

Sugarcane bagasse was collected from a nearby sugar processing unit. The collected bagasse contained moisture and impurities, which were removed before further processing.

5.2 Drying of Bagasse

The collected bagasse was dried under sunlight to reduce its moisture content. Proper drying improves fiber quality and enhances the bonding process during bowl formation.

5.3 Grinding and Preparation

The dried bagasse was ground into smaller fibers to obtain a uniform texture. Fine fibers help in achieving better molding and improved product strength.

5.4 Preparation of Binder

A natural starch-based binder was prepared using corn starch or tapioca starch mixed with water. The mixture was heated and stirred continuously until a gel-like consistency was obtained. The binder improves adhesion between bagasse fibers and increases the strength of the final product.

5.5 Mixing Process

The prepared binder was mixed thoroughly with the processed bagasse fibers to obtain a homogeneous mixture. Proper mixing ensures uniform distribution of binder throughout the material.

5.6 Molding and Compression

The bagasse-binder mixture was placed inside the lower die cavity of the bowl-making machine. The lead screw

mechanism was operated manually using a hand wheel to apply compressive force through the upper die. The applied pressure shaped the mixture into the desired bowl geometry.

5.7 Heating Process

The die assembly was heated using an electric heating arrangement. The heating process removes residual moisture and improves bonding between fibers, resulting in a stronger and more durable bowl.

5.8 Cooling and Demolding

After the required heating period, the formed bowl was allowed to cool. The bowl was then carefully removed from the die assembly without damaging its shape.

5.9 Finishing and Inspection

The manufactured bowl was inspected for dimensional accuracy, surface finish, and structural integrity. Excess material was trimmed and the finished product was prepared for testing.

5.10 Testing and Evaluation

The produced bowls were subjected to various tests including water absorption, oil resistance, strength, heat resistance, and biodegradability tests to evaluate their performance and suitability for food-serving applications.

Methodology Flow Chart



6. MACHINE DESIGN AND COMPONENTS

6.1 Introduction

The bagasse bowl-making machine was designed and modeled using Siemens NX software. The machine is manually operated and utilizes a lead screw mechanism to generate the compressive force required for forming biodegradable bowls from sugarcane bagasse. The design is simple, economical, and suitable for small-scale production.

6.2 Machine Design Overview

The machine consists of a rigid mild steel frame, lead screw mechanism, hand wheel, die assembly, guide rods, and heating arrangement. These components work together to compress and shape the bagasse mixture into disposable bowls.

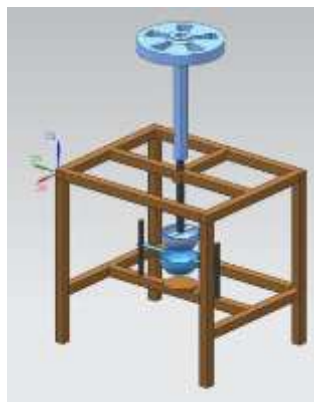


Figure 1: Complete Assembly of Bagasse Bowl-Making Machine

6.3 Frame Structure

The frame serves as the primary supporting structure of the machine. It provides stability and rigidity during operation. The frame is fabricated using mild steel square pipes due to their high strength, durability, and ease of fabrication.

Functions:

- Supports all machine components.
- Withstands compressive loads during operation.
- Maintains alignment of the screw mechanism and die assembly.

Material:

Mild Steel (MS)



Figure 2: Machine Frame Structure

6.4 Lead Screw Mechanism

The lead screw is the main force-transmitting component of the machine. Rotational motion provided through the hand wheel is converted into linear motion of the upper die.

Functions:

- Generates compressive force.
- Controls vertical movement of the upper die.
- Enables manual operation. Specifications:
- Screw Diameter: 20 mm
- Screw Length: 203.2 mm



Figure 3: Lead Screw Assembly

6.5 Hand Wheel

The hand wheel is mounted at the top of the lead screw and is used to rotate the screw manually.

Functions:

- Provides manual input force.
- Facilitates smooth movement of the screw mechanism.
- Allows easy operation without electrical power. Specifications:

- Hand Wheel Diameter: 228.6 mm

6.6 Die Assembly

The die assembly consists of an upper male die and a lower female die. These components determine the final shape and dimensions of the bowl.

Functions:

- Shapes the bagasse mixture into bowl form.
- Maintains dimensional accuracy.
- Ensures uniform compression.

Components:

- Upper Die (Punch)
- Lower Die (Mould)

Bowl Dimensions:

- Bowl Diameter: 101.6 mm
- Bowl Depth: 50.8 mm

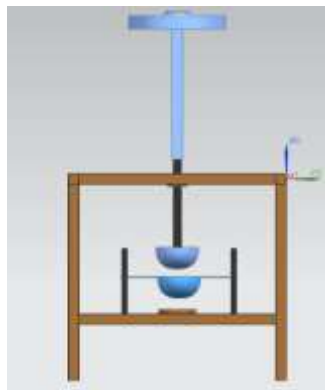


Figure 4: Die Assembly

6.7 Guide Rods

Guide rods are provided on both sides of the die assembly to ensure proper alignment between the upper and lower dies.

