FAL-SANJIVANI

Team Number:351

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Introduction

A diverse climate in India ensures that the country is able to produce fresh fruits and vegetables of all varieties. It ranks second in fruits and vegetable production in the world during 2019-20, India produced 99.07 million metric tonnes of fruits. Though being the second-largest producer of fruits India's share in the global market is still nearly 1% the only major reason is the lack of sufficient storage facilities and improper distribution of cold storage.18% of India's fruit and vegetable production – valued at Rs 13,300 crore – is wasted annually, according to data from the Central Institute of Post-Harvest Engineering and Technology (CIPHET).

Existing stand-alone and integrated companies and third-party logistics providers such as Coldman Logistics and Snowman Logistics Limited offering cold storage and transportation solutions are unable to meet the entire demand for such services and local vendors cannot afford these products. Two of the biggest contributors to food losses are the lack of refrigerated transport and the lack of high-quality cold storage facilities for food manufacturers and food sellers.

While the majority of available commercial products in the market try to reduce the temperature to preserve fruits, we were able to extend the shelf life of fruits by at least 3 months by using a simple method. We found that ethylene gas released by the fruits is a major reason for the decay of fruits and tried to reduce its concentration using $KMnO_4$ and zeolite.

Now imagine a product which works on a unique technology of removing ethylene gas released by the fruits using the abundant & cheap zeolite material.This would enable the vendors to sell their products for a much longer period of time . Moreover this product is also portable which can be carried easily on the vendor's vehicle and operated using cheap forms of electricity. Our product reduces the wastage of fruits & vegetables incurred by the vendor and makes them financially more confident about their profession. Hence we believe our product "FAL-SANJIVANI" can cause a revolution in terms of fruit storage and transportation.

PROBLEM DESCRIPTION

Food products such as fruits and vegetables, have thick cell walls that keep the food in an edible state for several time. Over time, though, those cell walls begin to break down. When this happens, one can feel these fruits and vegetables become less solid. They may also begin to turn colors, smell bad, and taste even worse!

The problem of early ripening comes down to these 7 factors :

Microbes: Bacteria can cause food spoilage by breaking down the food, producing acids or other waste products during this process.

Our solution : Providing an inert atmosphere by absorbing oxygen and mechanical sprinkling of antiseptic.

Light: Light can initiate certain enzymatic reactions which can increase the ripening of fruit.

Our solution : Providing an insulating and dark environment through PVC covering and rock wool

Temperature: Temperature also plays a role in food spoilage. As temperature increases, the chemical reactions that drive the spoiling process accelerate.

Our solution : Circulating cool water and air around the storage cylinders.

Role of ethylene: Ethylene is naturally released from fruit during ripening. This increase in ethylene concentration triggers an increase in the fruit's metabolism and causes the changes to the fruit that occur during ripening.

Our solution : Absorption of ethylene gas by zeolite and KM

Oxidation: Oxidation reactions occur in food and non-food items. Enzymic browning is a reaction which requires the action of enzymes and oxidation in order to occur. What happens during enzymic browning?

Oxygen in the air can cause sliced fruit to brown, a process called enzymic browning (an oxidation reaction). Phenols and the enzyme phenolase are found in the cells of the apple, and when these are exposed to oxygen in the air, for example through slicing, the oxygen causes a reaction.

Decrease in turgor pressure: Turgor pressure keeps the fruit firm, just like air pressure inside a balloon keeps the balloon firm. After maturation or harvest, fruits lose fluid (water), causing a decrease in turgor pressure, so the fruits shrivel.

Our solution : Providing a higher concentration of water(humidity) outside the fruit texture in the release of water from fruit.

Product Description

"PHAL-SANJIVANI" is a unique product which provides the long term and cheaper solution for keeping the fruit fresh for a longer time.

This product can be carried by the fruit vendors on their regular size carriage. As our product dimensions are radius 0.5m and height 0.5m, it can be placed at the centre of the carriage.

The implement draws the power from the __W battery and the water supply is provided by a 20L earthen pot which serves the purpose of cooling through circulation of water. In the interior of the product, 4 cylinders for storing the fruits are isolated from each other by the insulating material.

The storage space is maintained at a specific temperature and moisture for keeping the fruits fresh. The helical tube arrangement made of PEK is implemented on the inside surface of each cylinder. This arrangement ensures cooling because water is continuously flowing through tubes, which maintains the required temperature in the system. The system uses a water pump of 20 W for providing water to the cooling unit.

