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DESIGNING AND ANALYSIS OF THERMAL EFFECT IN WARE HOUSE WITH DIFFERENT NOZZLE ANGLE TO ENHANCE PARAMETER

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***Abstract*—Cold stores are the place wherever biodegradable product keep under control temperatures for the purpose to maintain the quality. Protection of food item can be done beneath frozen temperatures. For many alternative merchandise conditions aside from temperature could be needed. A cold storage may be a place where the assorted things like vegetables, fruits, medicines, etc. are kept to defend them from obtaining spoiled and to increase its preservation amount. In the current work, the CAD model of ware house has been developed by using ANSYS The model has been simulated using ANSYS software on fluent domain workbench in order to predict various parameters influencing the thermal performance of ware house. Three types of nozzle angle i.e, 3, 5 and 7 degree with constant velocity of 6m/s are considered to analyze the thermal effect. The optimum nozzle angle and velocity enhances the thermal effect in ware house. It was analyzed that 5 degree of nozzle angle with 6 m/s of constant velocity at each position of duct enhances the thermal effect inside ware house.**

Keywords* - *CAD, Nozzle, Anglr, Temp, etc.

I. INTRODUCTION

1.1 Introduction :- A cold storage is a commercial facility where perishable food items such as fruits, vegetable, medicines, etc. are stored for a longer duration under controlled temperature to prevent them from decaying. Cold stores are an integral aspect as it minimizes the loss that can occur in the post-harvesting period. Two important factors i.e., preservation temperature and relative humidity have a great impact on the product quality. Within the cold store, in order to preserve the quality of the perishable items, there has to be homogeneity in the temperature distribution which is being directly governed by the air flow pattern. The design of air distribution system allows the air flow field to cool or warm the refrigerated enclosure in a controlled manner while keeping fixed moisture content. Other factors that affect the performance of a cold store are refrigeration system, air supply mode, air flow field distribution, frosting characteristics, heat insulation performance.

Cold stores are the place wherever biodegradable product keep under control temperatures for the purpose to maintain the quality. Protection of food item can be done beneath frozen temperatures. For many alternative merchandise conditions aside from temperature could be needed. A cold storage may be a place where the assorted things like vegetables, fruits, medicines, etc. are kept to defend them from obtaining spoiled and to increase its preservation amount.

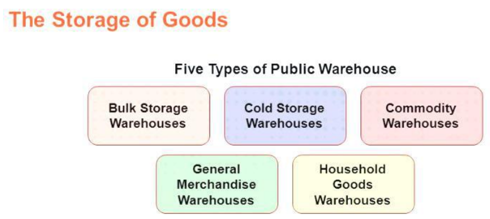

Fig. 1.1: Classification of cold storage

1.2 History of Cold Storage As per Albert Neuburger, in the technical arts and sciences of the ancients, he found the requirement of simple cold storage for the preservation of food from thousands of years. Neuburger notes proof of ice being gathered and stored for the purpose of packing the perishable food products various types of containers. In American history Oscar Anderson discus the old days of the US, when settlers would assembled ice to keep in cold-

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houses for the purpose of storing perishable food item. While some of the methods were very effective used on personal scale which were dangerous extremely and very hardworking, not only this but they were not even commercially viable.

II. LITERATURE REVIEW

Dr. Hoang et al.2(2000) proposed an analysis of air flow in a cold room by using computational fluid dynamics. Their model was based on steady state incompressible, RANS equation and RNG version of K-ε model. For discretization finite volume method was used. The error was 26% between calculated and measured velocity air inside the cold room. The air flow pattern which was responsible for the degradation of quality of the product was investigated. Reynolds stress models are interconnected with commercial CFD code this was more widely validated and considered as a improved model. And this proved a scientific way for simulation of cooling and storage problem.

Xu et al.12(2002)analyzed to improve the quality of stored potatoes by using computer modeling. The made a model with the help of CFD software (CFDS-CFX4) to find out the modification to air distribution that would improve the uniformity of air flow .Potato was treated as porous resistance material. On the basis of air flow analysis in lateral ducts & air tunnel they concluded that significant saving is achieved in potato storage. With increase in speed & storage capacity they found that CFD model become more complex there for produce simple model give quick response and would be cost effective.

