SIMULATION STUDY OF DRYING CHAMBER FOR MARINE PRODUCT

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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 “Simulation Study for Drying Chamber for Marine Product” 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.

Signature	:.	.....
Name of Supervisor	:	.....
Date	:	.....

DEDICATION

To my beloved mother and father

ABSTRACT

Drying chamber is one of the application in the drying process. This application is widely used in various industries such as marine, agricultural product and others. In this study, a drying chamber for drying process on marine product was selected. It able to produce high quality and hygienic of products. The propose design of drying chamber consist of trays that arranged differently for each design. However, the distribution of velocity and temperature along the trays is not uniform due to different position of trays. This uneven dried of product contributed to the low quality of product. Therefore, there are five configurations of trays has been analyzed in order to obtain the best performance of uniformity velocity and temperature distribution within drying chamber. The prediction of the distribution of velocity and temperature in the chamber along the trays has been simulated by using Computational Fluid Dynamics (CFD) software which is Ansys Fluent 16.1. Operating and boundary conditions is determined based on the literature review. A validation is performed by comparing the data obtained from the CFD simulation with the data experimental from the literature review to ensure the correct method is used. Then, the simulation conducted with 2-Dimensional geometry that sliced into two halves and the sliced face is set as a symmetry plane for the analyzation in steady state condition. Nine points are plotted at the different coordinates on the trays to obtain range of velocity and temperature on each trays for all the configurations. The data obtained is tabulated in a table based on the designs. Comparison all the configurations based on the difference values for each points. Less differences for each points contributed the more uniformity of distribution. The best configuration of trays is determined by achieved both of uniformity and proposed as the best design. From the results obtained, it concluded that design (A) and (D) are choose as the best designs for uniformity that can be developed in future study.

ABSTRAK

Kebuk pengering adalah salah satu aplikasi dalam proses pengeringan. Aplikasi ini digunakan secara meluas dalam pelbagai industri seperti produk marin, pertanian dan sebagainya. Dalam kajian ini, ruang pengering untuk proses pengeringan pada produk marin telah dipilih. Ia mampu menghasilkan produk yang berkualiti tinggi dan bersih. Reka bentuk yang dicadangkan untuk ruang pengering terdiri daripada dulang yang diatur secara berbeza untuk setiap reka bentuk. Walau bagaimanapun, pengedaran halaju dan suhu di sepanjang dulang tidak seragam disebabkan kedudukan dulang yang belainan. Produk kering yang tidak sekata ini menyumbang kepada kualiti produk yang rendah. Oleh itu, terdapat lima konfigurasi dulang yang dianalisis untuk mendapatkan prestasi terbaik keseragaman pengedaran halaju dan suhu dalam ruang pengeringan. Ramalan pengedaran halaju dan suhu di dalam kebuk yang merentasi dulang telah disimulasikan dengan menggunakan perisian Perkomputeran Dinamik Bendalir yang merupakan Ansys Fluent 16.1. Syarat operasi dan sempadan ditentukan berdasarkan semakan kesusasteraan. Pengesahan dilakukan dengan membandingkan data yang diperoleh daripada simulasi CFD dengan data eksperimen dari kajian literatur untuk memastikan kaedah yang digunakan adalah benar. Kemudian, simulasi dilakukan dengan geometri 2 dimensi yang dipotong ke dalam dua bahagian dan permukaan pemotongan ditetapkan sebagai satah simetri untuk dianalisis dalam keadaan tetap. Semua profil pengagihan halaju dan suhu dalam ruang pengeringan telah dianalisis oleh simulasi CFD. Sembilan titik diplot di atas dulang pada koordinat yang berbeza untuk mendapatkan julat halaju dan suhu pada setiap dulang untuk semua konfigurasi. Data yang diperolehi disusun dalam jadual mengikut reka bentuk masing-masing. Perbandingan semua konfigurasi dilakukan berdasarkan perbezaan nilai untuk setiap titik. Semakin rendah perbezaan untuk setiap titik, semakin mudah untuk mencapai keseragaman. Konfigurasi terbaik dulang ditentukan dengan mencapai kedua keseragaman dan akan dicadangkan sebagai reka bentuk terbaik. Dari hasil yang diperoleh, ia menyimpulkan bahawa reka bentuk (A) dan (D) dipilih sebagai reka bentuk terbaik untuk keseragaman yang boleh dibangunkan dalam kajian pada masa depan.

