VELOCITY MEASUREMENT OF FLOWING PARTICLE USING LED AND PHOTODIODE SENSOR

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This report in partial fulfilment of the requirements for the award of Bachelor of Electronic Engineering (Computer Engineering) With Honours

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To my family and friends

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ABSTRACT

This project describes an investigation of the use of light emitted diode and photodiode sensor in a correlative measurement of flowing solid particle velocity. The main purpose is to investigate the optical sensor capability to senses the moving particle in sensing area. This optical measurement circuit consists of sensor, signal conditioning circuit and data acquisition system. Sensors fixtures are designed based on parallel beam projection. To measure the velocity, cross correlation technique is used where eight pairs of sensor is mounted upstream and downstream of the pipe. Each pair of sensor is placed facing each other in parallel beam projection. Any object interfere the sensing area; conditional circuit will produce a signal in voltage form. The output from both sensors is cross correlated. Cross correlation is a process of comparing a signal with another signal by multiplication of the instantaneous value and taking the average. It is a function of the relative time between the signals. The transmit time obtained and the distance of upstream and downstream will be used to determine the velocity of the measurement before it be transferred by data acquisition (DAS) device into computer. The data is collected by using data acquisition system and it was an offline process. Then, the data obtained will be stored and compared into Microsoft ACCESS database. The final result of the velocity measurement will be measured and displayed by using Microsoft Visual Basic.

ABSTRAK

Projek ini melibatkan kajian terhadap penggunaan cahaya yang dipancarkan diod dan pengesan fotodiod dalam satu korelatif pengukuran halaju sesuatu objek. Tujuan utama adalah untuk menyiasat keupayaan pengesan optikal untuk mengesan objek dalam kawasan pengesanan. Litar pengukuran optikal ini mengandungi pengesan, litar penyesuaian isyarat dan sistem pemerolehan data. Kedudukan pengesan-pengesan adalah direka berdasarkan unjuran selari. Untuk mengukur halaju, kaedah korelasi silang digunakan di mana lapan pasangan pengesan diletakan di atas dan di bawah kedudukan paip. Setiap pasang penngesan adalah diletakkan berhadapan satu sama lain dalam unjuran selari. Sebarang objek melalui kawasan pengesan; litar kondisi isyarat akan menghasilkan satu isyarat dalam bentuk voltan. Keluaran daripada kedua-dua pengesan-pengesan akan disilang kait. Silang kait merupakan satu proses membandingkan satu isyarat dengan isyarat lagi , didarabkan dan mengambil purata bacaan. Ia adalah satu fungsi dimana masa berkadar dengan isyarat. Masa pergerakan yang diperolehi dan jarak di di atas dan di bawah paip akan digunakan untuk menentukan halaju sebelum ia dipindahkan oleh alat pemerolehan data (DAS) ke dalam komputer. Data dikumpul dengan menggunakan sistem pemerolehan data dan ia adalah satu proses ‘ offline’. Kemudian, data akan disimpan dan dibandingkan ke dalam pangkalan data Microsoft ACCESS. Pengukuran halaju akan diukur dipamerkan dengan menggunakan Microsoft Visual Basic.

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CHAPTER I

INTRODUCTION

This chapter will discuss the overview of project background, scope of project, problems statement, the aims and specific objectives of the project. The end of this chapter will list the thesis outline.

1.1 Project Background

In industrial processes that involved flow of solid such as powdered or granular in pneumatic conveyors, there is a need for automatic and practical field instruments for measuring velocity and mass flow through the pipeline. The measurement of particle velocity in conveying pipe is essential for monitoring and controlling the transport of solid object in the pipeline, and also to maintaining the desired flow rates. A commonly use technique for such purpose is the cross correlation technique. This technique is most popular and widely used in both laboratory and industrial for pipeline flow velocity measurement. This technique applied by comparing one signal with another by multiplication of the instantaneous values and taking the average. It done by using the optical sensor such as light emitting diode (LED) with photodiode sensor, it detects a particle or object present in a pipeline that produces random disturbance signal. Two pairs of sensors positioned upstream and downstream, installed in an axial distance (L) with each other in parallel beam projection. The transmit time (τ) taken from the time the particle moving from the upstream to downstream. The velocity measurement obtained by dividing the time and the distance between upstream and downstream.