Xie et al.11 (2006) proposed a 2-D mathematical model of cold storage [4.5m (l) X 3.3m (w) X 2.5m (h)]. Using CFD, air flow pattern of cold store was analyzed and concluded that several design parameters such as stack mode of foodstuffs, corner baffle and fan velocity largely affected the flow and temperature field.

Hoet al.3(2010)studied the distribution of the air velocity and its temperature in a refrigerated warehouse. The cold room which was under study had products stacked on pallets and a ceiling type cooling unit was installed in front of the array. Upon numerical analysis of steady state air flow on a 3-D model, it was concluded that as velocity of the blowing air increased uniformity in the temperature distribution and a better cooling effectiveness was achieved.

Akdemiret al.1(2013) studied on two different cooling systems and determined the distribution of ambient temperature and relative humidity in them. Cold store-II which included air conditioning system had better air distribution than the cold store-I which had classical cooling system consisting of compressor, condenser and evaporator as the cold air got distributed from the evaporator only.

Sakareet al.8 (2014)designed cold storage structure for thousandtonnes potatoes. They calculate Heat transmission through walls, Heat transmission through ceiling, Heat transmission through floor, Heat transmission through door: Equipment load Cooling down to freezing point: Heat evolved in storage: Heat of respiration: and Human occupancy and gave an overview for designing of compressor, condenser, throttling device and evaporator.

Praneethetal.7 (2015) conducted a CFD analysis to investigate the airflow and temperature fields within the coldstore and they conclude that: 1. Air gap should be provided between the racks to reduce the chances of formation of hot spots.2. The position of the inletand outlet optimized that it should be in line with the air gap between the crates of the racks, also for uniform temperature and uniform air inlets should be provided at top and bottom of the racks within the cold store.3. Multiple inlets are provided to reduce temperature variation and results into uniform temperature and uniform airflow, all these are difficult to achieve with single inlet.4. rack length of 500mm shows temperaturevariation of about 0.30C to 0.40C when compared to that of 1000 mm which provides better results with lesser temperature variation of 0.10C over the surface of the racks in which food produce are stored.

Jaiswalet al.4 (2015) conducted a study to investigate the influence of wind velocity and estimate the temperature distribution and relative humidity with the help of CFD. It was concluded that when evaporator with air flowing horizontally was a better arrangement than evaporator with air flowing vertically downwards due to proper heat exchange between cold air and the products.

III. METHODOLOGY

3.1 It is observed that when we are planning to store product in cold storage at low temperatures range there is a problem of uneven temperature distribution in the cold storage, due to this chance of formation of hot and cold spots arises which results into spoliation of the product. In this work, we analyse the air distribution and temperature distribution and cool down period for storage of potato. The storage temperature and relative humidity for potato are 3-4℃ and 90-95 % respectively.

IV. COMPUTATIONAL FLUID DYNAMICS THEORY

Dimension of the cold store under study is 5.9m(l) x 3.75m(b) x 3.83m(h) and inside it an evaporator of dimension 0.7(l) x0.4(b) x0.5(h) m is there along with a duct arrangement having three fans of radius 30cm on top and six slots of dimension 6(l) × 6(h) m on its front wall, also with optimization model consisting of nozzle at inlet with 3, 5, 7 degree. This 3-dimensional model of the cold storage is created with the help of ANSYS design modeller and CATIA. Table 5.1 shows the detailed dimensions of other parts present in the cold store.

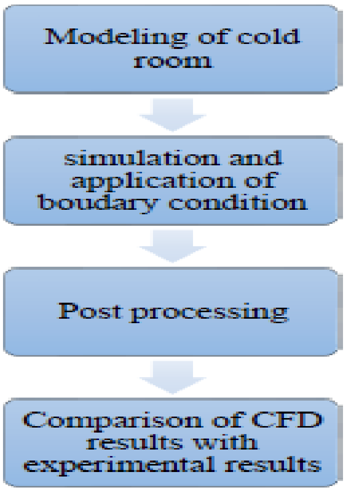


Fig. 4.1: Flow-chart showing the process implemented in this study

Table 4.1: Dimensions of various parts of cold store

Cold room dimension	5.9m (l) x 3.83m (h) x 3.75m (b)
Dimensions of inlet duct and outlet duct	Φ 0.3m x 0.4m (l)
Dimensions of the crates of the racks	0.52m (l) x 0.36m (b) x 0.29m (h)
Air gap between the crates of racks	0.2 m
Wall thickness	0.12m
Nozzle angle	3, 5, 7 degree