Functions:

- Prevent lateral movement.
- Improve dimensional accuracy.
- Reduce wear and misalignment.

6.8 Heating System

A heating arrangement is incorporated into the die assembly to improve bonding and moisture removal during bowl formation.

Functions:

- Removes residual moisture.
- Improves strength of bowl.
- Enhances surface finish. Specifications:
- Heater Type: Cartridge Heater
- Power Rating: 500 W
- Operating Temperature: 140°C – 160°C

6.9 Working Principle of Machine

The bagasse and starch binder mixture is placed inside the lower die cavity. The hand wheel is rotated manually, causing the lead screw to move downward. The upper die compresses the material inside the mould while heat is applied through the heating system. After sufficient heating and compression, the bowl is allowed to cool and is then removed from the die.

6.10 Advantages of Machine

- Simple construction.
- Low manufacturing cost.
- Easy operation and maintenance.
- Suitable for small-scale industries.
- Eco-friendly production process.
- Utilizes agricultural waste effectively.

6.11 CAD Modeling

The complete machine was modeled using Siemens NX software to verify assembly, dimensions, and working mechanism before fabrication. The CAD model assists in visualization, design modifications, and manufacturing planning.

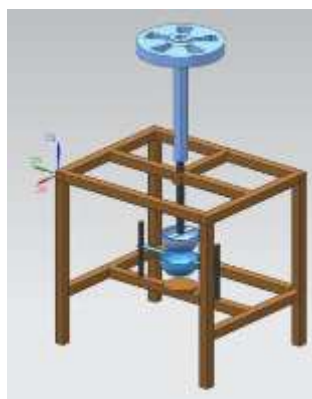


Figure 5: Complete CAD Model

7. FABRICATION AND ASSEMBLY

7.1 Introduction

Fabrication and assembly are important stages in the development of the bagasse bowl-making machine. After the completion of the machine design and CAD modeling, the individual components were manufactured and assembled to obtain the final working model. The machine was designed to be simple, economical, and suitable for small-scale production of biodegradable bowls.

7.2 Material Selection

The materials for machine components were selected based on strength, durability, availability, and cost considerations.

Component	Material
Frame Structure	Mild Steel
Lead Screw	Mild Steel
Hand Wheel	Mild Steel
Upper Die	Mild Steel
Lower Die	Mild Steel
Guide Rods	Mild Steel
Fasteners	Mild Steel

Mild steel was selected due to its good mechanical properties, ease of fabrication, and low cost.

7.3 Frame Fabrication

The machine frame was fabricated using mild steel square pipes. The pipes were cut according to the required dimensions and joined using welding operations.

Fabrication Steps:

1. Measurement and marking of square pipes.
2. Cutting using a power hacksaw or cutting machine.
3. Alignment of members according to design dimensions.
4. Welding of joints.
5. Grinding and finishing of welded surfaces.
6. Inspection of frame alignment.

The fabricated frame provides the necessary support and rigidity during machine operation.

7.4 Lead Screw Assembly

The lead screw mechanism was installed at the top center of the frame. A threaded nut arrangement was provided to facilitate smooth movement of the screw.

Assembly Procedure:

1. Fix the threaded bush to the top support frame.
2. Insert the lead screw through the threaded bush.
3. Attach the hand wheel to the top end of the screw.
4. Connect the upper die to the lower end of the screw.

The assembly converts rotational motion into vertical linear motion required for compression.

7.5 Die Manufacturing

The die assembly consists of an upper male die and a lower female die. Manufacturing Steps:

1. Material selection.
2. Machining of upper die profile.
3. Machining of lower die cavity.
4. Surface finishing.
5. Dimensional inspection.

The die assembly determines the final shape and quality of the bowl produced.

7.6 Guide Rod Installation

Guide rods were installed on both sides of the die assembly to ensure proper alignment during compression.

Functions:

Maintain die alignment.

Prevent lateral movement.

Improve bowl dimensional accuracy.

7.7 Heating System Installation

An electric cartridge heater was installed in the die assembly to provide the required temperature for molding and bonding.

Installation Procedure:

1. Prepare heater mounting provision.
2. Install cartridge heater.
3. Connect temperature controller.
4. Provide electrical wiring and safety insulation.
5. Test heater operation.

The heating system improves moisture removal and enhances bowl strength.

7.8 Assembly Procedure

The complete machine assembly was carried out in the following sequence:

1. Fabrication of machine frame.
2. Installation of lead screw mechanism.
3. Fixing of hand wheel.
4. Installation of guide rods.
5. Mounting of die assembly.
6. Heater installation.
7. Electrical connections.
8. Alignment and inspection.
9. Trial operation.

7.9 Final Machine Assembly

After assembling all components, the machine was inspected for proper alignment, smooth operation, and structural stability. Trial runs were conducted to verify machine performance.



Figure 6: Fabricated Bagasse Bowl-Making Machine

7.10 Working of Fabricated Machine

The prepared bagasse mixture is placed inside the lower die cavity. The hand wheel is rotated manually, causing the lead screw to move downward. The upper die compresses the material while heat is applied through the heating system. After sufficient compression and heating, the bowl is removed from the die and allowed to cool.

