A REVIEW STUDY ON EFFECT OF DESICCANT MATERIAL IN COLD STORAGE BY USING CFD

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***Abstract*: Cold storage is the one widely practiced method for bulk handling of the perishables between production and marketing processing. It is one of the methods of reserving perishable commodities in fresh and whole some state for a longer period by controlling temperature and humidity with in the storage system. Many agricultural commodities and food commodities are being kept in commercial cold storages. Problems associated with these cold storages are during power cuts for cold storage leads to an increase in temperature and can result in the loss in quality and value of stored products. In order to reduce the overall energy consumption levels by a cold storage unit, few critical points are discussed which need to be taken care off during design, construction and application phases. The paper begins with basic relevant information regarding cold storages particularly in Indian context. Review of various literatures opened various new aspects for modifying the cold storage system by using new desiccant dehumidifiers**.

Index Terms: cold storage, energy efficiency, alternate energy sources, clean energy, and refrigeration

I. INTRODUCTION

Cold Storage is a special kind of room, the temperature of which is kept very low with the help of machines and precision instruments. India is having a unique geographical position and a wide range of soil thus producing variety of fruits and vegetables like apples, grapes, oranges, potatoes, chillies, ginger, etc.[1] Marine products are also being produced in large quantities due to large coastal areas.

Besides the role of stabilizing market prices and evenly distributing both on demand basis and time basis, the cold storage industry renders other advantages and benefits to both the farmers and the consumers.[2] The farmers get opportunity of producing cash crops to get remunerative prices. The consumers get the supply of perishable commodities with lower fluctuation of prices. Commercially apples, potatoes, oranges are stored on large scale in the cold storages. Other important costly raw materials like dry fruits, chemicals, essences and processed foods like fruit juice/pulp, concentrate dairy products, frozen meat, fish and eggs are being stored in cold storages to regulate marketing channels of these products.[3]

The development of cold storage industry has therefore a very important role to play in reducing the wastages of the perishable commodities and assuring remunerative prices to the growers.[4]

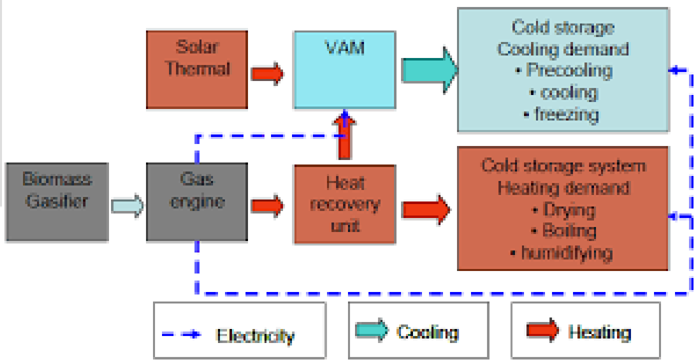

Figure: Cold storage system

Energy efficiency in buildings employed for operating cold storages is achieved through a multipronged approach involving adoption of bioclimatic architectural principles responsive to the climate of the particular location; use of materials with low embodied energy; reduction of transportation energy; incorporation of efficient structural design; implementation of energy-efficient other building system components; and effective utilization of renewable energy sources to power the building [4]. Thus, design and development of cold storages in India has always being a big issue in this sense. Indian climate can be easily classified into six major zones: cold and sunny, cold and cloudy, warm and humid, hot and dry, composite, and moderate. Translation of bioclimatic architectural design in the Indian context, therefore, provides a plethora of experiences and success stories to learn from. Several buildings have come up, fully or partially adopting the above approach to design.

The farmers usually seek for favorable combination of circumstances to produce cash crops and earn remunerative prices. The consumers get the supply of perishable commodities with lower fluctuation of prices. Besides the role of stabilizing market prices and evenly distributing commodities both on demand basis and time basis, the cold storages also render several other benefits to the farmers and the consumers. Expensive raw materials like dry fruits, chemicals, essences and processed foods such as fruit juice/pulp, concentrate dairy products, frozen meat, fish and eggs are also stored in cold storages to properly regulate marketing channels of these products.

