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CFD Modelling of Two Different Cold Stores Ambient Factors

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Abstract

Objective of the research was to determine ambient temperature and relative humidity distributions of two different cold stores which have two different cooling systems. One of the cold store which is called as Cold store-I, has classical cooling system such as compressor, condenser and evaporator. Second called Cold store-II, has air conditioning system for cooling, cold air ventilation and aspiration systems, and humidification system. Computational fluid dynamics was used for modelling of distribution of temperature and relative humidity of cold store walls. Storage temperature and relative humidity were assumed 2^{o}C and 90%, respectively. Boundary conditions were set as; Inlet-Surface of fluid inlet, Outlet-Surface of fluid outlet, and walls-solid, proof against flow of fluid. A tetrahedral mesh was created by using ANSYS 14.0 and calculation finished when accessing a solution. Turbulence was modelled using the k-ε (k-epsilon). Spatial distribution in two cold stores for two different cooling systems were modelled and evaluated in this research. Data determined from CFD models were compared for both cold stores. Cold store-II was better than Cold store-I because it has air distribution holes located on ceiling.

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Key words: Temperature, relative humidity cold storage, computational fluid dynamics, modelling

1. Introduction

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Computational fluid dynamics (CFD) uses powerful computer and applied mathematics to model fluid flow. It is only in recent years that CFD has been applied in the food processing industry (Xia, Da-Wen Su, 2002. 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 outside the building and possible addition of a hallway outside one of the cold store entrance. Both steady and unsteady computations were carried out (Margeirsson and Sigurjon Arason, 2008). A mono-scale three-dimensional Computational Fluid Dynamic model was developed for estimating of airflow, heat and mass transfer (Sajadiye et al., 2012). CFD modelling can predict the temperature during power loss and the results show a acceptable match with experimental results of a domestic freezer. The modelling was extended to predict the temperature changes in a large cold store and the results also indicate that PCM can limit the rise in air temperature (Gin et al., 2010). 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 (Kim et al, 2007). Computational fluid dynamics (CFD) has been used in many fields which is related with fluid flow. The cooling rate and quality of food stuffs in a cold store are highly dependent on the temperature field which is closely related to flow field (Xhie et al., 2006).

Objective of this research was to investigate temperature and relative humidity distributions of two different cold stores have two different cooling systems. Computational fluid dynamics was used for modelling of temperature and relative humidity distribution on cold store walls. Storage temperature and relative humidity were assumed 2^{o}C and 90%, respectively. Boundary conditions were set as; Inlet-Surface of fluid inlet, Outlet-Surface of fluid outlet, and walls-solid, proof against flow of fluid. Spatial distribution in two cold stores for two different cooling systems were modelled and evaluated. Data determined from CFD models were compared for both cold stores.

2. Materials and Methods

2.1. Material

2.1.1. Cold store-I

The cold store which is called as Cold store-I, has classical cooling system such as compressor, condenser and evaporator. Sizes of cold store-I were 4.60X 4.35X 3.41 m (in length, width and height) and its volume was 68.3 m^3 (Fig.1)

Fig. 1. Cold store-I dimensions and general view

Type and power of Compressor were hermetic and 7BG, respectively. Condenser has axial fan and its capacity was 15 kW.