COLD STORAGE MODEL OF THERMODYNAMIC PROCESS

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ABSTRACT

In the study of 'Thermodynamic cooling of cold storage', computational fluid dynamics (CFD) was very useful. CFD is helpful in temperature balancing and fluid flow techniques. Cooling of for maintaining their quality is highly dependent on flow field process. CFD is more efficient and helpful for flow field, since traditional methods used were time taking and doesn't give reliable results. In this research paper a 2D mathematical model which represents a mini type cold storage (was proposed and CFD is used for simulation). The results obtained from simulation gives the characteristics of temperature distributions and airflow in the model. Several design patterns (corners, fan, walls, etc) are analysed, which are going to affect the flow field. All these results that CFD is a powerful tool for designing and optimizing flow field in cold store.

INTRODUCTION:

A cold storage is a storage system used for maintaining a temperature below the surrounding atmosphere and a certain required temperature.[1] Heat exchange takes place between the air flow and the products present, types having mainly- Vegetables, fruits, drugs, medications, or a cold ventilated transportation system. The temperature maintained in the storage depends upon the factors as air flow pattern flux, flow temperature, either the flow is turbulent or laminar.[2] Compressible or incompressible. Wall, floor and ceiling heat gains due to conduction

Factors which play role in temperature at the cold storage:

- Wall and ceiling heat gains from solar radiation
- Load due to ingression of air by frequent door openings and during fresh air charge.
- Product load from incoming goods
- Heat of respiration from stored product
- Heat from workers working in the room
- Cooler fan load
- Light load
- Aging of equipment
- Miscellaneous loads, if any

A cold storage has inlet vents which provides with low temperature that is to be maintained generally the objects to be cooled are kept either in a solid case or porous case. From inlet the air flows in the facility and at the commodities exchange their temperature with the air. This process is followed and the products are kept at a temperature less than that of the surrounding. The air which is warm exits from the outlet vents. The basic structure designed in cold storage is so that the temperature is maintained across the whole facility and minimum fluctuation is present. The factors mentioned above are the source of problem for a cold storage. The heat emitted by the source of energy as fruits, vegetables people result in increase of overall temperature of the hall. The hot weather results in increased surrounding temperature, which requires higher amount of cooling energy. The air flow is not properly designed and the air flow does not reach all the parts of the facility hence the products are not sufficiently cooled. Due to which the perishable products start to rot. The constant flow of air from the external factors. As the transit gates when used, allow the outside air to flow inside, resulting in disturbance of the temperature variation across the facility. Improper mixing of the air in the cold storage- when the steady state is achieved ,the air does not maintain a same temperature throughout the facility which results in temperature fluctuation . It is also due to improper gaping between the stored commodities due to which the cold air does not reach the required location. Issue faced in cold storage is the temperature fluctuation inside the cold storage as the temperature varies with coordinates. For preliminary setup a simple cubical structure was made with a single inlet and outlet to study the air flow pattern not consisting of any heat generating elements (fruits and vegetables).For mapping and analysis of the same, cold storage model is used and image analysis of the 3D model is performed. This requires high accuracy and intricate meshing so as to provide with good results. Computational fluid dynamics is the tool used for analysis of the velocity and temperature distribution in the cold storage. Computational fluid mechanics use Eulerian approach.The governing equations are the Navier-stokes's theorem and Continuity equation for conservation of momentum and mass. Boundary condition are given for velocity and temperature for Inlet. Temperature for left, top, bottom left and right wall. The accuracy depends on the meshing and the boundary conditions.

Methodology

A cubical structure of 1m ×1m×1m is constructed using ICEM CFD.

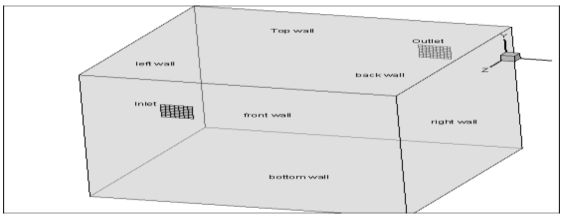

Figure 1Varios parts of the cold storage

The Boundary conditions are taken as

Part (s)	Boundary conditions	Temperature(K)	Velocity (m/s)
• Inlet	•	• 272	• 0.09
• Outlet	• Back pressure	• 272	• -
• Top wall	• Top wall	• 300	• -
• Bottom wall	• Bottom wall	• 300	• -
• Left wall	• Left wall	• 300	• -
• Right wall	• Right wall	• 300	• -

CFD Analysis

The following results were obtained at steady state.

From the X section slice it is observed that mixing doesn't take place properly in the 'a'-majority of a slice and temp is nearly 296K in the slice 'a', whereas in region 'b' the temperature is between 288K to 296K in all regions. For region "e" has temperature is not in the given range and is above the required temperature. As the required temp is 275-278K, where as it is 6K above the temperature. To improve this multiple cold inlets are required

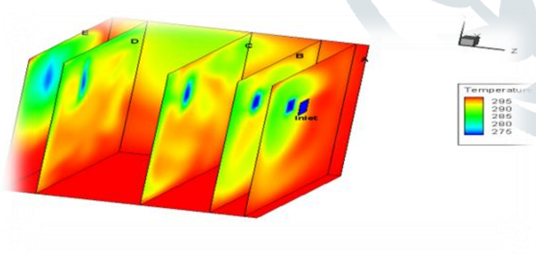

Figure 2slice in XY plane

The Z section shows that the front wall and region near A doesn't have any mixing of air and the temperature varies form 257 at upper part of 'E' to 295 at the base. Similar for the wall D and so on.

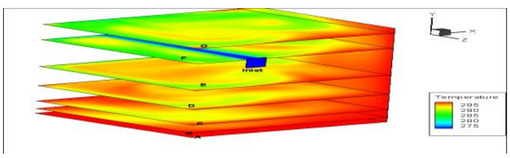

Figure 3 Slice along the XZ plane

The mixing of air doesn't take place at all at the base – temperature is around 295K. At F a short range , part which allows the flow of air has temp of 275K

The temperature in 'E,D,C,B,A' varies from 285-295. Below the expectations.

Conclusion

For further improvement of this system, the number of vents would be increased and the size of the inlet would be increased so that proper mixing a and sufficient amount of cold air coulbe provided to the facility, unlike now as the inlet is small due to which air doesn't pass through properly .By changing the size of the vents and the location of the temperature distribution can be made and less fluctuating. For better and detailed study the radiations emitted from the products inside the storage would be taken into consideration. The temperature is not evenly distributed and the cold air from the inlet does not mix properly throughout the cold storage model.The air at the inlet flows through in and the temperature surrounding Is 2(degrees) , which changes significantly at the outreaches-at the faces . The bottom wall and front wall does not show any change in the temperature at all. Infinite source of motivation, strength and steadiness. Also we would like to appreciate the support and hard work of our team members.

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