

## **Chapter one**

### **Introduction to control system**

#### **1.1. introduction**

- Automatic control system played a vital role in the advancement of engineering and science.
- In addition to its extreme importance in space-vehicle missile guidance and aircraft-piloting system
- Automatic control has become an important and integral part of modern manufacturing and industrial processes. For example automatic control is essential in such industrial operations as controlling pressure, temperature, humidity, ...
- Since advance in the theory and practice of automatic control provide means for attaining optimal performance of dynamic systems, improving the quality and lower the cost of production. Expand the production rate.
- Most of engineers and scientist must now have a good understanding of this field.

#### **1.2. Definitions:**

**Plants:** A plant is a piece of equipment, perhaps just a set of machine parts functioning together. In this lectures, we call any physical object to be controlled a plant as ( heating furnace, chemical reactor, or space craft)

**Process:** Progressively continuing operation or development marked by a series of gradual changes that succeed one another in a relatively fixed way and lead toward a particular results or end. In this lectures we call any operation to be controlled a process.

**System:** A system is a combination of components that act together and perform a certain objective.

**Disturbance:** A disturbance is a signal which tends to adversely affect the value of the output of a system.

- Internal disturbance: it is generated within the system.
- External disturbance: it is generated outside the system and is an input.

**Command Input:** the motivating input signal to the system, which is independent of the output of the system.

**Reference Input:** the reference signal produced by the reference selector, i.e., the command expressed in a form directly usable by the system. It is the actual signal input to the control system.

**Reference Selector (Reference Input Element):** The unit that establishes the value of the reference input. The reference selector is calibrated in terms of the desired value of the system output.

**Output (controlled variable):** The quantity that must be maintained at a prescribed value, i.e., following the command input without responding to the disturbance inputs.

**Forward element (system dynamics):** The unit that reacts to an actuating signal to produce a desired output. This unit does the work of controlling the output and thus may be a power amplifier.

**Feedback element:** The unit that provides the means for feeding back the output quantity, or a function of the output, in order to compare it with the reference input.

**Actuating signal:** The signal that is the difference between the reference input and the feedback signal, it is the input to the control unit that causes the output to have the desired value.

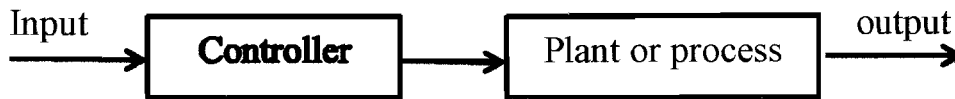
**Servomechanisms:** It is a feedback control system in which the output is some mechanical position, velocity, or acceleration.

**Automatic regulating systems:** It is a feedback control system in which the reference input or the desired output is either constant or slowly varying with time and in which the primary task is to maintain the actual output at the desired value in the presence of disturbance. For example a home heating system in which a thermostat is the controller.

**Process control systems:** An automatic regulating system in which the output is a variable such as temperature, pressure, flow, liquid level is called a process control system.

### **1.3. Classification of control system**

#### **A- Open Loop Control Systems**



*Fig (1-1) Open loop control system*

The open loop control systems in which the output has no effect upon the Control action. That is, the output is neither measured nor fed back for comparison with input.

#### **Examples:**

- 1- **Washing machine** which operate on time basis. The machine does not measure the output signal, namely the cleanliness of the clothes.
- 2- **Traffic control** by means of signal operated on a time basis. For each reference input, there corresponding a fixed operation condition. Thus the accuracy of system depends on calibration.

#### **Major advantages of open loop control system**

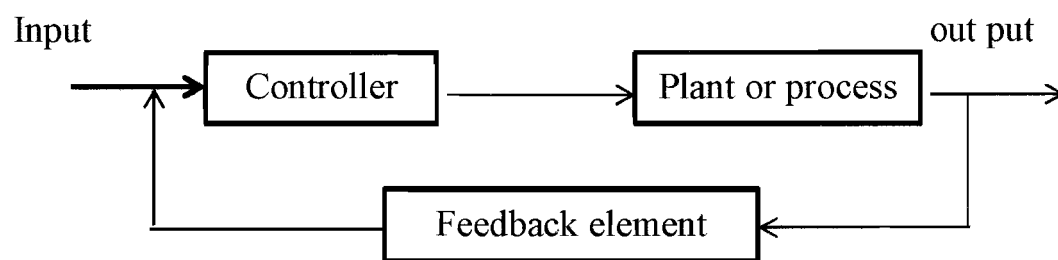
- 1- Simple construction and ease of maintenance.
- 2- Less expensive than the corresponding closed loop system.
- 3- There is no stability problem.
- 4- Convenient when output when output is hard to measure or economically not feasible.

#### **The 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.

### B- Closed loop control system:

A closed loop control system is one in which the output signal has a direct effect upon the control action. That is the closed loop control systems are feedback control systems. The actuating error signal (which is the difference between the input signal and the feedback signal) is fed to the controller so as to reduce the error and bring the output of the system to the desired value.



