STUDY AIR FLOW DISTRIBUTION IN THE DRYER SYSTEM THROUGH CFD SIMULATION

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled "Study Air Flow Distribution In The Dryer System Through CFD Simulation" is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal & Fluids).

Signature : ....

Name of Supervisor : ....

Date : ....

DEDICATION

I dedicate this report my lovely wife, Siti Aisyah Binte Mohammad Ghazali who has constantly given me her endless support, my family and friends, whom without their endless support, I wouldn’t be able to continue perusing my higher education. Special thanks and admiration to my supervisor, Dr. Suhaimi Bin Misha for without his wise suggestions, continuous guidance, and direct assistance, this report nor the project, could have gotten off the ground. I would like to thank my university, UTeM and my friends for their support and advice for this internship training. Thank you all for your enduring patience and continuous encouragement.

ABSTRACT

Tray dryer systems are continuously improving to be more efficient. The aim of this project is to increase the drying rate by studying the air flow distribution in the drying chamber using CFD simulation. This is done by re-designing the drying chamber and its trays. The study is being done using Computational Fluid Dynamics in Ansys Fluent. By using this software, it was possible to predict the air velocity and air temperature that flows on top of the trays and throughout the drying chamber. Drying rate is dependent on many factors. Air velocity, air flow distribution, and temperature are the main contributors in determining the drying rate. Four designs were suggested to improve the air distribution on the trays. Average velocity of each tray and the drying chamber, as well as the gap between the maximum and minimum tray average velocity had determined the best air flow distribution design. It was clear that the up-staging design had the most minimum gap as well as the maximum average velocity.

ACKNOWLEDGEMENT

I would like to express my deepest appreciation to my supervisor Dr. Suhaimi Bin Misha for giving me the opportunity to do my final year project with him. He never hesitated to give me advice and guidance whenever I confronted problems. I am thankful for his patience and advice while leading me in this project. I would like to thank my family for their efforts in helping me to complete the final year project and to my friends for their endless support and encouragement. Last but not least, I would like to thank my course mates for giving me their support, patience and encouragement.

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CHAPTER 1

INTRODUCTION

1.1 Background

Drying process is one of the most important methods to preserve the agricultural materials such as food, wood, rubber, etc. It is a method that has been used along the lifetime of the homoserines. Drying process is method where it includes dehydration that involves the simultaneously application of heat and removal of moisture from crops or foods so that it's easier to be preserved, stored, and marketed. Heat transfer involves in moving the heat from the heating medium to the point at which evaporation occurs. Once the moisture has been evaporated, the vapors produced must be transported through the product structure to the surrounding medium. This process involves air flow through the structure during the dehydration process. Many factors can cause food spoilage and these factors cannot occur without the moisture (Misha .S, 2013).

One of the traditional ways of drying is spreading the agricultural materials on a wide space where it will be exposed directly to the sunlight. This method of drying these materials is very difficult to control. As well as there are many factors for these materials to take a longer time than it supposed to be and these materials might not be able to be used anymore because of wind, birds, animals, require a large space, etc.

One of the new methods of drying is solar dryer. The air gets heated by the solar collector. Then the heated air flows to the drying chamber. There is a lot of real applications of the solar drying systems, but one of the new concepts design in Malaysia and was introduced (Misha .S, 2013). In his study (Misha .S 2013) introduced and created a new model of solar drying system as shown in Figure 1.1. Where the solar collectors increase temperature

Figure1.1: Drying system. (Misha .S, 2013)

of the water that flow in the copper tube from the tube tank. The hot water flows to heat the air for drying goes to the heat exchanger Figure 1.2. The drying chamber is the area where the trays are located. The required material is placed on top of the trays and spread them to expose them to high temperature airflow, where it passes through the desiccant prior to that. The desiccant is used to extract and reduce humidity from the air flowing to the drying chamber (Misha .S, 2013). However, the details of the hot water generator are not discussed in this project. The scope of this project is to study air flow distribution in the drying chamber through CFD simulator.