Complementing this is the air circulation which flows through the horizontal cross section and comes in contact with the PEK piping which driving the air mixture to the oxygen absorbent h enhanced the cooling effect.

The primary role of the air circulation is the better interaction of ethylene gas with zeolite-potassium permanganate duo. At the bottom of every container, there is a specific arrangement for a layer of zeolite. This is the part where the absorption of the ethylene gas takes place. The specific arrangement of zeolite container along with the air circulation forces ethylene gas to be adsorbed onto the surface of zeolite.

The air circulation has another important role of driving the air mixture into the oxygen absorbent chamber which provides the inert atmosphere of oxygen and nitrogen.

Atomisers in each container are used for maintaining the required humid atmosphere by inserting the required amount of H2O in the system. This insures that the turgor pressure inside the fruits is maintained. It also injects an antiseptic to prevent microbial growth.

Hence all the factors contributing early ripening/rotting of fruits are checked in a sequential manner.

Product Specification

Outer Cylinder

The outer cylinder acts as the basic framework for our product. The diameter is 1.4m and the height is 0.6m. It provides the inlet and outlet projections for both the air and water circulation through the electric pumps.It provides insulation to the four inside cylinders where the fruits are stored.It contains an airtight container to restrict interaction from outside from the atmosphere.

Inner cylinder

The inner cylinder is the place where fruits are stored. The diameter is 40cm and height is 0.5 cm. Special conditions are maintained within it through specific mechanisms. It consists of a helical PEX piping of 1.5 cm diameter with 3.5 cm spacing. It consists of a total of 10 turns through which water from the earthen pot flows to cool the air within the cylinder. Helix turns from cylinder continue to the next cylinder and is finally connected to the outlet to the outside cylinder.

The upper part of the cylinder consists of a plate with pores to enable air flow. The lower part of the cylinder is connected to the zeolite chamber which has where zeolite-potassium permanganate duo is stored in special grooves. The air is forced into these grooves for better absorption of ethylene.

The remaining air is channelised from the lower part of the inside cylinder to the outside cylinder for circulation of air.

Zeolite chambers:

There are a total of 4 zeolite loaded chambers in the design. In each chamber, zeolite packets are kept on the curved surfaces. The chamber is specifically built to maximize the absorption of ethylene.

Air from the inner cylinder enters the zeolite chamber through a semipermeable membrane. The grooves are made such that the air is bound to flow touching all the zeolite packets. This increases the pressure on the zeolite surface and hence the absorption.

Ethylene scavenger ($KMnO_4$ - zeolite) is made by dipping 25g of activated zeolite in a saturated solution of $KMnO_4$ (6.4g/100ml) for 90 minutes at 20°C and drying for 30 minutes under air. The dipping operation was repeated four times until the impregnated zeolite had dried completely for 24 hours. The dry zeolite powder was ground into a fine powder and placed in tea bags (cellulose).

$$3CH_2CH_2 + 12KMnO_4 \rightarrow 12MnO_2 + 12KOH + 6CO_2$$

Ethylene elimination using zeolite as an adsorbent has received significant attention in both industry and agriculture applications. As a result, zeolite-based ethylene scavengers are a viable commercial commodity.

The zeolite packets will be used in the base region of our product. The ethylene released by the fruits is transferred to the bottom of the container by air circulation from top to bottom. This air is circulated through sachets in a specifically built chamber with the aim of optimizing the amount of ethylene captured through adsorption.

Airflow circulation:

The container's inner lid has specific openings for the entry of air. Through holes on the lid, it flows inside the 4 cylindrical containers. When the outer top lid is closed, the air cannot escape, so the high pressure is maintained allowing air to flow through the 4 cylindrical containers. Air mixed with ethylene is absorbed by zeolite and the remaining air is simultaneously drawn out of the bottom of the zeolite chamber. The result is a top-to-bottom airflow circulation. As ethylene is heavier than air, its mixture with air is forced through the semipermeable membrane into the zeolite chamber (which does not allow water or liquids to pass through). Zeolite chambers have only one outlet in the middle. Zeolite packets are kept on curved surfaces of the design. Zeolite chambers are specially designed so that the mixture will flow through narrow gaps with a high velocity, increasing the chance that ethylene will be absorbed by the zeolite. Through a hole, the air is allowed to exit and circulated again.

