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STUDY OF VELOCITY AND TEMPERATURE DISTRIBUTION INSIDE THE FRUIT DRYER USING CFD

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Abstract: Drying is one of the most commonly used methods of preservation and processing of fruits and berries. All variety of foods and fruits in our day to day life needs some way of preservation mainly to reduce or stop spoilage, to make the dried fruits available throughout a year, to maintain desired levels of nutritional properties for the longest possible time span and to make value added products. Tray dryer is the most extensively used because of its simple and economic design. The main drawback of tray dryer is the non-uniformity of the final moisture content of the product. Good air flow distribution throughout the drying chamber can improve the drying uniformity. The models are designed in solid edge and the computational fluid dynamic analysis is done using ANSYS fluent software. CFD is considered an integral part of engineering design and analysis because of its capability to solve energy using numerical methods to predict the velocity and temperature in the drying chamber

Keywords — Fruit dryer, Tray drying, Temperature distribution, Velocity distribution, Uniform drying, CFD analysis.

I. INTRODUCTION

Drying is one of the most effective ways of preserving fruits of all variety which involves removal of water content and reduce its moisture content by application of heat. A variety of foods are preserved using drying, these include: marine products, meat products as well as all fruits and vegetables. Fruits can have moisture content as high as 90% or more (e.g. water melon has moisture content as high as 93%) which needs to be reduced to an acceptable value so as to avoid microbial growth. Traditionally food products are dried by open sun drying. Al-though this method is still common at several places for non-commercial use, there have been numerous efforts to develop advanced drying methods for fruits and food products on commercial scale. It is necessary to improve the drying techniques to reduce the spoilage and enhance the quality at minimal cost. The above researches were carried out through CFD using ANSYS fluent software. Brief reviews of literature related to the above studies are presented.

Suhaimi Misha et al... [1] Tray dryer is the most extensively used because of its simple and economic design. The main drawback of tray dryer is the non-uniformity of the final moisture content of the product. Good air flow distribution throughout the drying chamber can improve the drying uniformity. CFD is considered an integral part of engineering design and analysis because of its capability to solve equations for the conservation of mass, momentum, and energy using numerical methods to predict the temperature, velocity, and pressure profiles in the drying chamber.

Sohif Mat et al...[2] CFD simulation was used to predict air flow distribution in the drying chamber by considering the product as porous media. The experimental and simulation data were in good agreement. The drying rate of the product was significantly influenced by the average air velocity above the tray. The higher the average air velocity, the higher the drying rate of the products.

Bin Xia et al…[3] This paper reviews the application of CFD in the food processing industry. CFD can be used as a tool to predict food processes as well as to design food processing equipment. There has been considerable growth in the development and application of CFD recently in the area of drying, sterilization, mixing and refrigeration.

Franz Roman et al… [4 In this study, computational fluid dynamics simulations were carried out as a tool to improve the performance of a fixed-bed box dryer by improving the air distribution through the product. It was seen that by widening the entrance into the plenum chamber and thus reducing air velocity, a much more uniform air distribution to the boxes could be achieved.

S Rajashekar et al… [5] CFD, research in drying will enhance the design process and understanding of heat ,mass and moment transfer .The drier geometry configuration, air velocity and air temperature have much influence on the rate of effective drying. If we can optimize these parameters, we can optimize the industrial drying process easily .The benefits of CFD to the food processing industry in the area of drying are many. In the recent years great development has taken place in these areas..

II. METHODS AND SIMULATION

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A. *Design of a new drying chamber*

The constructed dryer system is designed to dry any fruits at high volume. The space of drying area is approximately 0.225 m2 . The wall of the dryer system was constructed using 0.035m thick. The drying chamber dimension is approximately 0.5m × 0.45m × 0.535 m (width, length, and height, respectively).The layout of the drying camber is shown in Fig. 1. The dryer system consists of 4 levels of trays. The end space in the drying chamber is used to occupy operator for loading or unloading the product to the last column of trays. The positions of trays in the drying chamber are shown in Fig.1.The velocity and temperature distributions were studied to predict the drying uniformity.

