THESIS REPORT

CONSISTENCY FLOW RATE OF GAS ARGON PURGING CONTROL SYSTEM

(DESIGN AND DEVELOPMENT OF GAS ARGON PURGING SYSTEM)

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ABSTRAK

Dengan menggunakan satu pengawal injap tunggal bersama dengan pengawal PI dalam suatu ujian, satu cadangan telah disyorkan untuk mereka dan membangunkan kepada sistem pemancuan gas argon pada masa kini. Di samping itu, cadangan tersebut adalah untuk membukti bahawa enam pegawal digital injap yang berlainan yang digunakan sekaraing tidak akan memberi bacaan "*flow rate*" yang sebenar dan jitu ketika pemancuan gas argon sistem itu dijalankan dalam cecair besi. Dalam tesis ini, cadangan yang disyorkan adalah yang berpadu dengan ABB PLC dan di samping ingin membuktikan setakat mana jitu sistem itu dikawal dengan baik. Cadangan tersebut sebenarnya adalah untuk menjangka ketepatan sistem dengan melaksanakan teori matematik PI. Dengan menggunakan simulasi MatLab, dapatlah kita tahu bahawa kestabilan pada model semua "*transfer function*" dan juga negatif "*feedback transfer function*". Simulasi akan digunakan untuk dilaksanakan kepada sistem pemancuan yang benar dan selepas itu keputusan akan dibandingkan. Selain itu, PI yang direka dalam sistem itu juga digunakan untuk mengistiharkan model dan kita boleh dapat output yang benar. Cadangan model yang disyorkan itu telah dapat memberikan keputusan yang hampir sama dengan sistem pemancuan yang benar. Pemilihan pengawal injap tunggal yang betul adalah sangat penting untuk suatu proses dengan mengira Cv, iaitu pemalar injap. Dimaklumkan bahawa nilai Cv yang tinggi adalah sesuai untuk "*flow rate*" yang besar, manakala nilai Cv yang rendah adalah sesuai untuk "*flow rate*" yang kecil. Ujian telah memaparkan bahawa penggunaan pengawal injap yang salah tidak akan memberi keputusan yang munasabah mahupun yang tepat. Walau bagaimanapun, penggunaan program ABB memang banyak berbeza dengan program PLC industri yang digunakan sekarang. Biasanya, industri sekarang banyak menggunakan Siemens, Mitsubishi dan Omron PLC yang selaras dengan program tanggal yang lebih mudah dikendalikan untuk kawalan program sistem kita. Program ABB adalah lebih rumit dan susah digunakan dalam cara penyambungan terminal "*Function Block Diagram*"nya. Operasian sistem yang lama, iaitu *Microsoft Workgroup 3.11* digunakan untuk memindahkan program ABB ke PLC. 2 signal analog dan 4 signal digital digunakan dalam pengawalan program itu. Kesimpulannya, rekabentuk pengawal PI untuk sistem yang disyorkan itu, telah memberikan keputusan yang lebih memuaskan berbanding dengan sistem yang digunakan dahulu.

ABSTRACT

Using a single pneumatic control valve with PI feedback controllers test, a method is proposed to design and develop to the current gas argon purging system while to identify that the present 6 different kinds of digital control valve may not give the actual flow rate to the liquid steel purging system. In the present work, a method is proposed, by incorporating the ABB PLC (Programmable Logic Controller) to explain how well the purging control system is being controlled. A method is proposed to estimate the accuracy of the system by implementing PI algorithm. Two MatLab simulation results are given on stable first second order and third order plus unity feedback transfer function models. The estimated PI models are compared with the real time implementation of PI controller in gas argon purging system. PI controllers are designed for the identified model and for the actual system. The proposed method gives performance close to that of the actual system. Using an appropriate pneumatic control valve is much concerned in this test by calculating out its coefficient of valve (Cv) by mean to identify higher flow rate may require higher value in Cv while lower flow rate requests for lower Cv. By the way, a test shows that by using wrongly control valve, the PI controller would produce intangible result. Using AMPL (ABB Master Program Language) with ABB PLC controller is much different from Siemens or Mitsubishi PLC programming which they intended to use ladder diagram as function for the control system. AMPL is used in two ways of connection of its programming, first is Data Base, and second is PC element. Data Base is held on intermediate between PC element and hardware's(input card and output card of PLC) connection. Mircosoft Workgroup 3.11 operating system is used to transfer the AMPL programming to the PLC. 2 analogue signals and 4 digital signals are used in the program to manipulate the control system. The analogue signals will be connected to analogue input card and output card while digital signal will be placed at only digital input card, because there are 4 digital input signals can be used to generate 16 steps setting for the gas purging system. The PI controller designed on the system identified by the proposed method gives a performance better than the present working system.

1. INTRODUCTION

1.1 Background

1.1.1 Gas Purging Background

This thesis is a project concerned with the consistency flow rate of ladle gas purging system. This system will begin to use in ladle car from tapping process until the ladle car transferred to ladle furnace by mean to avoid the solidification of molten steel. When the ladle car reach the ladle furnace station (Figure 1.1 and Figure 1.2), the gas purging system will still be used along the molten steel treatment process(at the ladle furnace station, the molten steel will have treatment to achieve the quality raw product of steel-billet). Therefore, the consistent flow rate of ladle gas purging system is making important role in the manufacturing process of steel. [8]

