Control system-pressure regulator

A type or certain group of elements that function together as a unified whole, is a system. This widened description thus gives some meaning to control systems as a whole. By re-establishing the basic principles and functions worked out, a system's limit can be extended to include little or more characteristics just as long as each singular variable contributes in a way to the particular system activity.

This explains that the system does not halt interaction to other systems or peripherals. In the process industry, the term control system is sometimes normally used to specify a process, and the apparatus basically required to run the process. The system is tested with various actions so it will conform to a standard, these include; load, commands and disturbances which cause it to respond in some individual manner. A system is best made so that it will respond positively.

In order for a system to act in the way prescribed is to control the system. The basic concept of comparing the measured and prescribed system performance, and then taking any action to change the process thereby minimizing errors, is called negative feedback. The system can vice-versa be called a closed-loop control system, or a negative feedback control system. To make a system automated it should be mechanized. To create the maintenance of a constant value in a control, is not the major primary objective of control; once the prescribed behavior is achieved, the control function is fulfilled.

Although the use of control measure is in most cases involved with mechanical equipment, they can also be used in fields such as (e. g. in the social, biological or in different other systems). Thescienceof achieving control, by using or not using feedback, is the method of control theory. This is applicable to system control in general. Most control systems have evolved by the practice of trial and error, for the critical design of system controls with the need for extensive analysis of two factors, the control devices and the process.

2. 0 TYPES OF REGULATORS-

2. 1 SIMPLE PRESSURE CONTROL SYSTEM (SELF OPERATED REGULATOR):

For a typical uncontrolled system, let us say it is required for it to provide a standard pressure, P, at a given measure and that the discharge, Q2, provides for an external system, which, its need for this fluid varies. At a given time interval, the external system regulates valve No. 2 to comply with the needed specifications. The curves given in Fig 1. 0

FIG 1. 1

Shows the way in which it alters the process of the pressure. In earlier results in time, t1, some initial stable condition exists where, Q1

and Q 2 are of the same and the process pressure is significantly at the aimed equivalent. A level change occurs at, Q1 when time is at, t1, this reduces the fluid mass between the valves. This is followed mainly by a drop in the process pressure. For a system which is uncontrolled the pressure decline will continue until the drop over valve No. 1 is enough again to build equal flows and a new constant state functioning condition is gained. The procedure can be controlled; i. e. the suitable needed pressure can be managed if the significant rise in Q1 were gotten by increasing the opening of valve No. 1.

A typical way of doing this is given in Fig 1. 1.

FIG 1. 3

The response for the process pressure is sent to a spring opposed diaphragm that gives free way for the pressure to manoeuvre the valve. In a working mode, the contraction in the spring will be set so that at some constant state working condition the required process pressure, acting on the diaphragm section, this balances the force that the spring carries. The aimed process pressure is known as a set point. Changes from the set point which is caused by load variation will be controlled because as the process pressure differs, the matching force given back to the diaphragm will regulate the valve position to reduce the pressure variance to a certain range of value around the set point.

The careful control of the pressure will rely on how big a flow change the regulator will be able to carry out for a minimal amount of pressure. The regulator flow change to process pressure change is the gain of the regulator and this will rely on the diaphragm area, the valve size, stiffness of the spring, and the general pressure drop over it.

The corrective activity done by the regulator is proportional to the change of the process from its set point. Such an element is called the proportional or proportional mode, control. When using the proportional control, the corrective action can only carry on when some different outlines exist. The final pressure change needed to completely stroke the regulator is known as the proportional band and it shows around what limits the regulator can control.

FIG 1. 4

illustrates where the process measurement supplies the whole valve actuating force, this is known as self-operated regulators.

FIG 1. 5

The above demonstrates a self operated regulators made for the control of temperature, flow and level. The operation method is practically the same with the pressure regulator. They are widely used in various applications of specialty in the industrial field.

3. 0 PILOT OPERATED PRESSURE REGULATOR:

This regulator uses a little pilot valve assembly to aide in actuating the main valve. Generally the pilot operated pressure regulator shown in Fig 1. 6

FIG 1. 6

when in operation, the process pressure works on the lower side of the main diaphragm which is similar to the self operated regulator. The pilot also quantifies the process pressure and, upstream pressure as power source, changes the loading on the top side of the main diaphragm. The diaphragm serves as an amplifier, generally bearing a gain from process to loading pressure of 10 to 20 psi per psi. This is because of both feed back path ways one through the direct one and the other through the pilot, the regulators demonstrate a more complex control action than the simple proportional mode.

