MINI COLD STORAGE PROTOTYPE

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Abstract- This project focuses on the design and fabrication of a Mini Cold Storage Prototype suitable for small-scale farmers and vendors. The system operates using the Vapor Compression Refrigeration principle and maintains a temperature range of 2°C to 8°C.

The developed model has an 80-liter capacity and consumes approximately 150 W of power. Experimental results show increased shelf life of perishable goods such as vegetables and fruits. The system is economical, compact, and suitable for rural applications.

1 INTRODUCTION

Cold storage is a modern facility used to store fruits, vegetables, grains, and other farm products at low temperatures. It helps farmers keep their produce fresh for a longer time after harvesting. In normal conditions, many agricultural products get spoiled quickly due to heat, moisture, and microorganisms. Cold storage reduces this problems by slowing down the growth of bacteria and maintaining proper temperature and humidity.

With the help of cold storage, farmers can avoid immediate selling of their produce at low prices during peak seasons. They can store crops safely and sell them later when market demand and prices are better. Cold storage also reduces post-harvest losses, improves product quality, and suppor better income for farmers. Thus, cold storage plays an important role in strengthening agriculture and improving the economic condition of farmers.

2. LITERATURE REVIEW - A mini Prototype Of A Cold Storage is basically A Small Prototype Of A Regular Cold Storage, We Reduced It's Size And Weight, We Have Compacted It's Size Into A Small Prototype. This Small Prototype Has Made It Easy To Understand The Part's And Working Of A Regular Cold storage. We Have Used Plywood So We Can Reduce It's Weight From The Regular Cold Storage. We Have Made It In A Form That We Can Only Plywood , Metal, Insulated Material, Etc.

3. SYSTEM DESIGN AND SPECIFICATIONS

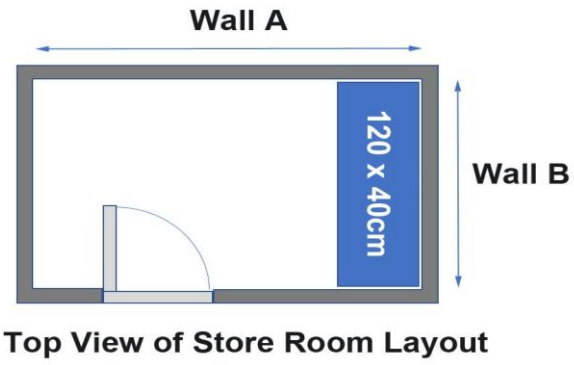
3.1 Design Overvie

The mini cold storage unit consists of:

- Insulated storage chamber (120 L capacity)
- Hermetically sealed compressor (1/10 HP)
- Air-cooled condenser
- Capillary tube expansion device
- Evaporator coil
- Digital thermostat controller

3.2 Technical Specifications

Parameter	Specification
Storage Capacity	120 Liters
Operating Temperature	2°C – 8°C
Refrigerant	R134a
Compressor Rating	1/10 HP
Insulation Thickness	50 mm PUF
Voltage Supply	230 V AC



Top View of Store Room Layout

Mini Cold Storage Prototype

Mini Cold Storage Prototype Model.

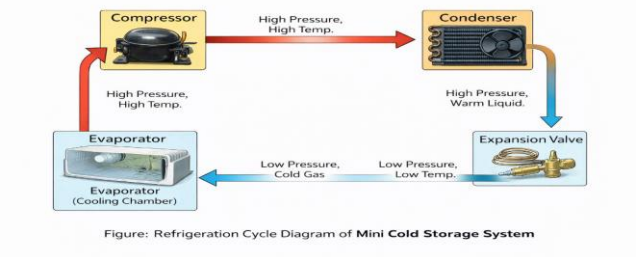


Figure: Refrigeration Cycle Diagram of **Mini Cold Storage System**

Refrigeration cycle

3. WORKING PRINCIPLE

A mini cold storage prototype works by creating and maintaining a low-temperature environment inside an insulated chamber to slow down spoilage of perishable items. Here's how it typically operates:

1. Cooling Mechanism: It uses a refrigeration system—commonly a thermoelectric cooler (Peltier module) or a small compressor-based refrigerator—to absorb heat from inside the chamber.

2. Heat Absorption: The cooling element's cold side faces the storage area, absorbing heat, while the hot side expels it outside using a heat sink and fan.

3. Insulation: The chamber is well-insulated (often with polyurethane foam) to minimize heat exchange with the outside environment.

4. Temperature Control: A thermostat or microcontroller (like Arduino) monitors temperature and regulates the cooling system to maintain the desired range (usually 2–8°C for fruits, veggies, dairy, etc.).