Figure 1.1 Rubber Pipe supply to Ladle Car

Figure 1.2 Ladle Station

1.1.2 Previously Purging System Background

Previously, the system consists of a Gas Unit (Figure 1.4) located below the ladle furnace platform, a main control unit and operation desk at the furnace control room (Figure 1.3). In the Gas Unit, it has high pressure inlet device (for max 25 bar) valve, pressure switch inlet valve, differentiate pressure transmitter, 3-2 way valve, pressure reducer, gas filter, dose module, controller, ventilation valve, bypass valve, monometer, pressure switch, outlet valve, pressure net inlet argon (8-20 bar), flow meter and some terminal lists for PLC control devices. The main control unit will be a set of PLC and measurement devices control system and it is interrelated with the operation desk control which located in the furnace control room. [8]

Figure 1.3 Control Desk of Existing System

Figure 1.4 Previously Gas Purging System Control Unit

1.1.3 Project Gas Argon Purging Control System Background

However, the proposed system will only consists of pneumatic control valve, differential pressure flow meter, ABB PLC control sets compatible with PI controller setting and 12 steps selector switch. Moreover, this is simply and easy to manipulate once the system successful developed and built up. This proposed system will operate under a closed-loop feedback system by using appropriate controller. The valve positioner is a device that precisely positions the trim of the control valve in accordance with the control signal. Basically, it has a feedback controller whose set point is the incoming control signal and the control variable for the positioner is the valve position. [4]

The positioner receives the output signal from the controller for use as its set point. The signal is compared to the actual valve position. If the valve stem is incorrectly positioned, the positioner will either add or exhaust air from the actuator (pneumatic control device) is required. Usually, the controller which is used is high-gain proportional controllers and it is used when the primary loop is slow responding. Local disturbances and nonlinearities can be compensated before their effect is felt by the primary controller. [4]

Nevertheless, under certain conditions, a positioner can improve the speed of response of the primary loop by matching the ranges of the controller and the valve actuator. [4]

1.1.4 Characteristics of Gas Argon In Molten Steel Purging System

Meanwhile, in the gas purging system, gas argon will be used. Argon is purged into the ladle through the porous plug at the bottom of the ladle. The gases will form stream circulation in the molten steel and purposely helps to:

i. Increase slag/steel interaction so that increase slag treatment rate.
ii. Homogenizing the heating of the steel and avoid temperature stratification.
iii. Homogenizing the steel temperature.
iv. Reduce the inclusion of molten steel.

Table below is a guideline for the argon flow rate and purging pressure at the different steps in gas purging system. [8]

Table 1.1: Setting Steps Guideline Table [8]

STEP	FLOW RATE (NL/MIN)	PRESSURE (BAR)
1	24	1.4-2.6
2	70	2.0-2.8
3	95	2.1-3.0
4	130	2.3-3.5
5	150	2.6-4.0
6	210	2.8-4.6
7	225	3.1-4.8
8	350	1.0-5.5
9	380	4.5-5.7
10	410	4.8-6.0
11	435	6.5-6.3
BYPASS	850	7.0-11.0

REMARKS:

Step 1 and step 2 = for cleaning purging.

Step 3 - step 6 = for normal purging.

Step 7 and step 8 = for desulfurization problem.

Step 9 – step 11 and bypass = for emergency use only. [8]

1.2 Review for Previous Purging System

For the previously purging system, there are several limitations that are due to *space limitation, complicated electronic circuits , cost maintenance limitation, modification limitation, stability limitation.*

a. **Space Limitation**: In the Control Unit Box, there are many components and parts involve in orders to control the purging system. Therefore, it consumes a lot of spaces to establish the system and some of parts are arranged in very limited way among each other. During the maintenance time comes, it is difficult to achieve high performance maintenance job for technician.

b. **Complicated Electronic Limitation:** The connection circuit in Control Unit Box is much complicated due to so many electronic components involved Therefore, it is hard to track the problem during the system is broken down.

c. **Cost Maintenance Limitation**: The maintenance cost is much higher because many of the equipments in the Control Unit Box are very expensive.

d. **Modification Limitation:** The modification for the system is much limited once the system needs to be upgraded due to space limitation and system limitation.

e. **Stability Limitation:** The previously system "contributes" unstable purging flow rate to the system. The system can not provide accurate value to the system and along this time is controlled by manually setting.

1.2.1 Problems Statement of Previous Purging System

The problem of the previous system includes complicated mechanical connection among the hardwares in the Gas Control Unit box, complicated connection within the controller and others hardwares, high maintenance cost for the system, difficult to modify the system even upgrading, the flow rate is unstable and inaccurate, while the space for continuous improvement is limited.

1.3 Objectives

The objectives of this project are to:

a. Analyze the conceptual design of mechanical piping connection for the gas argon purging system.

b. Design the piping layout and control system for purging controller.

c. Fabricate a piping connection for the gas purging control system.

d. Analyze the conceptual design of control system including sensor, controller, and electronic circuit for selector switch.

e. Design the block diagram for the gas purging control system.

f. Analyze the transfer function for all components and parts involved in the purging system and using MATHLAB to simulate it.

g. Program PLC which can provide stable and more accurate flow rate to the purging system.

h. Experiment the best programming method to fix the error of high overshoot, low response time, zero error offset, fast settling time.