Oxygen absorber:

In our product, we are using fine iron powder with a large surface area to absorb a large quantity of oxygen. The iron powder performs the oxygen-absorbing action through a chemical reaction as follows:

$$Fe + H_2O + 1/2O_2 \longrightarrow Fe(OH)_2$$

$$Fe(OH)_2 + H_2O + 1/2O_2 \longrightarrow Fe(OH)_3$$

In order to promote the reaction of the iron, it is advised to add an electrolyte such as sodium chloride or other alkaline or alkaline earth metal chloride as mentioned in this article. So, In our product, we are mixing a small amount of common salt with the iron powder to speed up the oxidation reaction. In our product, we place the mixture of iron powder and common salt in the air circulating tube. So, the air inside the sealed cylinder is driven out and oxygen in the air can be absorbed by the mixture.

Cooling systems:

The principle used for cooling in our product was evaporation. Evaporation produces a cooling effect which has been used to the product's advantage. The heat required for the evaporation of the fluid is taken from the ambient surface and atmosphere, and as a consequence, the ambience cools down.

Cooling using water: Cool water is pumped across each of the inner cylinders of the storage containers through helical pipes made using PEX. The cool water flowing through pipes absorbs

heat from fruits through conduction. Pex was specifically chosen because of its good conductivity, cost-effectiveness and unlike copper, is not subject to corrosion from minerals or moisture. The water which absorbs heat is passed through an earthen pot, where it gets cooled down through the process of evaporation. In this manner, we reuse the same water replenishing its coolness factor

Cooling using air: Fast flowing air is passed through the container. The kinetic energy of the air is imparted to the water droplets which are either present on the surface of the fruits and the surface of the container. This aids the process of evaporation and hence, more of it takes place. Due to the increased evaporation, the ambience gets cooled effectively.

Atomiser:

In order to tackle the issues of the spoilage of the fruits by microbial growth, and the loss of rigidity of the fruits due to reduction of turgor pressure, an atomiser has been introduced into the product:

It consists of a liquid which is a mixture of water and an antiseptic. It squirts out the droplets of the mixture and hence suspends them into the air of the container. This is helpful in 2 ways. Firstly, this introduces moisture into the system, and hence the tendency of the water to come out of the fruits decreases hence maintaining the turgor pressure. This is because of fact that the gradient of the concentration of the water across the fruit and the atmosphere is reduced.Secondly, the antiseptic in the mixture attenuates the existing microorganisms that are harmful to the product and prevent the growth of new ones.The release of the liquid is synchronised with the closing of the lid. The droplets get suspended in the air, whenever the lid gets closed.

Pumps:

Two pumps are required for the product. One is for air circulation and the other is for water circulation. The air pump circulates air perpendicular to the horizontal cross section of the cylinders. It uses 13.57 W. Hence, we can ensure that all air, and hence, all the ethylene in the container will definitely pass through the zeolites (ethylene scavengers) placed at the bottom of the container. Further, it makes sure that all the air in the container comes in contact with the oxygen absorber placed outside the system (container). This helps us tackle the problems that are faced if the fruits stored in the container come in contact with the oxygen absorbers directly (contamination). Finally, the pumping of air at high speed helps in cooling down the storage volume through the process of evaporation.The second pump is used to drive water in helices around the smaller cylindrical containers. It uses This is useful in creating a cooling mechanism by which the container and the products are maintained at a temperature cooler than room temperature. The heated up water is passed through an earthen pot, where it undergoes evaporation, cools down, and the cycle repeats.

Calculation

Power rating of the pumps: Power: P, Quality Factor: Q, Height of the tube: h,

Density of the fluid: ρ, Acceleration due to gravity: g, Flow rate of the fluid: v, Area of the cross section of the tube: a, Radius of the cross section of the tube: r,