Figure 1.2: Drying chamber. (Misha .S, 2013)

1.2 PROBLEM STATEMENT

The tray dryers are the most broadly utilized due to its basic and cheap design as in Figure 1.3. The required material to be dried is spread out on these trays. the tray dryer can dry more items as well as these materials can be stacked as the trays are orchestrated at various levels. Most tray dryers utilize hot air stream where moisture is vaporized from the materials and extracted from airflow. To produce the uniform dehydration is to have uniform air stream, which is distributed equally on each tray. The positions of trays in the in the drying chamber will determine the uniformity of air flow distribution. (Misha .S, 2013) introduced different arrangement of trays to have more distributed uniform air stream. In this Final Year Project, air flow distribution in the dryer system will be studied by changing and manipulating the arrangement of the trays to find if there are any improvements with new arrangement through CFD simulation.

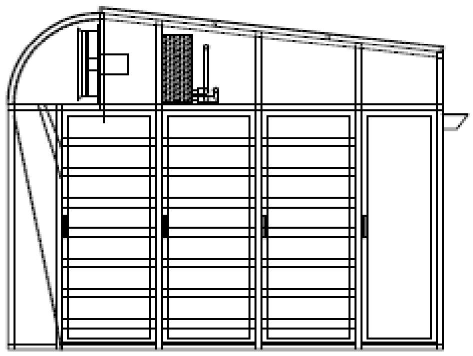

Figure1.3: The drying chamber, and in the middle, is the trays, (Misha .S,2013)

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To modify the existing trays positions in the drying chamber.
2. Investigate the air flow distribution in the drying chamber using Computational Fluid Dynamics (CFD) software.
3. To predict the drying uniformity on each one of the trays,

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. Re-locating or re arranging the trays using ANSYS.
2. A simulation of air stream lines, air distribution, and air velocity on the new re-located trays using ANSYS.
3. Observation of air distribution on the re-arranged tray using ANSYS.
4. Find the average velocity of air above the product.
5. Perfect the drying rate of each tray.

1.5 GENERAL METHODOLOGY

The actions that need to be carried out to achieve the objectives in this project are listed:

1. Literature review:

   Journals, articles, or any materials regarding the project will be reviewed.

2. Design:

   Develop the model. Sketch the new trays with specific dimension, choosing the new location.

3. Running Simulation:

   Visualization of simulation of air distribution.

4. Analysis and comparing:

   Analysis will be carried out on how hot air is distributed on the trays for all the different designs that will be presented. Comparing the results of each design to each other and suggest the best design based on the results presented.

5. Report writing:

   A report on this study will be written at the end of the research.

The methodology of this study is summarized in the flow chart as shown in Figure 1.4.