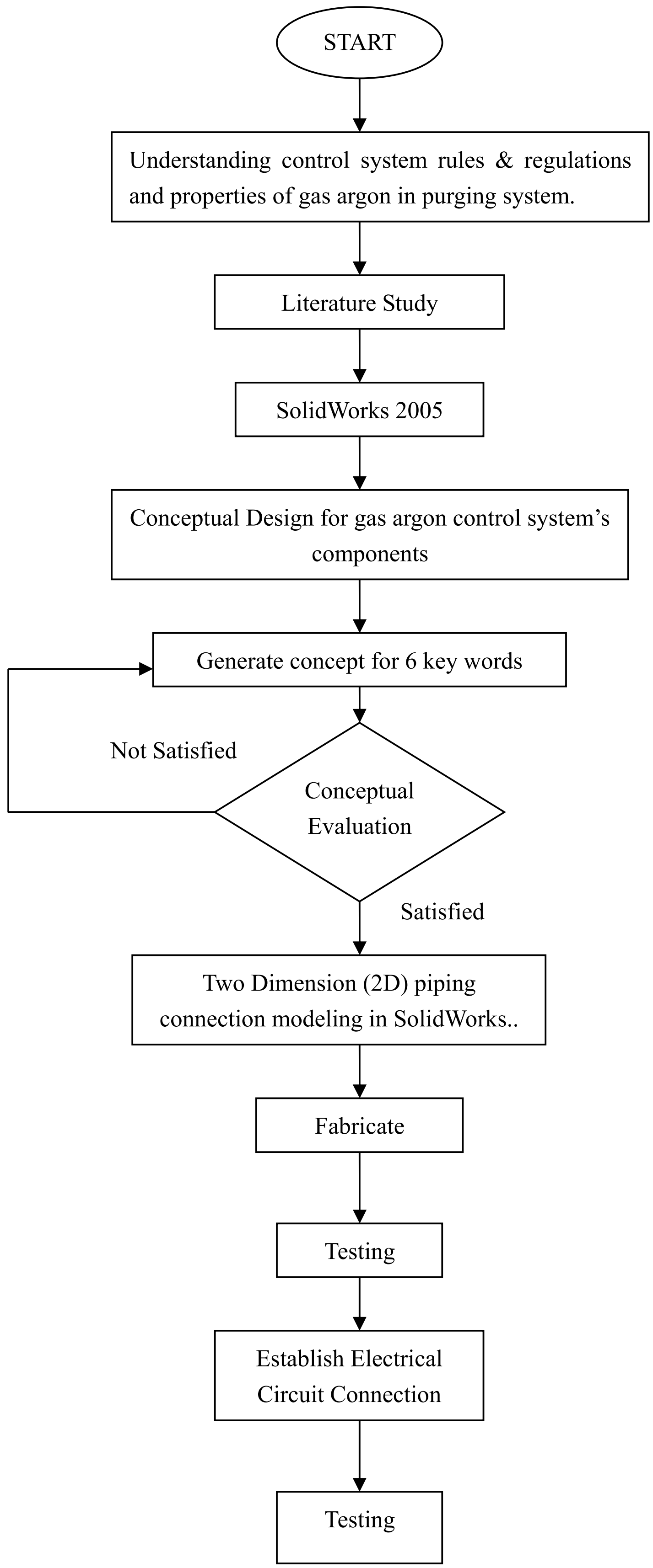
1.4 Project Scope

The scopes of this project are to:

a. Install regulator valve to existing system by replacing multi-valves flow controlled system.
b. Regulate the valve by mean of PI control through Advant Master PLC according to setting.
c. Create the monitoring display in Operator Station of Advant Master PLC.
d. Convert the existing control system to Advant Master PLC.
e. Improve and modify the Advant Master PLC for new system.
f. Experiment and test the control system module in a real environment and the feedback loop in fine-tuning the system to meet the objectives.
g. Update all the document of hardware and software including air control of regulator valve.
h. Training and briefing to SSB worker after modification.

1.5 Approach

This project begins with understanding the control system rules and regulations. Therefore, a literatures review is carry out to understand the system based on six key words which is mechanical piping connection, controller, actuator, sensor, electronic circuit and programming. The properties of gas argon are necessary to understand prior to analyze the criteria of mechanical piping connection. SolidWorks 2005 is used to draw the piping connection. MATHLAB is used to simulate the programming before downloading it to the control system. Purging control system is tested at the field continuously to observe its effectiveness for project improvement. Figure 1.5 shows the process flow charts for design, fabrication, analysis and testing procedure.


START
Understanding control system rules & regulations and properties of gas argon in purging system.
Literature Study
SolidWorks 2005
Conceptual Design for gas argon control system's components
Generate concept for 6 key words
Not Satisfied
Conceptual Evaluation
Satisfied
Two Dimension (2D) piping connection modeling in SolidWorks..
Fabricate
Testing
Establish Electrical Circuit Connection
Testing

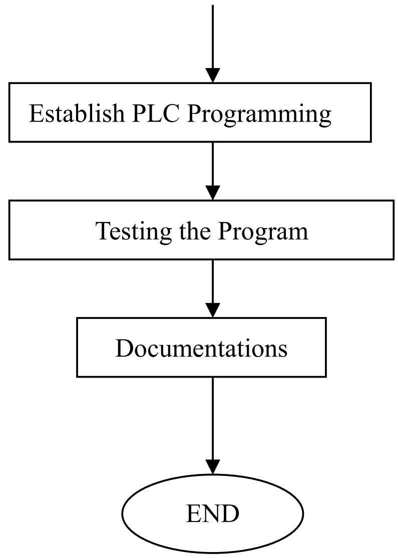


Figure 1.5: Overall Process Flow Chart

2. LITERATURE REVIEW

2.1 Conceptual Control System Design

A control system is a group of components that maintains a desired result by manipulating the values of another variable in the system. Normally, the control system divides to open-loop system and closed-loop system. As we know, an open-loop system does not compare the actual with the desired result to determine the control action. Instead, a calibrated setting-obtained by some sort of calibration procedure or calculation- is used to obtain the desired result.

Somehow, the feedback is the action of measuring the difference between the actual result and the desired result, and using that difference to drive the actual result toward the desired result. The term feedback comes from the direction in which the measured value signal travels in the block diagram. The signal begins at the output of the controlled system and ends at the input to the controller. The output of the controller is the input to the controlled system. Thus, the measured value signal is fed back from the output of the controlled system to the input. The term closed loop refers to the loop created by the feedback path. Figure 2.1 and Figure 2.2 show the block diagram of open loop and closed loop respectively. [7]

2.1.1 Operations Performed by a Feedback Control System

Measurement: Measure the value of the controlled variable

Decision: compute the error (desired value minus measured value) and use the error to form a control action.