B. *Simulation details*

- Firstly, the case study on the different types of fruit dryer geometries is done.
- The design parameters and the boundary conditions are determined.
- Validation of the temperature and velocity distribution from a research paper is compared with the CFD analysis value done in our software by taking the same boundary condition.
- The modelling of fruit dryer geometry is done using the solid edge.
- Then the meshing is done using ANSYS V.19 software.
- The fluid flow analysis is done using Ansys FLUENT to obtain air flow results and thermal results for the geometry.
- The results are compared and optimum results for better performance of a fruit dryer.

ANSYS fluent software is used for the computational fluid dynamics analysis of flow over a fruit dryer . The boundary conditions for above analysis are given in the table 1. The boundary conditions are assumed from previous journal papers. the model is imported and initially flow anlaysis is done to know the air flow and later thermal analysis is done to get velocity and temperature distribution .

TABLE 1

BOUNDARY CONDITIONS

PARAMETERS	VALUES
INLET VELOCITY	3M/S
INLET TEMPERATURE	65˚C
OUTLET GAUGE PRESSURE	0
ENVIRONMENT TEMPERATURE℃	33℃
ON THE TOP OF THE ROOF TEMPERATURE℃	55℃
HEAT LOSS AT BOTTOM SURFACE	0

While doing this analysis we have considered two reference planes for the half of the geometry and other half is symmetric, while doing thermal analysis temperature distribution profiles are obtained.

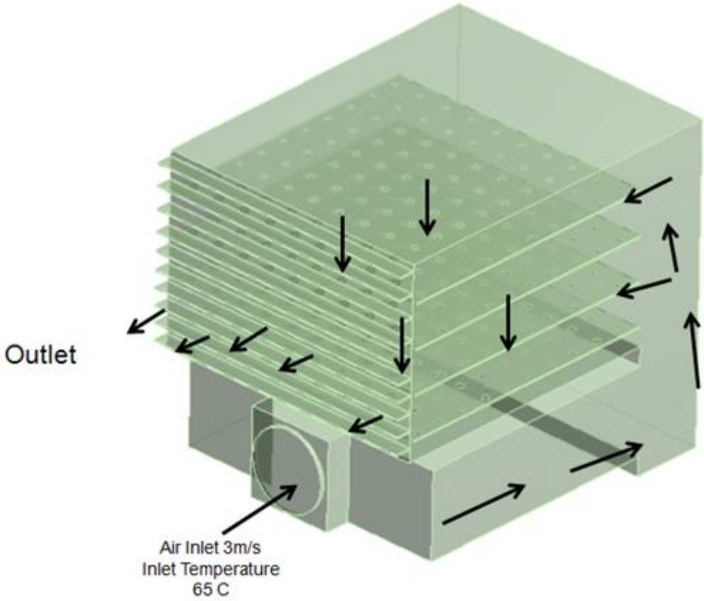

Fig.1 Computational fluid domain extraction

III. RESULT AND DISCUSSION

Even though the simulation was done in three dimension but analysis was carried out at plane1 and plane 2. Several planes have been studied but plane 1 and plane 2 is considered as poor zone in term of hot air distribution and on four trays. The hot temperature air from the inlet is 65°c

