MARATHA VIDYA PRASARAK SAMAJ'S

KARMAVEER ADV. BABURAO GANPATRAO THAKARE COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Presents

Technical Magazine

Mech-Spark

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Institute Vision

To be internationally accredited, Multidisciplinary, and Multi-collaborative institute working on technology enabled platform fostering innovations and patents through state-of-art academic system designed by highly qualified faculty for the development of common masses at large

Institute Mission

To educate and train common masses through undergraduate, post graduate, research programs by inculcating the values for discipline, quality, transparency and foster career and professional development for employment thereby contributing to the development of society

Department Vision

To be the centre for excellence and centre of learning for innovation, incubation and research in the domain of product design, thermal engineering and manufacturing technology thereby path finder for professionalism, entrepreneurship and new knowledge contributing to the common masses.

Department Mission

To educate and train undergraduate and post graduate students in Mechanical Engineering by inculcating the values for discipline, quality and transparency and profession development in the job and self-employment emphasis industry-based practices.

Program Education Objectives (PEO's)

PEO1: To prepare technocrats that can satisfy the need of mechanical and allied industries.

PEO2: To develop critical thinking, problem solving skills, research aptitude and career and professionalism among the students.

PEO3: To improve and expand technical and professional skills of students through effective teaching-learning and industry interaction.

Program Specific Outcomes (PSOs)

PSO1: Ability to design, analysis and problem-solving skills using basic principle of mechanical engineering.

PSO2: Ability to impart technical and professional skills through industry institute interaction

PSO3: Develop practical skills for the benefits of society.

Objectives of Magazine

1. Primary objective of the magazine is to provide a wide platform to the aspiring engineers to showcase their technical knowledge and to explore innovative ideas.
2. This magazine is intended to bring out the hidden literary talents in the students and teachers to inculcate strong technical skills among them.
3. Share the latest developments, trends, and innovations in engineering, including new technologies, methodologies, and industry standards.
4. Encourage creativity and innovation within the engineering community by highlighting groundbreaking research, new inventions, and novel solutions to existing challenges.

Design & Development of 3-axis Pneumatic Dumping Trolley

Conventional dumpers are limited to rear unloading, which is inefficient in narrow or congested sites. This project presents the design and fabrication of a 3-axis pneumatic dumping trolley capable of unloading in left, right, and rear directions. The system uses double-acting pneumatic cylinders, 5/2 DCV valves, and locking mechanisms for multi-directional tilting. The proposed design improves flexibility, reduces unloading time, and minimizes driver effort in restricted spaces.

Introduction

Dumpers and tippers are widely used for transporting bulk materials at construction sites and mines. Conventional systems unload only at the rear, often requiring difficult repositioning in compact areas. To address this, a three-way dumping mechanism is proposed, enabling unloading in multiple directions using pneumatic actuation.

Components

- Pneumatic Cylinder: Double-acting (Ø25 mm, 100 mm stroke) for lifting, with smaller cylinders (Ø25 mm, 50 mm stroke) for locks.

Fig: Pneumatic Cylinder

- Frame: Mild steel structure with three pivot sides.
- 5/2 DCV Valve: Directs compressed air for actuation.
- Pneumatic Hoses & Fittings: Flexible tubing to supply air.
- Locking Cylinders: Secure sides during dumping.

Working

The pneumatic circuit receives compressed air from a compressor. The main lifting cylinder raises the trolley bed, while locking cylinders ensure stability by securing two sides at a time.

- Rear Dumping: Rear lock engaged; left & right unlocked.
- Left Dumping: Left lock engaged; rear & right unlocked.
- Right Dumping: Right lock engaged; rear & left unlocked.

By controlling the 5/2 DCV valve, the operator selects the dumping side. The system achieves smooth operation with minimal effort.

Working Principle

The pneumatic circuit operates on compressed air supplied by a compressor. The main lifting cylinder is connected to the trolley bed, while locking cylinders secure two sides during unloading.