Fig. 4.2: Solid geometry of the cold room

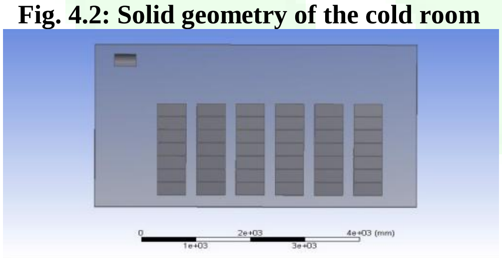
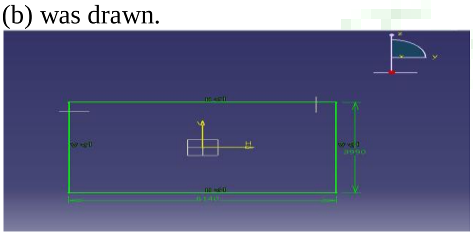


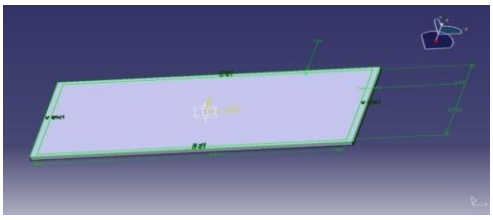
Fig. 4.3: Front view of the cold room

3-D modeling of the cold storage is done in CATIA. The steps for construction of the model are given below:

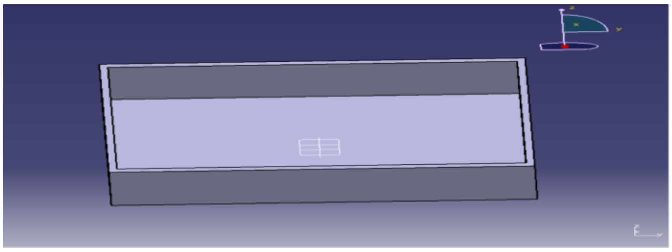
STEP 1:A 2D sketch of the wall of dimension 6.14 m (l) x 3.99 m (b) was drawn.



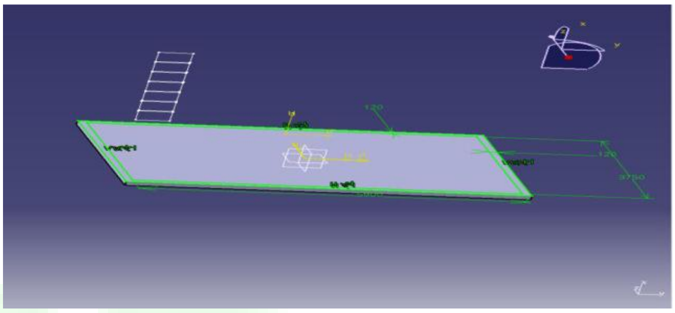
STEP 2: A wall thickness of 0.12 m was provided by PAD command



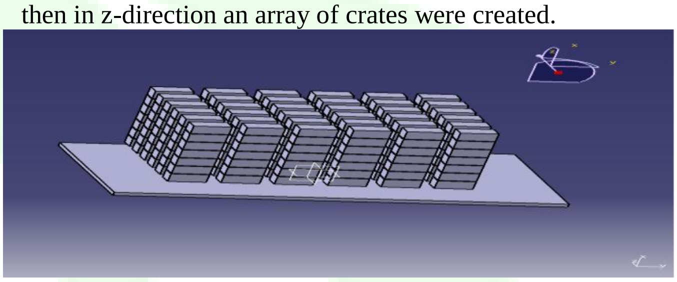
STEP 3: The side wall of the cold storage was drawn for the given dimension 5.9 m (l) x 3.75 m (b).