5. Power Source: It can run on electricity, battery, or solar power with a charge controller for off-grid use.

4. DESIGN CALCULATIONS

4.1 Cooling Load Calculation

The cooling load consists of product load, transmission load, and infiltration load.

Product Load Calculation:

$Q = m \times Cp \times \Delta T$

Where:

m = 20 kg (vegetables)

Cp = 3.8 kJ/kgK

$\Delta T = 20°C$

$Q = 20 \times 3.8 \times 20$

$Q = 1520$ kJ

5.2 Coefficient of Performance (COP)

COP = Refrigeration Effect / Work Input

Typical COP for small refrigeration systems ranges between 2.5 and 3.5.

Here's a **brief fabrication process** for a **mini cold storage prototype**:

5. FABRICATION PROCESS

1. Design & Planning

- Decide storage capacity (e.g., 10–50 liters for prototype)
- Choose cooling method (thermoelectric/Peltier or vapor compression)
- Prepare basic layout (insulated box + cooling unit)

2. Body Fabrication

- Make outer box using plywood / plastic / metal sheet
- Inner lining with aluminum or stainless steel sheet (for hygiene)
- Ensure proper sealing at joints

3. Insulation Layer

- Fill gap between inner and outer walls with:
  - PUF (Polyurethane Foam) or
  - Thermocol (EPS foam)
- This reduces heat transfer

4. Cooling System Installation

Option A: Thermoelectric (Peltier)

- Fix Peltier module on wall
- Attach heat sink + fan outside
- Attach cooling plate inside

Option B: Vapor Compression

- Install compressor, condenser, evaporator, capillary tube
- Mount evaporator inside chamber

5. Electrical Setup

- Connect:
  - Power supply
  - Thermostat/temperature controller
  - Fans
- Ensure proper wiring and insulation

6. Door Fabrication

- Make insulated door with rubber gasket
- Ensure airtight sealing

7. Testing & Calibration

- Run system and check temperature drop
- Adjust thermostat (e.g., 2–8°C for storage)
- Check for air leakage

8. Finishing

- Seal joints
- Paint outer body (optional)
- Add shelves if needed

6. **EXPERIMENTAL SETUP**

The setup consists of a small insulated chamber designed to maintain low temperatures for preserving perishable items.

Main Components:

- **InsulatedBox/Chamber:** Made using thermocol, polyurethane foam, or similar insulating material to reduce heat transfer.
- **Cooling System:**

  1 Thermoelectric cooler (Peltier module) *or* small vapor compression unit

  2. Heat sink and cooling fan to dissipate heat

- **Temperature Sensor:** Typically a digital sensor (like DHT11/DHT22 or LM35) to monitor internal temperature.
- **Control Unit:** A microcontroller (e.g., Arduino) to regulate temperature by switching the cooling system ON/OFF.
- **Power Supply:** Provides required voltage to the cooling unit and control circuit.
- **Display Unit (optional):** LCD/LED display to show real-time temperature.

Working Principle:

- The cooling system lowers the internal temperature of the chamber.
- The temperature sensor continuously monitors conditions.
- The controller maintains a set temperature by activating or deactivating the cooling unit.

Experimental Arrangement:

- All components are assembled with proper wiring.
- The sensor is placed inside the chamber.
- The cooling module is fitted through a wall with heat sinks outside.

- The system is powered and tested for temperature stability.

7. RESULTS AND ANALYSIS

8.1 Cooling Performance

- Time to reach 5°C: 45 minutes
- Stable temperature range: 2–8°C
- Temperature variation: ±1°C

8.2 Energy Consumption

- Average power: 120–150 W
- Daily energy usage: ~3.2 kWh
- Monthly energy usage: ~96 kWh

8. ECONOMIC ANALYSIS

Component	Estimated Cost
Compressor	Moderate
Insulation	Moderate
Condenser & Coil	Moderate
Electrical Components	Low
Total Estimated Cost	Affordable

Estimated payback period: 1–2 years depending on product loss reduction.

