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SOLAR ASSISTED VEGETABLE CART

Dr. Pravin Potdukhe[1], Ishwar P. Mantriwar,[2] Neeraj S. Punekar,[3] Vaibhav R. Lodhe,[4] Chandrakiran G. Sharnagat,[5] Roshan M. Mogare,[6] Pratik A. Shamkule[7]

[1,] Professor and Head of Mechanical Engineering, Rajiv Gandhi College of Engineering Research & Technology, Chandrapur.

[2to7]students of final year, Mechanical Engineering, Rajiv Gandhi College of Engineering Research & Technology Chandrapur

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Abstract – *Solar assisted vegetable cart has been developed to store fresh vegetables for a short duration. A three wheeler cycle rickshaw is modified to accommodate evaporative cooling system and storage racks for vegetables. The evaporating cooling pad(cellulose/honey comb) made of corrugated paper with spatial cross linking technology has been used. This has increased cooling efficiency. Shelf life of vegetables is also found to increase by 3 to 4 days. A solar panel 100 W/12 V module is used as the power source. It is used to run single fan (DC, 12 V, 0.7 A, 8.4 W) and water pump (DC 18W, 12V) for the evaporative cooling system.*

Key Words: **Evaporative cooling, Fruits and Vegetables, Solar-powered cart, Eco-friendliness, Relative Humidity, Temperature.**

1. INTRODUCTION

Mobile vendors find it difficult to keep the vegetables fresh to sell. It is well known that absence of sufficient storage and cooling facilities after purchase from main market of city results in deterioration in the quality of vegetables that reach the customers. This has an immediate impact on the distribution and availability of the required amount for human consumption. It also incurs financial loss to mobile vegetable vendor due to deterioration and damage to vegetables. Evaporative cooling system provides a solution to their problem.

Cooling is important to minimize quality loss when the vegetables are to be sold. Preserving such vegetables to remain fresh demands that the chemical, biochemical and physiological changes are restricted to a minimum by close control on temperature and relative humidity. The high cost involved in developing cold storage or controlled atmosphere storage on a movable cart is a major problem in India and several developing countries. Evaporative cooling is an efficient and economical means for reducing the temperature and increasing relative humidity in an enclosure.

Evaporative cooling is an environmental friendly air conditioning system that operates using induced processes of heat and mass transfer, where water and air are the working fluids. It provides an inexpensive, energy efficient, environmentally benign and potentially attractive cooling system.

A solar assisted vegetable cart(SAVC) using evaporative cooling is designed and developed for storage of vegetables at RCERT, Chandrapur.

2. LITERATURE REVIEW

Solar assisted vending cart have been developed by D. V. K Samuel, P. K. Sharma & J.P.Sinha [1].They have cited maximum temperature drop of 11.2^{0}C. Similar kind of cart had been developed by A. N. Ingale [2] & etal have reported to increase the shelf life by 2-3 days.

Many research papers have been contributed for direct storage of farm produce & useful for farmers. Generally passive evaporative cooling systems have been reported as low cost models. Active evaporative cooling system have also been reported but at higher costs. Research had been carried out in different parts of world under varying climatic conditions. Local materials such as khus, wood peelings, jute , straw, rice husk, cotton, river bed sand, charcoal, bricks , date palm fibres, saw dust, clay, pvc sponge, stones, aspen fibre, coconut coir, wood wool, rigid media cellulose have been tried & tested successfully. Temperature drop of 25C has been reported. Most of researchers have studied effects of change in pad thickness, its density its orientation & ,air velocity, water flow rate[3-7]

Testing of vegetables such as tomatoes, potatoes, leafy vegetables, oranges, grapes, potatoes, carrot, radish, Beet, banana, cauliflower have been carried out & their shelf life was increased considerably. The general performance index has been presented by Camargo J. R. Etal [8]in 2004.

3. DESIGN OF THE SOLAR ASSISTED VEGETABLE CART

The solar assisted vegetable cart is basically a three wheeler cycle rickshaw has been modified to accommodate active evaporative cooling system.

This rickshaw is redesigned to take into consideration of load of vegetables & evaporative cooling system to avoid any

failure. It is redesigned on following categories.
1. Mechanical design

Stress analysis of frame& chain

Maximum torsional stress calculated is under limit.

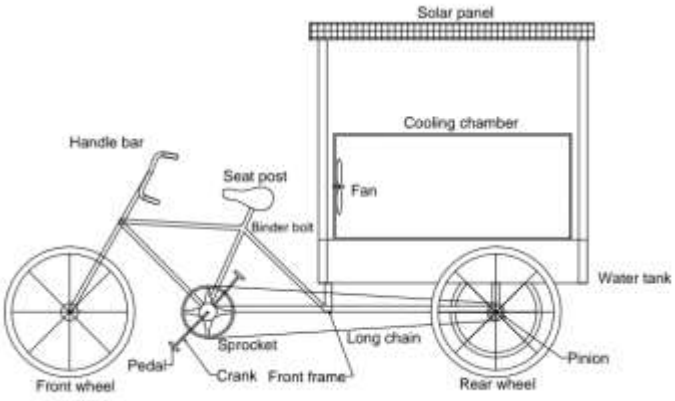

Fig1. Solar assisted vegetable cart

a. Bending moment Bending moment calculated is under limit

b. Power required to drive the cart can apply at start to move it.

