Temperature, Velocity & Pressure Distribution Analysis of A Cooling System in a Cold Storage Using Cfd

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ABSTRACT   *The research objective was to determine temperature, pressure and velocity distributions for one of the cooling system arrangement commonly used in cold stores. In this cooling system the evaporator coil is located at the top of one of the wall of cold storage. Computational fluid dynamics was used for modelling of distribution of temperature, pressure and velocity inside the cold storage. Storage temperature was assumed to be -20C. Boundary conditions were set as; Inlet-Surface of fluid inlet, Outlet-Surface of fluid outlet. A tetrahedral mesh was created by using ANSYS 14.5 and calculation finished when accessing a solution. Turbulence was modelled using the k- (k-epsilon). Spatial distribution in the cold storage for the cooling system was modelled and evaluated in this research. The results obtained from CFD explain more clearly the understanding of cooling.*

1. INTRODUCTION

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 using proper cooling system. Many cooling systems are used in cold storages; one of them is Evaporator coil located at the top of one of the wall of cold storage. We have analyzed this cooling system on CFD.

Computational fluid dynamics (CFD) uses powerful computer and applied mathematics to model fluid Flow problems. In the recent years CFD has been applied in the food processing industry [1]. Numerical modelling of airflow and temperature distribution in a cold store was performed using the Computational Fluid Dynamics (CFD). The aspects which were investigated include the influence of wind velocity. A mono-scale three-dimensional Computational Fluid Dynamic model was developed for estimating of airflow, heat and mass transfer [2]. A computational Fluid Dynamics model was developed to estimate distribution of temperature and relative humidity in greenhouses. The model was validated with data from a fog-cooling experiment in a single-span greenhouse [3].

2. MATERIALS AND METHODS
2.1 METHODS
2.1.1. COLD STORE
The cold system that has been analyzed has compressor, condenser and evaporator. Size of cold store was 14m x 7m x 8m (in length, width and height) and its volume was 784 m³ (Fig2.1). The building is divided into four floors.

Figure:-2.1 General inside view of cold storage.

Walls, ceiling and base of the cold store were fabricated with PUF (insulating material) .Heat transfer coefficient of polyurethane was 0.023 W/m-K. In addition, surface of the wall and ceiling panels were painted with polyester based paint in 0.5 mm thickness. Two nos. of Air Cooling Unit (ACU) were used with 40 KW of cooling capacity and 43500 CMH of flow capacity each. Operating parameters for ACU were -2^{0}C evaporator coil inlet air temperature & +3^{0}C Return. All the calculations were done as per NHB guidelines [4]-[5]. Apples were assumed to be kept in HDPE (High Density Polymer Ethylene) bin of 1.2m x 0.75m x 1m (L*B*H) with a capacity of 436 kg/bin. Total 600 bins were kept in the cold storage i.e. total capacity of the cold storage was 261.6 MT. The air circulation required was165 CMH/MT. Air flow velocity from the evaporator fan was 3 m/s. Total heat load was calculated for loading period; pull down period and holding period which came out to be 78.606 kw, 19.38 kw, 11.1683 kw respectively.

2.2. METHODS
Modelling of distribution of temperature; velocity and pressure in the cold storage was realised by using computational fluid dynamic (CFD). Software was Ansys Fluent 14.5. Computational analysis includes stages of geometrical modelling, creating numerical mesh, analysis and evaluating of results [7]. This process requires powerful computer system. In this research, this methodology was used to analyse the cold stores. For this purpose, boundary conditions of the cold storages were determined. Boundary conditions are; Inlet; Surface of fluid inlet, Outlet; Surface of fluid outlet, Walls; Solid, proof against flow of fluid

A tetrahedral mesh was created and calculation finished when accessing a solution. Turbulence was modelled using the k- **(k-epsilon). Heat transition from boundaries was neglected and lightening system was taken into account for modelling. Base of cold stores were accepted as isolated surface. As a boundary condition, constant heat transition were used for walls and ceiling. Storage temperature was assumed to be** -2ºC.

