CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1 Solar dryer greenhouse

Agriculture greenhouse is primarily used to protect crop from harsh environment such as heavy rain and also to protect the crop from pest and diseases. However due to higher temperature inside these greenhouses in hot climate zone such as Malaysia this greenhouse also can be used as a crop dryer. Greenhouse as a dryer offers a low-cost dryer as it can dry products in a bulk quantities due to its big size,but at the same time having low operating cost compared to other types of dryers.

The principle of crop drying inside a greenhouse under natural convection can be explained aswhen a plastic cover is placed over the crop, it will produce a greenhouse effect as it traps the solar energy in the form of thermal heat within the cover since the plastic cover acts essentially as transparency to the thermal heat radiation radiated by the sun and reduces the convective heat loss. Further, the remaining solar radiation will heat the enclosed air inside the greenhouse. This will increase the temperature of the air inside the greenhouse. The natural ventilation called buoyancy effect takes place due to the temperature difference between the greenhouse and ambient air.

Drying process is a process to reduce the water content or the moisture inside the crop. Therefore the moisture evaporation process is the most important aspect to ensure the success of crop drying. The rate of moisture evaporation depends on the vapour pressure difference between the crop and the greenhouse air. The moisture evaporation rate is also known as drying rate.

Drying speed or also known as drying rate is determined by the temperature and moisture content of the crop as well as the temperature, relative humidity and velocity of the drying air inside the drying chamber or in this case inside the solar dryer greenhouse. Therefore in developing solar dryer greenhouse efficient control on temperature, relative humidity and ventilation inside the greenhouse is very important. There are few methods to control the indoor environment. Incorporating mechanical ventilation system is one of the methods that offer direct methods to do this. This can be done by modifying the velocity and psychometric properties of the system that can precisely control indoor environment in all weather condition. Although it seems to be the most effective technique, this system used more energy and due to fuel price issue, natural ventilation method is now becoming more frequently investigated by researchers. Natural ventilation is driven by two mechanisms. The first mechanism is called “stack effect” where ventilation is caused by thermal buoyancy. This mechanism depends on the heating caused by the incoming convective and radiative fluxes or by the metabolism of the occupant. The second mechanism is by wind. In this mechanism ventilation is caused by the wind exertion pressure variation over the building envelope that forcing airflow across ventilation opening. For natural ventilation, the design of the structure plays the most important factor in controlling the indoor climate of the solar dryer greenhouse.

1.2 Scope of the dissertation.

A small scale solar dryer greenhouse (mono-span with pitch roof design) (Figure 1.1) was built at MARDI* to introduce a new method of drying agriculture product in Malaysia. The solar dryer greenhouse was built with the size of 4.5 m width by 4.5 m length by 3.0 m height of the drying chamber and the square shape chimney height of 3.0 m with 0.3m width and 0.3m length. As described by Rezuwan et al.(2007) the solar dryer structure was made of reinforce concrete floor, galvanized steel square hollow section frames, and clear polyethylene thermic film cladding for the drying chamber and the chimney. On a clear sunny day, the heat trapped inside the structure has increase air temperature inside the greenhouse and reduce air relative humidity as compare to outside environment. These conditions are necessary for the drying process of most tropical agriculture product. Due to its low cost, simplicity and ease of construction it can be easily adopted by farmers at all levels. Solar chimney was build at the top of the greenhouse roof to enhance the ventilation rate of the greenhouse.

This project has two objectives which are:

1. To analyse the temperature and air flow distribution inside solar dryer house by using three-dimensional computational fluids dynamic as a simulation tool.
2. To redesign and increase the efficiency of the current solar dryer greenhouse.