The pilot operated regulator are available for all the four major process variables; flow, pressure level and temperature even though the direct acting path is left out in some cases. With the pilot operated regulator it is generally easier to achieve a greater regulator gain. Both the self and pilot operated regulators share similar attributes that have, in many cases, brought about some restraints. In some instances like if the fluid is corrosive, loaded with contaminants or of very high temperature, apparent issues may arise. Essentially at most one of the diaphragm casings, should, be able, to hold the maximum process pressure.

The most possibly vital deficiency, from, the basis that static and dynamic elements of any specific form of process; i. e., level, pressure, etc. can differ respectively from one installation to the other so the choice of the amount of gain to be designed into a regulator without causing any sort of system instability, is made a very tasking procedure. It means that the regulator can not be altered to suit the characteristics of the process to which it has been applied. This Fig 1. 7 is the block diagram of a pilot operated regulator

FIG 1. 7

3. 1 INSTRUMENT CONTROL:

The pressure control system illustrated in Fig 1. 8

FIG 1. 8

it surpasses all the limits considerably attached to the self and pilot operated regulators. It generally contains three detachable hardware pieces: the process controller, the control valve, and the valve actuator. Other controllers such as this stands for one of an entirefamilyof peripherals generally referred to as instruments. The process fluid touches only the control valve and its sensing element. This is a small part which has no orifice and could get contaminated. They can be made from several types of materials to achieve high standard against corrosion and temperature. An external source for pneumatic power is used for working parts in the controller to provide clean, dry instrument air.

The air supply is regulated so that the pressure is at a standard rate and that the controller and actuator are made to work with a standard pressure signal level, free of the process fluid pressure. A regular standard pressure supply is within 20 psig with a usual ranging of signal within 2 to 15 psig.

They are ready for use with numerous sensing element and they give the significance of the process which is being controlled. They are commonly known as indicative controllers. To minimize trial and error the set point is normally calibrated to generally prevent subsequent start ups. The Fig 1. 8 is like most pneumatic controller models, it has two levels with an adjustable measure of response and amplification around both levels. The input variable moves an end of a beam which holds the air flow through a nozzle.

The pressure of the nozzle is sensitive to the point of the beam itself. The pressure of the nozzle performs on the top diaphragm of a pressure equal valve assembly that is the second amplifier level. As a result of the huge valve ports it is has the capacity to give an extreme flow progression to the actuator which works as a power amplifier. The pressure is given back to the amplifiers which moves the nozzle beams in a direction which opposes the sensing effect. Element motion (i. e. negative feedback).

The three way valve behaves as a pressure divider and its regulation decides what amount of feedback should be consumed. Leaving the dynamics out, the controller can be seen as having a high gain movement path with a regulated gain response path. It provides only proportional control mode but its area of reach can be freely adjusted over a vast range by means of the pressure divider.

The purpose of the integral mode is to remove any steady state process deviation and the reason for the deviation mode is to give an improved transient control. These modes improve the flexibility of the controller.

4. 0 COMPUTER CONTROL-

The reason for central control is to bring to a particular location, adequate information and hardware to allow an operator to control the plant variances, which are product yield and quality, and to manage the automated control of process variances, which are flow and temperature. In order for all duties to be carried out by the operator must have a sound knowledge of process variances, but how they should be. The adequate values for the process variances will differ as operating circumstances may be affected by things such as contamination, variations in reactants, load, changes in the products wanted or quality. The set points calculation can be made from the plant requirements and information about the plant operating elements. The early use of digital computers for process controls was for plant performance calculation the whole system works in an automated form sampling of transmitter signals. The optimizing of control and direct digital controls in Fig 1. 9

FIG 1. 9

Illustration of the hierarchy control as given in FIG 2. 0

LLOYD, SHELSON, G AND ANDERSON, GERALD, D. 1971. Industrial Control Process. An Introduction to Hardware . 1st edn. Marshaltown, Iowa: Fisher Controls Co. pp. 83-92.

