VELOCITY MEASUREMENT OF FLOWING OBJECT USING INFRARED SENSOR

NURUL FAZLIYANI BINTI RUSLI

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Sesi Pengajian : 2008/2009

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Supervisor's Name	**: En. Adie Bin Mohd Khafe**
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Specially dedicated to my family for their supports and eternal love.

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ABSTRACT

This project is to implement a simple measurement of velocity for a flowing object in a conveying pipe. The objective is to utilize the cross correlation method to obtain the velocity of that object by using infrared sensor. The measurements circuit consists of sensors, signal control circuit and data acquisition system. Sensors fixtures are designed based on parallel beam projection technique. To measure velocity, two arrays of sensors are placed upstream and downstream on the pipe. The output from both sensors is cross-correlated. The peak of the cross correlation graph represented the time for the object to move from upstream to downstream. The velocity is obtained by dividing the time and the distance between upstream and downstream. Prototype circuits will be implemented which involved design and implement of signal control circuit, jig and fixture design or fabrication. For data processing method, Visual Basic 6.0 is used for software algorithms on cross correlation calculation. The data is collected using data acquisition system and it was an offline process.

ABSTRAK

Projek ini adalah untuk melaksanakan satu pengukuran mudah bagi halaju untuk mengesan sebarang objek di dalam paip. Objektif projek ini adalah untuk menggunakan silang kaedah korelasi bagi memperoleh halaju objek dengan menggunakan penderia inframerah. Litar pengukuran ini mengandungi pengesan, litar penyesuaian isyarat dan sistem pemerolehan data. Kedudukan pengesan adalah direka berdasarkan teknik unjuran selari. Untuk mengukur halaju, dua susunan pengesan diletakkan di atas dan di bawah paip. Keluaran daripada kedua-dua pengesan akan disilang kait. Puncak korelasi silang pada graf mewakili masa untuk bergerak melalui paip dari atas ke bawah paip. Halaju objek di ambil dengan membahagikan masa dan jarak di antara kedudukan pengesan. Litar prototaip akan dilaksanakan dimana melibatkan rekaan litar dan perlaksanaan litar penyesuaian isyarat, dan rekabentuk paip. Bagi cara pemprosesan data, Microsoft Visual Basic digunakan untuk pembangunan aturcara dalam pengiraan silang kait. Data akan di kumpul menggunakan system pemerolehan data (DAS) ke dalam computer dan ia adalah satu proses ‘offline’.

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MEMS	-	Micro-electro-mechanical systems
IR	-	Infrared
PC	-	Personal Computer
DAQ	-	Data Acquisition
MS	-	Microsoft
LED	-	Light Emitting Diode
inGAas	-	Indium gallium arsenide
GAas	-	Gallium arsenide
TV	-	Television
DC	-	Direct Current
R	-	Resistor
SI	-	International System

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CHAPTER I

INTRODUCTION

1.1 Overview of the Flowmeter

There are several types of Flowmeter that used in industrial such as Mechanical flow meters, Optical flow meters, Turbine flow meter, Thermal mass flow meters, Vortex flow meters, Electromagnetic, ultrasonic and coriolis flow meters.

1.1.1 Optical flow meters

Optical flow meters use light to determine flow rate. Small particles which accompany natural and industrial gases pass through two laser beams focused in a pipe by illuminating optics. Laser light is scattered when a particle crosses the first beam. The detecting optics collects scattered light on a photo detector, which then generates a pulse signal. If the same particle crosses the second beam, the detecting optics collect scattered light on a second photo detector, which converts the incoming light into a second electrical pulse. By measuring the time interval between these pulses, the gas velocity is calculated as V=D/T where D is the distance between the laser beams and T is the time interval. Laser-based optical flow meters measure the actual speed of particles, a property which is not dependent on thermal conductivity of gases, variations in gas flow or composition of gases.

