FLAME IMAGING USING ULTRASONIC BASED TOMOGRAPHY

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"I hereby declare that this report is the result of my own work except for the quotes as cited in the references."

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Date : 9th May 2008

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Signature : .....

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Date : 9th May 2008

To my parents, family members, friends and all which involved

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ABSTRACT

This project investigates the using of ultrasonic based tomography in flame imaging. The concentration of the flame can be measured in a pipe of rectangular shape with size of 30cm x 40cm. The project aims to obtain the cross sectional image of flame. The ultrasonic tomography measurement circuit consists of sensors, signal conditioning circuits and data acquisition system. Sensors fixture are designed based on orthogonal projection technique. In the orthogonal projection, the amount of the transmitter and receiver is same. The signal is transmitted from the transmitter to the receiver. The signal conditioning circuit is then convert the ac signal from the ultrasonic transducer to the dc voltage. Interfacing card is used to interface the analog signals from receiver circuit to the computer. The sensors detect the attenuation of acoustic energy in ultrasonic system. This provides information on the cross sectional image of the flame. To measure the concentration profile of flame, the linear back projection (LBP) technique is used. Linear back projection (LBP) algorithm has been used to perform the image reconstruction. The concentration profile is generated by combining the projection data from each sensor with its computed sensitivity map. Visual Basic 6.0 is used for software algorithms on concentration measurement. The data is collected using data acquisition system and it was an offline process.

ABSTRAK

Projek ini mengkaji penggunaan ultrasonik untuk proses tomografi dalam memaparkan imej bagi api. Penumpuan pada api akan diukur dalam paip berbentuk empat segi bersaiz 30cm x 40cm. Matlamat projek ini adalah untuk mendapatkan imej keratan rentas bagi api. Litar pengukur bagi tomografi ultrasonik terdiri daripada pengesan, litar kondisi isyarat dan sistem pemungutan data. Alat pemasangan pengesan direka berdasarkan kepada teknik 'orthogonal projection'. Dalam teknik ini, bilangan penghantar dan penerima bagi pengesan tersebut adalah sama. Kemudian, litar kondisi isyarat akan menukarkan isyarat ac daripada pengesan ultrasonik kepada isyarat dc. Kad penyambungan digunakan untuk menyambung isyarat analog daripada litar penerima kepada komputer. Alat pengesan ultrasonik mengesan pengecilan kuasa akuastik. Dengan ini, maklumat tentang penumpuan api akan diperolehi. Untuk mengukur penumpuan pada api, teknik LBP digunakan. Algoritma LBP digunakan untuk memaparkan imej bagi api. Profil penumpuan dihasilkan dengan menggabungkan unjuran data daripada setiap pengesan dengan peta sensitivity. Visual Basic 6.0 telah digunakan dalam perlaksanaan algoritma perisian untuk pengukuran penumpuan. Pemungutan data dilakukan secara 'offline' oleh sistem pemungutan data.

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p	-	Density
c	-	Velocity of sound
R	-	Characteristic impedances
L	-	Distance
$f(x,y)$	-	Attenuation function
I_T	-	Energy intensity of transmitter
I_R	-	Energy intensity of receiver
f_R	-	Resonance frequency
f_H	-	Upper cutoff frequency
f_L	-	Lower cutoff frequency
T	-	Transit time
$V_{LBP(x,y)}$	-	Voltage distribution obtained using LBP algorithms
$S_{RX,TX}$	-	Signal loss amplitude of receiver Rx-th for projection Tx- th in unit of volt
$\overline{M}_{Tx,Rx(x,y)}$	-	The normalized sensitivity matrices for the view of Tx-Rx Linear Back Projection algorithms

LIST OF ABBREVIATIONS

ECT	-	Electrical capacitance tomography
EIT	-	Electrical impedance tomography
DAS	-	Data Acquisition system
d.c	-	Direct current
GUI	-	Graphical User Interface

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter will discuss the overview of project, the objectives of the project, problem statement and scope of the project. The end of this chapter will discuss the outline of the methology used in this project.

1.1 Overview Of Project

This project describes an investigation of the use of ultrasonic based tomography in flame imaging. The ability of this system is to monitor and control the flame. The system employs orthogonal projection with the using of ultrasonic sensor. This project also involved constructing hardware and interface it with software through Data Acquisition Card. The software will be use to interface the hardware is Visual Basic 6.0. The system can be applied to produce cross-sectional images of the flame. Hence the location of flame itself can be known to where the material is heat on.

1.2 Objectives of the Project

The aim of the project are to obtain the cross sectional image of flame. Hence the location of flame itself can be known to where the material is heat on The specific objectives of this thesis are to:

1. Become familiar with the concept of process ultrasonic based tomography.
2. To construct and design ultrasonic transmission mode tomography transmitting and signal conditioning circuit.
3. To integrate hardware and data acquisition system which will provide data for cross sectional image of flame.
4. Develop software using Visual Basic 6.0 to display the cross sectional image of the flame in 2D

1.3 Problem Statement

This project can be applied to industrial heat related process such as furnace, oven and brazing. Nowadays the conventional tranducer used in heat industrial are such as thermocouple and termistor. The problem found in using of those tranducer is it just can detect and sense heat at specific point where the sensor is located only. In case of non-uniform of heat distribution, conventional transducer cannot detect the flame. By using ultrasonic transducer, the distribution of the flame in a conveying pipe can be detected.