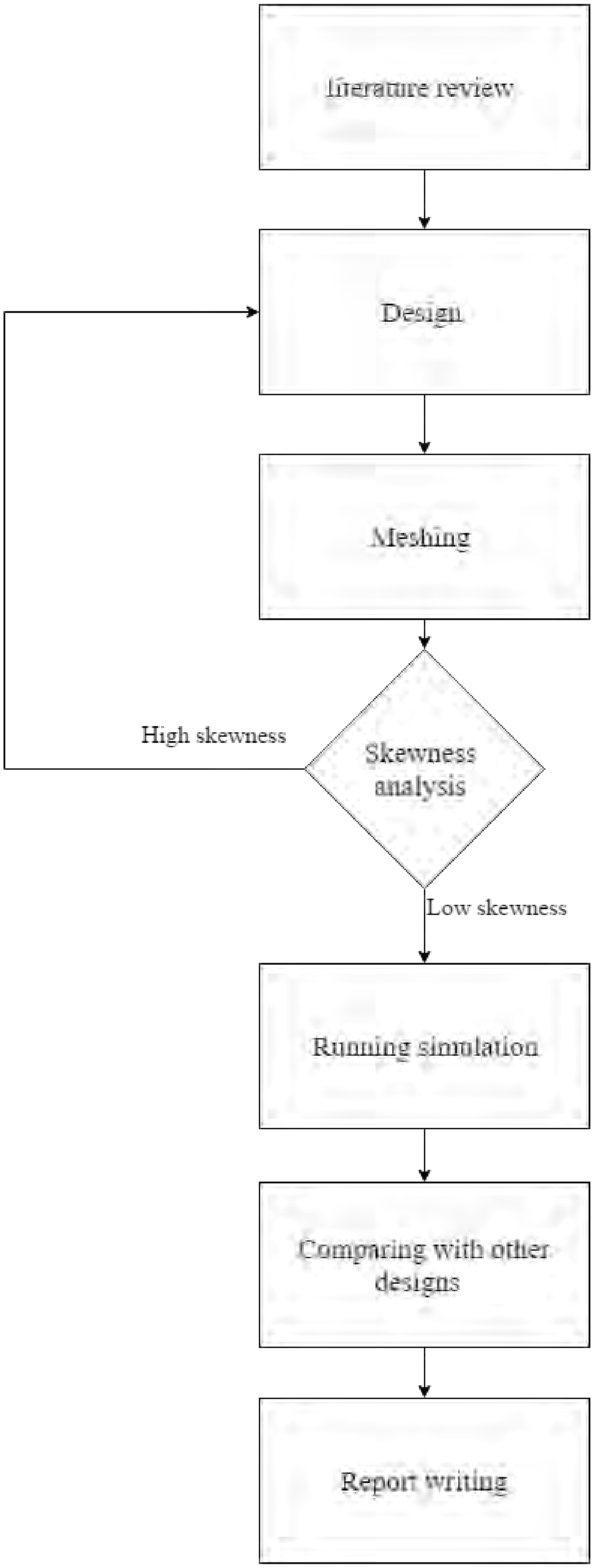

Figure 1.4: Methodology flow chart

CHAPTER 2

LITERATURE REVIEW

In this chapter, the most important journals will be reviewed as well as some will be referenced. This is done to have a clearer image about the future of this project and to have a better understanding of the theories.

2.1 Computational Fluid Dynamics

It can be very dangerous, expensive, time consuming and difficult for most of the experiments to run in order to find the results for the specific parameters, especially putting in consideration the error percentage for a large scale solar drying chamber and its trays as well as repositioning them to get the results (Misha .S, 2013). Computational fluid dynamics (CFD) simulation is widely used because of its ability to solve complicated equations for the conservation of momentum, energy, and mass using numerical methods to find and predict each of the pressure profiles, velocity, temperature at any point or any position needed in the drying chamber. Computational fluid dynamics (CFD) is used in this project to simulate the velocity and temperature profiles at each tray in the drying chamber, as well as the fluid pressure if required (Misha .S, 2013).

The CFD is utilized as an instrument to predict the temperature in the drying chamber as well as the air flow distribution to acquire the uniform drying. CFD has additionally been widely utilized as a part of food industry to explore the stream example of the air in the drying chamber. Uniform airflow distribution in the drying chamber is important in light of the fact that it gave huge impact on the proficiency and the homogeneity of the items being dried (Misha .S, 2013).

2.2 Designs of the drying chamber

The design of the drying chamber is very important due to its capability to affect the airflow distribution. Designing and locating the trays as well as placing them in a pattern is just as important as the design of the drying chamber itself. This is because placing the trays at the exact proper position, and having them positioned in the proper pattern can help reduce the drying time and drying uniformity at each tray. Normally, trays that are far from the source will take longer time to get dried.

Drying is the process of mass transfer and heat to remove the water or any other solvent by evaporation from a liquid, solid, or semi-solid. Typically, hot air stream is applied to dry any material, and usually the drying process is separated into two phases. In the first phase, the surface and inner side of the item have the same dampness content at first. The surface of the product or the material will be saturated with vapour when it gets heated by hot air, and then the water will evaporate. In the second phase, when the material surface gets dried, the moisture will slowly move from the inner side of the material to the outer surface, having it exposed to the dry airflow and high temperature to evaporate that moisture. Be that as it may, a few materials do not go through neither of the first or second phases. Belessiotis and Delyannis (2011) are characterized under another phase. On the third phase, for hygroscopic materials where the dampness content keeps on evaporating until the material accomplish its equilibrium stage. However, most materials quit drying before this phase.

Drying time relies on the way the material behaves in nature and the drying conditions. Imperative parameters in the drying procedure are mugginess, temperature, and wind stream rate. A few materials like food, and other materials that are sensitive to heat are not appropriate for drying at high temperature since material quality might be debased or harmed. Drying utilizing desiccant material produces dry air since the desiccant material adsorbs dampness from the air. The handled air delivered after dehumidification is dry, as well as increments in temperature because of the isothermal process. Drying at low temperature and dampness can only be completed utilizing a desiccant, which can keep up the colours of the material which in this case its food. Other drying strategies can just create low humidity in the air at high temperatures.