5. 0 CONTROL ELEMENTS-

5. 1 BASIC ELEMENT:

Any system can be broken down into various divisions for understanding it's rather important to consider two levels of dub divisions. The first are those components in a control loop that are manufactured, tested, purchased and even design as standalone pieces of equipments.

5. 2 MATHEMATICAL MODELS OF PHYSICAL DEVICES:

The mathematical representation of physical devices can be done with the use of the fundamental physical laws which include Ohm's Law Newton's Laws, flow equations, conservation of mass and energy, etc.

The use of impedance is often but not always helpful when deriving a mathematical model when a system is dynamic there is a circumstance which is forcing the change. This force is always some kind of potential energy . When a change occurs that is the dynamic system which is a movement known as flux. This flux generally depends on the physical characteristics of the system. Some forms of flux are shown in Table 1. 0.

TABLE 1. 0

Impedance shows the mathematical relationship between potential and flux, it is the ratio of an increase change in potential to an increase change in flux.

EQUATION. 1

LLOYD, SHELSON, G AND ANDERSON, GERALD, D. 1971. Industrial Control Process. Basic Elements. 1st edn. Marshaltown, Iowa: Fisher Controls Co. pp. 93-94.

6. 0 PROCESS CONTROL SYSTEM

The performance of a process control system is calculated by considering the system's output to the set point. The difference between both amounts is error or system deviation . The response of a regulatory system, for a step increase in load. Many standard words are defined in the schematic and several of them are used to describe the mistakes which might occur. It is obvious that no certain way such as settling time, maximum value of transient deviation, steady- state deviation gives a measure of system performance. Different approaches methods have been used for the error index. A tank which has several sources of flow as given in Fig 2. 1 can be easily described by using block diagrams and flow components. For easy understanding lets say Pc = constant. The equation for flow is:

PRESSURE PROCESS STEADY FLOW (FIG 2. 1)

In order to illustrate the nature of a process control system consider Fig 2. 2 for the control equipment has a valve, diaphragm, actuator, and a locally mounted PI measuring controller

FIG 2. 2

LLOYD, SHELSON, G AND ANDERSON, GERALD, D. 1971. Industrial Control Process. Process Dynamics . 1st edn. Marshaltown, Iowa: Fisher Controls Co. pp. 202-204.

7. 0 ACCURACY AND SENSITIVITY

7. 1 ACCURACY

" In general, the greatest accuracy-closest regulation-is obtained with the largest diaphragm and shortest range which will give the required control pressure. For example, a control pressure of 40 psig can be obtained with any of the three ranges in model RP-1065-A and with two of the three ranges in model RP-1066-A. Closest regulation can be expected with the 5 - 50 psi range of model RP-1066-A (size 10 diaphragm). See table for " Accuracy of Regulation." Unbalanced port areas are not considered in the values tabulated. Small amounts of unbalance are present in single-seated 1/2" " A" valves and in semi-balanced double seated valves 2" through 4". Under conditions of high pressure drop, the forces opposing valve closure will influence selection of the regulator model (diaphragm size). See " Accuracy of Regulation" tabulation for actual port area unbalance"

FIG 2. 3

[WWW] http://www. skilenvironmental.

com/documents/160_RP1065A_1066A. pdf

In addition what changes can made to the diaphragm area, spring rate, orifice size, and inlet pressure, the regulator accuracy can be enhanced by simply putting a pitot tube. Internal to the regulator, the pitot tube joins the diaphragm cover with a low-pressure, high velocity region inside the regulator body. The pressure in the area will be lower than P2 when it goes downstream. By using a pitot tube to calculate the lower pressure, the regulator change in its response to any change in P2. The pitot tube tricks the regulator.

7. 2 SENSITIVITY

The principle of operation and loading, actuating, and control components are in all designs. Many regulators use simple wire coil springs to control the downstream pressure. Numerous size springs are used to allow regulation of the secondary pressure around a target range. The needed pressure is at the centre one-third of the rated outlet pressure range. In the lower end of the pressure range, the spring loses some sensitivity; at the high end, the spring close to it maximum capacity.