Manipulation: use the control action to manipulate some variables in the process in a way that will tend to reduce the error.

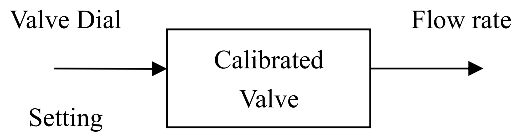


Figure 2.1 Open Loop Block Diagram

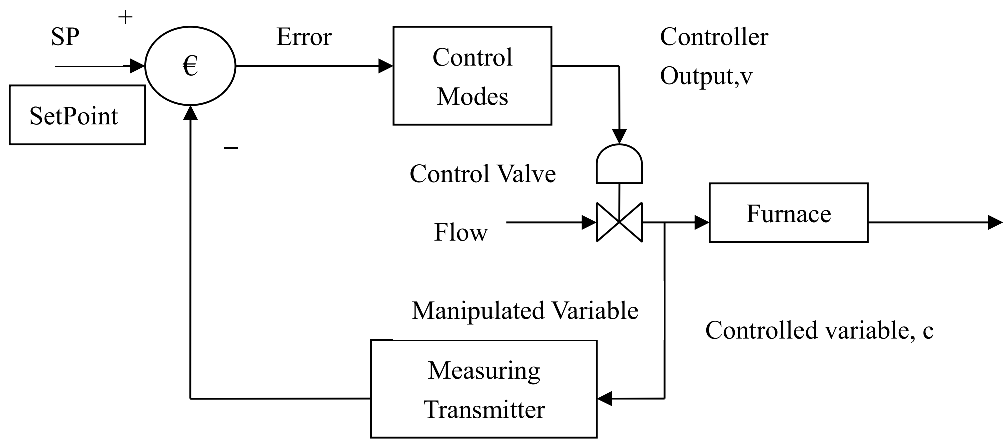


Figure 2.2 Closed Loop Block Diagram

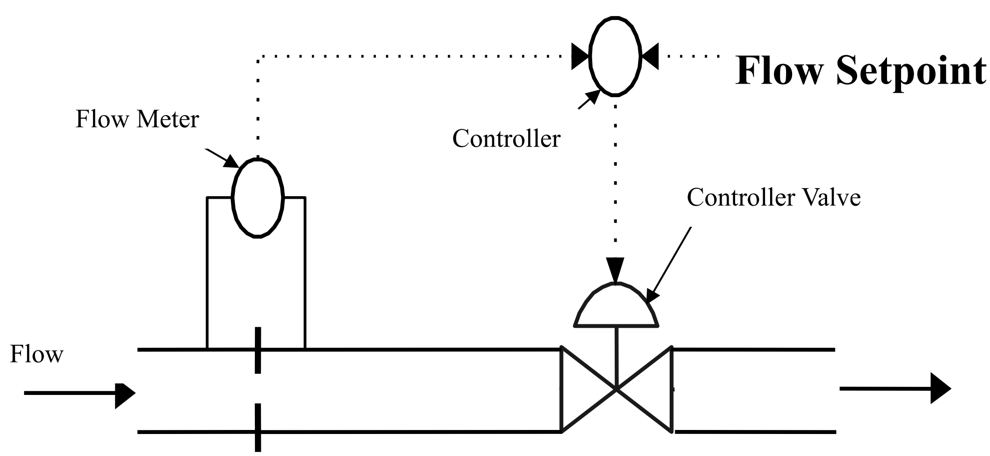


Figure 2.3 FeedBack Control Flow System

2.2 Process

The process block in Figure 2.3 represents everything performed in and by the equipment in which a variable is controlled. The process includes everything that affects the controlled or process variable except the controller and the final control element. For the project carried on, the process is referred to our valve. The process is responsible to provide the consistency flow rate to the molten steel in purpose to prevent modification of molten steel, eliminate the slag by causing the slag floating up on the top layer of molten steel, homogenizing the heating of the steel and avoid temperature stratification, homogenizing the steel temperature, reduce the inclusion of molten steel. However, the Figure 2.3 doesn't show the good arrangement for flow meter. Suppose the flow meter should be placed after the control valve so that the flow rate can be feedback to the controller act as comparison for producing error. Therefore, there are limitations to the process of flow rate. First, the flow rate doesn't follow the right setting as desired. Second, the operator who responsible to the purging system has to trial and error to get the actual flow rate approximate the setting flow rate between the tolerance of plus or minus 5L/min.

2.3 Measuring Sensor

The measuring sensor senses the value of the controlled variable and converts it into a usable signal. The term "measuring sensor" is a general term to cover all types of signals. Normally, the flow transmitter converts flow rate into electric current in the range 4-20mA. Measuring the flow of liquids is a critical need in many industrial plants. In some operations, the ability to conduct accurate flow measurements is so important that it can make the difference between making a profit or taking a loss. With most liquid flow measurement instruments, the flow rate is determined inferentially by measuring the liquid's velocity or the change in kinetic energy. Velocity depends on the pressure differential that is forcing the liquid through a pipe or conduit. Because the pipe's cross-sectional area is known and remains constant, the average velocity is an indication of the flow rate [7]. The basic relationship for determining the liquid's flow rate in such cases is shown as equation 2.1:

$$Q = V \times \frac{\pi d^2}{4} \quad \text{(Equation 2.1)}$$

Where,

Q = liquid flow through the pipe

V = average velocity of the flow

d = inner diameter of pipe

Other factors that affect liquid flow rate include the liquid's viscosity and density, and the friction of the liquid in contact with the pipe. Direct measurements of liquid flows can be made with positive-displacement flow meters. These units divide the liquid into specific increments and move it on. The total flow is an accumulation of the measured increments, which can be counted by mechanical or electronic techniques. [7]

Reynolds Number

The performance of flow meters is also influenced by a dimensionless unit called the Reynolds Number. It is defined as the ratio of the liquid's inertial forces to its drag forces. The Figure 2.4 shows the different type of flow happening in a pipe.

