FLAME IMAGING USING OPTICAL SENSOR AND LASER

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Laporan ini dikemukakan untuk sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Elektronik (Kejuruteraan Komputer) Dengan Kepujian

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ABSTRACT

This project describes an investigation of the combination between optical sensor and laser in flame imaging. The aim of this project is to obtain the concentration profile of the flame to be incorporated in laser-based transmission tomography measurement system for the burning process online monitoring. Tomography method being chosen because it can obtain the concentration profile of the flame with the measurement section in the form of a visual image. This project actually can be applied in industrial heat process such as furnace, oven, and brazing. Tomography method is cheaper and safer than the most of the current methods which mostly made use of radioactive methods. Image of the flame are capture using optical sensors that will be digitalized into a form suitable for computer processing of the flow pictures. This project used two orthogonal projections with one laser source. Laser diode was used as the transmitter and photodiode are used as the receiver. The laser source will supply 16 light beams, so the cross-section of the pipe being interrogated by a total of 16 beams. The flame is placed in specific places in the measurement cross-section and voltage output will calculated by the individual sensor. Besides the hardware, this project includes the use of software which is Visual Basic 6.0 program to visualize the concentration profile of the flame.

ABSTRAK

Projek ini dijalankan adalah untuk mengkaji gabungan penggunaan antara alat pengesan optikal dan laser pada pemgimejan nyalaan api. Tujuan utama projek adalah untuk mendapatkan sisi muka pada penumpuan nyalaan api yang akan digabungkan menggunakan sistem tomografi berdasarkan penghantaran laser bagi mengukur tahap proses nyalaan api secara on-line. Kaedah tomografi dipilih adalah kerana ia boleh mendapatkan penumpuan sisi muka pada nyalaan api dengan seksyen pengukuran dalam bentuk imej visual. Projek ini sebenarnya boleh diaplikasikan dalam industri proses pemanasan seperti dapur leburan, oven dan brazing. Kaedah tomografi lebih murah dan selamat digunakan berbanding dengan kaedah yang digunakan sekarang iaitu melalaui kaedah radioactive. Imej pada nyalaan api diambil menggunakan optikal laser dan akan di digitalized dalam bentuk yang sesuai untuk diproses oleh computer dalam bentuk aliran gambar. Projek ini akan menggunakan pandangan unjuran dua orthogonal dengan satu sumber laser. Laser diod akan digunakan sebagai pemancar manakala photodiode digunakan sebagai penerima pancaran signal. Sumber laser tersebut akan melancarkan 16 sumber laser dan akan menegenai photodiode yang diletakkan merentasi paip tersebut. Nyalaan api diletakkan pada tengah paip tersebut untuk pengukuran imej keratan rentas dan pengeluaran voltan akan dikira oleh setiap pengesan. Selain dari litar yang digunakan, projek ini juga menggunakan program visual basic 6.0 untuk memaparkan keputusan pada penumpuan nyalaan api tersebut.

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I	=	Transmitted Intensity (Wm^{-2})
Io	=	Initial Incident Intensity (Wm^{-2})
N	=	Thickness Of The Absorbing Material (m)
µ	=	Linear Absorption Coefficient (m^{-2})
$V_{LBP}(x,y)$	=	Voltage distribution obtained using LBP algorithm (concentration profile in unit volt) an n × m matrix where n equals to dimension of sensitivity matrix.
$S_{Rx,Tx}$	=	Signal loss amplitude of receiver Rx-th for projection Tx-th in unit of volt.
$\overline{M}_{Rx,Tx}(x,y)$	=	The normalized sensitivity matrices for the view of Tx–Rx
PØ	=	Projection Angle
x'	=	Detector Position In X-Plane
f(x,y)	=	Coordinate Of Real Object
N	=	Total Number Of Receiver
M	=	Total Number Of Projection
$D_{Rx,Tx}$	=	Width Of The Light Beam Of Tx-Th Emitter To Rx-Th Receiver
$\alpha_{Rx,Tx}$	=	Angle Between The Tx-Th Emitter To Rx-Th Receiver
$m_{Rx,Tx}$	=	Slope Of The Line Node Tx-Th Emitter To Rx-Th Receiver
d	=	Gap Between The Emitter And Receiver

$V(x, y)$ = The Concentration Profile Obtains With Resolution Of n x n Pixels For Modeled Image Or Reconstruction Image

$pixels_{sum}$ = The Total Of Pixels Occupied By Any Light Beam. Determined By Counting The Number Of Elements In Total Sensitivity Matrix That Possessed Non-Zero Value.