Regulators can use diaphragm or piston to detect or sense downstream pressure. Diaphragms are more sensitive to pressure variations and react quicker. They can operate where sensitive pressure settings are needed (lower than 0. 04 psi). Pistons generally are more rugged and give a larger effective sensing area in a particular size regulator. The functional difference between general-purpose and precision regulators is the degree of control accuracy of the output pressure. Output pressure accuracy is gotten by the droop due to flow changes (regulator characteristics). [WWW] http://machinedesign. com/article/pneumatic-pressure-regulators-1115

8. 0 FEEDBACK

This section will develop the performance limitations imposed by a particular load when a conventional flow control valve is utilized in the valve-actuator component. It will then show that the load versus flow characteristic of the forward loop can be modified very advantageously. Various techniques utilized in the past for this purpose, such as controlled actuator by-pass leakage and structural feedback, are compared with a new technique called dynamic pressure feedback (D. P. F.). The analytical work is fortified by reports of actual tests of a representative system. The electrohydraulic position servo can be represented by the block diagram shown in Fig 2. 4. This diagram separates the valve-actuator integration from the hydraulic and structural compliance of the actuator.

The diagram also represents the particular load case under discussion. The analysis of servo stability and performance is affected by the choice of position feedback location. Output position can be measured at the actuator or at the load. If the feedback is from the actuator position, the analytical task is made more difficult. However, it is apparent from the block diagram that the quantities Xp and X0 react in a proportional manner to inertia forces. It is reasonable to conclude, therefore, that the two cases should yield similar results.

This discussion will be based on selection of feedback intelligence from the load position, X0, due to the relative simplicity of analysis. However, a careful comparison of this simpler case with the more difficult to analyse case of actuator feedback position has been carried out. An analogue computer was utilized for this comparison. The results of the study confirmed that the two cases are really very similar in dynamic performance achievable. The use of actuator position feedback suffers some comparative penalty statically withrespectto error introduced by external (load disturbance) forces." [WWW] http://www. emeraldinsight. com/Insight/ViewContentServlet; jsessionid= 6464D27CC3E73FAFE7C6220F352B4F85? contentType= Article&Filename=/published/emeraldfulltextarticle/pdf/1270320604. pdf

FIG 2. 4

[WWW]http://www. emeraldinsight. com/Insight/ViewContentServlet; jsessionid= 6464D27CC3E73FAFE7C6220F352B4F85? contentType= Article&Filename=/published/emeraldfulltextarticle/pdf/1270320604. pdf

9. 0 PRESSURE MEASUREMENT

" Fluid pressure can be defined as the measure of force per-unit-area exerted by a fluid, acting perpendicularly to any surface it contacts (a fluid can be either a gas or a liquid, fluid and liquid are not synonymous). The standard SI unit for pressure measurement is the Pascal (Pa) which is equivalent to one

Newton per square meter (N/m2) or the KiloPascal (kPa) where 1 kPa = 1000 Pa. In the English system, pressure is usually expressed in pounds per square inch (psi). Pressure can be expressed in many different units including in terms of a height of a column of liquid.

CONVERSION UNITS FOR COMMON UNITS OF PRESSURE (TABLE 2)

PRESSURE TERMS RELATIONSHIP (FIG 2. 5)

Table lists commonly used units of pressure measurement and the conversion between the units. Pressure measurements can be divided into three different categories: absolute pressure, gage pressure and differential pressure. Absolute pressure refers to the absolute value of the force per-unit-area exerted on a surface by a fluid. Therefore the absolute pressure is the difference between the pressure at a given point in a fluid and the absolute zero of pressure or a perfect vacuum. Gage pressure is the measurement of the difference between the absolute pressure and the local atmospheric pressure. Local atmospheric pressure can vary depending on ambient temperature, altitude and local weather conditions.

The U. S. standard atmospheric pressure at sea level and 59ï¿½F (20ï¿½C) is 14. 696 pounds per square inch absolute (psia) or 101. 325 kPa absolute (abs). When referring to pressure measurement, it is critical to specify what reference the pressure is related to. In the English system of units, measurement relating the pressure to a reference is accomplished by specifying pressure in terms of pounds per square inch absolute (psia) or pounds per square inch gage (psig). For other units of measure it is important to specify gage or absolute. The abbreviation . abs' refers to an absolute measurement.