*Fig (1-2) Closed loop control system*

#### **Example:** Temperature control

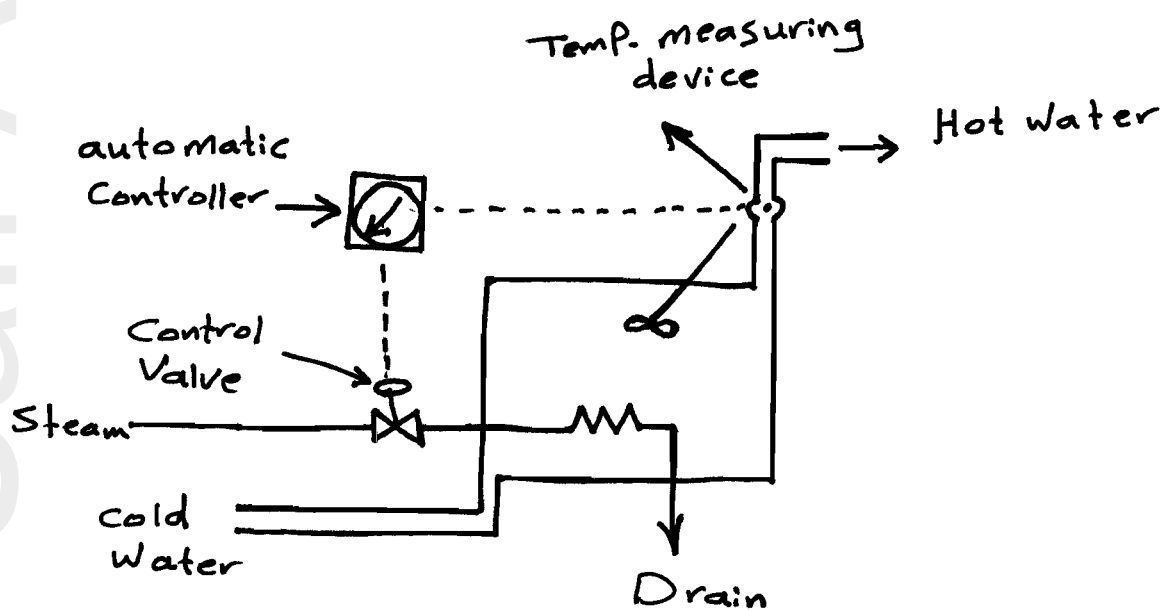
- Human being act as controller
- Thermometer measure the actual temperature of the hot water (output)

A human watches the thermometer, he finds:

- a- Temperature higher than the desired one then he reduces the amount of steam supply in order to lower the temperature.
- b- Temperature lowers than the desired one he increase the amount of steam.

If an automatic controller is used to replace the human operator, the control system becomes automatic.

- The position of the dial on the automatic controller sets the desired temperature.
- The output; the actual temperature of the hot water is compared with the desired temperature in order to generate an actuating error signal.
- The measured temperature is converted to the same unit of input by means of transducer (A transducer is a device which converts a signal from one form into another).
- Error signal produced in automatic controller is amplified and sent to the control valve in order to change the amount of steam. If there is no error, no change the value.
- In system considered, the ambient temperature & cold water temperature may be considered as external disturbance.



*Fig (1-3) manual F.B. control of thermal system*

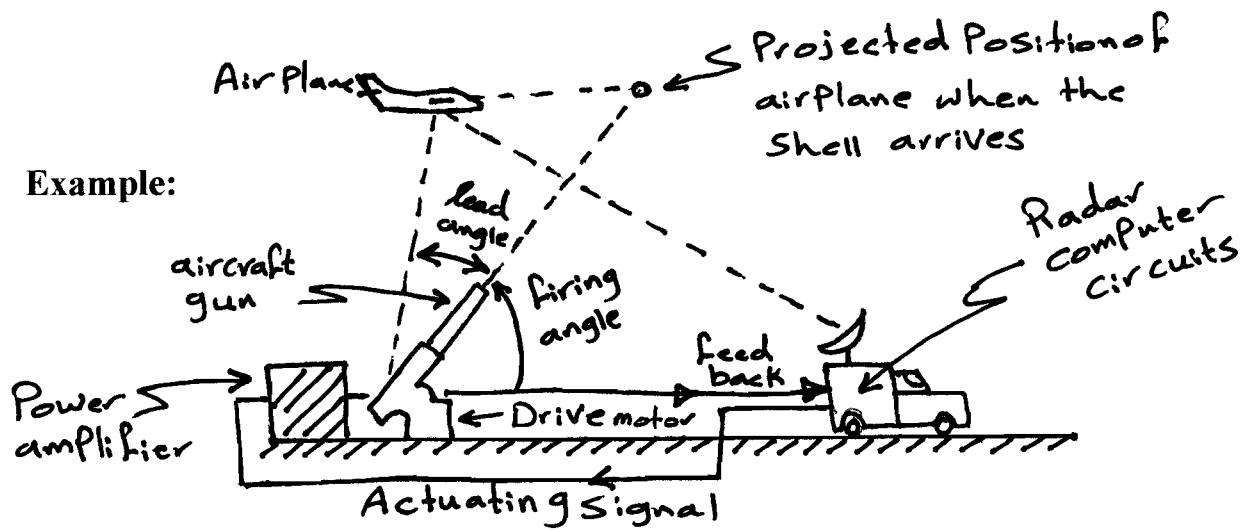


Fig (1-4) antiaircraft radar tracking control system

- The radar antenna detects the position and the velocity of the target airplane.
- The computer takes the information and determines the correct firing angle for the gun.
- Firing angle includes the necessary lead angle so that the shell reaches the projected position at the same time as airplane.
- The output signal of the computer (actuating signal) is fed into a power amplifier whose output voltage is applied to drive motor.
- The motor rotate the gun to the desired firing angle.

Open-Loop Control System	Closed-Loop Control System
1. An open-loop system has the ability to perform accurately, if its calibration is good. If the calibration is not perfect its performance will go down	1. A closed-loop system has got the ability to perform accurately because of the feedback
2. It is easier to build.	2. is difficult to build.
3. Weak against disturbance	3. Can reduce the effect of disturbance
4. If non – linearity's are present; the system operation is not good	4. Even under the presence of non – linearity's the system operates better than open loop system
5. Feedback is absent	5. Feedback is present