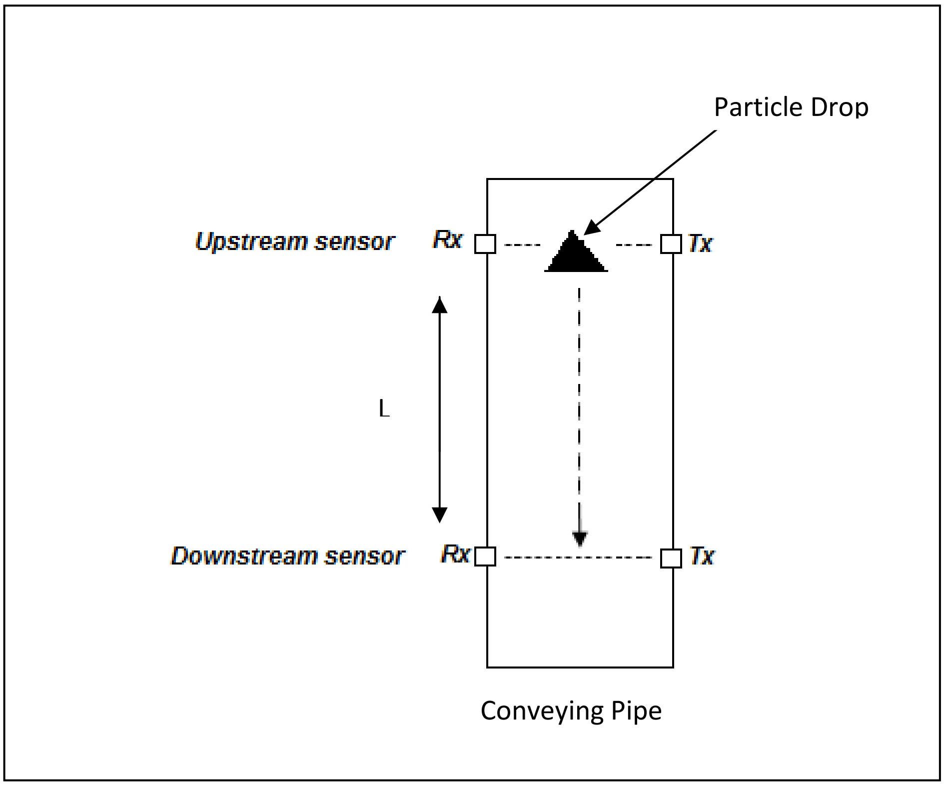

Figure 1.0 Model of Basic Operation

1.2 Project Objectives

The aim of this project is to obtain the velocity measurement when solid particle dropped from upstream to downstream through the sensing area of pipe. That will allow us to observed and control the velocity of the particle movement. The specific objectives are to:

1. Evaluate the LED sensor and design & fabricate circuit to be used to implement in this measurement system.
2. Implement a measurement system that will provide data obtained from sensor for velocity measurement in pipeline.
3. Understand how cross correlation method can be implemented in velocity measurement of flowing particle.
4. Focus on software development using Visual Basic to determine the velocity.

1.3 Problem statement

In industry that involved conveyer pipe, the current technology use for measuring velocity is divided into several methods. The methods are:

- Mechanical flow meter
- Turbine flow meter

These method involving a physical contact with the product that convey through the pipeline. If there is any existence of particle occurred during the conveying of product which may damage the apparatus to measure the velocity such as the piston, turbine or valve, the flow velocity measurement cannot be done. It is hard to control the flow pattern of the particle due to the effect of the velocity reading accuracy. This procedure is important to avoid any unwanted state or incident 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 those disadvantages that exist in the system that had been used currently in the industry. In other word, it is hope that this project research will come out a good solution and more practical be used in the real world situation.