- Rear Dumping: Rear lock engaged, left & right released → trolley tilts backward.
- Left Dumping: Left lock engaged, rear & right released → trolley tilts left.
- Right Dumping: Right lock engaged, rear & left released → trolley tilts right.

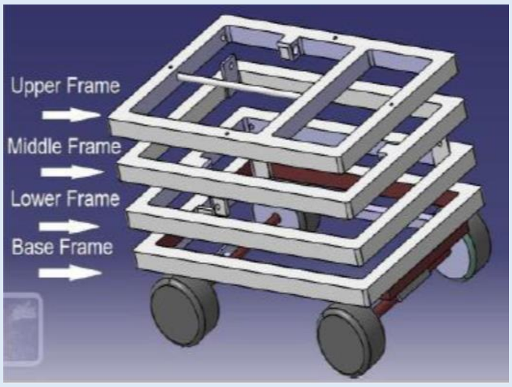

Fig: Concept of 3-ways dumping trolley.

The 5/2 DCV valve enables smooth and precise switching between directions. Flow control valves regulate lifting speed, ensuring stability under varying loads.

Testing and Results

The prototype was fabricated and tested under different load conditions using foundry sand (~25 kg).

- Leak Test: No air leakage observed at 6 bar.
- Locking Test: Cylinders engaged and disengaged correctly, ensuring controlled tilting.
- Load Test: Stable unloading achieved without frame deformation or excessive vibration.
- Cycle Time: Complete unloading cycle achieved in ~2 minutes.
- Performance: Smooth tilting in all three directions, proving effective in confined areas where conventional dumpers fail.

Fig: Model of 3-ways dumping trolley.

These results confirm that the design is safe, reliable, and practical for small-scale applications such as construction sites, municipal waste collection, and farming.

Conclusion

The developed 3-axis pneumatic dumping trolley successfully meets the objective of enabling multi-directional unloading. The system reduces fuel usage, unloading time, and operator effort compared to traditional rear-only dumpers. It is compact, cost-effective, and user-friendly, making it suitable for applications where space is constrained.

Future enhancements may include integration of electronic control with microcontrollers, larger capacity cylinders for heavy loads, and adaptation to industrial vehicles for commercial deployment.

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Design and Development of Flaps Bundling Machine

This project involves the development of a Flaps Bundling Machine, sponsored by Art Rubbers Pvt. Ltd., Ambad MIDC, Nashik. The machine replaces manual flap folding and tying, a process that is slow, labour-intensive, and inconsistent. By automating this task, the system ensures faster, more reliable, and cost-effective packaging. It reduces manual dependency, improves productivity, and enhances packaging quality. Designed for efficiency and sustainability, the machine offers manufacturers a competitive advantage by optimizing workflow and reducing operational expenses.

Introduction

In modern industries, packaging is an essential but labour-intensive process that often reduces efficiency and increases costs. To overcome these challenges, the Flaps Bundling Machine, developed for *Art Rubbers Pvt. Ltd., MIDC Ambad, Nashik*, aims to automate the folding and bundling of packaging flaps. This innovation enhances speed, accuracy, and consistency while reducing labour costs, human error, and material wastage. By streamlining workflow, the machine increases production capacity, ensures high-quality packaging, and supports sustainable operations, making it a significant step forward in industrial automation.

Fig. shows Butyl Rubber Flap bundle

Problem Statement

In industrial packaging, manual folding and tying of flaps is time-consuming, labour-intensive, and often inconsistent, leading to higher costs and reduced productivity. To overcome these challenges, this project introduces a flaps folding machine that automates the process, ensuring faster, more consistent packaging while reducing labour dependency and operational costs.

Methodology and Scope

5.1 Material Selection

Mild Steel (MS) A36 was selected for the structure due to its strength, durability, cost-effectiveness, and ease of manufacturing.

