



Faculty of Electrical Engineering

**DESIGN AND DEVELOPMENT OF PROCESS AND PRODUCTION
PLANT FOR AGARWOOD OIL**

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Master of Science in Electrical Engineering

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**DESIGN AND DEVELOPMENT OF PROCESS AND PRODUCTION PLANT FOR
AGARWOOD OIL**

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**A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Electrical Engineering**

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this thesis entitled “Design and Development of Process and Production Plant for Agarwood Oil” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Norul Rasyidi Bin Muhammad Nasardin

Date :

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electrical Engineering.

Signature :

Supervisor Name : Prof Madya Mohd Ariff Bin Mat Hanafiah

Date :

DEDICATION

To my beloved parents and friends for support and encouragement, love and cares in the entire master program.

ABSTRACT

Agarwood oil is very valuable oil and widely used in medicine, perfume, religious, cultural applications and cosmetic industries. In addition, the production of agarwood has a diverse range of prospects in Malaysia. However, knowledge on distillation process and standard for quality of the oil are far from sufficient. Nowadays, the quality of agarwood oil is difficult to maintain because of the uncontrolled the process system. Therefore, the purpose of this research is to design a fully automated system for hydro distillation process that can produce higher oil yield with better quality with high monitoring security. The hydro distillation process takes into account of several parameters which is emphasizes on two most significant process parameters: temperature and pressure. In this study, the Agarwood raw materials will be soaked with mineral water for a certain period of time before going through the hydro-distillation process. The raw materials boiling will be closely monitored and will be automatically agitated at periodically at certain speeds by using a fully automated PLC-based control system with the help of HMI/SCADA. The whole hydro-distillation process itself can also be monitored and operated remotely using HMI/SCADA. For the result, the process with fully automated system has increased 60% oil yield compared to manual system. In addition, the yield of oil also increased by 13% using the inoculated wood (Roselle biotech formula Inoculation) compared to natural wood. The analysis of FTIR and GCMS has shown that there are less organic alcohol presence and many organic nature compound was detect. In conclusion, the improvement of the process system had been shown that the system has increases the profit, high monitoring, less human error, increases inefficiency of process and reduce capital cost.

ABSTRAK

Minyak gaharu adalah minyak yang sangat berharga dan digunakan secara meluas dalam bidang perubatan, minyak wangi, agama, aplikasi kebudayaan dan industri kosmetik. Di samping itu, pengeluaran gaharu mempunyai pelbagai prospek di Malaysia. Walau bagaimanapun, pengetahuan tentang proses penyulingan dan standard untuk kualiti minyak adalah jauh dari mencukupi. Pada masa kini, minyak gaharu sukar untuk mengekalkan kualiti produk kerana sistem kawalan yang tidak terkawal. Oleh itu, tujuan penyelidikan ini adalah untuk merekabentuk sistem automatik sepenuhnya untuk proses penyulingan hidro yang dapat menghasilkan hasil minyak yang lebih tinggi dengan kualiti yang lebih baik dengan keselamatan pengawasan yang tinggi. Proses penyulingan hidro mengambil kira beberapa parameter tetapi ia menekankan pada dua parameter proses yang paling penting: suhu dan tekanan. Dalam kajian ini, bahan mentah Agarwood akan direndam dengan air mineral untuk jangka masa tertentu sebelum melalui proses hidro-penyulingan. Bahan mendidih mentah akan dipantau dengan teliti, dan secara automatik akan digali secara berkala pada kelajuan tertentu dengan menggunakan sistem kawalan berasaskan PLC automatik sepenuhnya dengan bantuan HMI / SCADA. Proses hidro-penyulingan itu sendiri juga boleh dipantau dan dikendalikan dari jauh menggunakan HMI / SCADA. Hasilnya, proses dengan sistem automatik sepenuhnya meningkat 60% hasil minyak berbanding dengan sistem manual. Di samping itu, pengeluaran minyak juga meningkatkan hasil minyak sebanyak 13% dengan menggunakan kayu yang diocok (Roselle biotech formula Inoculation) berbanding dengan kayu tulen. Analisis FTIR dan GCMS telah menunjukkan bahawa terdapat kehadiran alkohol yang kurang organik dan sebilangan sifat organik organik telah mengesan. Untuk kesimpulan, peningkatan sistem proses telah ditunjukkan bahawa sistem telah meningkatkan keuntungan, pemantauan yang tinggi, kurang kesilapan manusia, meningkatkan ketidakcekapan proses dan mengurangkan kos modal produk.