A gage pressure by convention is always positive. A . negative' gage pressure is defined as vacuum. Vacuum is the measurement of the amount by which the local atmospheric pressure exceeds the absolute pressure. A perfect vacuum is zero absolute pressure. Fig 2. 5 shows the relationship between absolute, gage pressure and vacuum. Differential pressure is simply the measurement of one unknown pressure with reference to another unknown pressure. The pressure measured is the difference between the two unknown pressures. This type of pressure measurement is commonly used to measure the pressure drop in a fluid system. Since a differential pressure is a measure of one pressure referenced to another, it is not necessary to specify a pressure reference.

For the English system of units this could simply be psi and for the SI system it could be kPa. In addition to the three types of pressure measurement, there are different types of fluid systems and fluid pressures. There are two types of fluid systems; static systems and dynamic systems. As the names imply, a static system is one in which the fluid is at rest and a dynamic system is on in which the fluid is moving". [WWW] http://www. scribd. com/doc/2339144/Understanding-Pressure-and-Pressure-Measurement

10. 0 CONTROLLERS

The major use of controllers is to detect errors in the variables and to create error correction messages that which is caused by the error. To complete this task the controller design must have an adjustable set point that can be comparison to the process variable. The error that is given is sent as a response for needed action to be carried out. The block diagram is given in Fig . The input could be as an input from the transmitter, which happens in the situation involving a receiver-controller.

A three mode controller transfer function likely should be as given in the equation , the static gain has been resolved in two perspectives ; K is the nominal output and input ps and this would normally n= be unity for a receiver controller, and Kc is an adjustable measurement known as proportional gain.

EQUATION. 2

The three modes stated above give the derivative, integral, and proportional modes respectively.

FIG 2. 6

Simpler controller designs employing one or two modes are often used. The basic combinations are

P- Proportional only

I- Integral only

PI- proportional plus integral

PD proportional plus derivative

PID proportional plus integral plus derivative

The transfer function may be derived from EQUATION. 2 by eliminating the appropriate terms.

In the self operated regulator the actuator, controller and sensor are normally the same thing and with the same element. The controller has no other than the set point and has fixed gain and practically no adjustments. The transfer function is taken as:

EQUATION. 3

Considering an example with a regulator with a set point of 5 psig and a flow capacity of 0. 6, a temperature of 60 degree (Fahrenheit) and a pressure of 5 psig. The off set flow capacity will be 20 percent. The density can be determined with the use of the equation of state of a perfect gas as shown below:

CALCULATION . 1

LLOYD, SHELSON, G AND ANDERSON, GERALD, D. 1971. Industrial Control Process. Control Components . 1st edn. Marshaltown, Iowa: Fisher Controls Co. pp. 115 - 148.

11. 0 INPUT AND OUTPUT

" This simple valve model has three states: OPEN, WORKING, and CLOSED.

As the valve is the only component of the pressure-regulator that has state, the composite device, likewise, has only three states: [OPEN], [WORKING], and [CLOSED]. Suppose the input pressure is decreasing and the pressure-regulator is in state [WORKING], then dXFp = +, which causes A, the cross-sectional area available for flow to increase. This raises the possibility that A

In this state, the pressure-regulator provides no regulation at all because the input pressure is less than the regulator's target output pressure. The resulting state diagram is illustrated in FIG 2. 7 the diagram in the case where the input pressure is increasing. This example, although extremely simple, illustrates the task of drawing inferences concerning the termination of states and the determination of the next state.

Note that no input disturbance can cause the valve to move to or from state CLOSED. In this device, every increase in input pressure results in a decrease in area available for flow. But even if the input pressure continues to grow unboundedly, the area will never become zero (if it were zero, the output pressure would be zero and hence the action of the sensor could be holding the valve closed). For any finite pressure, the area will be non-zero. Only as pressure tends to infinity does the area approach zero as the mathematical limit. This is a counter-example to the seductive fallacy that infinite sums of non-zero values always diverge. The point to be made here is that even though the qualitative algebra is extremely simple, it nevertheless concerns derivatives, integrals, and time, and one must be careful least one fall into the well-known pitfalls concerning infinitesimals."