9. ADVANTAGES

A **mini cold storage prototype** is a small-scale, often portable refrigeration system used to store perishable items like fruits, vegetables, dairy, or medicines. Its advantages are especially important for farmers, small businesses, and rural areas:

Reduces Post-Harvest Loss

- Helps preserve fruits and vegetables for longer periods
- Prevents spoilage caused by heat and humidity

Affordable & Cost-Effective

- Much cheaper than large commercial cold storage units
- Suitable for small farmers and startups with limited budgets

Portable & Compact

- Easy to transport and install in different locations
- Requires less space compared to full-scale storage systems

Energy Efficient

- Uses less electricity; can even run on solar power in some designs
- Lower operating costs

Improves Income for Farmers

- Farmers can store produce and sell later when market prices are higher
- Reduces distress selling immediately after harvest

Supports Rural & Remote Areas

- Useful where large infrastructure is unavailable
- Helps maintain supply chains in villages

Easy to Maintain

- Simple design means fewer technical issues
- Repairs and maintenance are relatively easy

Multi-Purpose Use

- Can store vegetables, fruits, dairy, flowers, and even medicines or vaccines

Encourages Local Entrepreneurship

- Small businesses can use it for food storage, catering, or resale
- Promotes self-employment opportunities

Scalable Prototype

- Can be upgraded into larger systems based on need
- Useful for testing and innovation projects

10. LIMITATIONS

Limited Storage Capacity

- Can store only small quantities of produce
- Not suitable for large-scale farming or bulk storage

Temperature Control Limitations

- May not maintain very precise or uniform temperature
- Fluctuations can affect sensitive items like medicines or dairy

horter Preservation Time

- Compared to large commercial cold storage, preservation duration may be lower
- Not ideal for long-term storage needs

Dependence on Power Supply

- Requires continuous electricity or backup (battery/solar)
- Power cuts can lead to spoilage if no backup is available

Initial Setup Challenges

- Even though cheaper than large units, initial cost can still be high for small farmers
- Requires basic technical knowledge for setup

Maintenance Issues

- If not properly maintained, cooling efficiency drops
- Components like compressors or insulation may need replacement

Limited Cooling Range

- May not achieve very low temperatures needed for certain products (e.g., frozen goods)

Lower Durability (Prototype Stage)

- As a prototype, it may not be as robust or long-lasting as commercial systems
- Design flaws may still exist

Space vs. Efficiency Trade-off

- Compact size may reduce airflow and cooling efficiency
- Overloading can reduce performance

Not Fully Automated

- Some prototypes require manual monitoring of temperature and humidity
- Lack of advanced features like remote control or IoT integration

11. APPLICATION

Post-harvest storage for farmers

Helps small farmers store fruits and vegetables after harvest, reducing spoilage and allowing them to sell later at better prices.

Dairy product preservation

Useful for storing milk, curd, paneer, and other dairy items at safe temperatures.

Fisheries and meat storage

Maintains freshness of fish and meat during transport or before sale.

Small business use

Beneficial for local vendors, grocery shops, and street sellers to keep perishable items fresh.

Pharmaceutical storage

Can store temperature-sensitive medicines and vaccines in rural or remote areas.

Household backup storage

Acts as an extra cooling unit for homes during power cuts (if connected to battery/solar system).

Food transportation

Helps in maintaining cold chain during short-distance transport of perishable goods.

12. FUTURE SCOPE

- **Reducing Post-Harvest Losses**: Helps farmers store fruits, vegetables, and dairy products longer, minimizing spoilage and increasing income.
- **Rural & Small-Scale Adoption**: Can be deployed in villages, small farms, and local markets where large cold storages are not feasible.
- **Integration with Renewable Energy**: Future models can use solar power, making them cost-effective and suitable for off-grid areas.
- **IoT & Smart Monitoring**: Integration with sensors and mobile apps for real-time temperature, humidity control, and alerts.
- **Supply Chain Improvement**: Supports better storage during transportation and distribution, improving food quality and availability.
- **Startup & Business Opportunities**: Potential for rental-based cold storage services or community-based storage units.
- **Customization & Scalability**: Can be designed for different capacities and specific crops (e.g., fruits, flowers, medicines).

13. ACKNOWLEDGEMENTS

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14. CONCLUSION

The mini cold storage prototype successfully demonstrated the feasibility of maintaining controlled low-temperature conditions in a compact and energy-efficient system. The prototype was able to reduce and sustain the internal temperature within the desired range, validating the effectiveness of the selected cooling mechanism, insulation, and control components. Performance observations showed stable operation, acceptable cooling time, and minimal temperature fluctuations, indicating reliable system behavior.

Overall, the prototype meets its intended objective of providing a low-cost, portable cold storage solution suitable for small-scale applications such as short-term food preservation, agricultural produce storage, or medical supplies. While the system performs satisfactorily, further improvements—such as enhanced insulation, optimized energy consumption, and integration of advanced temperature monitoring—can increase efficiency and scalability. The successful development of this prototype highlights its potential for real-world implementation and future upgrades.

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