It is found to be 400N which a human being can power by using his legs & feet.

a. Cooling system design

1.Rate of heat removal
Heat removal for 100kg vegetables of different variety (Q_{veg})is calculated using
$Q=mC_p\Delta T$
Q_{veg}=4134.5KJ
Heat extracted by incoming cooling air $Q_{cooling\ air}$= 5.34 KJ/s
Time required for heat transfer from vegetables to cooling air= Heat to be removed from vegetables/ Heat extracted by incoming cool air=4134.5/5.34=778s=13 minutes

b. Cooling fan capacity

Ashrae standards provides guide lines for cfm calculations
Required cfm= Room Volume in cubic feet/7.5=3.28x3.28x3.28/7.5= 4.70cfm
Cfm of fan is selected which is available in market.

c. Water collection sump

(Reservoir capacity)=21.6 litres
4. Storage capacity= 100 kg vegetables

4. CONSTRUCTION OF SAVC

The three wheeler cycle rickshaw is fitted with the evaporative cooling system at rear side of loading platform& solar panel.
The evaporative cooling system consists of cooling pad, water supply, a suction fan & water collection sump

1. Cooling pad

It is made of rigid cellulose media(RCM) & material has following properties

- High efficiency
- High durability
- More cooling effect
- Minimum density

The three sides are enclosed with cooling pads of dimensions.

2. Water supply

A dc water pump delivers water to cooling pads continuously wet.

3. Suction fan

It is mounted on the fourth side of enclosure of evaporative cooling system. The three sides are covered by cooling pads. It draws cold air stream through cooling pad into storage of vegetables.

4. Water collection sump

A reservoir of dimensions is fabricated by G. I metal sheet. It is checked for any leakage of water. This serves as water collection sump. This reservoir is linked to the cooling system at the bottom through a pvc pipe supplying water to keep the cooling pad continuously wet.

5. Storage of vegetables

The space formed by rectangular enclosure of cooling pads & fan is utilised for storage. The storage is divided into different parts to store variety of vegetables separately.

6. Slider

The top portion of enclosure is covered by slider made of plywood & aluminium channel to load & unload the vegetables.
Solar Panel

A solar panel 100 W/12 V module is used as the power source. This panel provides power to suction fan & dc water pump of evaporative cooling system.

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5. PERFORMANCE EVALUATION

Experiments were conducted on the SAVC for the no load condition & loaded condition.

Thermocouples copper constantans were mounted to measure temperature at various locations. The sling psychrometer is used to measure the wet bulb temperature.

Results indicate that the cooling chamber maintains the temperature of 18 -20 C throughout the day. The graph of temperature vs time of the day clearly indicates the above observation. This temperature is sufficient to maintain the freshness of vegetables. Thus the vendor can sell it at high prices.

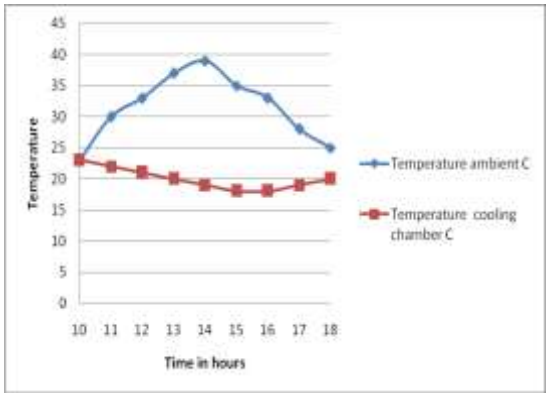

Fig 2 Graph between temperature vs time

The photographs of vegetables inside and outside the cooling chamber

1 st day

5 th day inside the cooling chamber

5 th day outside the cooling chamber

The above photographs clearly depict the quality of vegetables preserved in SAVC.

6. CONCLUSIONS

India is the fruit and vegetable basket of the world. Approximately 23–35% of the horticulture produce goes waste due to improper post harvest operations and due to lack of enough storage facilities at vendor.

1. Evaporative cooling systems have a very large potential to propitiate thermal comfort. Nowadays, evaporative cooled storage system is increasingly being used for on-farm storage of fruits and vegetables. Evaporative cooling system not only lowers the air temperature surrounding the produce, it also increases the moisture content of the air.

2. The cart is developed for common vegetable vendor. The cost of the cart is very low relative to other carts and vendors can afford.

3. The fabrication of cart is very simple and no need of any special skills. The assembly and disassembly of cart is very simple, no external help is required.

4. The cart reduce the temperature about 15-16 degrees than surroundings temperature, so that shelf life of vegetables will increases.

5. In the performance evaluation carried out it is established that the shelf life of vegetables can be increased by 2 to 3 days that prevents loss of vegetables vendor.

6. The maintenance cost of cart is also less.

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