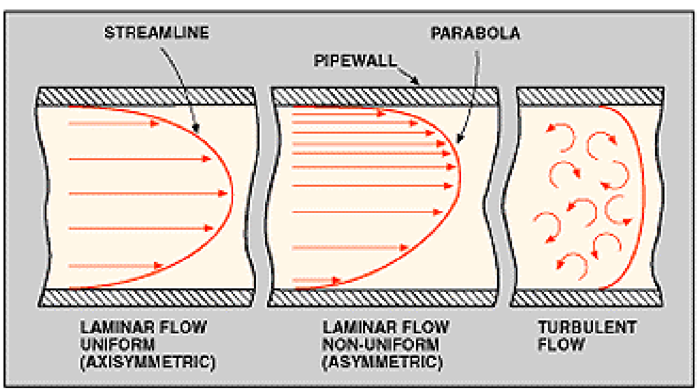


Figure 2.4 Types of Flow in Pipe

At very low velocities or high viscosities, R is low, and the liquid flows in smooth layers with the highest velocity at the center of the pipe and low velocities at the pipe wall where the viscous forces restrain it. This type of flow is called laminar flow. R values are below approximately 2000. A characteristic of laminar flow is the parabolic shape of its velocity profile.

However, most applications involve turbulent flow, with R values above 3000. Turbulent flow occurs at high velocities or low viscosities. The flow breaks up into turbulent eddies that flow through the pipe with the same average velocity. Fluid velocity is less significant, and the velocity profile is much more uniform in shape. A transition zone exists between turbulent and laminar flows. Depending on the piping configuration and other installation conditions, the flow may be either turbulent or laminar in this zone. The equation of Reynolds Number (RE) for gas flow is shown at equation 2.2: [6]

$$RE = \frac{4W}{\mu \pi d} \quad \text{(Equation 2.2)}$$

W = gas flow rate, kg/sec

μ = absolute viscosity of fluid, Pascal seconds

d = inner diameter of pipe, m

2.3.1 Differential Pressure Flow Meters

Differential pressure flow meters, like most flow meters, have a primary and secondary element. The primary element causes a change in kinetic energy, which creates the differential pressure in the pipe. The unit must be properly matched to the pipe size, flow conditions, and the liquid's properties. And, the measurement accuracy of the element must be good over a reasonable range. The secondary element measures the differential pressure and provides the signal or read-out that is converted to the actual flow value. [10]

2.3.2 Positive Displacement Flow Sensor

Positive displacement flow meters measure the volume or flow rate of a moving fluid or gas by dividing the media into fixed, metered volumes. These devices consist of a chamber that obstructs the media flow and a rotating or reciprocating mechanism that allows the passage of fixed-volume amounts. The number of parcels that pass through the chamber determines the media volume. The rate of revolution or reciprocation determines the flow rate. Positive displacement flow meters differ in terms of electrical outputs. Analog current levels such as 4 to 20 mA are suitable for sending signals over long distances. [8]

2.3.3 Electromagnetic Flow meter

The operation of electromagnetic flow meters is based upon Faraday’s law. When a conductive fluid passes through a magnetic field, a voltage is generated at right angles to the velocity and magnetic field vectors. The voltage being detected by a pair of diametrically opposed electrodes mounted in the meter’s body. [10]

2.3.4 Vortex Flow meter

The frequency of the vortex shedding is directly proportional to the velocity of the liquid flowing through the meter. The three major components of the flow meter are a bluff body strut-mounted across the flow meter bore, a sensor to detect the presence of the vortex and to generate an electrical impulse, and a signal amplification and conditioning transmitter whose output is proportional to the flow rate. The meter is equally suitable for flow rate or flow totalizer measurements. Use for slurries or high viscosity liquids is not recommended. [8]

2.4 Controller

The controller includes the error detector and a unit that implements the control modes. The error detector computes the difference between the measured value of the controlled variable and the desired value (or setpoint). The difference is called the error and is computed according to the following equation: [9]

$$\text{Error} = \text{setpoint} - \text{measured value of controlled variable}$$

The control modes convert the error into a control action or controller output that will tend to reduce the error. The three most common control modes are proportional mode (P), the integral mode (I), and the derivative mode (D).

2.4.1 Proportional Mode(P)

The P Mode is the simplest of the three modes. It produces a control action that is proportional to the error. If the error is small, the proportional mode produces a small control action. If the error is large, the proportional mode produces a large control action. The proportional mode is accomplished by simply multiplying the error by a gain constant, K. [9]

(controller output) = (error)*100/(proportional band)

2.4.2 Integral Mode(I)

The I Mode produces a control action that continues to increase its corrective effect as long as the error persists. If the error is small, the integral mode increases the correction slowly. If the error is large, the integral action increases the correction more rapidly. In fact, the rate that the correction increases is proportional to the error signal. Mathematically, the integral control action is accomplished by forming the integral of the error signal. [9]

(controller output) = (1/INTEGRAL) (Integral of) e(t) d(t)