The different operating principle enables optical laser technology to deliver highly accurate flow data, even in challenging environments which may include high temperature, low flow rates, high pressure, high humidity, pipe vibration and acoustic noise. Optical flow meters are very stable with no moving parts and deliver a highly repeatable measurement over the life of the product. Because distance between the two laser sheets does not change, optical flow meters do not require periodic calibration after its initial commissioning. Optical flow meters require only one installation point, instead of the two installation points typically required by other types of meters. A single installation point is simpler, requires less maintenance and is less prone to errors. Optical flow meters are capable of measuring flow from 0.1 m/s to faster than 100 m/s (1000:1 turn down ratio) and have been demonstrated to be effective for the measurement of flare gases, a major global contributor to the emissions associated with climate change [1].

1.1.2 Turbine flow meter

The turbine flow meter (better described as an axial turbine) translates the mechanical action of the turbine rotating in the liquid flow around an axis into a user-readable rate of flow. The turbine tends to have all the flow travelling around it. The turbine wheel is set in the path of a fluid stream. The flowing fluid impinges on the turbine blades, imparting a force to the blade surface and setting the rotor in motion. When a steady rotation speed has been reached, the speed is proportional to fluid velocity.

1.1.3 Thermal mass flow meters

Thermal mass flow meters generally use combinations of heated elements and temperature sensors to measure the difference between static and flowing heat transfer to a fluid and infer its flow with knowledge of the fluid's specific heat and density. The fluid temperature is also measured and compensated for. If the density and specific heat characteristics of the fluid are constant, the meter can provide direct mass flow readout, and does not need any additional pressure temperature compensation over their specified range. Technological progress allows today to manufacture thermal mass flow meters on a microscopic scale as MEMS sensors, these flow devices can be used to measure flow rates in the range of nano litres or micro litres per minute. Thermal mass flow meter technology is used for compressed air, nitrogen, helium, argon, oxygen, natural gas. In fact, most gases can be measured as long as they are fairly clean and non-corrosive. For more aggressive gasses, the meter may be made out of special alloys (e.g. Hastelloy), and pre-drying the gas also helps to minimize corrosion.

1.2 Flow measurements.

Flow measurements belong to the most difficult ones because the medium being measured can occur in various physical states, which complicate the measuring procedure. They are namely, temperature, density, viscosity, pressure, multi-component media (liquid-gas, solid-gas), the type of flow, etc. The choice of the method is further directed by specific requirements for the flow meter, e.g. the measuring range, minimum loss of pressure, the shortest possible recovery section, and a sensor without moving parts, continuous operation of the sensor, etc. That is why about 60 measuring methods have been developed to meet the increasing demands of laboratory and industrial measurements of flow of gases, liquids, vapours and solid particles in one-phase or multi-phase media [2].

1.2.1 Open channel flow measurement

1.2.1.1 Level to flow

The level of the water is measured at a designated point behind a hydraulic structure (a weir or flume) using various means (bubblers, ultrasonic, float, and differential pressure are common methods). This depth is converted to a flow rate according to a theoretical formula of the form Q=KHX where Q is the flow rate, K is a constant, H is the water level and X is an exponent which varies with the device used, or it is converted according to empirically derived level/flow data points (a 'flow curve'). The flow rate can then integrated over time into volumetric flow.

1.2.1.2 Area / velocity

The cross-sectional area of the flow is calculated from a depth measurement and the average velocity of the flow is measured directly (Doppler and propeller methods are common). Velocity times the cross-sectional area yields a flow rate which can be integrated into volumetric flow.

The measurement section can be subdivided into four main parts: (1) the sensor, (2) the signal conditioning circuit, (3) the data acquisition system, and (4) the display. Figure 1.1 is the example of the measurement section around the flow pipe which contains 64 pairs of infra red sensors configured in a parallel beam projection. Since the infra red sensors are the critical part, the selection of infra red transmitters and receivers are considered carefully. The sensors should be arranged such that they cover the whole pipe. Another set of sensors were constructed 100mm downstream to measure velocity using the cross-correlation method. The sensors used must be of high performance, compact, require minimum maintenance or calibration and be intrinsically safe.