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LIST OF ABBREVIATIONS

CFD	Computational Fluid Dynamic
FE	Finite Element
FD	Finite Dynamic
CAD	Computer-aided Design
2D	Two dimensional
3D	Three dimensional
UV	Ultra-violet

LIST OF SYMBOL

ρ	=	Density of fluid
k	=	Turbulent kinetic energy
ε	=	Rate of dissipation
μ	=	Dynamic viscosity
μ_t	=	Turbulent viscosity
S_k, S_ε, S_h	=	User-defined source terms
G_k	=	Generation of turbulent kinetic energy due to the mean velocity gradients
G_b	=	Generation of turbulent kinetic energy due to buoyancy
σ_k	=	Turbulent Prandtl numbers for k
σ_ε	=	Turbulent Prandtl numbers for ε
C_p	=	Specific heat capacity at constant pressure
T	=	Temperature
Pr_t	=	Prandtl number
E	=	Total energy
p	=	Pressure

CHAPTER 1

INTRODUCTION

1.1 Background

Drying process are widely used in several of industries especially in food industry which have a huge impact to this industry (Fuente-blanco and Sarabia, 2006). Drying is defined as a mass transfer process resulting in the removal of water moisture or moisture from another solvent, by evaporation from a solid, semi-solid or liquid (hereafter product) to end in a solid state (Arun, 1995; Noh, Mat and Ruslan, 2018; Pravin et al., 2017). The purpose of drying process is to lessen the amount of water content in the product to make sure the environment become inappropriate for proliferation of microorganisms (Putra and Ajiwiguna, 2017; Noh, Mat and Ruslan, 2018). Therefore it can prolong the shelf-life of products and furthermore can decrease the expenses of transportation and capacity (Zhang and Fournier, 2017).

Drying process is important as the most effective and practical method for food preservation to reduce losses especially in produced marine product such as salted fish, anchovies and others since it can be safely stored for longer period of time. This method widely used at the state whereas nearby with the sea such as Terengganu, Sabah and others as their business.

Normally, people at the Malaysia are using open sun drying method to dry their marine products such as salted fish, small prawns, anchovies and others. However, this method has several disadvantages such as exposed to the dust, air pollution or the case of

pest or insect attacked on the products and lack of hygienic (Pravin et al., 2017; Rizal and Muhammad, 2018; Misha *et al.*, 2014). Besides that, this method also not effective when the condition is not conducive such as rainy season, therefore artificial drying process is needed to be develop (Pravin et al., 2017; Putra and Ajiwiguna, 2017). It will took a long period of drying rate during cloudy weather and limitations of time during rainy day. Therefore, the products of drying become low quality of products (Pravin et al., 2017; Jamila et al., 2018).

There are many advantages for using this method which are the quality of the products is higher due to sun drying because it can prevent the products from the contamination and the case of pest and insect attacked on product is reduced (Pravin et al., 2017; Anna et al., 2014; Jamila et al., 2018).

Other than that, solar drying system can save energy, consume less time, use less space, enhance the quality of product, improve the efficiency of the drying process and save the environment (Misha and Yusof, 2018).