5.2 Design

Key parts such as the actuator plate, vertical beam, and supports were designed in Siemens NX CAD. The framework aligns and supports the pneumatic system, ensuring accuracy and stability.

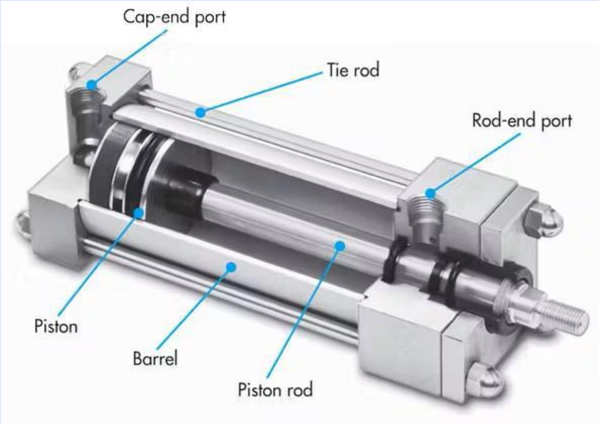

Fig. shows Pneumatic Actuators

5.3 Assembly

The complete machine was virtually assembled in NX CAD to check fit, detect clashes, and confirm manufacturability with precise tolerances.

5.4 Analysis

FEA in NX CAD was used to test the frame, folding arms, and bundling mechanism. Stress points were identified and reinforced to ensure durability and stable operation.

Process Flow

1. Feeding – Flaps are manually fed and aligned.
2. Folding – Pneumatic actuators fold flaps uniformly.
3. Tying – Bundles are tied securely.
4. Ejection – Finished bundles are pushed out for handling.

Material Selection

The frame of the flaps bundling machine requires good stiffness, moderate load-bearing capacity, fatigue resistance, and high weldability at low cost. After evaluating materials like SS304, 6061-T6 aluminum, and cast iron, Mild Steel (MS) A36 was selected due to its yield strength of 250 MPa, elastic modulus of 200 GPa, excellent weldability, easy fabrication, and economic availability. Factor of Safety calculations and simulations confirmed that A36 safely withstands the working load, making it the most suitable choice for the structure.

Design

The Flaps Bundling Machine comprises six main assemblies: pneumatic actuators, structure/frame, a 5/2 directional control valve (DCV), pneumatic tubing, an FRL (filter–regulator–lubricator) and associated fittings. Two double-acting pneumatic cylinders were selected from the functional requirements: a vertical cylinder (stroke 800 mm) and a horizontal cylinder (stroke 200 mm). Site pressure is 6 kg/cm² (≈6 bar); the required folding force (75 kg) gives a calculated bore ≈40 mm, so 40 mm diameter actuators were chosen. A 5/2 DCV controls extend/retract sequences for the double-acting cylinders. PU push-fit tubing, 1/2" diameter and 5 m runs, was chosen for flexibility and 6-bar compatibility. An FRL at the system inlet provides filtration, pressure regulation, and lubrication to protect components and extend life.

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Fabrication

The fabricated model of the Flaps Bundling Machine is a vertically operated system designed for efficient flap bundling. It features a robust frame, a linear actuator for vertical movement, guide rods for stability, and a bundling chamber for holding and compressing flaps. The design ensures smooth operation, safety, and easy maintenance. Its compact and modular structure makes it well-suited for industrial use, delivering reliable performance with minimal manual intervention.

Fig. shows Fabrication Model

Conclusion

The Flaps Bundling Machine stands as a practical, efficient, and industry-oriented automation solution. It not only meets its targeted objectives but also sets a foundation for future automation projects in small- and mid-scale industries. By reducing manual intervention, improving productivity, and ensuring consistency, the machine demonstrates the impact of engineering innovation on real-world industrial challenges.

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Autonomous Farming and Surveillance Agribot in Adjacent Boundary

This project presents the design of an **Autonomous Farming and Surveillance Agribot** capable of seed sowing, ploughing, and real-time field monitoring. Powered by solar energy and equipped with wireless communication, it enhances efficiency, sustainability, and productivity while reducing labor dependence in farming.

