EXPERIMENTAL ANALYSIS OF AIR FLOW BY EVAPORATOR ARRANGEMENT AT TOP, MEDIUM AND BOTTOM

AJEET MISHRA

** Assistant Prof. Madhyanchal Professional University, Faculty of engineering and Technology, School of Mechanical Engineering, Bhopal, M.P **

Email. ajeet.aajeet.mishra@gmail.com

ABSTRACT

This thesis investigates the influence of air circulation on cold storage efficiency and food preservation quality. Experimental analyses were conducted using a hot wire anemometer to measure air velocity and temperature distribution at different points within the cold storage environment. The air flow model was developed based on the arrangement of evaporators at the top, medium, and bottom of the cold storage unit. The results obtained from this arrangement were analysed, and a parametric study was performed using an equivalent model with varying blowing air velocities and cooling unit locations. The findings indicated improved cooling effectiveness and temperature uniformity in the cold store, achieved through higher blowing velocities and strategically placing cooling units lower and closer to the array of produce packages. The research also explored the spatial distribution of air velocity at the ceiling, medium, and floor levels in the experimental cold storage, alongside temperature variations in different locations within the cold storage unit.

Keywords: Air flow model ,Temperature, Air velocity, Experimental cold storage

Introduction:

Efforts to improve infrastructure, including the development of cold storage and transportation facilities, are essential for creating a more efficient and sustainable food supply chain. Additionally, raising awareness among farmers about proper post-harvest management practices and encouraging the adoption of technology can further contribute to addressing the issue of food wastage in India's agricultural sector

Types of cold storages:-

The cold storage can be classified in following types:

Multipurpose Cold Stores: -These are designed for handling and storing a variety of products simultaneously throughout the year. The products that can be stored in this type of cold chamber are potato, fruits like mango, banana, dairy products etc. Location for establishing this type of chamber should be nearer to consumer centers.

Bulk Cold Stores: -These type of cold storage facility store only single type of commodity for a long term duration such as storage of potato, apple etc.

Small cold stores with precooking facilities: -These are used for storing contemporary fruits and vegetables, chiefly, for export oriented things like Grapes etc. The major portion of those units is in Maharashtra however the trend is currently reading in different states like state, Andhra and Gujarat etc.

Frozen food stores with or without process: - Frozen food stores with or without process and state change facility for meat, poultry, dairy merchandise, fish and processed fruits and vegetables. These units help in the promotion and therefore the growth of frozen foods sectors, both in the domestic and therefore the export markets.

There are the some prescribed crops that required the pre cooling for pulling down and storage conditions. And for the fresh fruit and vegetables and some other horticulture products, the pre cooling are not needed. The fresh potato tubers for following purposes:-

1. Early Crops (pre mature)
2. Seed Potatoes
3. Table Potatoes
4. Process Potatoes

A. French Fries

B. Chipping

C. Onions, garlic, tamarind

Principles of Operation of a Cold Storage Room:- The cold room like every other refrigerating systems of the same magnitude employs the vapour compression method of mechanical refrigeration . Fig.1 presents the T-s diagram of the vapour compression cycle, while the illustrates the processes of the refrigeration employed in the cold room, respectively.

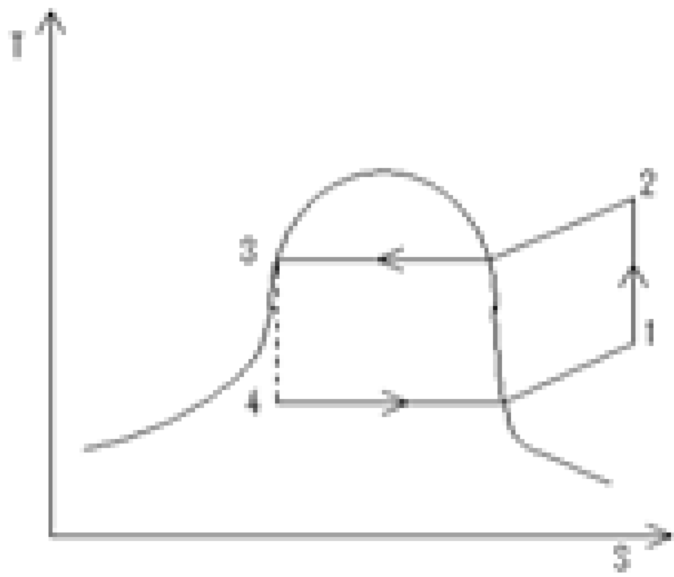

Fig.1: Temperature-entropy diagram of the cold room storage cycle processes

OBJECTIVES:

The basic objective of the present study is to see the performance analysis of cold storage with the use of duct with slot arrangement

METHODOLOGY:

In Indian cold storage industry the two most important problems are higher energy consumption and storage losses beyond the permissible limit. In India storage losses in potato cold store account for 3-10 % of the stored product in the form of rotting, cold injury weight losses, sprouting Nutritive value degradation etc.. The parameter affects the energy consumption is improper heat and mass transfer in cold storage and also depend in air distribution of the cold storage as well as relative humidity and cooling coils or evaporator arrangements of the cold storage.

Air distribution-As discussed above that thermal gradient inside the cold storage is dependent on air distribution and its disturbance. Various factors are responsible for air flow and its distribution, like selection of evaporator coil position, fan speed, height and gape between stakes rows and columns, cold room geometry etc. Cold storage length and width and height are very important for air flow and its distribution in chamber. Cold Air is blow from evaporator coil is picked heat from the preserved items and transfer it to refrigeration system. Thus as maximum the reach of cool air, higher the refrigerating effect. Researchers were observed that cold air from evaporator coil is not able to cover whole length of chamber there is a stagnant zones with poor ventilation in the rear part of the cold storage. Poorer reach of air in farthest part (from the evaporator) of chamber causes higher temperatures at the section in comparison to parts near to evaporator [1-3]. Son H. Ho et al 2010, in his simulation analysis of cold storage demonstrate that cold air from evaporator not move too away from evaporator coil and short circuit back to cooling coil. This phenomenon cause high temperature region at rear portion of cold store.

Based on the air circulation and its effect it is observed that the design and mounting of cooling coils play an important role to achieve the fast cooling.

Evaporator arrangement: In this type of arrangement the cooling coil is located at the top of one of the wall of the cold storage. The air throw is horizontal and directly strikes on the products which generally kept in front of cooling coil.

Fig.2 Evaporator located on the Top

General configuration deals with only closed chamber equipped with evaporator and measuring arrangements, no other system is applied inside the chamber. It is similar to empty cold storage plant. In this case flow velocity in chamber is measured along the vertical central plane at different locations which are marked along the length and height of vertical plane. As shown in figure 4.1