Principle of Food Preservation: The principles underlying methods of preservation used in the past are still the same as today. The aim of preservation is to prevent food spoilage as a result of growth of micro-organisms and breakdown of food by enzymes. A good technique of food preservation is one that slows down or prevents altogether the action of the agents of spoilage.[5]

- **Temperature** -Chilling or freezing the food to retard growth of micro-organisms and inhibit enzyme activity. Alternatively, heating the food to destroy micro-organisms and prevent enzyme activity.
- **Oxygen-**Food kept in an airtight container will deprive micro-organisms of oxygen and prevent contamination.
- **Moisture-**Reducing the moisture content of the food to make water, (which is essential for growth), unavailable to micro-organisms. Alternatively, placing food in a sugary solution will make water unavailable for the growth of micro-organisms.
- **pH level** -Placing food in an acidic or alkaline solution will inhibit the growth of micro-organisms. [6]

Factors affecting cold storage:

- Properties of the product and package to be put in cold storage.
- Cold Storage Filling Method.
- Surface areas and structures of the evaporator.
- The difference between the evaporator surface temperature and room temperature.
- Air dispersion environment in cold storage.
- Working time of cold room devices.

Desiccant dehumidifiers provide reduced energy consumption, increased safety and a cleaner environment. The control of moisture in freezers and loading docks is an operational concern in many facilities. Cold storage warehouses, product coolers and cold docks typically have large, central refrigeration systems to control the freezers and docks at their operational temperature. At temperatures below 50ºF a refrigeration system alone is not practical for controlling moisture and condensation. This can result in wet or icy floors, frosted evaporator coils, fog, and frosted product.

A Desiccant Dehumidification System provides an effective long-term solution to remove the moisture from infiltration and reduce or eliminate frost on evaporator coils.

It also eliminates wet floors and ice buildup on walls, floors, refrigeration components and conveying systems. Moisture absorption of cardboard containers is also controlled, keeping them strong and stable. This makes the entire operation safer and provides a more energy-efficient installation.

Removal of the moisture from the ambient air before it enters the freezer/dock is the key to preventing the condensation and ice and frost build-up on walls, floors, coils and ceilings. A desiccant dehumidification system provides a source of cool, dry air and allows the freezer/dock to operate under positive air pressure preventing the moisture from entering the space. The dehumidifier is sized based on the size and construction of the freezer and docks, the number and type of dock and freezer doors, and the expected traffic through the dock and freezer.

II. LITERATURE REVIEW

[7] A. M. Elansari and Y. S. Mostafa (2018) paper investigate the effect of the cooling rate of the Navel orange as a function of fruit size, air direction (vertical forced and vertical induced) and air velocity, on weight loss and electrolyte leakage. A cold store with an air temperature of 4 °C was used to host the supplementary experimental set-up and provide the supply air temperature. The fruit temperature for different treatments recorded at equal time intervals (1 min). the forced-air pre- cooling with highest air velocity of 1m/s resulted in the shortest significant cooling time in all fruit sizes. The forced air cooling at the 3 rates did not significantly affect either the fruit weight loss percentage or the electrolyte leakage of 3 fruit sizes of navel orange after 2 weeks at $5\pm 1\ ^0$C +1 week at room temperature.

[8] Siddharth Shukla and K. Choudhary (2017) paper represents the temperature distribution and velocity distribution for axial flow evaporator and mix flow evaporator arrangement in a refrigerated cold storage. A CFD analysis is done under steady state for air flow distribution and temperature distribution using a three dimensional model. In this paper a three dimensional model for a cold storage [10 m(l)× 08 m(w)×09m(h)] prepared. The outcome of this paper was both temperature distribution and velocity distribution is better in mix flow cooling coil arrangement compare to axial flow cooling coil arrangement for same initial and boundary condition.