Introduction

Traditional farming is costly, labor-intensive, and dependent on multiple machines, making it inefficient to meet the growing global food demand.

This project develops an autonomous Agricultural Robot (Agribot) to automate ploughing, seed sowing, and field surveillance. The system uses Arduino UNO, ESP32 Cam, Bluetooth control, Li-ion batteries, and DC motors, integrated into a modular design for scalability and easy maintenance.

Key objectives include:

- Automating farming tasks to reduce manual effort.
- Ensuring precise seed placement and crop spacing.
- Monitoring field conditions with sensors and cameras.
- Operating efficiently across diverse crops and field sizes.
- Using sustainable energy to lower costs and environmental impact.

The Agribot was designed, fabricated, programmed, and tested through bench trials and field experiments. Results show improved efficiency, accuracy, and adaptability, making it a cost-effective, sustainable solution to boost farm productivity and meet rising food demands.

Design, Selection and Analysis of Agribot

This chapter outlines the methodology, hardware, and software used to develop an automated ploughing and seeding machine.

Methodology
The system integrates:

- Power & Battery: Li-ion 18650 cells with TP4056 charging module for portable operation.
- Control: Arduino Uno as central controller with HC-05 Bluetooth for wireless input.
- Monitoring: ESP32-CAM for real-time field observation.
- Actuation: Relay-based motor drivers powering DC motors for traction, ploughing, and seeding.
- Mechanisms: Ploughing for soil preparation; seeding unit ensures proper depth and spacing.

Hardware

- Arduino Uno R3: ATmega328P-based microcontroller.
- DC Motors (100 RPM, 12V): Drive motion, ploughing, and seeding.
- ESP32-CAM: Dual-core MCU with Wi-Fi, Bluetooth, and camera.
- HC-05: Bluetooth module for wireless control.
- Relay Module: Switches motor circuits.
- TP4056: Safe charging for Li-ion batteries.

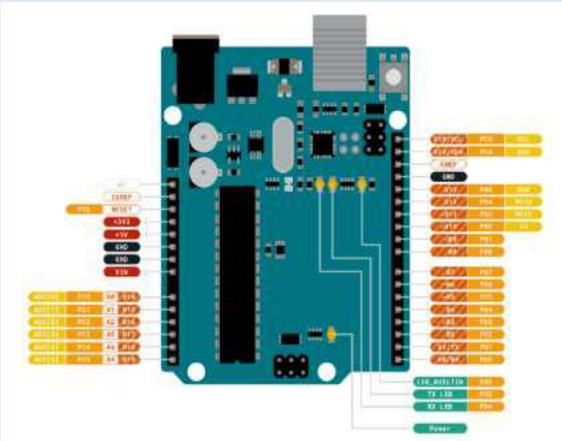

Fig: Connector Pinout

Software

- Arduino IDE for coding, compiling, and uploading sketches.
- Bluetooth commands enable remote movement and operation of mechanisms.
- Camera server via ESP32-CAM provides live feed and monitoring.

Circuit Overview

- Li-ion batteries power Arduino and motors.
- H-bridge drivers enable forward/reverse motor control.
- Relays allow safe switching.
- Arduino processes Bluetooth inputs and controls all actuators.

Testing of Mechanism

Flow of Operations

The Agribot starts with power initialization, Bluetooth setup, and camera activation. Operators control it remotely, monitoring status via live feed. Motors drive ploughing and seeding operations, while sensors provide feedback for real-time adjustments. After task completion, the system powers down and logs data.

Seed Sowing Mechanism

A cylindrical tray with four motor-controlled dispensing holes and flexible pipes ensures accurate seed dropping at fixed intervals.

Ploughing Mechanism

A 12V DC motor powers the plough to cut furrows. Depth and angle are adjustable (10–30 cm standard, >60° for deep-rooted crops).