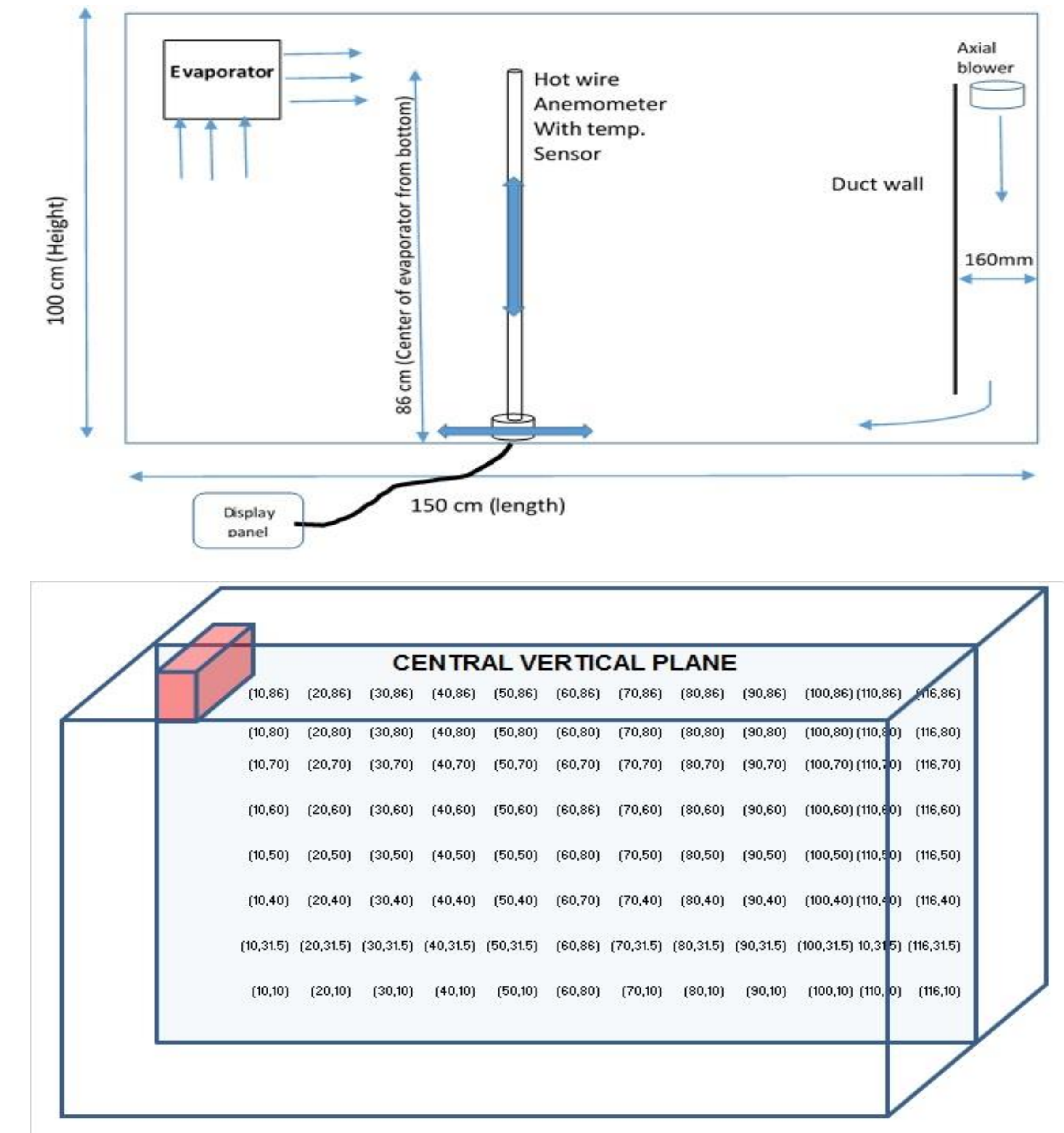

Fig 3 Line diagram of experimental setup

Flow capacity of evaporator: 2.28 m^3/min

Air flow velocity at evaporator 3m/s

Duct

Pressure at duct side when fans are running: 0.3 bar

Duct fan capacity 1.14m^3/min

Duct wall size: 1m x 0.8m

10 cm above ground and 10 cm below the top face.

Duct wall is 0.16m away from chamber wall opposite to evaporator.

Two fans fitted at top of duct and through air axial downward.

For third condition for experiment is duct wall having equally spaced slots of 12 cm x 84 cm cuts horizontally length wise. Our AC fans are available in frequencies of 50 Hz and 60 Hz.

SPECIFICATION: -

- Model number:- AC12038
- Rated voltage:- 220 VAC
- Frequency:- 50/60Hz
- current:- 0.14/0.13 amp
- Rated input power:- 22 watt
- Speed:- 2600rpm
- Size:- 120*120*38mm
- Maximum air flow:- 90/100 CFM
- Noise:- 40/45 DB-A
- Body Material:- aluminum die-cast with coating
- Fan Blade:- Plastic P.B.T.
- Bearing Type:- sleeve

RESULT AND ANALYSIS

Results

In the present work air flow velocity is measured in a modelled cold storage room with the help of ansys. The data collected using ANSYS FLUENT 14.5 included the temperature data, and airflow velocity at the monitor point and the temperature distribution and airflow velocity at all node points in the model room.

❖ **On comparison of figure 4,5 &6given below following findings are listed**-

- Fig 4 shows that velocity at top layer or in front of evaporator is in order of 2.5 m/s to 3 m/s. but drop drastically away from source.
- Velocity at rear section is in range of 0.47 m/s to 0.947 m/s at 80cm above the ground and 90 cm away from evaporator.
- Velocity at mid section and around the buckets was observed in the range of 0.15 m/s to 0.6 m/s.