[9] A. Kaood, E. E. Khalil, and M. El-Hariry (2016) The present work made use of a computational fluid dynamics technique to adequately predict the cold storage airflow pattern variations within the cold room under various evaporator arrangements of sizes, numbers and positions. Design parameters included local temperatures and velocity distributions inside a large cold store using standard k-e model with mesh element 5,400,000 tetrahedral cells.

[10] Q. S. Mahdi and H. M. Hadi (2014) In the present work a prototype cold storage for meat has been designed. Temperature distributions were determined for different storage temperature, -2°C, -10°C, -20°C and -21°C, inside empty cold store experimentally. The Air temperature distribution also been determined for storage temperatures -20°C and -21°C inside loaded cold storage with 10.8kg. The Mean air velocity distribution also been measured for empty cold store, by using a hot wire anemometer.

[11] S. Bhawsar, V. N. B. Hekhar, and Rajat Shekhar (2014) Moisture content is an intrinsic property that is influenced by the humidity in the surrounding air, and secondarily, by temperature. In a sealed container moisture content will not change. Effective and economic design of cold storage is an important requisite in business as ineffective design may lead to financial loss and in certain case may lead to unsafe operation of the system. A part from the loss of capital due to degradation of quality of the products, there is also a loss of power and in the country like ours, it becomes of greater importance to save as much of power as possible. In this project, emphasis has been given on cold storages preserving fruits and vegetables.

[12] M. K. Chourasia and T. K. Goswami (2007) A satisfactory agreement was found between the experimental transient temperature data, as obtained in a commercial potato cold store, and simulated one, with an average temperature difference of 1.470±0.98 ^{0}C. Thereafter, the effect of aspect ratio (width/height), volume, width and height of the stack on average product temperature and cool-down time was studied using the validated CFD model. Under the stacking arrangement, the effect of horizontal gap between the bags in a stack and vertical gap between the stacks was also investigated on the average product temperature and cool-down time.

[13] Y. Xu, D. Burfoot, and P. Huxtable (2002) A model, solved using computational fluid dynamics software (CFDS-CFX4), was produced to identify modifications to air distribution systems that would improve the uniformity of the air flows. The model treats the potatoes as a porous resistance around the ducts and predicts the flows inside the air supply ducts. A commercial store which experienced condensation and rotting each year was modified on the basis of predictions from the model and both problems in the store were eliminated.

[14] M. L. Hoang, P. Verboven, J. De Baerdemaeker, and B. M. Nicolaõè (2000) The validation of the model has been performed by a comparison of the calculated time-averaged velocity magnitudes with the mean velocities measured by means of a hot-film type Omni-directional velocity sensor. A relative error on the calculated air velocities of 26% was observed. The RNG **k**-ε model does not help to improve the prediction of the recirculation. Both a finer grid and enhanced turbulence models are needed to improve the predictions.

III. CONCLUSION

A good deal of experience is required to make a correct calculation of a cold store's refrigeration requirement and this should therefore only be done by a qualified person.

- Cold storages run on electric power and their energy efficient operations should have to improve to reduce the electricity consumption. This becomes much more important, as in country like India; we need more successfully operating cold storage units with an even distribution.
- We must timely understand the need of energy efficient cold storage units and prepare for upgrading ourselves with better technology.
- The energy efficiency can be increased by optimizing the freezing processes. Coefficient of performance of compressor or if definable, the coefficient of performance of whole system can be taken as basis for optimization analysis.
- These efforts can improve energy efficiency by as much as 50% when compared with normal practice.
- Use of suitable desiccant dehumidifiers will increase the efficiency of the cold storage by increasing the quality and also through reducing the usual requirements. The material used as the desiccant humidifier plays an important role in the efficiency of the cold storage.

Future studies around the cold storage solution, can include additional refrigeration systems and ways to integrate several system into a larger cold chain. This way, the problem with unorganized cold chains and numerous intermediates can be addressed.

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