The solution algorithm SIMPLE (semi-implicit method for pressure-linked equations) used to solve for the velocity field in all three directions. Turbulent Kinetic Energy (k) and Turbulent Dissipation Rate (e) were First order upwind.
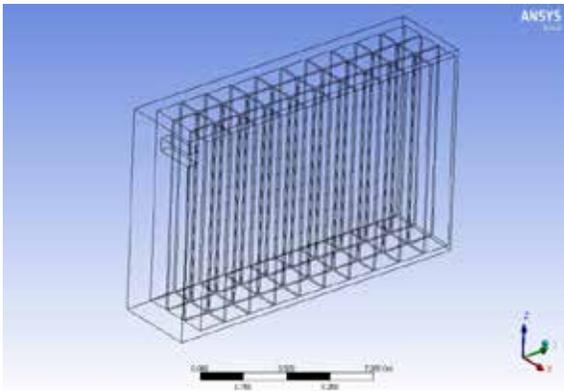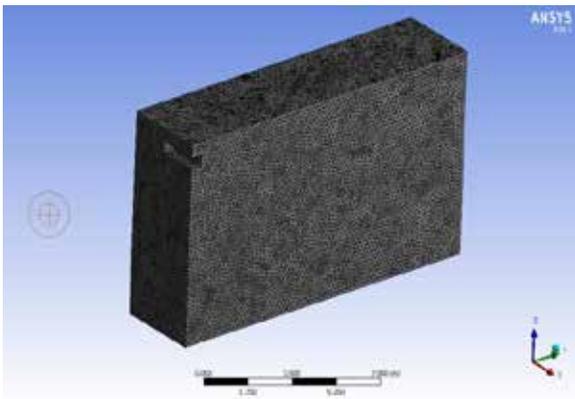
Figure:-2.2 3D Model of the proposed cold Storage.

Figure:-2.3 Mesh Model of the proposed cold Storage.

3. RESULTS AND DISCUSSION

Results obtained after completing all the requirements on CFD are as follows. We can easily analyze the distribution of temperature, velocity and pressure inside the cold storage.

Fig 3.1, 3.1.1, 3.1.2, & 3.1.3 show the temperature distribution of the air. It is clear from the figures that air temperature is very much evenly distributed till the end wall of the cold storage.
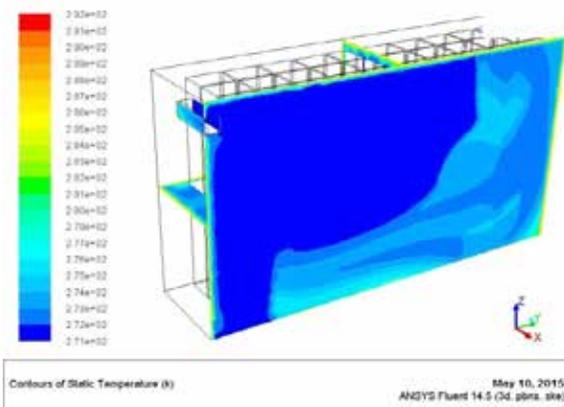
Fig3.1:- Temperature distribution inside the cold storage (k)
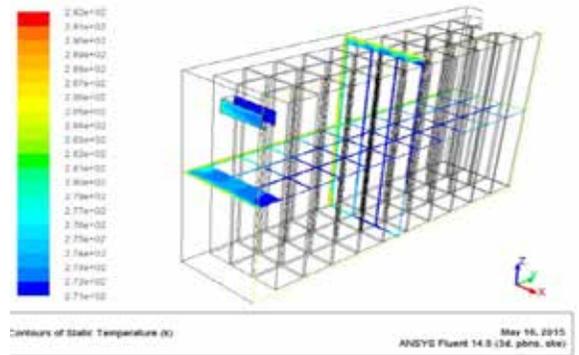
Fig3.1.1:- Temperature distribution inside the cold storage (k)
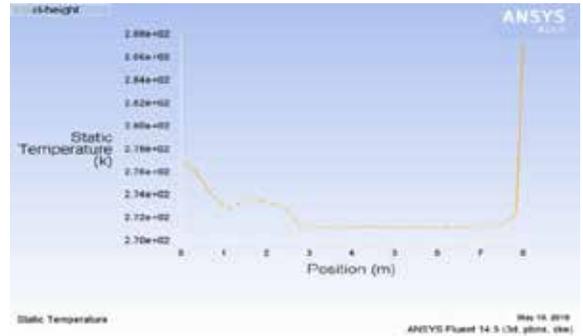
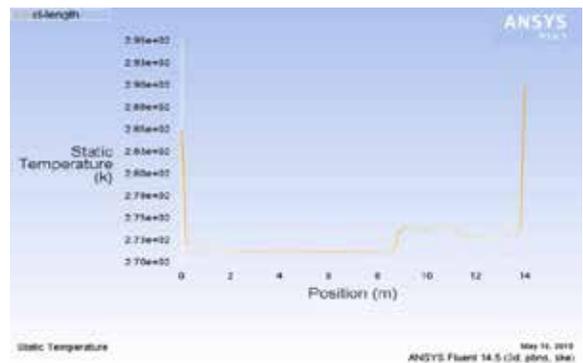**Fig3.1.2:-** Temperature distribution curve along the height of the cold storage (k)