A. Case 1- Velocity and Temperature distribution profiles on 1st reference plane.

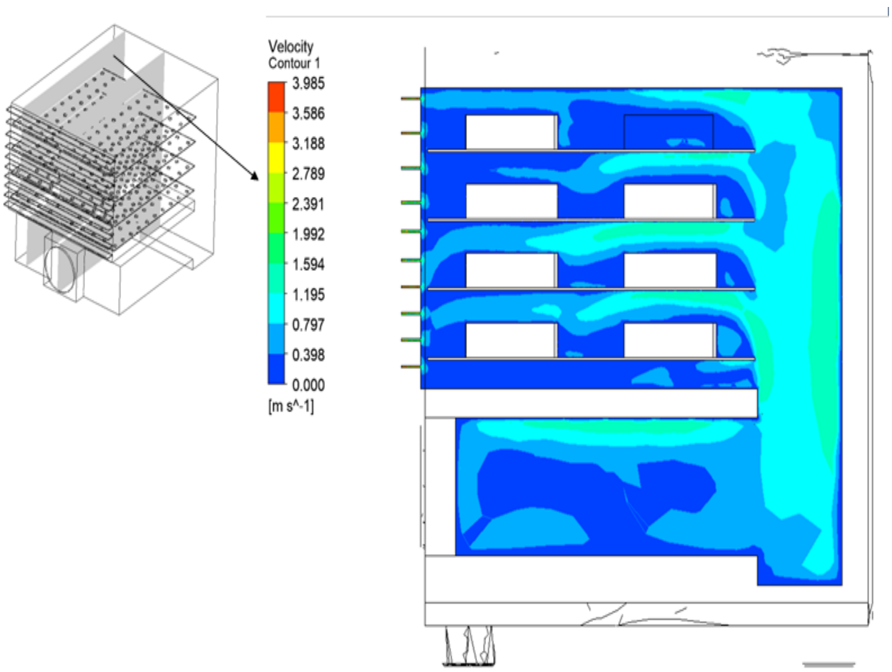

Fig.2 Velocity Distribution profile on 1st plane

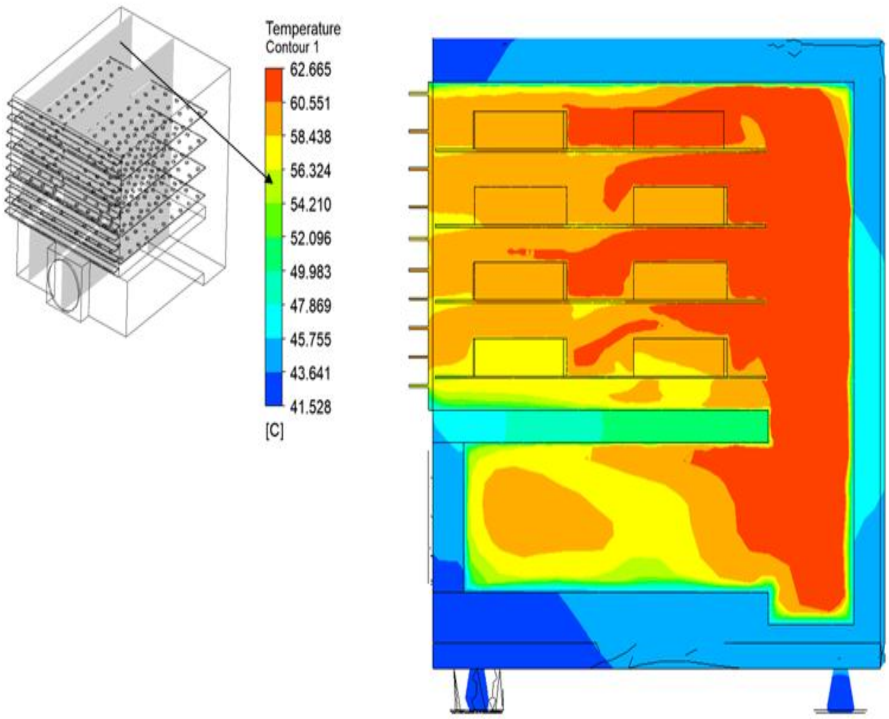

Fig.3 Temperature Distribution profile on 1st plane

B. Case 2- Velocity and Temperature distribution profiles on 2nd reference plane.

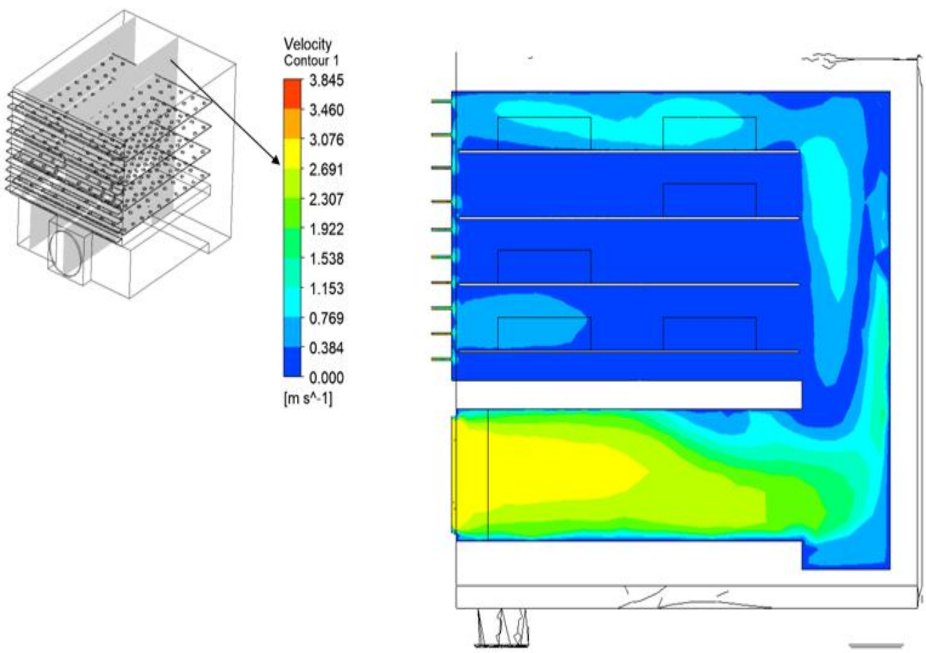

Fig.4 Velocity Distribution profile on 2nd plane

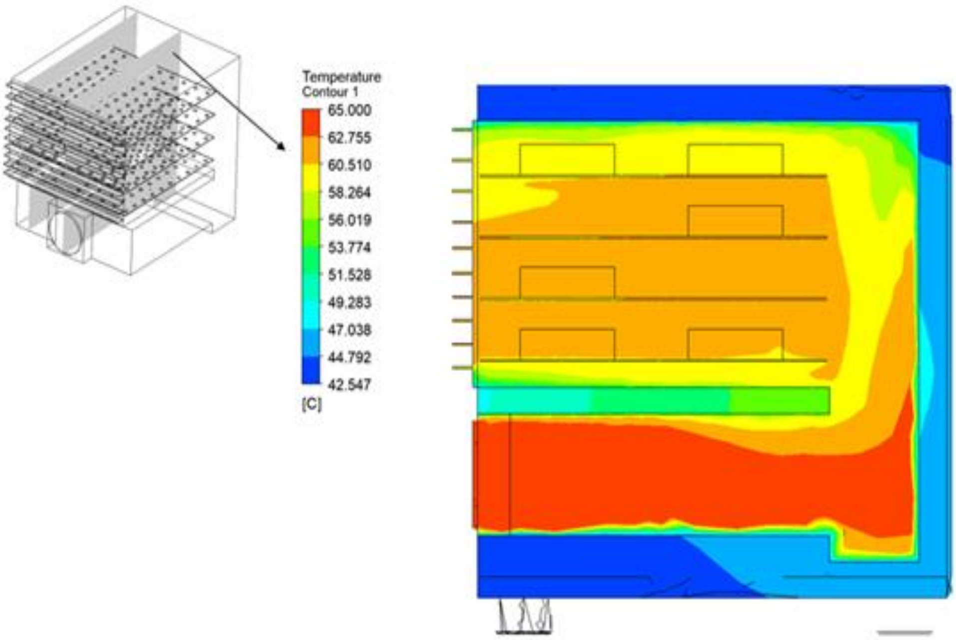

Fig.5 Temperature Distribution profile on 2nd plane

TABLE.2

THERMAL ANALYSIS RESULTS

COMPONENTS	VELOCITY DISTRIBUTION M/S	TEMPERATURE DISTRIBUTION ℃
1ST REFERENCE PLANE	0-3.955	62.665℃
2ND REFERENCE PLANE	0-3.845	65.000˚C
1ST TRAY	0-1.621	62.784˚C
2ND TRAY	0-1.609	62.730˚C
3RD TRAY	0-1.475	62.629˚C
4TH TRAY	0-1.279	62.382˚C

Similarly velocity and temperature distribution profiles were obtained for all the four trays and the results are tabulated in the tabular column. It was found that on the 4th tray the temperature was low. But the difference of the temperature among the trays is considered as small and it can be assumed that the design successfully achieved the reasonable uniform air temperature in the drying chamber.