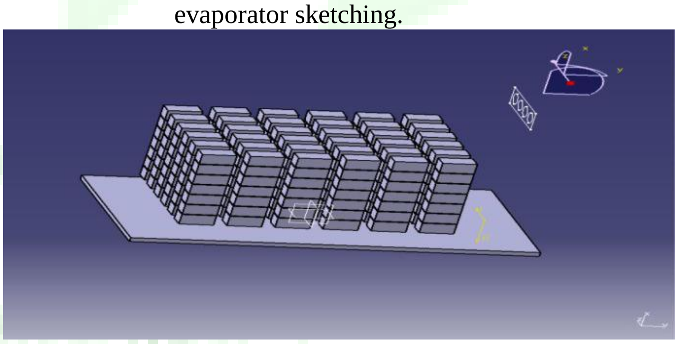
STEP5: The bottom wall was selected to draw the cartes on it.



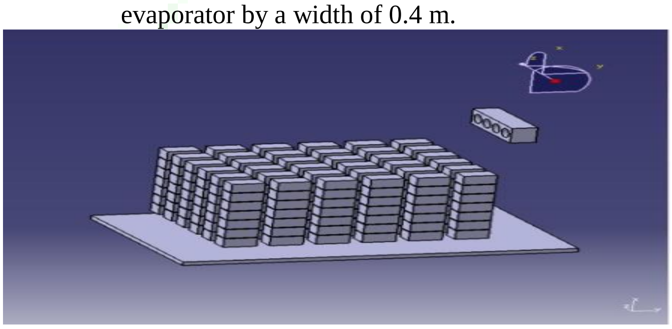
STEP 6: By using pattern command in y-direction and then in z-direction an array of crates were created.



STEP 7: A reference plane was created for the evaporator sketching.



STEP 8:PAD command was used to extrude the evaporator by a width of 0.4 m.



4.3 MESHING :-The model of cold room of dimension 5.9 m (l) x 3.75 m (b) x 3.83 m (h) defined above is created using CATIA and then imported in ANSYS software for grid generation. Naming of parts of model before meshing was done. With the help of ANSYS workspace global

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mesh parameters are defined which resulted in an unstructured type mesh with 657639 tetrahedral elements and 127649 no. of nodes. Fig. 5 shows the meshed geometry of the cold store.

V. RESULT AND SIMULATION

5.1 GENERAL :- The results obtained indicate the flow and temperature distribution which are generated by CFD. Student version of ANSYS FLUENT 19.0 included the temperature data and airflow velocity for the temperature distribution. The required preservative conditions for potatoes are 3-4 degree temperature and 95% relative humidity. The three-dimensional K-ε turbulence models are used to simulate the air distribution and temperature distribution. Initially temperature of product was 300k and the air coming out from the evaporator have temperature 276 K and at 6 m/s velocity. It takes 16 h and 40 min to reach 277 K.

5.2 VELOCITY DISTRIBUTION

From simulation, the following results were obtained:

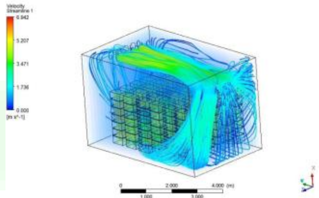

Fig. 5.1: Streamline distribution inside the cold room

Fig. 5.1 illustrates the mainstream flow velocity in the designed cold storage. The air flow in the enclosure follows a straight line path for some distance and after a while before reaching the opposite wall, it gradually flows in the downward direction.

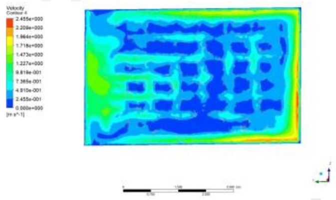

Fig. 5.2: Velocity distribution along yz-plane lying at the 2.265m from bottom.

The above fig. 5.2 depicts the velocity distribution along a horizontal plane when viewed from the top of the cold storage located at 2.265m from bottom. It was observed that the velocity was much lower in between the crates and the air velocity was found to be highest near the opposite wall of the evaporator.

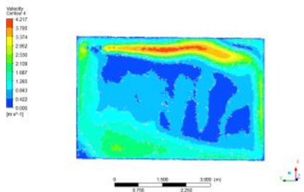

Fig. 5.3: Velocity distribution along xy-plane lying at the center of the enclosure

Fig. 5.3 shows the velocity distribution along a vertical plane lies at centre of bottom wall, when viewed from the front. It was observed that the velocity was highest just when the air left the evaporator due to the fact that the air stream was thrown into the enclosure with the help of electric motor and as the flow went along, the velocity gradually decreased. The air flows along the wall coming back from where it got started.