The characteristics of great drying chamber are the uniformity air flow distribution in the chamber to make sure uniform drying of product (Misha *et al.*, 2014; Paper, 2015; Jia *et al.*, 2016; Zhang and Fournier, 2017; Zhang and Long, 2017). Drying uniformity can be enhanced when air flow distribution throughout the drying chamber in a good condition (Misha *et al.*, 2013, 2014). The purpose of uniform air flow distribution is to improve the efficiency of drying chamber so that the homogeneity of product being dried become improved (Misha *et al.*, 2014). In order to get uniformity air flow distribution, the arrangement of tray dryer must be improved. The alternate arrangement of dryer tray position was embraced to guarantee that all the plate are exposed straightforwardly to drying air and to enhance airflow distribution throughout the drying chamber (Paper, 2015). Other

than that, air temperature and velocity also influenced in the drying process. The range of air velocity in the drying process is 1.5 m/s to 3 m/s (Putra and Ajiwiguna, 2017). However, sometimes the air velocity is depended on moisture content of product. The evaporation rate from the product will be rise when the temperature of air increased. So that, the capacity of water vapour become larger (Misha et al., 2015).

There are many components in the drying chamber as shown in Figure 1.1. The main components of the drying chamber are:

1. The cabinet / chamber

2. Dryer tray

3. Heat Source

4. Inlet and outlet

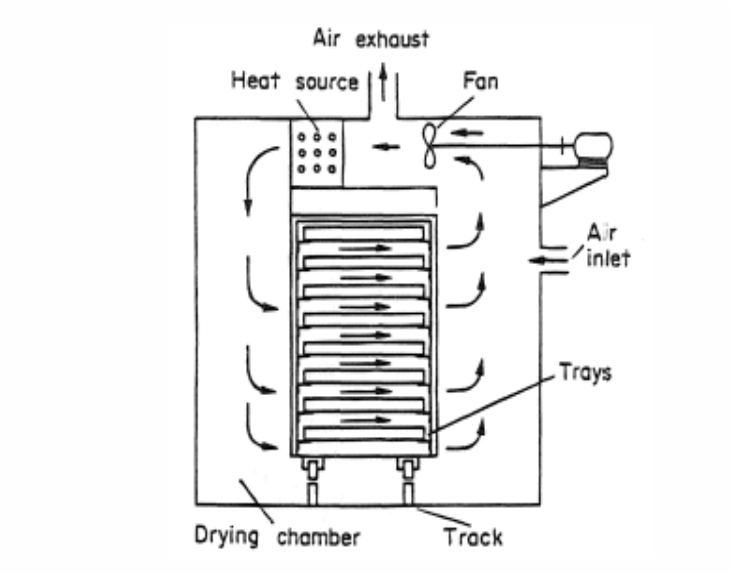

Figure 1.1 The example of drying chamber *(*After Sloan ,1967)

The most suitable method to evaluate that drying chamber is simulated by Computational Fluid Dynamics (CFD) due to the expensive and difficulties of the measurement for drying parameters if doing an experiment. Nowadays, the CFD simulation is used extensively because it's capable to solve the equations for many cases such as conservation of mass, momentum and energy using numerical methods to predict drying parameters which are temperature, velocity and pressure profiles (Misha *et al.*, 2014; Paper, 2015). The users of CFD simulation become increase throughout the year. They become more realized that used CFD simulation is easier than experimental. This is because it is very appropriate to use for estimation of drying parameters in the drying chamber compared to the experiment which are expensive, difficulties and consume a lot of time to install a few equipment (Paper, 2015). Besides that, by using this software, all the parameters can be adjusted freely in orders to get the best solutions.

In this study, the prediction of drying time of a marine product to dry are simulated and compared by using Computational Fluid Dynamics (CFD) analysis which is ANSYS. The study has involved two-dimensional fluid domain in steady state simulation. This state has study about the predicted air flow and temperature distribution of domain. The profiles of air velocity and temperature can be studied for analysing the uniformity distribution in the chamber.

