13 BASICS OF PROCESS CONTROL AND CONTROLLER

Introduction

- Process control involves the control of variables such as temperature, pressure, flow rate, etc., processes ranging from oil refining and mineral processing to pharmaceuticals and food processing. However, from a broader planning and management perspective, process proving safety, and reducing harmful impacts on the environment.
- Process control is already a key party of almost every process operation and will increase significantly in scope and importance as the full impact of computers, communication, and software technology reaches the process plant level.
- The features of a process are usually measured by process variables. The control of process variables is achieved by controllers (hardware elements or software programs) and final control elements like control valves.
- There are certain difficulties encountered in implementation of process control arising due to the following factors.

Nonlinear and non-stationary nature of process

Process gain (resulting in nonlinearity) and/or dynamic parameters (resulting in non-stationary nature) change with the operating point. This causes the process to exhibit highly variable behavior — sluggish to respond at times, while oscillatory (even unstable) at other times.

Unavailability of accurate measurement of controlled variable

In many cases, it is not possible to measure the quantity to be controlled, so it has to be estimated.

Time delays

- Time delays are encountered in the process and manipulated simultaneously, interactions among the variables are unavoidable, making the task of control a challenging one.

...ivity to noise and disturbances

...sses are continuously subjected to various types of known and unknown disturbances and noises which ...e the task of process control challenging.

...of Process Variable

...rolled Variable and Control Signal or Manipulated Variable

...controlled variable is the quantity or condition that is measured and controlled. The control signal or ...ipulated variable is the quantity or condition that is varied by the controlled so as to affect the value of the ...rolled variable. Normally, the controlled variable is the output of the system. Control means measuring the ...ue of the controlled variable of the system and applying the control signal to the system to correct or limit ...iation of the measured value from a desired value.

...studying control engineering, we need to define additional terms that are necessary to describe control ...stems.

...nts

...plant may be piece of equipment, perhaps just a set of machine parts functioning together, the purpose of ...hich is to perform a particular operation. In this book, we shall call any physical object to be controlled (such ...a mechanical device, a heating furnace, a chemical reactor, or a spacecraft) a plant.

...ocesses

...e Merriam – Webster Dictionary defines a process to be a natural, progressively continuing operation or ...elopment marked by a series of gradual changes that succeed one another in a relatively fixed way and lead ...ward a particular result or end; or an artificial or voluntary, progressively continuing operation that consists of ...series of controlled actions or movements systematically directed toward a particular result or end. In this ...ok we shall call any operation to be controlled a process. Examples are chemical, economic, and biological ...ocesses.

...stems

...system is a combination of components that act together and perform a certain objective. A system need not ...physical. The concept of the system can be applied to abstract, dynamic phenomena such as those ...ncountered in economics. The word system should, therefore, be interpreted to imply physical, biological, ...onomic, and the like, systems.

...isturbances

...disturbance is a signal that tends to adversely affect the value of the output of a system. If a disturbance is ...nerated within the system, it is called internal, while an external disturbance is generated outside the system ...nd is an input.

Feedback Control

Feedback control refers to an operation that, in the presence of disturbances, tends to reduce the diffe between the output of a system and some reference input and does so on the basis of this difference. Here unpredictable disturbances are so specified, since predictable or known disturbances can alway compensated for within the system.

In this section we shall present a few examples of control systems.

Speed Control System

The basic principle of a Watt's speed governor for an engine illustrated in the schematic diagram of Figur The amount of fuel admitted to the engine is adjusted according to the difference between the desired a actual engine speeds.