Theconditionsthat are taken into considerations are as shown in table below:

Table 1.1: Conditions considered in the study

Condition	**Description**	**Date**	**Time**
1	Roof and side openings opened	13th March 2011 and 21st March 2011	10.30 am, 1.30 pm and 4.30 pm (for each date)
2	Roof opening opened and side openings closed	26th March 2011 and 4th April 2011	10.30 am, 1.30 pm and 4.30 pm (for each date)

*MARDI = Malaysia Agriculture Research and Development Institute

The results from the simulation will be compared with the measured data as a validation of the simulation process. From the results, further study will be carried out to improve the efficiency of the solar dryer greenhouse.

Figure 1.1:Solar dryer greenhouse building at MARDI.

1.3 Proposed method

Computational fluid dynamics is a tool that can be used to analyse the solar dryer greenhouse design before the actual dryer is build. Although physical experimentation allow for accurate environment measurement without the need for modelling assumption, it would not only require expensive equipment but also required large amount of time. Computational fluid dynamics (CFD) is a simulation technique that can be used to accurately quantifying indoor climatic variables of ventilated buildings under various design condition within a virtual environment. Therefore by using CFD designprocess of the solar dryer can be done more efficiently before the actual structure is developed. In this study CFD commercial software ANSYS CFX version 12.1 is being used. The steps included in performing the analysis areshown in Figure 2.1:

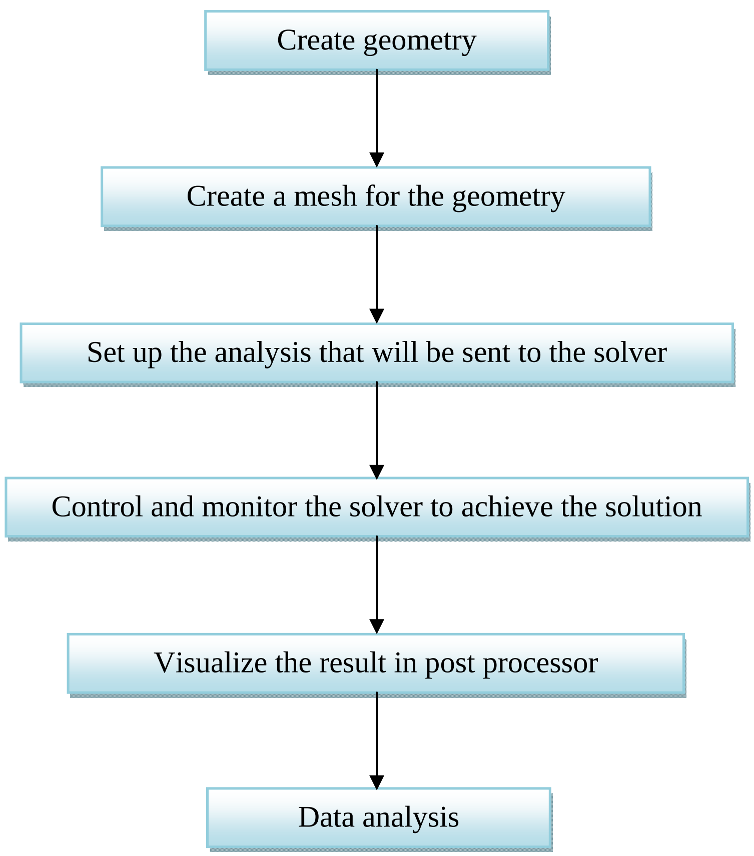

Figure 1.2: Steps included in performing the CFD analysis in this project.

1.4 Outline of the dissertation

The remainder of this thesis is organized as follows,

i) Chapter 2 introduces the literature review on history, design and development of the solar dryer greenhouse, previous studies on greenhouse using CFD tools and the governing equations behind CFD analysis.

ii) Chapter 3 presentsa detailed methodology on how the simulation and data collectionare carried out.

iii) Chapter 4 discusses the simulation results compared to the measured data.

iv) Chapter 5 discusses on the proposed improvement to the current design of solar dryer greenhouse.

v) Chapter 6 summarizes the conclusions of this dissertation.