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# Air flow analysis of cold storages using CFD-A review

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**ABSTRACT**

*This paper presents a review of some of the studies carried out on analysis of air flow inside a cold storages using Computational Fluid Dynamics. This paper shows the use and importance of CFD tool to analyse the flow properties of cooling air inside a cold storage in a very fast and efficient manner.*

**KEYWORDS : CFD, Cold Storage, Effect on flow properties, Flow Analysis, Simulation.**

## INTRODUCTION

Experimental analysis of any system is often expensive, time consuming and somewhat hectic. In order to reduce experimental cost, saving of time and for easy analysis we go for computer simulation. CFD is the required tool for all such requirements. Many studies have been conducted on CFD for analysis of any system. Some of them have been discussed in the following paper. It will enlighten the scope, importance and utility of CFD in the research field..

## COLD STORAGE

Cold storages are the facilities where perishable foodstuffs are stored under controlled temperatures with the purpose of maintaining quality. Preservation of food can be done under frozen or chilled temperatures. For many other products conditions other than temperature might be required. A cold storage is a place where the various items such as vegetables fruits, medicines etc. are stored to protect them from getting spoiled and to prolong their preservation period. This is done by storing the products at their preservation temperature and humidity etc [1].

Design of cold storage to be effective and economic is an important criterion in business as ineffective design may lead to financial loss and in some cases may lead to unsafe operation of the system. Beside from the loss of capital due to degradation of quality of the products, there is also power loss and in the country like India, it becomes of greater importance to save as much of power as possible.

## COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics is the computer based analysis by which we can analyse the various things like fluid flow, pressure distribution, heat transfer, and related to the phenomenon in the chemical reactions. And the CFD simulation software is predicted to the impact of the fluid throughout the designing as well as during the end of the use. The CFD gives the qualitative prediction of the fluid flow with the help of the following tools :-

•Mathematical model (partial differential equations).
•Numerical method (discretization and solution of the problem).
•Software tools (pre and post processing, solver).

**The CFD simulations are used in the various field of the fluid flow for example:-**

•Design the vehicle to improve the fluid characteristic.
•In chemical engineering to maximize the yield of their equipments.
•Architects engineers used to design the home for safe living.
•Military organizations to develop weapons and estimate the damage.
•Aerodynamic lift and drag i.e. airplanes and wind mills.
•Power plant combustion
•Biochemical engineering like simulating the blood flow in the veins.

There are the three main elements for the processing of the CFD simulations: the pre-processor, solver, and post-processor are described.

### 1. Pre-processor

A pre-processor is defined to the geometry of the problem. And it is fixed to the domain for the computational analysis and then generates the mesh of the geometry.

### 2. Solver

In the solver processor the calculations is done by using the numerical solution methods. There are the many numerical methods which are used for the calculations for example:-the finite element method, finite volume method, the finite difference method and the spectral method.

### 3. Post Processor

The post-processor is provided to the visualisation of the results of the solutions. It includes the capability to display the geometry and mesh also. And in this processor we can create the vectors, contours, and 2D and 3D surface plots of the problem solutions. Here the model also can be manipulated. In this process we can also see the animation of the problem.

## SOME OF THE RESEARCHES DONE USING CFD

We have taken mostly papers of M.K. Chourasia, Reader, Department of Food Engineering Bidhan Chandra Krishi Viswavidyalaya Mohanpur, Nadia (W.B.) and T.K. Goswami, Professor, Department of Agricultural and Food Engineering, IIT Kharagpur.

CFD simulation of effects of operating parameters and product on heat transfer and moisture loss in the stack of bagged potatoes.[2]

M.K. Chourasia, and T.K. Goswami analyzed the cold storage under Steady state using the CFD modeling approach. It was found that increasing the porosity of the bulk medium as well as product diameter reduced the product temperature and moisture loss during the cooling. The metabolic heat of respiration and storage air temperature increased the temperature of the product and moisture loss during the transient cooling and steady state. Moisture loss and RH in the bulk medium increased with increasing the skin mass transfer coefficient. Increasing the storage air temperature linearly increased the average product temperature at steady state.

Efficient design, operation, maintenance and management of cold storage [3].

M.K. Chourasia, and T.K. Goswami dealt with different aspects of design of cold storage and its improvement over the existing ones. Cold air flow being one of the key components in establishing the performance of a cold storage, a CFD analysis has been done and the results have been discussed in this paper. The problems generally encountered in running a cold storage have also been high lighted and their probable solutions have also been suggested in this paper.

