IMAGING CONCENTRATION PROFILE OF FLOWING PARTICLE USING HALOGEN LAMP AND OPTICAL SENSOR

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honours

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Date	: 9 MAY 2008

Dedicated to my family, lectures and to all my friends,
My appreciation to all of you for providing me assistance and encouragement
throughout my final year project in Universiti Teknikal Malaysia Melaka (UTeM)

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ABSTRAK

Projek ini bertujuan untuk mengkaji kombinasi lampu halogen dan optik untuk mengukur profil penumpuan bagi objek bergerak. Lampu halogen berfungsi sebagai pemancar cahaya dan penderia optik (potodiod) digunakan sebagai penerima. Pemancar dan penerima diletakkan bertentangan antara satu sama lain , jadi cahaya dari pemancar dipancarkan terus kepada penerima. Ini memberi imej keratan rentas taburan bahan yang melalui satu paip penghantaran. Imej ini di bentuk melalui pemprosesan semula data yang diperoleh daripada jujukan sensor yang diletakkan di bahagian luar paip penghantaran. Kemudian, komputer digunakan untuk mempamerkan imej tersebut. DAS kad berfungsi sebagai perantara antara perkakasan dan perisian bagi permbentukan kerataan rentas imej tersebut.Selain perkakasan, projek in juga menggunakan perisian Visual Basic bagi tujuan penghasilan imej visual profil penumpuan bagi partikal bergerak tersebut. Pada masa kini, kaedah radioaktif digunakan dan ianya bahaya pada pengguna. Oleh yang demikian, projek ini mempunyai banyak kebaikan berbanding cara tomograpi yang lain seperti ianya murah dan selamat dan juga dapat mengurangkan pembaziran dan menambahbaik produk didalam industri pemprosesan.

ABSTRACT

This project describes an investigation of the use of combination of halogen lamp and optical sensor in the measurement of concentration profile of flowing particles. The halogen lamp is functioning as an emitter and the optical sensor (photodiode) as a receiver. The emitter and receiver were positioned opposite of each other so that the light from the emitter strike directly at the receiver. It provides cross-sectional image of the distribution of the materials. This image is formed by reconstruction of data obtained from the array of sensors. A computer is used to display the reconstruct images of the cross section being interrogated by the sensor. Data acquisition system (DAS) card is used to interfaces the hardware and software for performing image reconstruction. Besides hardware, this project will include the used of Microsoft Visual Basic to visualize the concentration profile of flowing particles. Currently, radioactive method is used in tomography process and it hazard to human body. Thereby, this project has more advantages than the other tomography method such as more cheaply and safer and also can minimize waste and improve the product in process industries.

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CT	-	Computer Tomography
ECT	-	Electrical Capacitance Tomography
AC	-	Alternating Current
PC	-	Personal Computer
A/W	-	Actual weight
DAS	-	Data Acquisition System
DC	-	Direct current
PCB	-	Printed Circuit Board
LBP	-	Linear Back Projection
FLBP	-	Filtered Linear Back Projection
VLBP	-	Voltage Linear Back Projection

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The word 'tomography' is derived from the Greek words 'tomos' meaning 'to slice' and 'graph' meaning 'image'. The Oxford English Dictionary defines Tomography as "Radiography in which an image of a predetermined plane in the body or other object is obtained by rotating the detector and the source of radiation in such a way that points outside the plane give a blurred image. Also in extended use, any analogous technique using other forms of radiation". The Encyclopedia Britannica (volume 11, page 837) describes tomography in a more application-orientated manner which is "a still more complex technique variously called computerized tomography (CT), or computerized axial tomography (CAT), was developed by Godfrey Hounsfield of Great Britain and Allan Cormack of the United States during the 1970s. Most tomographic techniques are concerned with abstracting information to form a cross-sectional image. A computer is used to reconstruct a tomographic image of the cross-section being observed by the sensors.

The basic components of any process tomographic instrument are hardware (sensors, signal/data control) and software (signal reconstruction, display and interpretation facilities, and generation of output control signals to process hardware). The sensor system is at the heart of any tomographic technique. The basis of any measurement is to exploit differences or contrast in the properties of the process being examined.

A variety of sensing methods can be used based on measurements of transmission, diffraction or electrical phenomena. Whilst most devices employ a single type of sensor, there are a number of opportunities for multi-mode systems using two (or more) different sensing principles. At present, the usual objective of tomographic systems is to obtain concentration profile of moving component of interest within measurement section in the form of a visual image which is updates at a refreshment rate dependent upon the process being investigated.

1.2 Aim and Objectives of this Project

The objective of this project is to use the tomographic measurement for monitoring of flowing particles to provide cross-sectional image of the distribution of materials. The specific objectives of this project are:

1. To investigate the use of combination and of halogen lamp and optical sensor for imaging the concentration profile of flowing particles.