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LIST OF ABBREVIATIONS

SCADA	-	Supervisory Control and Data Acquisition
HMI	-	Human Monitoring Interface
PLC	-	Programmable Logic Controller
GC-MS	-	Gas Chromatography Mass Spectrometric
GC-FID	-	Gas Chromatography Flame Ionization Detector
FTIR	-	Fourier Transform Infrared Spectroscopy
HMD	-	Human Monitoring Device
DC	-	Direct Current
NMR	-	Nuclear Magnetic Resonance
E-nose	-	Electronic Nose

LIST OF SYMBOLS

W_{H_2O}	-	Water weight in condensate
W_{oil}	-	Oil weight in condensate
P_{H_2O}	-	Vapour pressure of water
P_{oil}	-	Vapour pressure of oil
M_{H_2O}	-	Molecular weight of water
M_{oil}	-	Molecular weight of oil

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1. Nasardin, N.R.M., Hanafiah, M.A.M., Zainon, M., Ibrahim, M., Rahman, A.I.A., Baharudin, Z.A., Husin, M.H.M., Mahir, I., and Zulkefle, A.A., 2018. Comparison of Chemical Compounds of Essential Oils from Natural Agarwood and Inoculated Agarwood (Roselle-Based Inoculation). *Indonesian Journal of Electrical and Computer Science*, 11(2), pp. 677–681. (Indexed by SCOPUS)
2. N.R.M., Nasardin, M.A.M., Hanafiah, M., Zainon, M., Ibrahim, A.A., Zulkefle, and A.I.A., Rahman, 2018. Comparative Study on Steam Distillation and Hydro-Distillation Methods for Agarwood Oil Extraction. *International Journal of Applied Engineering Research*, 13(8), pp. 6253–6256. (Indexed by SCOPUS)

CHAPTER 1

INTRODUCTION

Automation system has been evolving rapidly in industrial fields and all types of machines that need a system to change from manual system to automated system. This change will ease the whole procedures involved and produce a high-quality product. The purpose of this research is to design and innovate the development of process and production plant for agarwood oil with fully automated system.