Simulation of Effect of Stack Dimensions and Stacking Arrangement on Cooldown Characteristics of Potato in a Cold Store by Computational Fluid Dynamics.[4]

M.K. Chourasia, and T.K. Goswami done the present work was to simulate the effect of stack dimensions and stacking arrangement on heat transfer characteristics in a stack of bagged potatoes during cooling, developing a computational fluid dynamics (CFD) model and validating the same with the existing prevailing situation. 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_+470.98$^0$C. Thereafter, the effect of aspect ratio (width/height), volume, width and height of the stack on average product temperature and cooldown time was studied using the validated CFD model.

Simulation Simulation of Transport Phenomena during Natural Convection Cooling of Bagged Potatoes in Cold Storage, Part II: Mass Transfer.[5]

M.K. Chourasia, and T.K. Goswami studied the model of the moisture loss in a single bag packed with potato kept in cold store under natural convective environment using the computational fluid dynamics technique. It was found that in spite of high specific humidity, maximum moisture loss occurred in the upper half of the bag during the initial cooling period. As the cooling proceeded, the zone of maximum moisture loss shifted towards the bottom of the bag.

Steady state CFD modeling of airflow, heat transfer and moisture loss in a commercial potato cold store.[6]

M.K. Chourasia, and T.K. Goswami airflow, heat transfer and moisture loss was investigated in a potato cold store of commercial scale under steady state condition using the computational fluid dynamics technique. The developed CFD model was a two-dimensional simplification of the cold store. Heat and mass transfer at the cooling coils were not modeled, instead temperature and relative humidity in the air space were specified based on measured values. The model was validated in a commercial scale cold store and was found to be capable of predicting the air velocity as well as product temperature with an average accuracy of 19.5% and 0.5$^0$C, respectively and also the simulated average total moisture loss was found to be only 0.61% water (w.b) higher than the experimental one for a storage period of 6 months.

Three dimensional modeling on airflow, heat and mass transfer in partially impermeable enclosure containing agricultural produce during natural convective cooling.[7]

A three dimensional model was developed to simulate the transport phenomena in heat and mass generating porous medium cooled under natural convective environment. Unlike the previous works on this aspect, the present model was aimed for bulk stored agricultural produce contained in a permeable package placed on a hard surface. This situation made the bottom of the package impermeable to fluid flow as well as moisture transfer and adiabatic to heat transfer. The velocity vectors, isotherms and contours of rate of moisture loss were presented during transient cooling as well as at steady state using the commercially available computational fluid dynamics (CFD).

A Multi-Scale Three-Dimensional CFD Model of a Full Loaded Cool Storage.[8]

Seyed Majid Sajadiye*, Hojjat Ahmadi developed a multi-scale three-dimensional computational fluid dynamics (CFD) model was developed to predict airflow, heat and mass transfer in a typical full loaded cool storage. In order to reduce the computational costs, the porous media parameters of the bed of the apples inside the vented containers were extracted using a series of wind tunnel CFD simulations and then applied in the cool storage model. The model was validated against experiments by means of velocity, product temperature, and product weight loss measurements in cool storage. The errors of about 23.2 and 9.1% were achieved for velocity magnitude prediction in the cool storage and the product weight loss after 54 days of cooling in the loaded cool storage, respectively.

A CFD Simulation of 3D Air Flow and Temperature Variation in Refrigeration Cabinet.[9]

Limin Wanga, Lin Zhanga and Guoping Lianb Presented a 3D simulation of the air flow and temperature variation in an ice drink refrigeration cabinet, during an automated dynamic cycle of switching on and switching off. To correctly model the effect of perforated plate separating evaporator and storage compartments, a benchmark problem is designed, and used as a reference to determine the parameters in the porous-jump model by parameter optimization. Full 3D CFD simulation of refrigeration system provides not only detailed temperature distribution in the cabinet but also operational parameters of the system such as for switch on-off cycle. Those output from simulation are important for cabinet design to improve the storage quality of products while reducing the energy use.

## CONCLUSION

After studying all the above research papers we can conclude that CFD is a very effective tool. It is less expensive and less time consuming. We can also analyse very critical problems on CFD and can get the expected results effectively. It has a very wide range of field of application. Its future scope is quite broad.

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