Fig3.1.3:- Temperature distribution curve along the Length of the cold storage (k)

Fig:- 3.2, 3.2.1, 3.2.2, & 3.2.3 show the velocity distribution of the cold air. It is clear from the figure that air is penetrating till end wall of the cold storage. It means that every product inside the cold storage is coming in proper contact with the cold air.
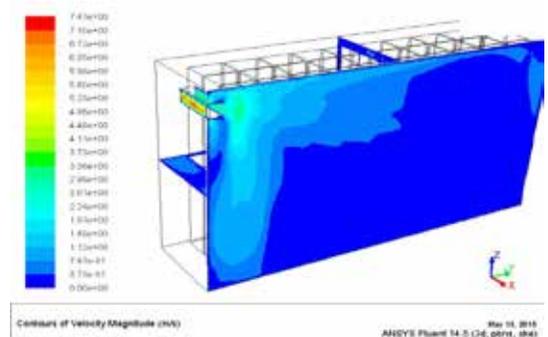
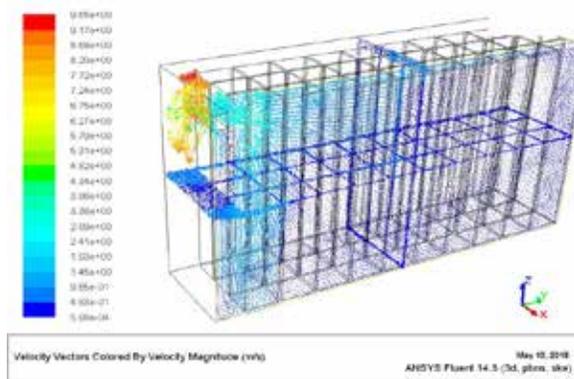**Fig3.2:-** Velocity distribution inside the cold storage (m/s)

Fig3.2.1:- Velocity Vectors distribution inside the cold storage (m/s)
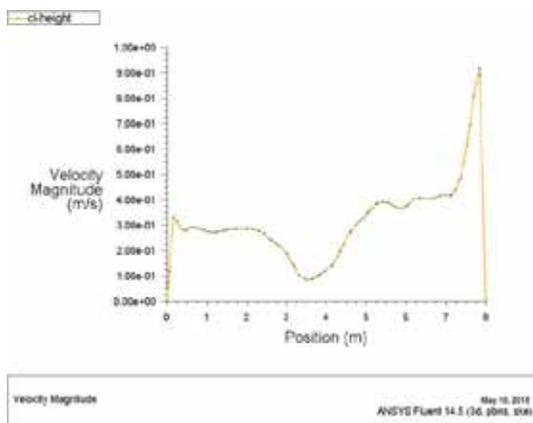