1.4 Scope of the Project

This project is divided into two stages, which are:

Stage 1: Hardware Development

Firstly, literature study of tomography technique for flame imaging by using ultrasonic sensor are revised. Second, the selection of suitable sensor and design sensor's fixture are made. Then, the transmitting circuit by using Timer555 are designed and tested. After that, the signal conditioning circuit are designed and tested. Finally, the concentration of flame in a pipe line in terms of dc voltage is measured.

Stage 2: Software development and interfacing to the data acquisition system (DAS)

At this stage, the designing of graphical user interface (GUI) will be made by using Visual Basic 6.0. Then, the signal conditioning circuit is interfaced to the DAS card to obtain the data. The data will perform the resulting image reconstruction of the flame. After that, the results are analyzed and finally completed the thesis writing.

1.5 Methodology

Below is the flow of the methodology used in this project:

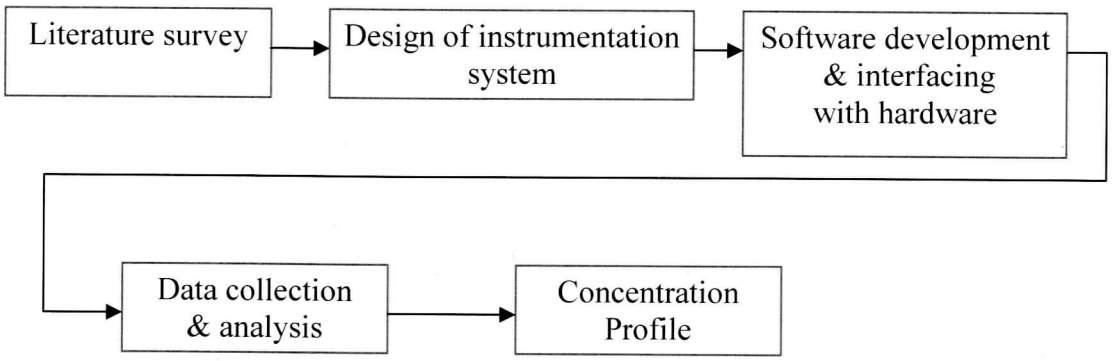

Figure 1.1 : Methodology flow

1. Literature Survey
   - Process tomography
   - Sensing techniques
   - Image reconstruction algorithms

2. Design of Instrumentation System
   - Sensor's fixture
   - Transmitter & receiver selection
   - Signal conditioning circuit

3. Software development & interfacing with hardware
   - Interfacing DAS card with measurement system

4. Data collection & analysis
   - Process measurement
   - Data collection & analysis

5. Concentration profile
   - Tomographic image reconstruction by using Visual Basic

1.6 Thesis Outline

Chapter 1 presents an overview of project, the objectives of the project, problem statement, scope of project, methodology and thesis outline.

Chapter 2 covers the literature review on the tomography technique for ultrasonic tomography, the principle of ultrasonic sensor system and the arrangement of tranducers.

Chapter 3 describes in details the ultrasonic system methodology, the hardware and software development, the technique used to display the reconstruction image of flame.

Chapter 4 presents the results from simulation,PCB circuit test and the results of concentration experiment. All the results have been discussed in details.

Chapter 5 discusses the overall conclusions and suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The main objective of this chapter is to review the literature regarding of ultrasonic tomography system and it basic theories. At the end of this chapter the arrangement of tranducer are discussed.

2.2 Tomography Technique

Tomographic technology involves the acquisition of measurement signals from sensors located on the periphery of an object, such as a process vessel or pipeline. This reveals the information of the nature and distribution of components within the sensing zone. Most tomgraphic techniques are concerned with abstracting information to form a cross sectional image (R.A William and M.S Beck, 1995). The heart of any tomoraphic technique is the sensor system that is deployed. The basic of any measurement is to exploit differences or contrast in the property of the process being examined.

2.3 Ultrasonic Tomography System

Ultrasonic process tomography is potentially useful for imaging processes where differences in object density and elasticity offer the most significant sensing opportunity, for example, for imaging bubble gas / liquid flows (W.Li and B.S. Hoyle, 1996). Ultrasonic tomography is now developed in industrial flow imaging, especially in liquid borne mixtures. Its imaging can provide images of a cross section of pipe or vessel and thus information about the gas / liquid inside the pipe can be extracted by analyzing the image obtained.

Ultrasonic tomography of flame imaging also has the changes in temperature that will affect the velocity of sound. It gives the opportunity of providing quantitative and real time data on chemical media within a full scale industrial process. The major potential benefits are, it is possible to gain an insight into the actual process; secondly, since ultrasonic tomography is capable of on-line monitoring, it is the opportunity to develop closed loop control systems and finally, it can be non-invasive and possibly non-intrusive system (R.A Williams and M.S Beck, 1995). The overall anticipated effects are improvements in product yield and uniformity, minimized input process material, reduced energy consumption and environmental impact and the lowering of occupational exposure to plant personnel.

2.4 Ultrasonic Sensor Systems

Ultrasonic technique have been available for more than 50 years, and they are inherently well suited to the characterization of composition, state of reacting systems, mixing and multiphase flame properties and providing real time images and characterization of processes.

The heat will interaction with the ultrasonic beam through some form of acoustic scattering and interaction must then be sensed to yield information about the flame. Ultrasonic sensor system are based upon interactions between the incident ultrasonic waves and the flame to be image. For example, the incident wave maybe reflected