- Return air velocity just below evaporator is 1.1m/s.
- With duct fitting at rear section i.e. 110 cm away from evaporator velocity at 86 cm above and ground now maintaining velocity in higher range as compare to last case. I.e. velocity is 0-9 m/s to 1-74 m/s from 80 cm to 100cm from evaporator.
- With use of duct the return air velocity at bottom now is in the range of 0.9 m/s to 1.11 m/s.
- Return air velocity just below evaporator is posses much higher speed as compare to first case.
- Near buckets velocity at mid section is not improve too much.
- In fig 5 slotted duct is used and because of slotting improvement at midsection is sighted'
- Velocity near buckets in this case is in the range of 0-9 m/s to 1-2 m/s at mid parts of chamber.

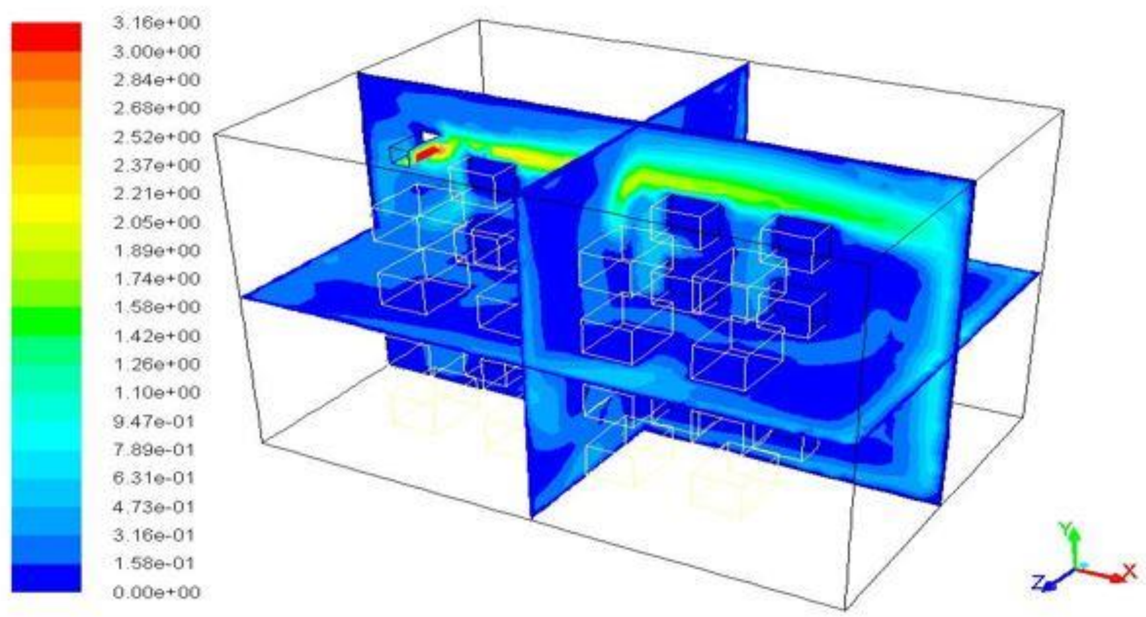

Fig 4 cold storage bucket velocity in central plane

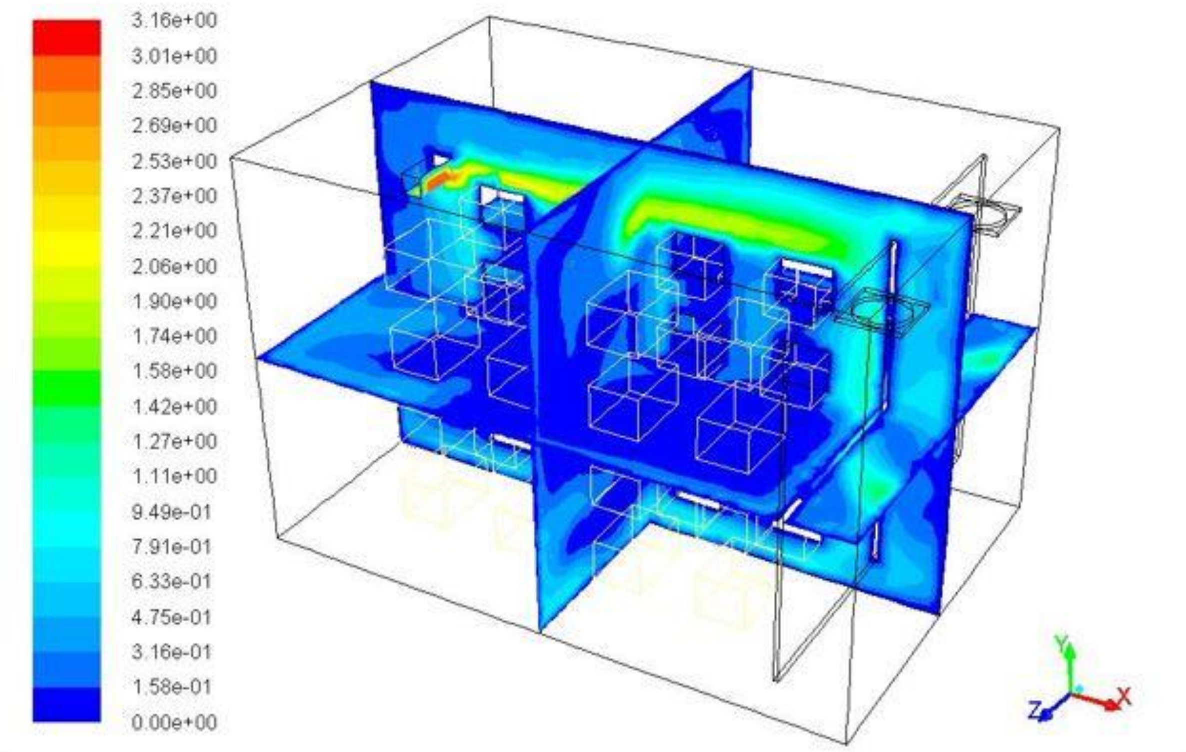

Fig5 cold storage bucket with duct velocity in central plane

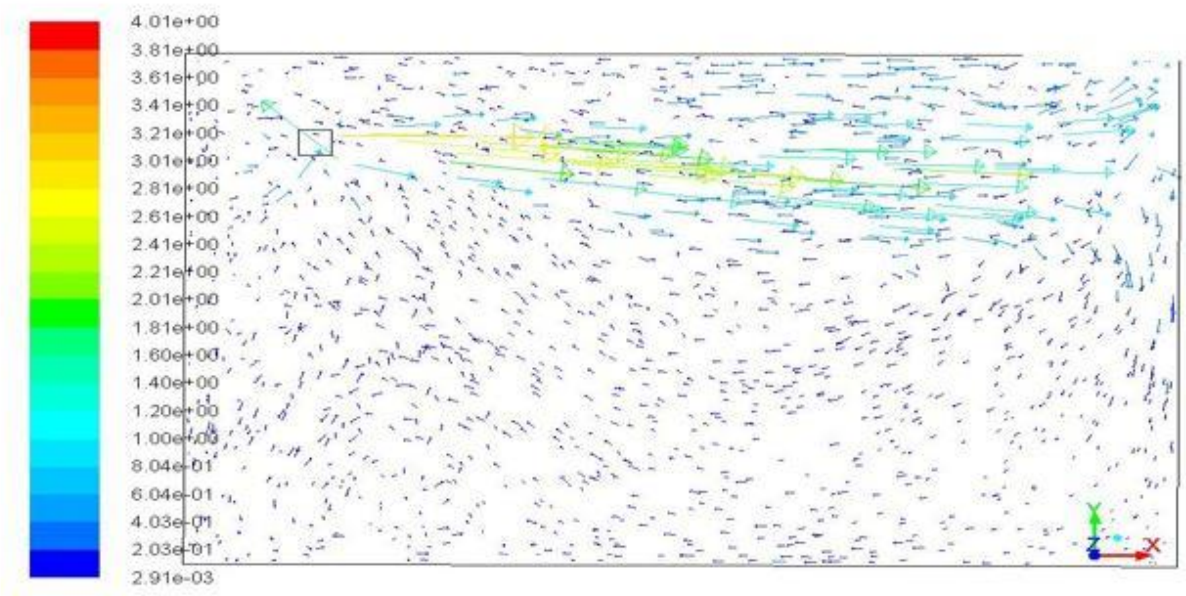

Fig 6 cold storage velocity vector graph

CONCLUSION

Air Velocity Variation:

The analysis revealed that the variation in air velocity is less at the middle and bottom levels of the cold store compared to the top level. This is attributed to the placement of the evaporator at the top level of the cold store.

Duct with Slotted Arrangement:

The introduction of ducts with a slotted arrangement has been found to improve air flow in cold storage facilities. This suggests that incorporating this design enhances the overall efficiency of air circulation.

Optimal Air Circulation Height:

At a height of 86 cm above the ground, it was observed that using induced ducts with slots resulted in better air circulation in the chamber. Figures 4, 5, and 6 demonstrate that, when positioned 100 cm away from the evaporator, the air velocity without ducts is 1 m/s, while with ducts it increases to around 1.5 m/s and further to approximately 1.9 m/s with ducts featuring slots. This indicates that using ducts with slots ensures proper air distribution in the cold storage environment.

REFERENCES

[1] A. Stamou, I. Katsiris, 2006; Verification of a CFD model for indoor airflow and heat transfer. Building and Environment 41, 1171–1181.

[2] Ambaw, M.A. Delele , T. Defraeye , Q.T. Ho , L.U. Opara , B.M. Nicola, P. Verboven, 2013; The use of CFD to characterize and design post-harvest storage facilities: Past, present and future; Computers and Electronics in Agriculture 93, 184–194

[3] American Society of Heating, Refrigeration and Air Condition Engineers, Inc. – ASHRAE Handbooks

[4] Baired,C.D, and Gaffney,J.J,1976.A numerical procedure for calculating heat transfer in bulk loads of fruits or vegetables. ASHRAE Transactions 94(1), pp 1434-1454 [5] C. R. Boon, 1978; Airflow patterns and temperature distribution in an experimental piggery. J. AgricEngng Res, 23:123-39

[5] Cheng CH, Wu CY(2000). An approach combining body-fitted grid generation and conjugate gradient methods for shape design in heat conduction problems. Numerical Heat Transfer Part B 2000; 37:69–83

[6] Environs Ugwu, Hyginus Ubabuike*, Ogbonnaya, Ezenwa Alfred, Design and Adaptation of a

Commercial Cold Storage Room for Umudike Community ,IOSR Journal of Engineering May. 2012, Vol. 2(5) pp: 1234-1250

[7] F.T.M. Nieuwstadt. 1990;Direct and large-eddy simulation of free convection. Proc. 9th Int. Heat Transfer Conf. 1: 37-47, Jerusalem

[8] G.G.Maidment, G.T. Prosser(1998) Investigation into the Viability of CHP in Cold Storage Facilities, in: International Institute of Refrigeration Conference, Refrigerated Transport, Storage and Display Conference, Cambridge, 29 March, 1998.

[9] H. B. Nahor M. L. Hoang, P. Verboven, M. Baelmans, B. M. Nicolai, 2005, CFD model of the airflow, heat and mass transfer in cool Stores International Journal of Refrigeration 28, 368–380.

[10] H. Wang, S. Touber, 1990; Distributed dynamic modeling of a refrigerated room, International Journal of Refrigeration 13, 214–222.

[11] H.B. Nahor, M.L. Hoang, P. Verboven,"CFD model of the airflow, heat and mass transfer in cool stores", International Journal of Refrigeration, Vol. 28, Issue 3, pp. 368–380, 2005.

[12] H.L. Choi, L.D. Albright, M.B. Timmons, 1990; An application of the ke3 turbulence model to predict how a rectangular obstacle in a slot-ventilated enclosure affects air flow, Transactions in Agriculture 33, 274e281