2. To create a program for image reconstruction using suitable software.

3. To construct hardware and interfaces it with software through Data Acquisition Card.

1.3 Problem Statement

Currently, certain types of tomography process used radioactive material in tomography process for monitoring of flowing particles. This method is hazard for human body and the cost of this method is expensive and need license or permit to use the instrument.

1.4 Scope

The scopes of this project are:

1. To investigate the suitable types of optical sensor use for imaging concentration profile of flowing particle and to design the receiver circuit with an appropriate gain.

2. To design the signal conditioning circuit on printed circuit board.

3. To search information regarding hardware fabrication techniques

After designing the hardware, data acquisition system is used to interface it with software for data collection and performing image reconstruction. The software is developed by Microsoft Visual Basic.

1.5 Methodology of Project

Firstly, a lot of review from journals, books and articles must be done to really understand this project such as the process of tomography sensing technique and image reconstruction algorithm. Then prototype of a transmitter and receiver circuit can be designed before it is transfers to PCB. For Visual Basic, when the program is functioning and successful, the next step is to interface it with hardware. Then, the result is measured and the data will be analyzed. Finally, the concentration profile of flowing particles can be identified. All the process to complete this project is illustrated in the figure below:

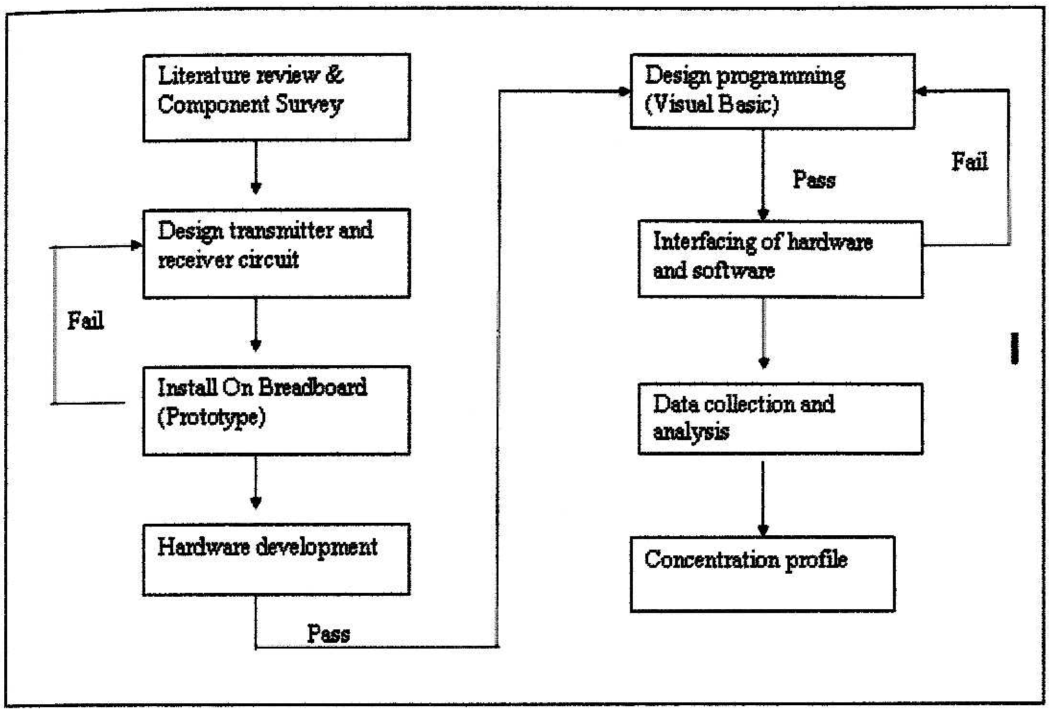

Figure 1.1: Methodology of Project

CHAPTER 2

BACKGROUND STUDY

This chapter presents the overall of tomography background, tomography technique and the background of transmitter and receiver is being used in this project.

2.1 Tomography

Tomography is imaging by sections or sectioning. A device used in tomography is called a tomograph, while the image produced is a tomogram. The method is used in medicine, archaeology, biology, geophysics, oceanography, materials science and other sciences. In most cases it is based on the mathematical procedure called tomographic reconstruction.

For example, in conventional medical X-ray tomography, clinical staffs make a sectional image through a body by moving an X-ray source and the film in opposite directions during the exposure. Consequently, structures in the focal plane appear sharper, while structures in other planes appear blurred. By modifying the direction and extent of the movement, operators can select different focal planes which contain the structures of interest. Before the advent of more modern computer-assisted techniques, this technique, ideated in the 30's by the radiologist Alessandro

Vallebona, proved useful in reducing the problem of superimposition of structures in projectional (shadow) radiography.

The mathematical basis for tomographic imaging was laid down by Johann Radon. It is applied in Computed Tomography to obtain cross-sectional images of patients. This article applies in general to tomographic reconstruction for all kinds of tomography, but some of the terms and physical descriptions refer directly to X-ray computed tomography.