2.4.3 Derivative Mode(D)

The D Mode produces a control action that is proportional to the rate at which the error is changing. For example, if the error is increasing rapidly, it will not be long before there is a large error. The derivative mode attempts to prevent this future error by producing a corrective action proportional to how fast the error is changing. The derivative mode is an attempt to anticipate a large error and head if off with a corrective action based on how quickly the error is changing. Mathematically, the derivative control action is accomplished by forming the derivative of the error signal. [9]

$$\textbf{(controller output) = DERIVATIVE} \quad \frac{dm}{dt}$$

2.5 Manipulating Element

The manipulating element uses the controller output to regulate the manipulated variable and usually consists of two parts. The first part is called an actuator, and the second part is called final control element. The actuator translates the controller output into an action on the final controlling element, and the final controlling element directly changes the value of the manipulated variable. Valves, dampers, fans, pumps, and heating elements are examples of manipulating elements. [12]

A pneumatic control valve is often used as the manipulating element in processes. The actuator consists of air-loaded diaphragm acting against a spring. As the air pressure on the diaphragm goes from 3 psi to 15 psi, the stem of the valve will move from open to closed (air to close) or from closed to open (air to open). Figure 2.5 shows the structure of pneumatic control valve. [8]

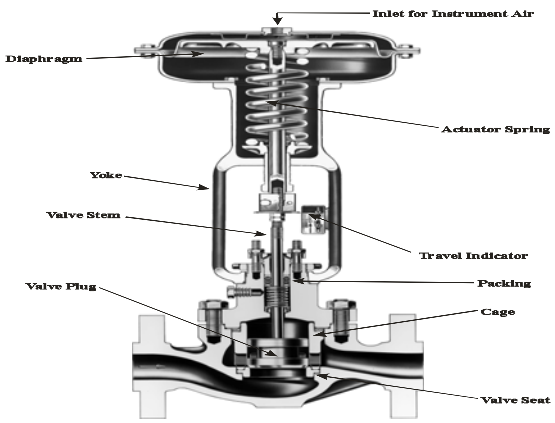


Figure 2.5 Structure of Pneumatic Control Valve

2.5.1 Pneumatic Actuator

It is most commonly used in today industrial. It is operated by combination of force created by air and spring force. There have two different styles of pneumatic actuator: i) Direct acting, ii) Reverse acting. The characteristics of direct acting actuator are: increasing air pressure will result in a downward motion of the actuator stem and decreasing air pressure will result in upward motion of the actuator stem. While the characteristics of reverse acting actuator are: increasing the air pressure results in upward motion of the actuator stem and decreasing air pressure results in downward motion of actuator stem. The Figure 2.6 shows the two different types of pneumatic in controlling the percentage of valve opening. [8]

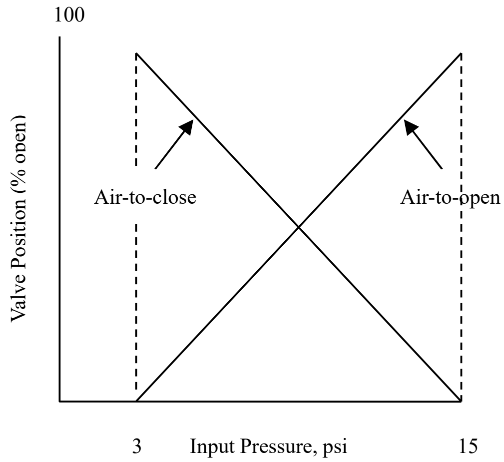


Figure 2.6 Control valve input-output graph

2.5.2 Hydraulic Actuator

It is using hydraulic system to operate the actuator. Normally, the piston types most common and when hydraulic force is greater than spring force, piston moves upward, valve opens. When hydraulic oil is drained from cylinder, hydraulic force becomes less than spring and piston moves downward, valve closes. Valve can be positioned between fully open and fully close. [10]

2.5.3 Electric Solenoid Actuator

It consists of a coil, armature, spring and stem. When current flow through coil, magnetic field is formed, and then attracts armature toward centre of the coil, valve opens. [8]

2.6 General Piping Design Concept

Most failures of liquid process systems occur at or within interconnect points -- the piping, flanges, valves, fittings, etc. It is, therefore, vital to select interconnecting equipment and materials that are compatible with each other and the expected environment. Materials selection is an optimization process, and the material selected for an application must be chosen for the sum of its properties. That is, the selected material may not rank first in each evaluation category; it should, however, be the best overall choice. Considerations include cost and availability. Key evaluation factors are strength, ductility, toughness, and corrosion resistance. [4]

2.6.1 Fluid Flow Sizing

The sizing for any piping system consists of two basic components fluid flow design and pressure integrity design. Fluid flow design determines the minimum acceptable diameter of the piping necessary to transfer the fluid efficiently. Pressure integrity design determines the minimum pipe wall thickness necessary to safely handle the expected internal and external pressure and loads. [4]

2.6.2 Carbon Steel

Carbon steel is a hot-rolled, all-purpose material. It is the most common and economical metal used in industry. It will readily rust (corrode) in ambient atmospheres, and some ideas such as casting applications can be applied to fabricate the carbon steel. It will also become embrittled with prolonged contact with alkaline or strong caustic fluids and contact with acid accelerates corrosion. [4]

2.6.2.1 Carbon Steel Pipe Specifications

A wide variety of mechanical properties is available by varying the carbon content and heat treatments. The most commonly specified carbon steel piping is manufactured to meet ASTM(American Society for Testing Materials). For example, ASTM A 587 specifies an electric-resistance welded carbon steel pipe intended for use in the chemical industry. The pipe is available in two nominal wall thicknesses from 15 mm (½ in.) to 250 mm (10 in.) in diameter. Another carbon steel pipe standard is ASTM A 106 which specifies seamless carbon steel pipe for high temperature service, but graphitization at prolonged high temperature may still occur. ASTM standards are reviewed for unusual process conditions or requirements to select the material most compatible to the application. [4]

2.6.2.2 Carbon Steel Fittings

Fittings for carbon steel piping can be threaded, welded or flanged; all are commonly used. Fitting materials can be cast malleable iron, forged carbon steel and low-carbon or other specialized steel. Other ASTM materials may also be appropriate; select a material and fitting that are compatible to the application.