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

As defined in one encyclopedia (Helicon 1991), the word "tomography" is derived from the Greek language which *tomo* means "slice" and graph means "picture". In another word, tomography is a method of viewing the plane section image of an object.

Process tomography provides several real time methods of viewing the cross-section of a process to provide information relating to the material distribution. This involves by taking numerous measurement from sensors which placed around the section of the process being investigated and processing the data to reconstruct an image. The process involves the use of non-invasive sensors to acquire vital information in order to produce two or three-dimensional images of the dynamic internal characteristic of process system. Information on the flow regime, vector velocity, and concentration distribution may be determined from the images. Such information can assist in the design of process equipment, verification of existing computational modeling and simulation techniques, or to assist in process control and monitoring.

Process tomography refers to any tomographic method used to measure the internal state of a chemical process (e.g. material distribution in a reactor, multiphase flow fields in piping or concentration uniformity in mixers). By tomographic techniques can measure quantities such as the flow rate or solid concentration of material flowing through a pipeline and the distribution of material inside a chemical reactors or a mixer. This type of information is not usually obtainable with the sensor traditionally used by engineer, therefore these techniques gives a better understanding of the flow of material through the plant and the data can be used to design better process equipment and to control certain processes to maximize yield and quality.

From an engineering perspective, tomographic technology involves the acquisition of measurement signals from sensors located on the periphery of an object. This reveals information on the nature and distribution of components within the sensing zone. Most tomographic techniques are concerned with abstracting information to form a cross sectional image.

Basically, in tomography system several sensors are installed around the pipe or vessel to be imaged. The sensor output signal depends on the position of the component boundaries with their sensing zones. A computer is used to reconstruct a tomographic image of the cross-section being interrogated by the sensor. Real times image can be obtain which measure the dynamic evolution of the parameter being detect at the sensor.

1.1 Objectives of the Project

This project aims to investigate the use of tomographic measurement for online monitoring of two-component especially providing cross sectional image of flame concentration. The specific objectives of this project are:

1. To investigate the use of laser based tomography in measurement of concentration profile of flame.
2. To implement the using of laser diode as the transmitter or source.
3. To utilize photodiode as a detector.
4. To develop cross sectional image using suitable software.
5. To measure the concentration profile and visualize an image reconstruction of flame using Visual Basic 6.0

1.2. Problem Statement

This project actually can be applied in industrial heat process such as furnace, oven, and brazing. This method is cheaper and safer than the most of the current methods which mostly made use of radioactive methods. In industrial section, we usually using transducer to detect and sense heat process. A transducer is a device, usually electrical, electronic, electro-mechanical, electromagnetic, photonic, or photovoltaic that converts one type of energy to another for various purposes including measurement or information transfer. Transducers that we usually used in heat industry are from thermoelectric type which is RTD (Resistance Temperature Detector), thermocouple, thermistor and peltier cooler. We usually used thermistor and thermocouple to detect and sense heat in industrial section.

In electronics, thermocouples are a widely used type of temperature sensor and can also be used as a means to convert thermal potential difference into electric potential difference. They are cheap and interchangeable, have standard connectors, and can measure a wide range of temperatures. While a thermistor is a type of resistor used to measure temperature changes, relying on the change in its resistance with changing temperature. But, usually conventional transducer which is thermocouple and thermistor cannot detect and sense heat at specific point where the sensor is located. The case of uniformity of heat distribution makes the conventional transducer cannot detect. This type of information not usually obtained with the traditionally sensor that always been used before.

1.3. Project Scope

1. The Sensor Fixture And Selection Of Sensors
   i. To investigate the suitable mounting method of transmitter and sensor
   ii. To investigate the suitable type of optical sensor.
2. Signal Conditioning Circuit
   i. To design the receiver circuit with an appropriate gain and applying suitable signal processing technique.
3. Designing Printed Circuit Board (PCB)
4. Data Acquisition System Design
   i. To use a data acquisition system for signal or data that been obtained from sensor.
5. Software Development
   i. Design graphic user interface (GUI) using suitable software for performing online image reconstruction.
6. Thesis writing

1.4. Project Methodology

This part is the explanation for the procedures and methods that will be used to complete the project. It will explain step by step the process build the project until it finished. The first step until the last step is literature survey, design of instrumentation system, software development and interface with hardware, data collection and analysis, concentration profile and lastly completing thesis writing. The figure below shows procedure and steps that will be used to achieve the objectives of this project.