Fig: Back View of our designed system

Trials & Experiments

Field trials confirmed stability, traction, and effective soil penetration. Experiments validated seed dispensing, ploughing depth, power efficiency, and Bluetooth UI responsiveness.

Results and Discussions

5.1 Results Obtained

The designed Autonomous Agricultural Robot (Agribot) effectively integrates ploughing, seed sowing, and real-time monitoring. Field trials confirmed its automation efficiency, reduced labor, and improved precision.

A. Power & System Setup

- Powered by 18650 Li-ion batteries (3.7–12V) with TP4056 charging protection.
- Arduino UNO initializes the Bluetooth (HC-05) module and ESP32-CAM upon startup.

B. Wireless Communication & Control

- HC-05 pairs with a smartphone for ploughing, sowing, or stopping commands.
- Signal latency <300 ms; reliable control within 5–10 meters.

C. Real-time Monitoring (ESP32-CAM)

- Streams 15–30 fps video for:
  - Seed path verification
  - Furrow consistency monitoring
  - Obstacle detection (stones, uneven patches)

D. Ploughing Performance

- DC motor plough turned soil to 4–8 cm depth with consistent 3–4 cm furrows.
- Geared motors maintained torque in harder soil.
- Angle adjustment via servo improved adaptability across soil types.

E. Seed Sowing Performance

- 1 L seed cylinder with drop holes dispensed seeds based on wheel rotation.
- Guided tray ensured accurate placement in furrows with >90% precision.
- Minimal blockage due to smooth tray rotation and pipe alignment.

F. Navigation & Synchronization

- Sequential operation: plough → sow → synchronized movement.
- Relay modules controlled motors effectively with negligible interference.

G. Battery & Power Analysis

- Continuous operation (plough + sow): 1.5–2 hrs.
- Monitoring-only mode: 4+ hrs.
- TP4056 ensured safe charging and overvoltage protection.

Conclusion

The Agribot proved effective in real-time farming with automated ploughing, sowing, and live monitoring. Field trials showed consistent furrow depth, ~90% seed accuracy, and reliable video feedback. Its energy-efficient, modular design reduces labor, optimizes resources, and offers a cost-effective solution for small- to medium-scale farmers.

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Performance and Emission Analysis of Ethanol-Diesel Combustion using RCCI Technique

The demand for clean and efficient engines has led to interest in Reactivity Controlled Compression Ignition (RCCI), which uses two fuels of different reactivities. This project analyzes a diesel–ethanol RCCI engine using *Enginesoft* simulations.

Both direct blend and dual-fuel injection techniques were tested under different load and speed conditions. Engine performance (BTE, BSFC, EGT) and emissions (CO, CO_2, NO_x, HC) were compared.

The results show that ethanol improves combustion and reduces NO_x emissions by lowering peak cylinder temperatures. However, slight increases in CO and HC occurred due to incomplete ethanol burning. Overall, the diesel–ethanol RCCI system provided a good balance of efficiency and emissions, making it a strong candidate for cleaner automotive and stationary engines.

Introduction

Internal Combustion (IC) engines generate power by burning fuel inside cylinders and are widely used in vehicles and machinery due to their high power-to-weight ratio. However, they face challenges such as low efficiency (25–30%), fossil fuel dependence, and harmful emissions (CO_2, NO_x, particulates).

Dual-fuel systems address these issues by using two fuels to improve efficiency, reduce emissions, and lower costs. Examples include diesel–ethanol, diesel–natural gas, diesel–hydrogen, and gasoline–ethanol blends.

This project investigates the use of diesel and ethanol in an RCCI (Reactivity Controlled Compression Ignition) engine. Ethanol is injected via a separate injector alongside diesel, enabling better combustion control. The objectives are to evaluate engine performance, efficiency, and emission reduction, while addressing challenges of stable combustion and dual-fuel injection control.