In drying application, the temperature, velocity and humidity of drying air condition gives significant effect to the drying process. In this stimulation study only temperature and velocity of the drying air can be analyzed. Humidity analysis will be done in the future experimental work. The velocity distribution in plane 1 ranges from 0-3.955m/s and in plane 2 ranges from 0-3.845m/s, it is found that on the plane 1 velocity distribution is more comparatively on plane 2. It shows that the velocity achieved the maximum value at 3m/s determined in the inlet boundary condition . Generally the velocity around the tray is very low in the range of 0-1.621m/s. The air velocity above the trays is very important to carry the moisture from the product. The variation of final moisture content of the product may occur based on the velocity profile. The high air velocity at above product (tray) will make the product dry faster compared to the product with low air velocity. The temperature profiles in the drying chamber can be considered as uniform because the temperature drop is very small. However the air velocities above the trays are not uniform. The products on 3rd and 4th tray may dry little less when compared to 1st and 2nd tray . Because 3rd and 4th tray is away from the air inlet and 1st and 2nd tray is near to the air inlet

IV. CONCLUSIONS

Tray dryer is the most extensively used because of its simple and economic design. The main drawback of tray dryer is the non-uniformity of the final moisture content of the product. Good air flow distribution throughout the drying chamber can improve the drying uniformity. CFD is considered an integral part of engineering design and analysis because of its capability to solve energy using numerical methods to predict the temperature, velocity, and pressure profiles in the drying chamber. Therefore the performance of new dryer designs may be predicted by simulation work. Generally the temperatures are considered uniform for all trays. The new design of dryer is suitable for agricultural drying because it can produce acceptable uniform drying at high capacity of product. The drying efficiency of this system may be increased with high air velocity inlet. The uniform drying and increasing of drying rate will also improves the quality of dried product. The uniformity of the drying may be improved by using additional baffle to direct the air flow to each tray, exchange the positions of the tray during the drying process or conducted in semi-continuous mode. However it will increases the overall cost of drying. The actual dryer will be developed in the future and the experimental work will be conducted to validate the simulation.

REFERENCES

[1] Suhaimi Misha: The Prediction of Drying Uniformity in Tray Dryer System using CFD Simulation: International Journal of Machine Learning and Computing, Vol.3,No.5, October 2013.

[2] S. MISHA: Simulation of Air Flow Distribution in a Tray Dryer by CFD

[3] Bin Xia: Applications of computational fluid dynamics (CFD) in the food industry: a review, Computers and Electronics in Agriculture 34 (2002) 5–24.

[4] Franz Roman:Improvement of air distribution in a fixed-bed dryer using .Computational fluid dynamics: Bio systems engineering 112 (2 0 1 2) 359e369.

[5] S.Rajasekar: A review on computation fluid dynamics studies in drying processes: JOFSR, 1(1), 2016 [027-031]Volume 1 Issue1

[6] Jonathan Fabregas Villegas1: Obtaining Fruit-Drying Curves and CFD Analysis for Corozo: Contemporary Engineering, Sciences Vol. 10, 2017, no. 12, 569 – 577.

[7] Sheidu Sumaila Onimisi: Optimization of Developed Multipurpose food dryer using ANSYS: Journal of Scientific and Engineering Research, 2016, 3(5):72-76.

[8] Singham Pragati :Technological Revolution in Drying of Fruit and Vegetables: International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 ,Impact Factor (2012): 3.358.

[9] Naseer Ahmed: Different Drying Methods: Their Applications and Recent Advances: International Journal of Food Nutrition and Safety, 2013, 4(1): 34-42 .

[10] Uche Eunice Ekpunobi : Investigation of the thermal properties of selected fruits and vegetables: American Journal of Science and Technology 2014; 1(5): 293-297.