Due to the relative in-expense of carbon steel flanges, carbon steel piping is usually flanged at connections to equipment and appurtenances such as valves or other items that may have to be removed or replaced. In addition to fittings described above, carbon steel piping may be joined by mechanical couplings. The pipe sections must, however, be specified with grooved ends. Most of the manufacturers that produce mechanical couplings for ductile iron piping also produce them for carbon steel piping. [4]

2.6.3 Stainless Steel

Stainless steel is the product of steel alloyed with chromium and, to a lesser extent, nickel. Other elements such as molybdenum, copper, manganese and silicon may also be included as part of the alloy for various steel types. Chromium is the primary additive that makes steel "stainless"; stainless steels are actually a very broad range of highly corrosion resistant alloys that have a variety of trace elements. [4]

2.6.3.1 Stainless Steel Pipe Specifications

Ferritic and martensitic stainless steels are used less commonly than austenitic. Unlike austenitic steels, ferritic stain less steels do not contain nickel and do not resist reducing chemicals such as hydrochloric acids. Ferritic stainless steels have excellent resistance to chloride attack and organic acids. Martensitic stainless steels. However, may contain nickel because their chromium content is limited . Typically, martensitic steels exhibit less corrosion resistance than austenitic steels. Ferritic and martensitic stainless steel piping should conform to ASTM, which addresses both seamless and welded pipe intended for general corrosive and high-temperature service. [4]

2.6.3.2 Stainless Steel Fittings

Welding fittings are typically specified under ASTM, similar to austenitic stainless steel fittings. Threaded and flanged fittings are specified in accordance with ASTM standard..[4]

2.6.4 Aluminum

Aluminum is highly ductile. Although it has relatively low strength, its high strength-to-weight ratio results in the extensive use of aluminum alloys where that feature is required. a. Aluminum Pipe Use Alloys 1060, 3003, 5052, 6061, and 6063 are the most common compositions of its aluminum pipe. Alloy 6063 is most widely used due to cost, good corrosion resistance, and mechanical properties. However, the cost of aluminum is much higher and so it doesn't look great to use in argon purging system. [4]

2.6.4.1 Aluminum Pipe Specifications

Alloys 3003 and 5052 are best used for extremely low temperatures. Alloy 5052 has the best corrosion resistance for slightly alkaline solutions. Aluminum piping resists corrosion well by forming a protective aluminum oxide film. It is very resistant to sulfur compounds and most organics, including halogenated organic compounds. Aluminum should not, however, directly contact concrete because alkalis in the concrete will attack the aluminum. An example would be strong resistance to either carbon tetrachloride or methyl alcohol separately, but poor resistance to a mixture of the two. Also, aluminum has poor resistance to contaminants such as halide ions (like chloride) and reducible metals (like copper) contained in commercial chemical grades of some chemicals. [4]

2.7 Components For Mechanical Piping Connection

The components are needed to establish a stable piping system. It responsible to ensure the piping system is free of leakage. Moreover, the pressure in the pipe must be constant and also there isn't head loss for the gas flow by equipping appropriate components of the piping connection. The components are gaskets, flanges, bolts and nuts. [4]

2.7.1 Gaskets

Gaskets and seals are carefully selected to insure a leak free system. A wide variety of gasket materials are available including different metallic and elastomeric products. Two primary parameters are considered, sealing force and compatibility. The force that is required at this interface is supplied by gasket manufacturers. Leakage will occur unless the gasket fills into and seals off all imperfections. The metallic or elastomeric material used is compatible with all corrosive liquid or material to be contacted and is resistant to temperature degradation. Gaskets may be composed of either metallic or nonmetallic materials. Metallic gaskets are commonly designed to ASME (American Standard Mechanical Engineering). The Figure 2.7 shows the gasket material and its initial compression of the material has been using. [4]

Gasket Material	Initial Compression, MPa (psi)
Soft Rubber	27.6 to 41.4 (4,000 to 6,000)
Laminated Asbestos	82.7 to 124 (12,000 to 18,000)
Composition	207 (30,000)
Metal Gaskets	207 to 414 (30,000 to 60,000)
Note: These guidelines are generally accepted practices. Designs conform to manufacturer's recommendations. Source: SAIC, 1998	

Figure 2.7 Gasket Compression [4]

2.7.2 Flanges

Seven pressure classes: 150, 300, 400, 600, 900, 1,500 and 2500 are provided for flanges in ASME standard. The ratings are presented in a matrix format for 33 material groups, with pressure ratings and maximum working temperatures.