1.4 Scope of Project

This project is divided into two stages, which are:

Stage 1: Hardware Development

Firstly, literature study on the velocity measurement technique of moving particle using optical sensor are revised. Investigate the compatible pipe, projection of transmitter and receiver. Then, the selection of transmitter and receiver of the sensor, and also the design of sensors fixture are made. After that, the signal conditioning circuit with an appropriate gain and applying suitable signal processing techniques are designed and tested. The jig or particle models suitable for the measurement testing were fabricated. Finally, the velocity of the moving particles in the pipeline in terms of dc voltage was measured.

Stage 2: Software development and Interfacing to the data acquisition system

At this stage, the utilization of DAS card in data collection is studied, so that it can collect the data from the signal conditional circuit. The data captured was stored into the database system on the Microsoft Access. Then, the graphical user interface (GUI) was developed by using the Microsoft Visual Basic 6.0. This software will performed the cross correlation method, process from the database and at the same time display the result in graphical form.

1.5 Project Methodology

This part explained the procedure and method taken to achieve the project objectives. Divided into 5 stages, it starts with project planning, literature review, circuit and jig design, circuit prototype and lastly the software development.

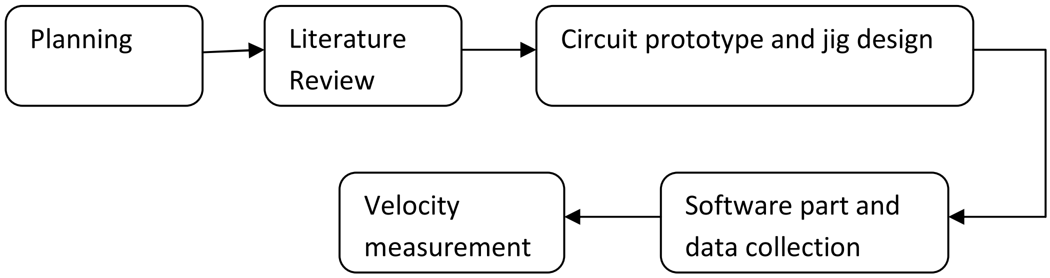

Figure 1.1 Block diagram of project methodology

Planning

In this planning section, it will focus on project title discussion. Project method & approach also will be determined.

Literature review

In Literature review section, it covers several topics of study:-

- Study on sensor (LED & Photodiode sensor).
- Study about parallel beam projection.
- Familiarize with cross correlation method.
- Understand the conveying pipe process system.

Circuit prototype and jig design

In this section, the signal conditional circuit is designed. Sensor fixture and jig design is determined.

Software part and data collection

Microsoft Access will be use to store the collected data into database. By applying cross correlation method, the velocity will be measure and the result will be display by using Visual Basic software.

CHAPTER II

LITERITURE REVIEW

This chapter will review the literature regarding on the velocity measurement and flow meter theories. At the end of this chapter, the optical sensor theories, light emitted diode, photodiode and sensor arrangement are discussed.

2.1 Velocity

Velocity is defined as the rate of change of position. It can be measure indirectly by either integrating an acceleration measurement or differentiating a dynamic position measurement. It is measured in meters per second: (m/s) or ms^{-1} in the SI (metric) system [1]. The scalar absolute value (magnitude) of velocity is speed. The average velocity *v* of an object moving through a displacement (Δx) during a time interval (Δt) is described by the formula:

$$\bar{\mathbf{v}} = \frac{\Delta \mathbf{x}}{\Delta t}. \qquad (2.1)$$

The rate of change of velocity is referred to as acceleration.

2.2 Relative velocity

Relative velocity is a measurement of velocity between two objects as determined in a single coordinate system. Relative velocity is fundamental in both classical and modern physics, since many systems in physics deal with the relative motion of two or more particles. In Newtonian mechanics, the relative velocity is independent of the chosen inertial reference frame. This is not the case anymore with special relativity in which velocities depend on the choice of reference frame.

If an object A is moving with velocity vector **v** and an object B with velocity vector **w**, then the velocity of object A *relative to* object B is defined as the difference of the two velocity vectors:

$$V_A relative\ to\ B = v - w \qquad (2.2)$$

Similarly the relative velocity of object B moving with velocity **w**, relative to object A moving with velocity **v** is:

$$V_B relative\ to\ A = v - w \qquad (2.3)$$

Usually the inertial frame is chosen in which the latter of the two mentioned objects is in rest.