Air pump: v = 1 m/s, r = 0.7 m, h = 0.6 m, g = 9.8 m/s2, ρ = 1.5 Kg/m3,

a = **π***r2

Q = a*v = **π***r2*v

P= Q*ρ*g*h

= **π***r2*v*ρ *g*h

= **π***(0.7)2 *1*1.5*9.8*0.6

= 13.57734 Watts

Water pump: v = 3 m/s, r = 0.075 m, h = 0.6 m, g = 9.8 m/s2, ρ = 1 Kg/m3,

a = **π***r2

Q = a*v = **π***r2*v

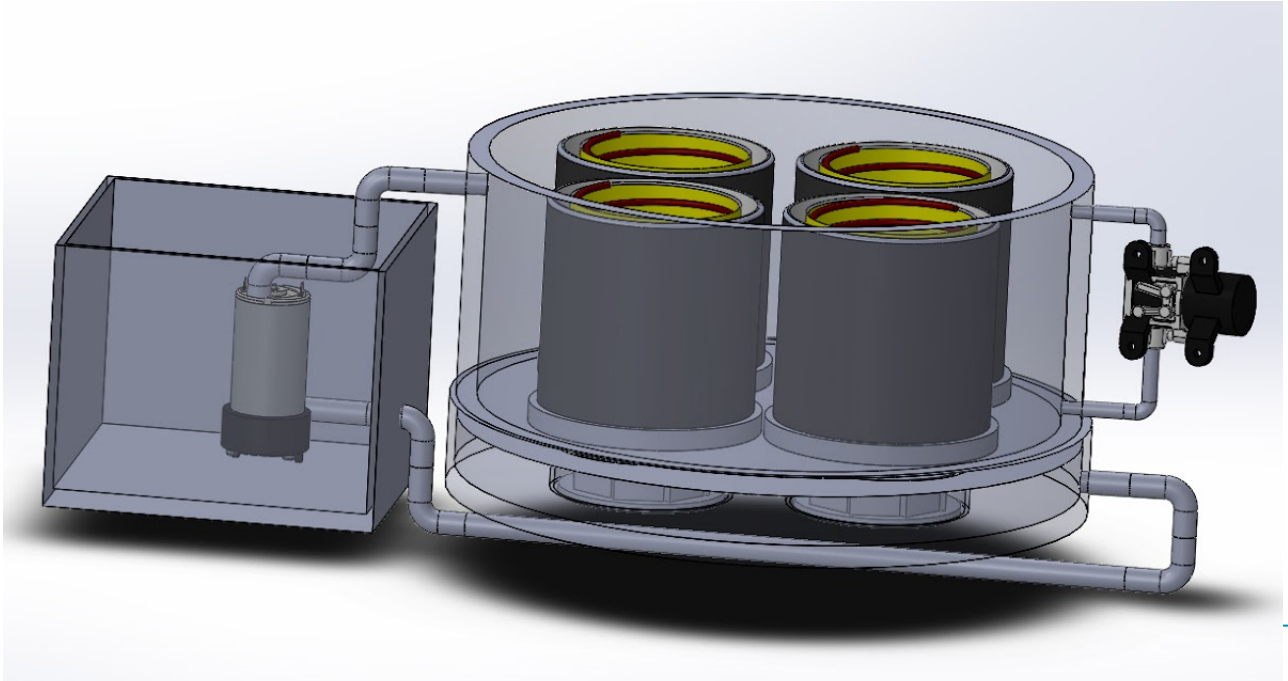
P= Q*ρ*g*h

= **π***r2*v*ρ *g*h

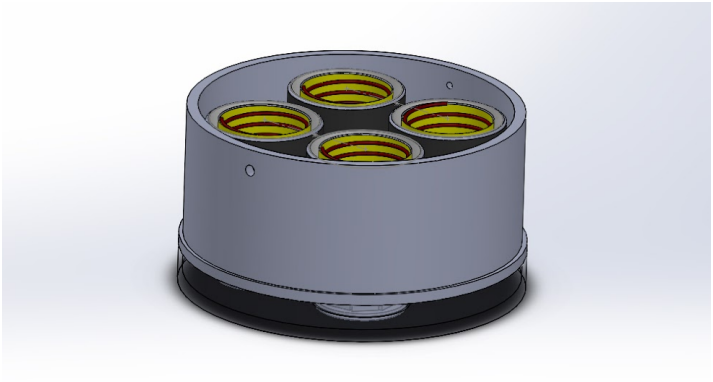
= **π***(0.075)2 *3*1*9.8*0.6

= 3.1172453105 Watts