2.8 Bolting Materials

Carbon steel bolts, generally ASTM grade B material, should be used where cast iron flanges are installed with flat ring gaskets that extend only to the bolts. Higher strength bolts may be used where cast iron flanges are installed with full-face gaskets and where ductile iron flanges are installed (using ring or full-face gaskets). [4]

2.9 Programmable Logic Controller (PLC)

A PLC is a digital, electronic device designed to control machines and processes by implementing function such as logic, sequence control, timing, counting, and arithmetic operations. A programmable controller is a digital computer-it has a processor, a memory unit, and an input/output unit. Most programmable controllers can perform the following operations: Relay logic, Timing, Shift Register, Addition, Comparison, Binary conversion, Counting, Subtraction, PID controller and etc. the Figure 2.7 shows the block diagram of a common programmable controller used in industry. Most programmable controllers are programmed using a symbolic language that is very similar to the ladder diagrams used for relay logic controllers. This method programming is sometimes called *contact symbology*, but moe often it is simply called *ladder diagram* programming. However, as programmable controllers acquired more functions, ladder diagram became more cumbersome. Therefore, higher-level languages were developed to supplement ladder diagram programming, for instance, functional block diagram elements will be used to replace the ladder diagram programming. [1]

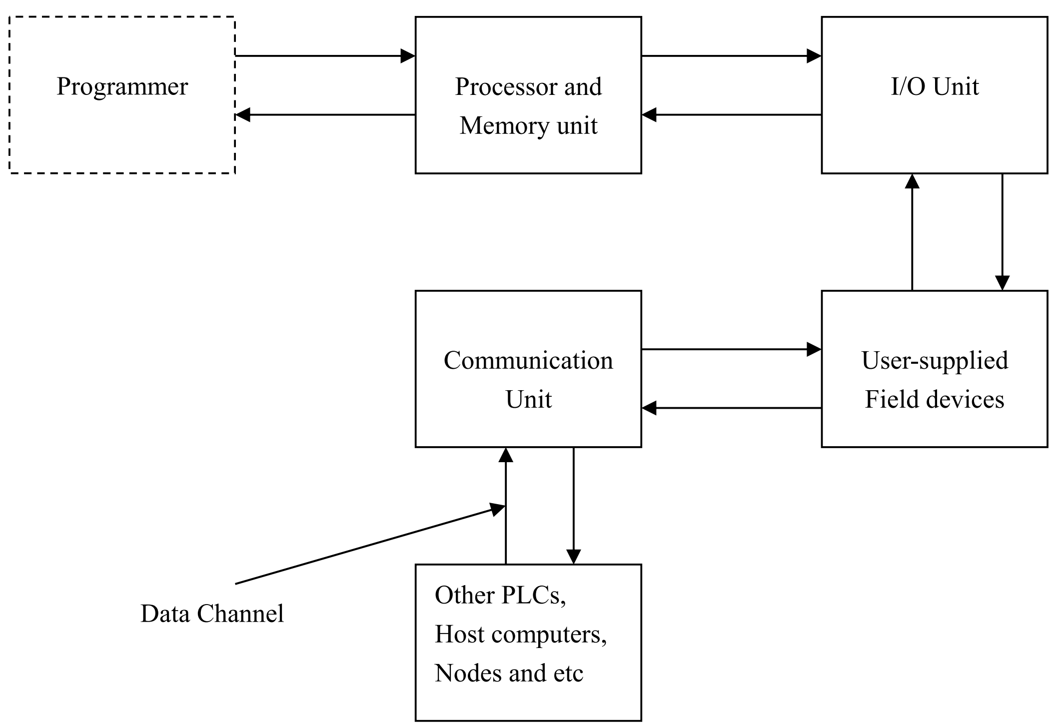


Figure 2.8 Block Diagram of A Programmable Controller.

3. METHODOLOGY

3.1 Overview

Development and design are defined as an iterative decision-making process to conceive and implement an optimum system to enhance the stability and improve performance which the previously system can not achieve. In achieving the purpose of development of the system, it is proud to produce an efficient and effective solution to the problem, a series of development steps must follow: understanding the working environment (argon gas purging system field, design characteristic), review of previous gas purging system and final concept generation evaluation.

3.2 Working Environment

The working environment of an argon purging system may affects all the aspects of development and design a stable and high performance system. Hence, this is much important to design and develop a system which can configure and tolerate with the environments in steel making plant. The argon gas purging system is one of the working environments in the steel making plant which is used during implementing treatment for molten steel. The flow rate of gas argon purging must be consistency and stable along the process in molten steel treatment. Due to solidification of molten steel aspect, the purging system needs to be fast to stable and constant once the ladle furnace transferred from Electrode Arc Furnace to ladle station by ladle car. Therefore, the gas purging system is needed to control the temperature of molten steel in ladle furnace.

3.3 Review of Previous Gas Purging System

It is important to have a review on the past system designs so that study can be done on advantages and disadvantages of the designs and its shortcomings can be improved. This will prevent the repetition of the same design process, and further modifications can be made. Table 3.1 below shows the characteristics of Gas Argon Purging System in steel making plant.

Table 3.1 Characteristics of Argon Gas Purging System

Characteristics	Methods / Materials	Observation
Structure of unit	Mounted on a protected steel box	High space consumption
Electrical driving control system	Integrated electronic components functions	Accurate positioning, but complicated
Switching and output	Digital & Analogue	8 digital input & 8 digital output signals involved in setting flow rate value. Analogue inputs are used in inlet pressure and differential pressure control.
Flow rate Controller	Dose Module & controller	6 digital valves in the dose Module catridge.
Wiring for control overall system	Circuit diagram	Wires labelled by code and colour but complicated
Electric	AC	Connect to 220VAC
Pressure Source	High pressure connection	Must not be higher than 25 bar
Power Source for unit	DC	24VDC(for unit enable and flow action
Controller pressure	FLOW MUST REMAIN CONSTANT	0-9 bar only
Programmable Logic Controller	To ON or OFF the 6 digital valves.	PLC responsible to activate the 6 digital valves by different combinations.
Control Loop	Open Loop	The flow isn't the actual flow rate, the digital valves ON or OFF as they being set.

3.3.1 Function of Previously Purging System

The function is controlled by the dose module which has 6 different size flow rate control valve inside it. The six valves have the function for control the flow rate as below:

Valve 1 = 10L/min

Valve 2 = 20L/min

Valve 4 = 80L/min

Valve 5 = 160L/min