Utilizing an alternate drying process, a similar item demonstrated critical impacts in surface, shading, and supplement content (Misha .S, 2012)

The hybrid solar thermal drying system in the present work was developed from a mixed mode common convection solar dryer, regular convection thermal back up unit, and recuperation dryer (Tadahmun A. Yassen, 2016). The mixed mode regular convection solar crop-dryer is possibly best and it seems, by all accounts, to be especially encouraging in tropical moist zones where climatic conditions support sun drying of agrarian items. The regular convection sun powered dryer was built from single pass twofold stream sun based air radiator with the roughened safeguard plate and drying chamber. The recuperation dryer was a half breed dryer built from an immediate sort regular convection sunlight based dryer and rectangular conduit. The warm go down unit involves gas-to-gas warm exchanger and fuel burner. (Tadahmun A. Yassen, 2016)

The drying chamber was made from aluminum angles to prevent heavy weight. The drying chamber size is (1100 mm in width × 420 mm in depth × 900 mm in height). The dryer connected with the solar collector directly through the duct the trays are made portable to permit loading, unloading and cleaning. The trays were placed on top of each other in order of bottom tray, middle tray, and top tray or as shown in Figure 2.1.

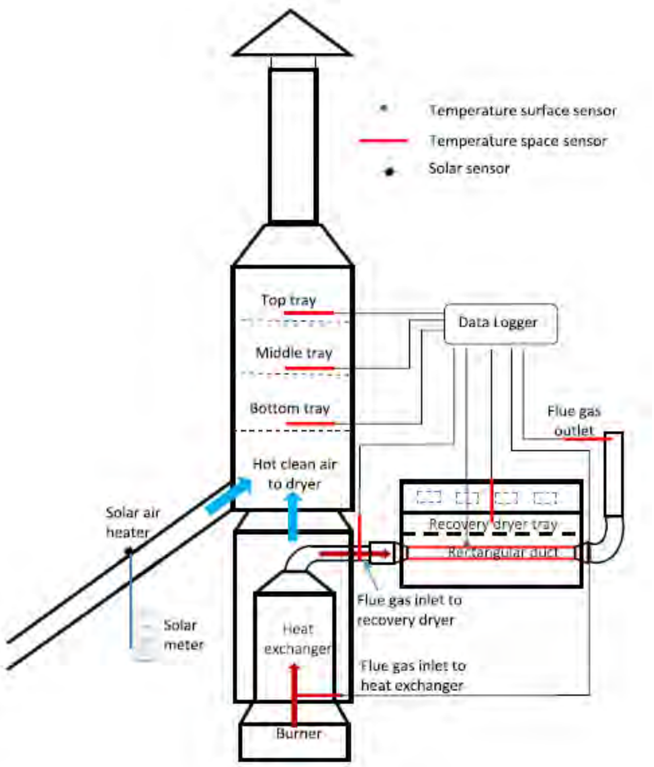

Figure 2.1: Hybrid solar thermal drying system. Source: (Tadahmun A. Yassen, 2016)

The hybrid solar thermal drying system have the trays placed on top of each other leaving a gap between each tray and the one above it. This pattern creates a various drying rate for each of the trays. So, the bottom tray gets heated first which allows the material placed on that tray to get dried first. Time delay will occur in drying each of the rest of the trays, because the bottom tray gets the most of heat as well as the airflow. After that, the middle tray gets dried and the top tray will be the last to get dried. This non-uniform drying rate can affect the quality of the material that is required to get dried, in which the bottom tray gets dried first. During the top and middle still in the process of drying their material, the bottom tray would have its full drying period. By the time the rest of the trays have completed their drying time the bottom tray will be a little over dried, which can affect the quality of the material. The same issue happens between the middle and the top tray (Tadahmun A. Yassen, 2016). The Figure 2.2 this affect by looking at the temperature difference in the early stages. the hybrid solar thermal drying system cannot contain big amounts of materials due its number of trays in the drying chamber.