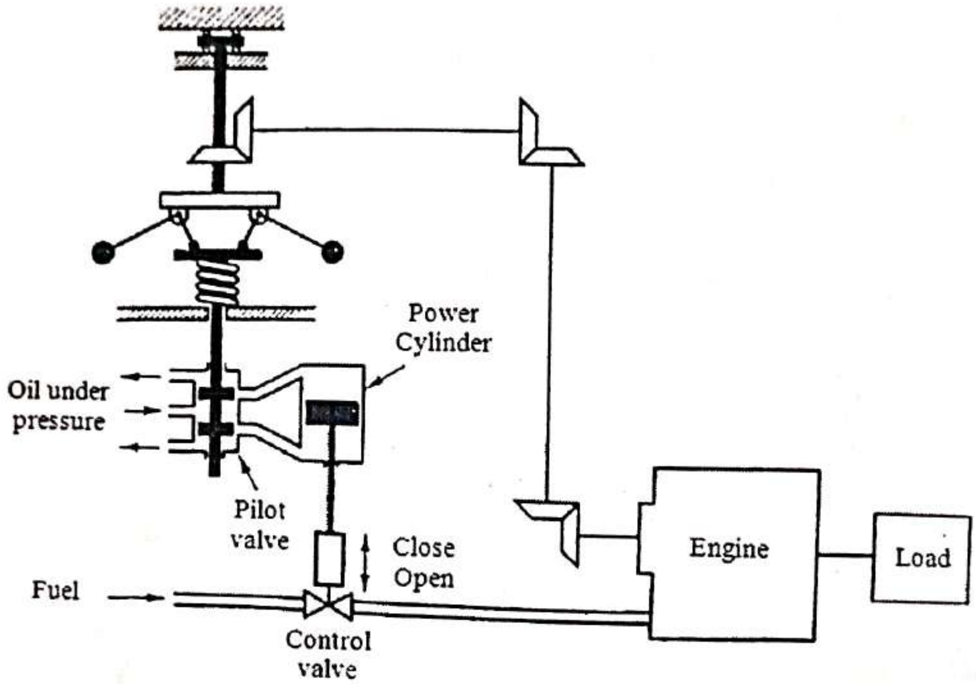


Figure : Speed Control System

The sequence of actions may he stated as follows: The speed governor is adjusted such that, at the de speed, no pressured oil will flow into either side of the power cylinder. if the actual speed drops belo desired value do disturbance, then the decrease in the centrifugal force of the speed governor the control to move downward, supplying more fuel, and the speed engine increases until the desired value is reache the other hand, if the speed of the engine increases above the desired value, then the increase in the centri force of the governor causes the control valve to move upward. This decreases the supply of fuel, and the s of the engine decreases until the desired value is reached.

In this speed control system, the plant (controlled system) is the engine and the controlled variable is the s of the engine. The difference between the desired speed and the actual speed is the error signal. The co signal (the amount of fuel) to he applied to the plant (engine) is the actuating signal. The external inp disturb the controlled variable is the disturbance. An unexpected change in the load is a disturbance.

...ature Control System

...hows a schematic diagram of temperature control of an electric furnace. The temperature in the electric ...is measured by a thermometer, which is an analog device. The analog temperature is converted

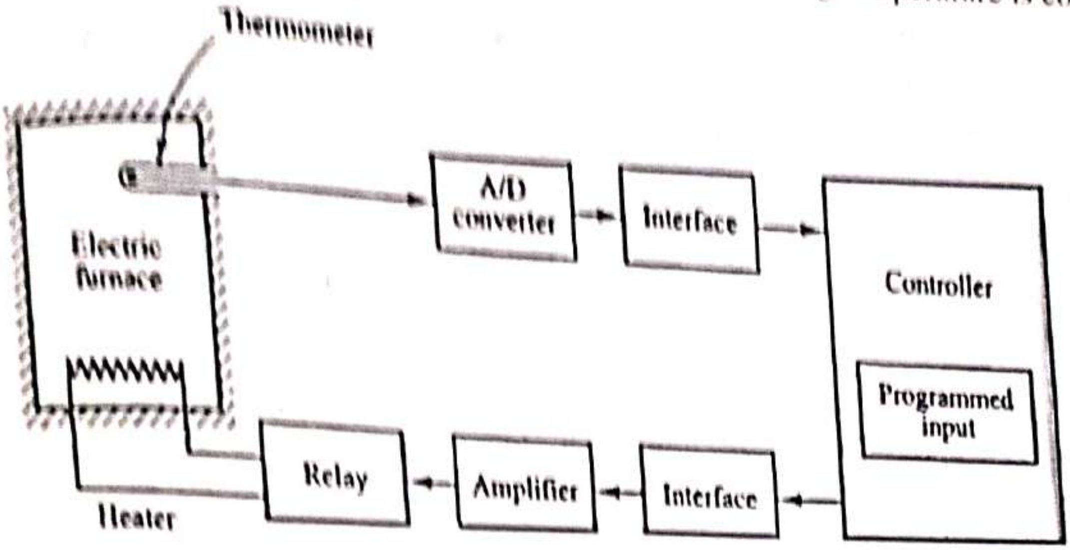


Figure : Temperature control system

...digital temperature by an A/D converter. The digital temperature is fed to a controller through an interface. ...digital temperature is compared with the programmed input temperature, and if there is any discrepancy ...the controller sends out a signal to the heater, through an interface, amplifier, and relay, to bring the ...ace temperature to a desired value.