More modern variations of tomography involve gathering projection data from multiple directions and feeding the data into a tomographic reconstruction software algorithm processed by a computer. Different types of signal acquisition can be used in similar calculation algorithms in order to create a tomographic image.

2.2 History & Development of Process Tomography

It is easily forgotten that not yet a hundred years ago the only way to look into the patients' body was via invasive procedures. Within the year of the discovery of X-rays by Conrad Röntgen the need for three dimensional imaging had been voiced .The concept of Tomography was first published as early as 1826, by Abel, a Norwegian physicist, for an object with axi-symmetrical geometry. In 1917, an Austrian mathematician, Radon, extended Abel's idea for objects with arbitrary shapes. Between 1910 and 1940, classical tomography has been the product of individuals rather than collective groups. It is only in the mid thirties that scientists found out about each other and started to correspond vigorously. In 1931 Ziedses des Plantes published the most extensive and thorough study on tomography. In the forties and fifties stagnation is noticed; only further refinements to the existing equipment are carried out [9].

Although Frank and Takahashi published the basic principles of axial tomography in the mid forties, we had to wait for the necessary developments in electronics before Hounsfield was able to develop and commercialize the first axial computer tomography in 1972 (EMI-Scanner). At the time all the big radiology companies rushed into the field and soon, second, third and fourth generation CT scanners became available. Godfrey Hounsfield and Allen Cormack were jointly awarded the Nobel Prize in 1979 for their pioneering work on X-ray Tomography.

In the 1970's, a number of applications of tomographic imaging of process equipment were described but generally these involved using Ionising Radiation from X-ray or isotope sources, and were not satisfactory for the majority of process applications on a routine basis because of the high cost involved and safety constraints. Most of the radiation-based methods used long exposure times which meant that dynamic measurements of the real time behavior of process systems were not feasible. Only a few years later a new way of generating images without using ionizing radiation was introduced. Lauterbur and Damadian produced the first low quality images with magnetic resonance, a technique called zeugmatography by its inventors.

In the mid-1980s work started that led to the present generation of Process Tomography systems. At Manchester there began a project on Electrical Capacitance Tomography for imaging multi-component flows from oil wells. About the same time a group at the Morgantown Energy Technology Center in the USA were designing a Capacitance Tomography system for measuring the void distribution in gas fluidized beds. The capacitance transducers used for both these systems were only suitable for use in an electrically non-conducting situation. Around the same time medical scientists began to realize the potential of Electrical Impedance Tomography (measuring electrical resistance) as a safe, low-cost method for imaging the human body. There was rapid progress in several centres with Sheffield University and Royal Hallamshire Hospital, Sheffield, in the UK (United Kingdom) as well as Wisconsin University and Rensselaer Polytechnic Institute in the USA taking major roles. The success of this early work encouraged the setting up in 1988 of a European Concerted Action on Electrical Impedance Tomography for Medical applications (CAIT - Concerted Action on Impedance Tomography).

The development during the 1980s of low-cost parallel computers has done much to solve the previous problems of high cost and slowness in image reconstruction using Van-Neuman computer architectures and this has led to Process

Tomography becoming a cost effective technique. Developments in the availability of sophisticated computer aids have also changed the design capabilities in the chemical process industries. Design strategies are now firmly founded on a variety of modelling techniques and simulations which may incorporate thermodynamics, reaction kinetics and hydrodynamics. For instance, the widespread use of computational fluid dynamics models for increasingly realistic process scenarios must be accompanied by independent validation of each model against experimental results. It is in this context that the various sensing methods of Process Tomography offer a convenient means of model verification in an industrial environment, rather than in a simplified 'model' reactor using conventional laser or optical tracer techniques. Conventional techniques require invasive sampling methods or that the process mixture is modified in some artificial manner (e.g. solid/liquid suspensions have to be diluted in order to gain optical access for measurements). Furthermore measurement information is normally restricted to one small zone within the process vessel, or requires a multiplicity of measurement zones, whereas tomographic techniques have an excellent spatial range and can be used for imaging in 2 and 3 dimensions.

2.3 Basic Principles of Tomography System

Process tomography is a measurement technique that is being developed for measurement in two and multi component flows to visualize the internal cross section of pipeline. At present, the usual objective of using tomographic system is to obtain concentration profiles of moving component of interest within the measurement section in the form of a visual image, which is updated at a refreshment rate dependent upon the process being investigated. In tomography, there are many types of projection patterns that can be used to detect the flow materials within pipeline.

Process tomography should enhance an understanding of particles dynamics for both steady and unsteady flow and further, assist in the validation of fundamental design equations through accurate determination of parameters such as phase mass flow rate and flow velocity. The spatial variation of solids concentration and velocity