7.11 Advantages of Fabricated Machine

- Low manufacturing cost.
- Easy fabrication and assembly.
- Simple operation.
- Low maintenance requirement.
- Suitable for rural and small-scale industries.
- Environmentally friendly production process.

7.12 Safety Precautions

- Wear safety gloves during operation.
- Avoid direct contact with heated dies.
- Ensure proper electrical insulation.
- Inspect screw mechanism regularly.
- Maintain proper alignment of components.
- Follow safe fabrication practices during welding and machining operations.

7.13 Summary

The fabrication and assembly process successfully resulted in the development of a manually operated bagasse bowl-making machine. The machine is capable of producing biodegradable bowls using agricultural waste and can serve as an economical solution for eco-friendly disposable product manufacturing.

8. EXPERIMENTAL TESTING AND RESULTS

8.1 Introduction

After the fabrication of the bagasse bowl-making machine, experimental testing was carried out to evaluate the performance and quality of the manufactured bowls. The tests were conducted to determine the strength, water resistance, oil resistance, heat resistance, and biodegradability of the final product.

8.2 Water Absorption Test Objective

To determine the water resistance of the manufactured bowl.

Procedure

The dry bowl was weighed and immersed in water for 30 minutes. After removal, excess water was wiped off and the bowl was weighed again.

Observation

The bowl retained its shape and showed only slight moisture absorption.

Result

The water absorption was found to be within acceptable limits, indicating good water resistance.

8.3 Oil Resistance Test Objective

To evaluate the bowl's resistance to oil penetration.

Procedure

Edible oil was poured into the bowl and retained for 30 minutes.

Observation

No leakage or structural damage was observed.

Result

The bowl demonstrated satisfactory oil resistance and was suitable for serving oily food items.

8.4 Strength Test

Objective

To evaluate the load-carrying capacity of the bowl.

Procedure

Gradually increasing loads were applied to the bowl until deformation occurred.

Observation

The bowl maintained its structure under normal food-serving loads.

Result

The bowl exhibited sufficient mechanical strength for practical applications.

8.5 Heat Resistance Test

Objective

To determine the ability of the bowl to withstand hot food.

Procedure

Hot food at approximately 80°C was placed inside the bowl.

Observation

No visible deformation, cracking, or softening was observed.

Result

The bowl successfully withstood elevated temperatures and remained structurally stable.

8.6 Biodegradability Test Objective

To evaluate the environmental compatibility of the bowl.

Procedure

The bowl was buried in soil and observed periodically.

Observation

Gradual decomposition was observed over time.

Result

The bowl showed natural biodegradation, confirming its eco-friendly nature.

8.7 Results Summary

Test Conducted	Observation	Result
Water Absorption Test	Slight moisture absorption	Good
Oil Resistance Test	No leakage	Good
Strength Test	Withstood normal load	Satisfactory
Heat Resistance Test	No deformation	Good
Biodegradability Test	Natural decomposition observed	Excellent

8.8 Discussion

The experimental results indicate that the developed bagasse bowl possesses adequate mechanical strength, water resistance, oil resistance, and thermal stability for food-serving applications. The biodegradable nature of the product makes it a suitable replacement for plastic and thermocol disposable bowls. The results demonstrate the effectiveness of using sugarcane bagasse as a sustainable raw material for eco-friendly tableware production.

9. Conclusion

The present research successfully demonstrates the design and development of a manually operated bagasse bowl-making machine for the production of biodegradable disposable bowls. The machine was designed using a lead screw mechanism, die assembly, guide rods, and a heating system to convert sugarcane bagasse into useful eco-friendly products.

Sugarcane bagasse, an abundant agricultural waste material, was effectively utilized as the primary raw material for bowl manufacturing. The addition of a natural starch-based binder improved the bonding and strength of the final

product. Experimental testing confirmed that the manufactured bowls possess satisfactory water resistance, oil resistance, heat resistance, and mechanical strength suitable for food-serving applications.

The developed machine is simple in construction, economical to fabricate, and easy to operate. It provides a sustainable alternative to plastic and thermocol disposable products while promoting agricultural waste utilization and environmental conservation.

Therefore, the proposed bagasse bowl-making machine can be considered technically feasible, economically viable, and environmentally beneficial for small-scale production and rural entrepreneurship.

10. Future Scope

The developed machine can be further improved to increase productivity and commercial applicability. The following enhancements can be considered in future work:

- Development of a fully automatic bowl-making machine.
- Integration of hydraulic or pneumatic pressing systems.
- Advanced temperature control for improved product quality.
- Production of bowls in different sizes and shapes.
- Manufacturing of biodegradable plates, trays, and food containers using the same technology.
- Large-scale industrial production for commercial applications.
- Use of alternative natural binders to improve product strength and durability.
- Implementation of renewable energy sources for machine operation.

The future development of bagasse-based disposable products can contribute significantly to sustainable manufacturing, waste management, and reduction of plastic pollution

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