...OSED-LOOP CONTROL VERSUS OPEN-LOOP CONTROL

...back Control Systems

...stem that maintains a prescribed relationship between the output and the reference input by comparing ...and using the difference as a means of control is called a feedback control system. An example would be a ...-temperature control system. By measuring the actual room temperature and comparing it with the ...rence temperature (desired temperature), the thermostat turns the heating or cooling equipment on or off in ...a way as to ensure that the room temperature remains at a comfortable level regardless of outside ...ditions.

...sed-Loop Control Systems

...dback control systems are often referred to as closed-loop control systems. In practice, the terms feedback ...trol and closed- loop control are used interchangeably. In a closed-loop control system the actuating error ...al, which is the difference between the input signal and the feedback signal (Which may be the output ...al itself or a function of the output signal and its derivative, and/or integrals), is fed to the controller so as to ...uce the error and bring the output of the system to a desired value. The term closed-loop control always ...plies the use of feedback control action in order to reduce system error.

Open-Loop Control Systems

Those systems in which the output has no effect on the control action are called open-loop control systems. In other words, in an open_ loop control system the output is neither measured nor fed back for comparison with the input. One practical example is a washing machine. Soaking, washing, and rinsing in the washer operate on a time basis. The machine does not measure the output signal, that is, the cleanliness of the clothes.

Closed-Loop versus Open-Loop Control Systems

An advantage of the closed-loop control system is the fact that the use of feedback makes the system response relatively insensitive to external disturbances and internal variations in system parameters. It is thus possible to use relatively inaccurate and inexpensive components to obtain the accurate control of a given plant, whereas doing so is impossible in the open-loop case.

The major advantages of open-loop control systems are as follows:

1. Simple construction and ease of maintenance.
2. Less expensive than a corresponding closed-loop system.
3. There is no stability problem.
4. Convenient when output is hard to measure or measuring the output precisely is economically not feasible. (For example, in the washer system, it would be quite expensive to provide a device to measure the quality of the washer's output, cleanliness of the clothes.)

The major disadvantages of open-loop control systems are as follows:

1. Disturbances and changes in calibration cause errors, and the output may be different from what is desired.
2. To maintain the required quality in the output, recalibration is necessary from time to time.

Regulatory Control

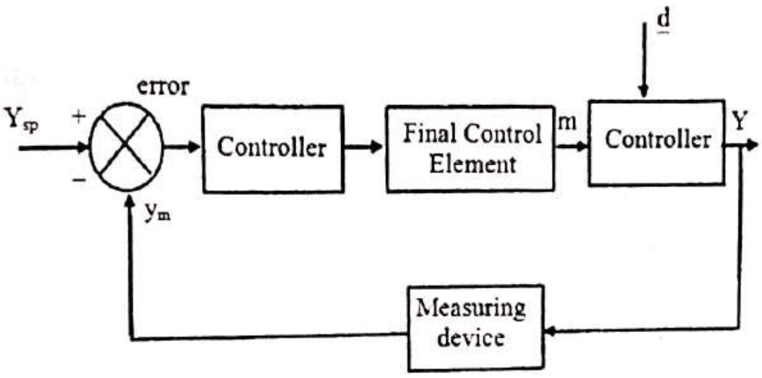
- In this case, deviation of the output from the set point is minimized in the face of changing circumstances by adjusting the inputs to the system. Controlling the temperature in a room in spite of ambient temperature variation is an example of regulator operation.
- A regulatory control system will normally have a fixed reference or set point. This does not mean that the set point cannot be changed. Set points do change, but the changes are not very frequent. Set points remain constant for relatively longer periods of time. In regulatory process control systems, load variations usually present the primary problem.
- Electrical power generation is a typical example of a regulatory system.

Servo Control

- In Servomechanism, the main concern is the determination of controlled variation able respond according to the changes in reference.

- A typical example of servomechanism is – numerical control of a milling machine. The reference is continuously changing and the milling cutter must duplicate this change to produce a satisfactory product.
- In batch control of reactors, after the reactor has been lowed – another example of servo control. In this type of system, few, if any, external or load disturbances affect the system.
- In most servo control applications, the position, speed or acceleration of an object is made to follow the set point closely.

back Control Configuration



Process Control loop with Feedback

back systems play a important role in modern engineering practice because they have the potential to orm their assigned tasks automatically. Consider the generalized process control loop shown in the Fig., It an output y, a potential disturbance d, and an available manipulated variable m. The disturbance d (also wn as load or process load) changes in an unpredictable manner, and control objective is to keep the value e output y at a desired level

lforward Control Configuration