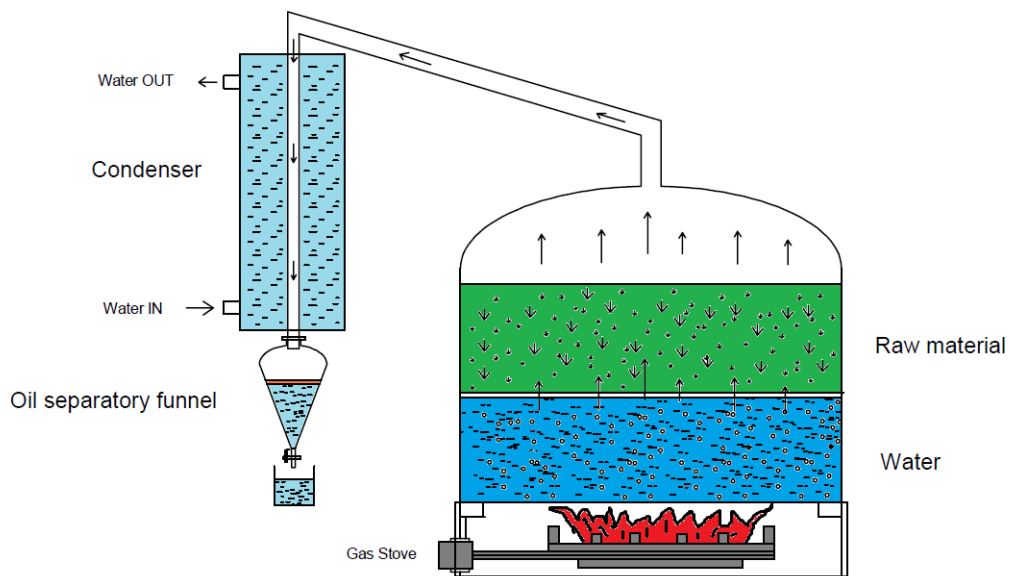
1.1 Introduction to Agarwood Oil

Nowadays, world research and development in process agarwood oil technology is rather encouraging. However, in Southeast Asian, the development in process and production agarwood oil is very slow. Few studies on evaluation of agarwood oil in Southeast Asian continental have been reported. (Atikah et al., 2015; Abidin et al., 2015; Nazurah et al., 2009), Thailand (Pornpunyapat et al., 2011) and Bangladesh (Akter et al., 2013; Islam et al., 2014). These studies proved that Southeast Asian continental have potential in developing agarwood oil in term of raw material and type of process.

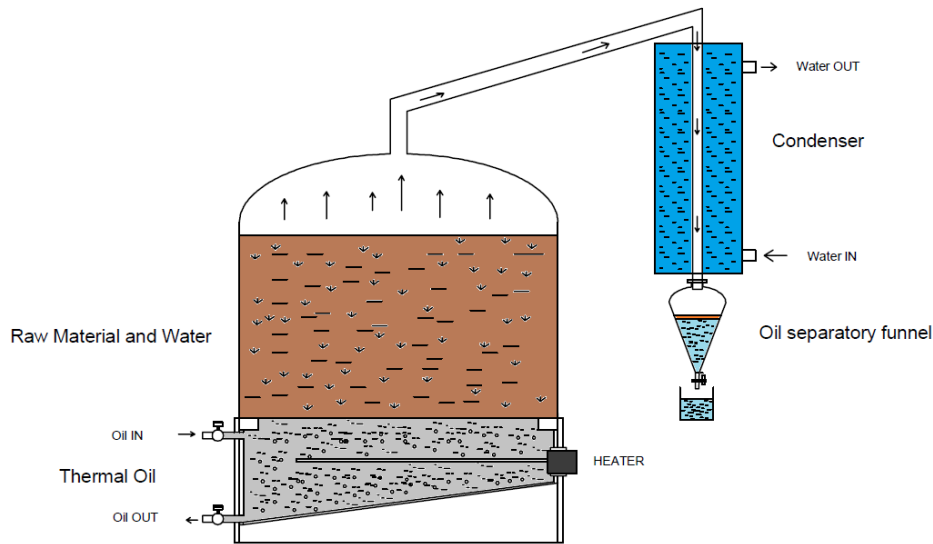
Agarwood oil is widely used in medicine, perfume, religious, cultural applications and cosmetic industries due to its unique properties and high medicinal value. In medicine, they used agarwood oil as one of the combination chemicals for treatment for a skin disease. For Muslims, they used agarwood oil as their perfume during prayer. In China, people used agarwood oil as their daily health drinks which is mixed with one drop of agarwood oil. They

believe that the agarwood oil can make their body become healthy and energetic. Other than that, the agarwood wood can also be used to make Chinese plug for their religious prayer.

The agarwood oil distillation process is used in distillation process, there are two methods; hydro-distillation (manual) and hydro-distillation (automated) according to Figure 1.1. The best technique to produce good and high production oil is the hydro-distillation process. In hydro-distillation process there are two stages; immersion process and refining process. In Immersion process, there will be a timer to monitor the duration for the raw material to sink in with the mineral water. Then, for the refining process the raw material will be heated and water vapor will be produced. The water vapor will flow to the condenser and hence, the agarwood oil is produced. This condenser will control the temperature by using the chiller.