1.2 Problem Statement

Drying process by sun drying is the most popular method used by Malaysian citizen to dry their foods especially in marine product such as salted fish, anchovies and others as food preservations. However, this method has many limitations caused of weathers at the Malaysia is not hot throughout the year since Malaysia located at the equator of the earth which are hot and rainy weather. Therefore, it took a long period of drying during cloudy weather and the product does not dry well that caused the declined quality of product and reduced time to store. Basically, sun drying needed a large space when involved a lots of quantities of dried products. So that, the products exposed the product to the contamination of dust, pollution and insect. Therefore, a drying chamber with technology must be develop to overcome this problem. However, various of drying chamber in the industries also have limitations such as the sources of heat likes fan or blower installed in the infrared drying system causing the inaccurate distribution of temperature in the chamber as well as limiting amount of product to be dried. The influence of geometry of drying chamber such as the locations of inlet and outlet and also the arrangement of trays in the chamber will also affecting the rate of drying. Furthermore, the not suitable temperature with the moisture content of product will caused it either over dried or not-fully dried. So that, the texture and freshness of product will be damaged. So, the product will lack of quality to be in food industry. Therefore, in order to improve the performance of drying chamber in industries, simulation by using Computational Fluid Dynamics (CFD) can be conducted in order to identify and predict the best design of drying chamber that can fulfil all the issues related the performance of drying chamber especially in term of uniformity drying rate.

1.3 Objectives

The objectives of this study are:

1. To determine the best temperature distribution in drying chamber using Computational Fluid Dynamic (CFD) Simulation.
2. To determine the best velocity distribution in drying chamber using Computational Fluid Dynamic (CFD) Simulation.
3. To propose the best configuration of trays using CFD simulation.

1.4 Scope of Work

The scope of works for this study are:

1) Specifically for the marine product.
2) Verification and validation results of existing drying chamber from publish journal.
3) The simulation will be carried out by using CFD simulation which is ANSYS Fluent 16.1.
4) The simulation conducted in 2 dimensional geometry.
5) To perform steady state condition of analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Drying

Drying has been used widely as the method for food preservation and one of the integral part of food processing. This method has been discovered and carried out since the early recorded history of human civilization (Henry, 2018). Drying process is defined as the process of the mass transfer that resulting in the removal of water content or moisture content from another solvent from solid, semi-solid or liquid (hereafter product) by evaporation to end in a solid state. The proper drying results in a concentrated food source which is can be handle easily and distribute due to weight and volume reduction of the product.

The purpose of drying process is to lessen the amount of the water content in the product especially in marine product to make sure the environment become inappropriate for the growth of microorganisms such as bacteria, insects larvae and others. The activity of this microorganisms and insects is inhibited in an environment where the equilibrium relative humidity is below 70%. Therefore, it can prolong the shelf life of products and can reduce the expenses of transportation and capacity. So that, the product can be safely stored for a long time. The process is very important as the most effective and practical method for food preservation to reduce losses especially in produced dried squid since it can be safely stored for a longer period of time. Therefore, the preservation of the merchandise (dry product), drying will bring on savings in storage and transport of foods will be reduced as a

result of the reduction in the amount of weight and bulk that happens throughout most ways of drying (Rizal and Muhammad, 2018).

Drying process is affected by many factors such as air velocity, temperature and pressure to ensure all the process worked well. The most important factor that affected the drying rate is temperature of drying air (Krokida et al., 2003). Babalis et al. state that air velocities in drying process in greater that 2 m/s has no significant effect on the drying rate. In the conclusion, the most significantly affected by the air temperature is drying kinetics.

Putra and Ajiwiguna (2017) have conducted an experiment to analyse the effect of the air temperature and velocity in the process of drying. Based on the result obtained, it can be concluded that the effect of temperature is less significant at high air velocity. The basic principle of drying process is to transport water vapour from wet object to the air. Velocity of air is proportional to the mass flow rate of air. At higher mass flow rate, the capacity increase since a lot of amount of air.

2.2 Method of Drying

2.2.1 Natural Drying

In the history, the natural resources such as the sun and the wind were used in order to remove the water or moisture from the food likes fruits, meats, grains and herbs (Ahmed *et al.*, 2013). Natural drying as shown in Figure 2.1 is the method of drying where the product has been exposed to the sunlight directly to reduce the moisture content of product as food preservation also known as sun drying. So that, it can be stored safely in longer time of period. In the developed countries, the most common method for drying is open sun drying as the simplest and most economical method of food preservation. Open sun drying also known as traditional drying method before technology has been developed in the world.