2.3 Flow measurement

Flow measurement is the quantification of bulk fluid movement. Two types of flow measurement are:

Point Velocity measurement**:** for investigation purpose, limited use in industrial environment.

Quantum flow instrumentation: can be in terms of flow rate, average velocity, volume flow rate.

2.4 Type of flow meter

Magnetic Flow meter

A magnetic flow meter is a volumetric flow meter which does not have any moving parts and is ideal for wastewater applications or any dirty liquid which is conductive. Magnetic flowmeters will generally not work with hydrocarbons, distilled water and many non-aqueous solutions. Magnetic flowmeters are also ideal for applications where low pressure drop and low maintenance are required.

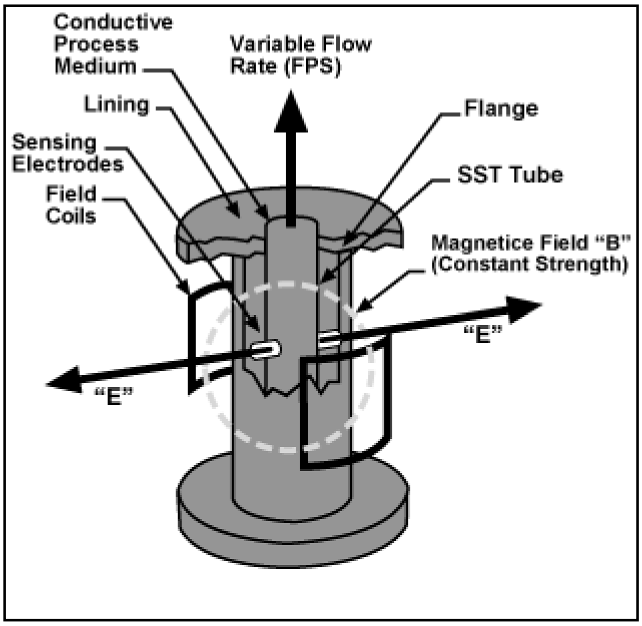

Figure 2.1 Magnetic flow meter

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 (gpm, lpm, etc.). The turbine tends to have all the flow traveling around it.

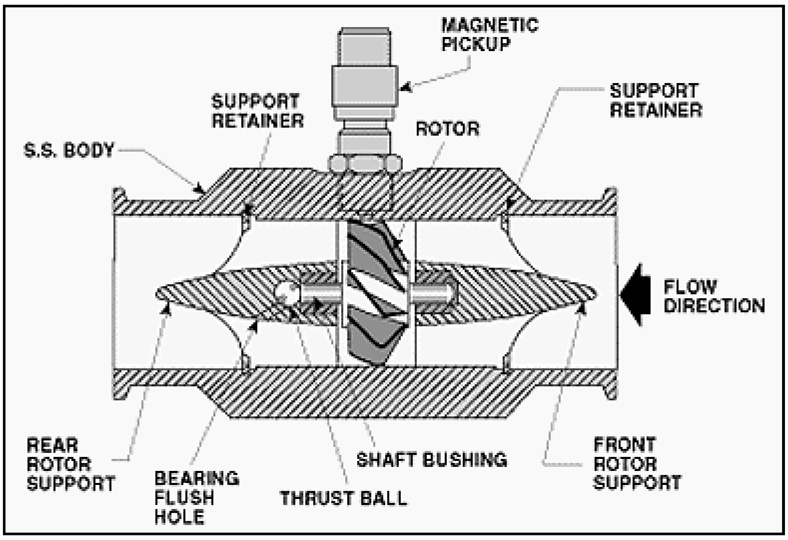

Figure 2.2 Turbine flow meter

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.

Optical Flow meter

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. Light is scattered when a particle crosses the first beam. The detecting optics collects scattered light on a photodiode, which then generates a pulse signal. If the same particle crosses the second beam, the detecting optics collect scattered light on a second photodiode, which converts the incoming light into a second electrical pulse. It 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.