Fig3.2.2:- Velocity distribution curve along the height of the cold storage (m/s)
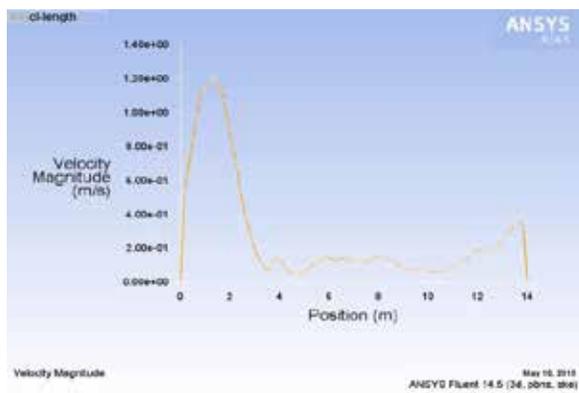

Fig3.2.3:- Velocity distribution curve along the Length of the cold storage

Fig. 3.3, 3.3.1, & 3.3.2 show the pressure distribution of the cold air. Pressurized air coming out of the evaporator coil traveling in straight direction with decrease in pressure.
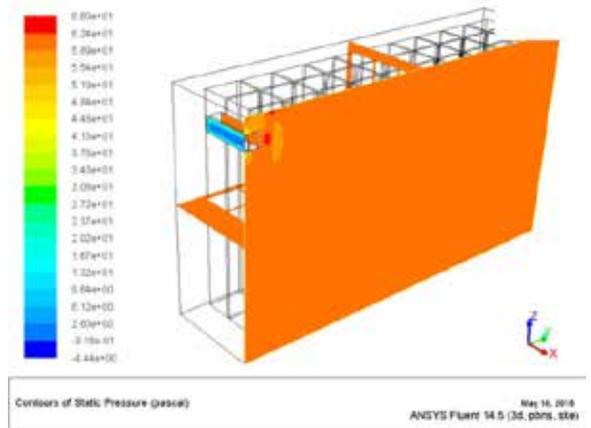

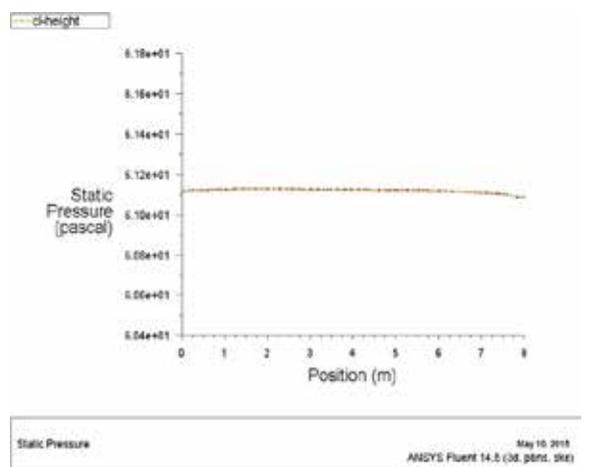**Fig3.3:- Pressure distribution inside the cold storage (Pascal)**

Fig3.3.1:- Pressure distribution curve along the height of the cold storage (Pascal)
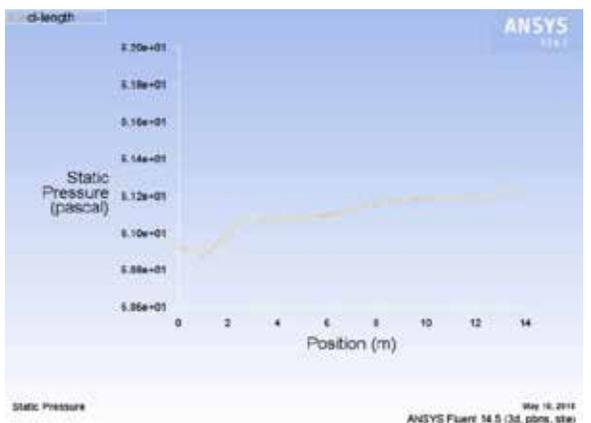

Fig3.3.2:- Pressure distribution curve along the Length of the cold storage (Pascal)

Table3.1 Final Outcomes of the Simulation Results

Air-inlet temp in K	Air outlet temp in K	Inlet vel. in m/s	Air-outlet-temp-max	Pressure-drop in Pa
271.15	273.694	3	276.41	60.70536

CONCLUSIONS:

It is clear from the above results that the chosen cooling system is good in terms of temperature, velocity & pressure distribution. Further more cooling systems can also be analyzed using CFD and then they can be compared to get the better one

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