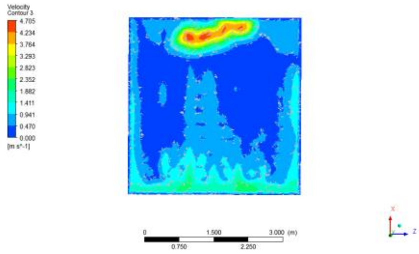

Fig. 5.4: Velocity distribution along zx-plane lying near the evaporator

Fig. 5.4 illustrates the velocity distribution along a zx-plane near the evaporator, when viewed from the side opposite to the evaporator wall. It was found that the velocity near the walls were comparatively higher than the velocity near the crates. The velocity was also found to be high near the evaporator region. The velocity of the air flowing in the cold store was less near the evaporator region thereby creating the chances of formation of the hotspots which can result in deteriorating the quality of the product.

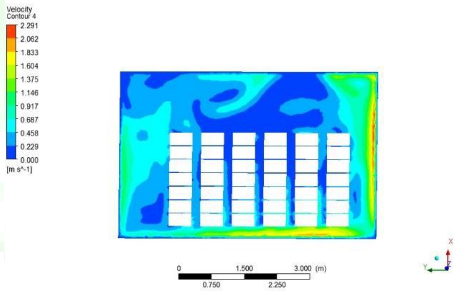

Fig. 5.5: Velocity distribution in the vertical plane lying perpendicular to the evaporator

In the above figure, velocity distribution was shown in xy-plane which was perpendicular to the plane containing the evaporator lying near the back wall. The velocity was found to be too low in the upper region there for heat transfer rate decreases hence temperature in this region increases which can lead to the formation of hotspots.

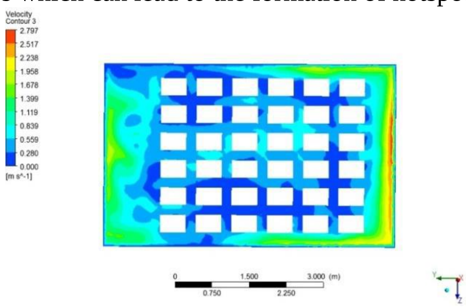

Fig. 5.6: Velocity distribution in the horizontal plane lying in yz-plane

Fig. 5.6 shows the distribution of velocity in the horizontal plane lies at 2.265m from the bottom wall and comparison of this velocity distribution with base paper data is shown in fig.5.7.

Table 5.1: Comparison of velocity in CFD and base paper results

Probe Point	Velocity inside ware house at 6 m/s	
	CFD Result	Validation Result (Base paper experimental)
(2.25, 0, 0)	0.375876	0.34
(2.25, 1.5, 1.08)	0.551994	0.57
(2.25, -1.2, -0.05)	0.129115	0.13
(2.25, -3, -0.08)	2.63506	2.3

VI.CONCLUSION AND FUTURE WORK

5.1 Conclusion • Adaptive In the proposed work velocity and temperature distribution of the cold storage having dimensions of 5.9m(l) x 3.75m(b) x 3.83m(h)have been found out by using computational fluid dynamics and results were compared with experimental data. The following major conclusions were drawn:

1. The 5 degree nozzle angle of duct is found effective in temperature distribution.
2. The velocity is increased in effective nozzle angle. Thus, low velocity could be imparted to achieve effective thermal enhancement inside ware house.
3. Effective velocity inside the warehouse is found thus optimum temperature is achieved in less time.
4. The temperature increased in the region where the air was stationary.
5. Temperature decrement of the crates lying near the wall opposite to the evaporator was found to be faster than the other crates.
6. Crates near the evaporator cooled at a very slow rate and temperature decreasing rate was found to be very high for the crates that were away from the evaporator.
7. Hot spots were found at a region just near the evaporator and cold spots were found in the gap between the racks.
8. CFD analysis gave the most appropriate result when compared with the experimental result with a maximum error of 14.56%.

5.2 Future Scope From the above study, it is recommended to use forced air circulation which can reduce the chances of formation of hot and cold areas within the cold store.

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