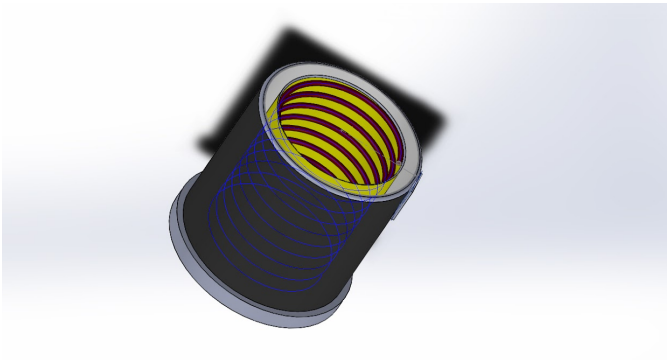
THE OVERALL PRODUCT



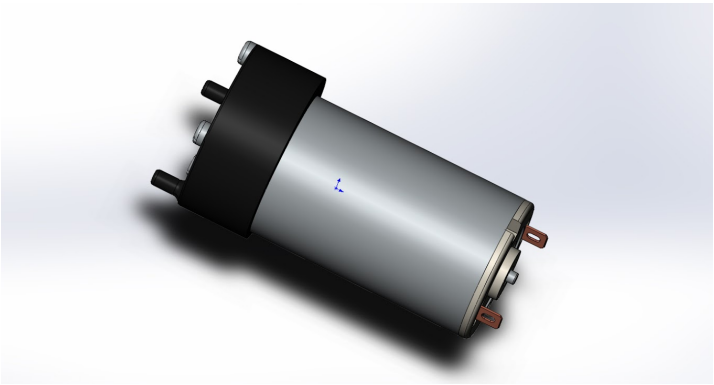
1) Outside cylinder consisting 4 inner cylinder:



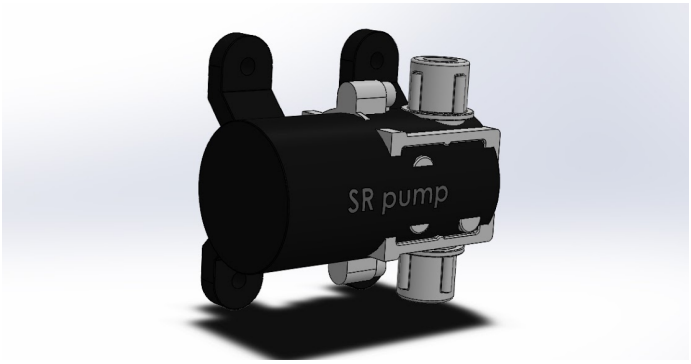
2) Inner cylinder with helix piping:



3)Air pump for O2 absorption (15W)

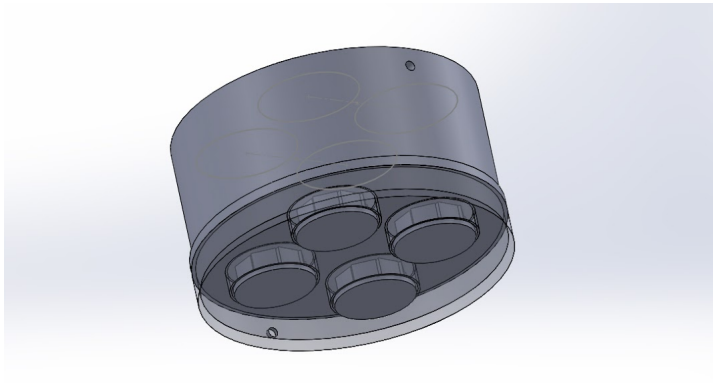


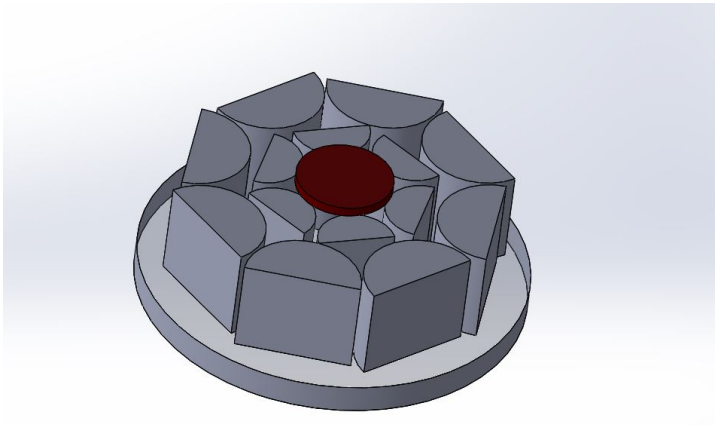
4)Water pump for product cooling (15W)



5)Four Zeolite chambers for ethylene absorption

6)Zeolite packets dipped in KMnO4 with SPM





ANNEXURE