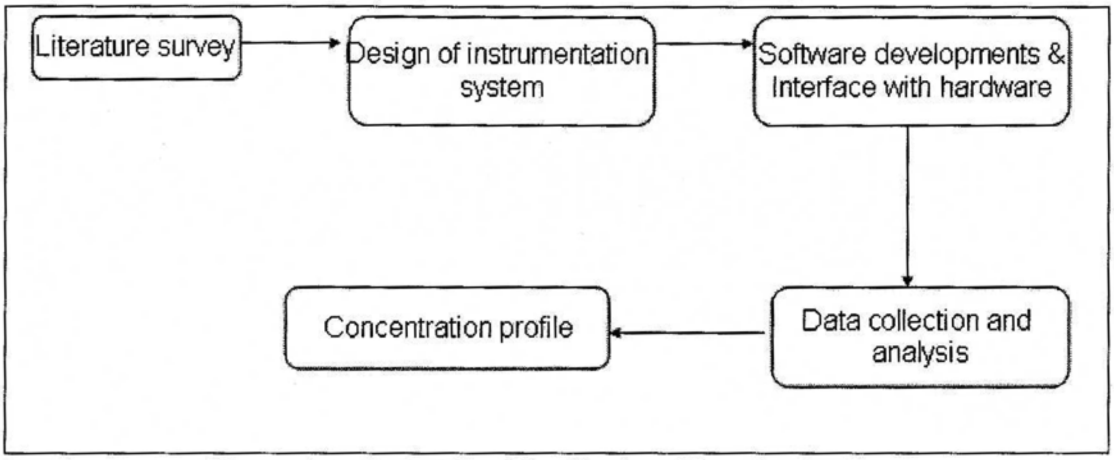

Figure 1.1: Flow Chart for Project Methodology

1. Literature Survey
    i. Process tomography
    ii. Sensing techniques
    iii. Image reconstruction algorithm
2. Design Of Instrumentation System
    i. Sensor fixture
    ii. Transmitter and receiver
    iii. Signal condition
3. Software development and interfacing with hardware
    i. Software development
    ii. Interfacing DAS card with measurement system

4. Data collection and analysis
    i. Process measurement
    ii. Data collection and analysis
5. Concentration profile
    i. Tomographic image reconstruction

CHAPTER II

LITERATURE REVIEW

Process tomography involves the use of non-invasive sensors to acquire vital information in order to produce two or three dimensional images of the dynamic internal characteristic of process systems. Information can assist in the design of process systems. Information can assist in the design process equipment, verification of existing computational modeling and simulation techniques, or to control and monitoring.

At present, the usual objectives of using tomographic system is to obtain concentration profile of moving components 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.

Basically, in tomography system, several sensors are installed around the pipe to be imaged. The sensor output signals depend on the position of the component boundaries within their sensing zone. A computer is used to reconstruct a tomographic image of the cross section being interrogated by the sensors. Real time images can be obtained which measure the dynamic evolution of the parameters being detect at the sensor. And all the required for a practical system is an imaged updated frequently enough for the smallest relevant feature of the flow to be observe.

2.1 Basic Tomographic System

Tomographic techniques vary widely in their instrumentation and applications, all of them can be characterized by a common two step approach to the imaging process; firstly gather projection data based on some physical sensing mechanism, then reconstruct a cross sectional image from the projections. The term projection has a meaning tomography which a projection can be visualize as type of radiography of the process vessel.

In tomography, many projections are needed to reconstruct the interior volume or cross section of an object. Projection actually can be referred as sensor arrangement. There are several types of projection that can be applied in to measure flame concentration, which are;

1. orthogonal projection
   i. two orthogonal projection (figure 2.1)
   ii. two rectilinear projection (figure 2.2)
   iii. three rectilinear projection (figure 2.3)
   iv. a combination of two orthogonal and two rectilinear projections (figure 2.4)
2. Fan beam projection.
   i. Three fan beam projection (figure 2.5)
   ii. Four fan beam projection (figure 2.6)