(a)



(b)

Figure 1.1: Types of agarwood oil process (a) hydro distillation (manual) and
(b) Hydro-distillation (automated)

Distillation is defined as “the separation of the components of a mixture of two or more liquids by virtue of the difference in their vapour pressure” (Stephen Miall, 1940). The most important thing is to produce an essential oil using the distillation process. There are two general types of distillation process to be considered. First, the distillations are not miscible and will be carried out in two phases that practically will be applied to the rectification and fractionation of essential oils with the steam to the isolation of volatile oils from an aromatic plant. Hydro-distillation is the general term that implies the distillation process that may be carried out either by boiling the plant materials or essential oil with water by creating the steam or introduced into the retort live steam generated with a separated steam boiler. Second, the distillation of liquids which are completely miscible in each other and only form one phase that practically applies to the rectification and separation of an essential oil into several fractions without the use of steam.

The composition of the oil distillates from a mixture of two insoluble liquids, the weight quantities of the two substances depend primarily upon the boiling points, or the vapour pressure at the distillation temperature. The quantitative composition of the oil distillates can be calculated in advance when the hydro-distillation is chemically uniform with the substances insoluble in water. The basic hydro-distillation rules of the essential oils or volatile substances in general can be expressed in equation (1.1).

$$\frac{W_{H_2O}}{W_{oil}} = \frac{P_{H_2O}}{P_{oil}} \times \frac{M_{H_2O}}{M_{oil}} \quad (1.1)$$

In which, W_{H_2O} is the weight of water in the condensate; W_{oil} is the weight of oil in the condensate; P_{H_2O} is the vapor pressure of water at a distillation temperature; P_{oil} is the vapor pressure of oil at a distillation temperature; M_{H_2O} is the molecular weight of water (=18) and M_{oil} is the molecular weight of oil (assuming that this constant may be determined as an average figure).

All of the heater and cooling system will fully control by Programmable Logic Controller (PLC). The temperature sensor will send the input to PLC and show the value at the Human Machine Interface (HMI) and Supervisory Control and Data Acquisition (SCADA). Both of this will be the monitoring system and control data collection system.

1.2 Motivation of Research

This research embarks into following motivation: -

- 1) The important things for the process of agarwood oil is about the temperature control. If the temperature is too hot, the quality production of the oil will be effect with the smell become a foul odor (Zubir et al., 2016).

- 2) Nowadays, there are many Agarwood producers did not apply any safety features when they are doing this process. The safety is crucial because the process is involving the high-pressure process. If the pressure is too high the system will release high pressure from pressure relief valve (Rajkanna et al., 2016). So, to make the process become safer the pressure sensor must be installed inside the system. The heat will be cut off after the pressure reached the maximum state.
- 3) For monitoring system, HMI and SCADA will be used and connected to PLC. This system will help and ease the job to monitor the situation of the process (Shyr et al., 2013). Other than that, this system will be easy for the worker to operate the process of hydro-distillation.
- 4) The grade of the oil will come out by using the FTIR and GCMS. From there the chemical composition of the oil and the presence of others chemical will know (Alia et al., 2015).

1.3 Problem Statement

The process of agarwood oil starts from the natural equipment and evolved until the high modern machine. Nowadays, manual system is still used to process the oil. There are several problems that need to be improved. Firstly, the heat controls. When the process is overheated, the quality of the oil decreases and an unpleasant smell will be produced. Some of the agarwood producers produce the oil by using wood fire or gas stove. The heat cannot be controlled correctly by using that method. Otherwise, if the heat temperature reached its maximum level, the raw material will close up the closure funnel.

The process is difficult to be monitored manually and when a problem occurs during the process, they will not be alerted with the problem and it is impossible for them to solve the