Objectives:

- Implement dual-fuel injection of ethanol and diesel.
- Evaluate performance (BTE, BSFC, power).
- Analyse emissions (NOx, CO, HC, PM).
- Study combustion stability, ignition delay, heat release.
- Identify optimal blend ratio and injection timing.

Methodology

- Prepare ethanol–diesel blends (E10–E40).

- Conduct direct-blend and dual-injection tests under different loads.
- Inject ethanol in intake stroke, diesel in compression stroke.

Experimental Setup and Process

- Engine Setup: Single-cylinder, 4-stroke, VCR Kirloskar TV1 diesel engine (5.2 kW @ 1500 rpm, CR 17.5), coupled with an eddy current dynamometer.

- Fuel System: Separate tanks for diesel (HRF) and ethanol (LRF), fuel pump, filters, burette for consumption measurement, and ECU for precise control.
- Air System: Air filter, air drum, and U-tube manometer for steady, clean intake.
- Instrumentation: Sensors (pressure, temperature, crank angle), AVL gas analyzer, smoke meter, encoder, and DAQ system.
- Measure in-cylinder pressure, performance (BTE, BSFC), and emissions.
- Compare results to determine optimal conditions for efficiency and emission reduction.
- Software: *Enginesoft* (LabVIEW-based) for real-time monitoring, PV diagram, HRR, BTE, BSFC, and emission analysis.

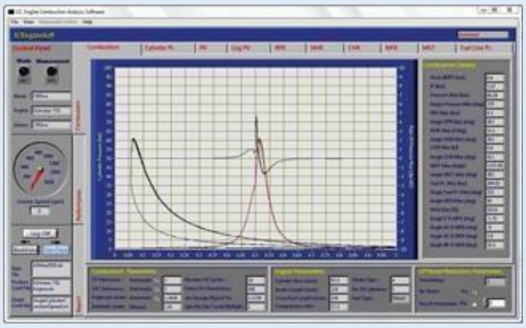

Fig: Software Window (EngineSoft)

Process: Ethanol injected into intake → premixed with air → diesel injected near TDC → RCCI combustion achieved. Load applied via dynamometer, and performance/emissions recorded using *Engine soft*.

Results and Discussions

In the dual-fuel injector test, the ethanol injection rate increased linearly from 5 to 18 cc/min up to PFI level 5, ensuring smooth and stable combustion. At PFI 6, engine knocking occurred, indicating excess ethanol and loss of reactivity control. Thus, the safe operating limit for ethanol flow in RCCI mode is around 18 cc/min or slightly lower. In the direct blend test, smoke emissions increased with load across all blends, but E25 showed the lowest smoke levels, making it the optimal blend, while E20 produced the highest smoke at full load. Performance analysis revealed that thermal, mechanical, and volumetric efficiencies generally improved with ethanol addition up to E25. Emission analysis showed reduced HC, CO, CO_2, and smoke opacity with ethanol blends, alongside higher O_2 levels, though NOx varied with load. In RCCI mode, indicated thermal and mechanical efficiencies were higher than in direct blend mode, with significantly lower HC, CO, NOx, and smoke due to better reactivity control and low-temperature combustion. Comparing E20 at 3 kg load, RCCI mode outperformed direct blending by offering higher efficiency, reduced emissions, and more stable operation.

Conclusion

This study investigates a single-cylinder VCR diesel engine operated in RCCI mode using diesel and ethanol. Two strategies were tested: ethanol port injection with diesel direct injection (dual-fuel RCCI) and direct blending. Results showed that dual-fuel RCCI achieved higher Brake Thermal Efficiency, lower BSFC, and improved combustion control compared to conventional diesel. Emission analysis confirmed significant reductions in NOx, smoke, CO, and HC, particularly at mid-to-high loads. Overall, the diesel–ethanol RCCI approach proves to be an efficient, cleaner, and cost-effective alternative, with scope for future research on advanced injection control, multi-cylinder engines, and other biofuels.

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