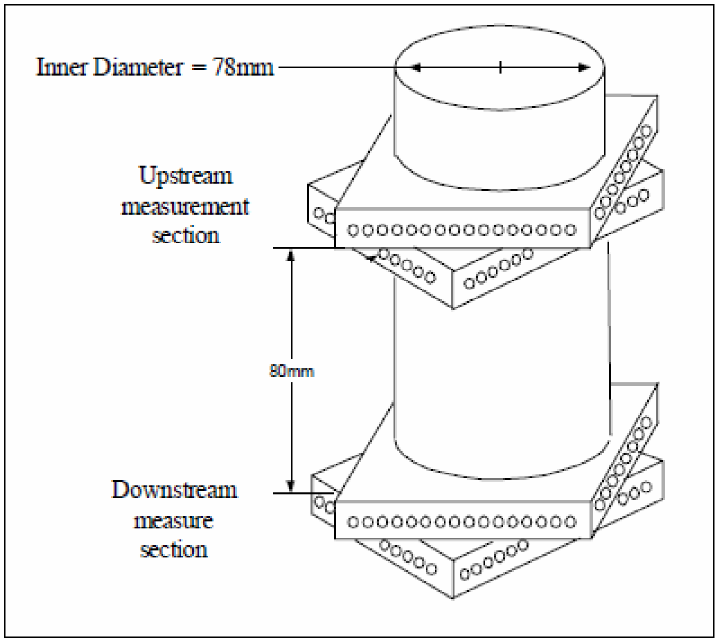

Figure 1.1: The Measurement section

The infra red emitters and detectors are linked to the measurement section. Light passing through the pipe passes through the optical fibre and is then converted into an electrical signal by the IR receiver. The signal is amplified and filtered. Data is then passed through a Keithley KUSB-3100 Series data acquisition system before it enters a PC. It was then processed offline using several algorithms such as cross correlation. The algorithm was developed using the Visual Basic 6.0 software to display the velocity.

1.3 Objectives of the Project

The aims of this project are to obtain the velocity when objects are dropped through the sensing area of the pipe using infrared sensor. Specifically the objectives of this project are:

1. To utilize simple measurement of velocity of flowing objects in a pipe using infrared sensor.

2. To design and develop the electronic measurement system which consist of sensors, signal conditioning circuits and output.
3. To implement a measurement system that will provide data obtained from sensor for velocity measurement in pipeline.
4. To understand how cross correlation method can be implemented in velocity measurement of flowing object.
5. To develop software using Visual Basic 6.0 software algorithms on cross correlation calculation.

1.4 Problem Statement

Nowadays, there are many industries that used conveyor pipe to measure velocity. The current technology method used are mechanical and turbine flowmeter. These method involving a physical contact with the product that convey through the pipeline. If any existing of object occurred during the conveying of product damaging the mechanism to measure the velocity such as the turbine or valve, the velocity measurement is failed. Because of this, it is hard to control the flow pattern of gas or liquid and influence the velocity reading accuracy. This procedure is important to avoid any unwanted state happen while conveying process at any circumstances. High velocity may cause fracture or damages on the piping system. The objective of this project is to overcome the entire problems that exist in the system that have been used in the industry.

1.5 Scope of the Project

This project is divided into two stages, which are:

1. Hardware Development

Firstly, literature studies on the concept of flow measurement techniques using infrared sensor. Second, the selection of sensors and design sensors fixtures are made. The sensors are located at upstream and downstream in order to capture the velocity of moving object. Then, the signal conditioning circuits are designed. There are several different sizes of box are used to get the different measurements of velocity. Finally, the velocity of flowing object in a pipe line in terms of time and distance are measured. The results will be compared between the theoretical calculation and experimental result.

2. Software Development and Interfacing to the data acquisition System (DAQ).

At this stage, the designing of graphical user interface will be made by using Visual Basic 6.0. Then, the signal conditioning circuit is interfaced to the DAQ card. Data is captured. DAQ card is used in PC and then the MS Access before it will convert to the Visual Basic 6.0. The offline monitoring of velocity object flowing into the pipe are made. To measure the velocity, cross correlation method is used where the peak of the output from cross-correlation method graph represented the time for the object to move from upstream to downstream. The velocity of the particle is obtained by simply dividing the time and the distance between upstream and downstream.

1.6 Project Planning

This project is implemented based on the project planning schedule. The project started from July 2008 to April 2009. The project planning schedule is presented in Appendix.