

Introduction to: Measurement and Control System

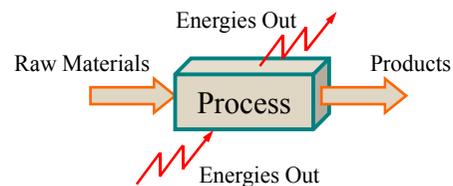


Introduction to Process Control

Definition (1)

□ Process

- A series of interrelated actions which transform material
It covers all resources that are involved in the **process** and talks about **process** “inputs” (e.g. resources, raw material) and “outputs” (e.g. finished product)



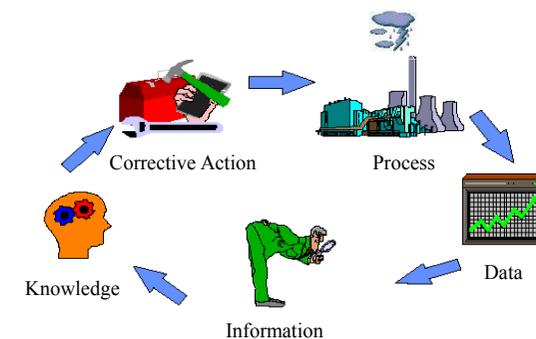
□ Control

- To maintain desired conditions in a physical system by adjusting selected variables in the system

Definition (2)

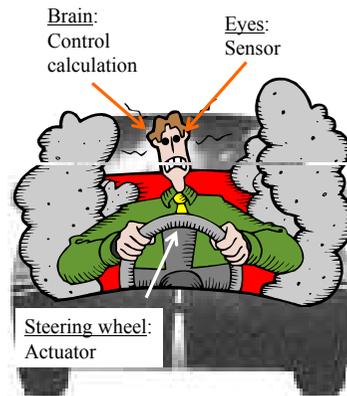
□ Process Control

- To maintain desired conditions in a physical system by adjusting selected variables in the system in spite of disturbances affecting the system and observation noise



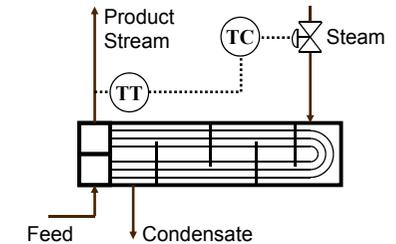
Daylife Example: Driving a Car

- ❑ Control Objective (Setpoint):
 - Maintain car in proper lane
- ❑ Controlled variable:
 - Location on the road
- ❑ Manipulated variable:
 - Orientation of the front wheels
- ❑ Actuator:
 - Steering wheel
- ❑ Sensor:
 - Driver's eyes
- ❑ Controller:
 - Driver
- ❑ Disturbance:
 - Curve in road
- ❑ Noise:
 - Rain, fog



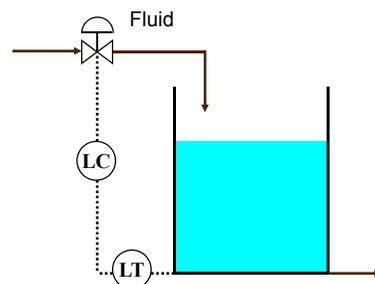
Industrial Example #1: Heat Exchanger

- ❑ Control Objective (Setpoint):
 - Maintain temperature
- ❑ Controlled variable:
 - Outlet temperature of product stream
- ❑ Manipulated variable:
 - Steam flow
- ❑ Actuator:
 - Control valve on steam line
- ❑ Sensor:
 - Thermocouple on product stream
- ❑ Controller:
 - Temperature controller
- ❑ Disturbance:
 - Changes in the inlet feed temperature
- ❑ Noise:
 - Measurement noise

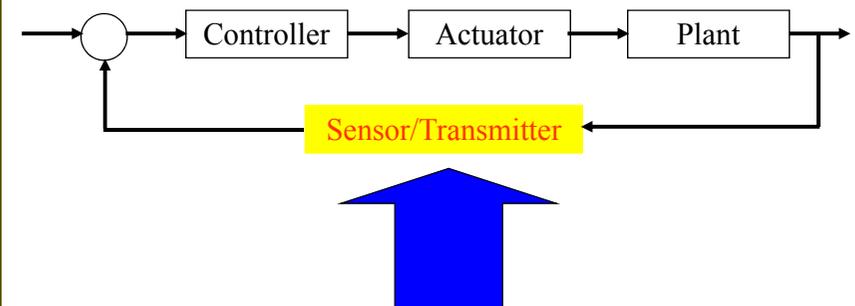


Industrial Example #2: Liquid Level Control

- ❑ Control Objective (Setpoint):
 - Maintain level
- ❑ Controlled variable:
 - Fluid level in the tank
- ❑ Manipulated variable:
 - Fluid flow
- ❑ Actuator:
 - Control valve on fluid line
- ❑ Sensor:
 - Level transmitter on the tank
- ❑ Controller:
 - Level controller
- ❑ Disturbance:
 - Changes in the inlet feed flow
- ❑ Noise:
 - Measurement noise



Block Diagram of Control System



Transducers: Sensor and Actuator

- ❑ **Tranducer:**
 - A device that converts a signal from one physical form to a corresponding signal having a different physical form
Physical form: mechanical, thermal, magnetic, electric, optical, chemical...
 - Transducers are ENERGY CONVERTERS or MODIFIERS
- ❑ **Sensor:**
 - A device that receives and responds to a signal or stimulus
 - This is a broader concept that includes the extension of our perception capabilities to acquire information about physical quantities
- ❑ **Transducers:**
 - **Sensor:** an input transducer (i. e., a microphone)
 - **Actuator:** an output transducer (i. e., a loudspeaker)

Measurement System & Devices

- ❑ A measurement system is any set of interconnected parts that include one or more measurement devices
- ❑ Measurement devices perform a complete measuring function, from initial detection to final indication
- ❑ Measurement devices such as sensors, or primary elements, measure the variable

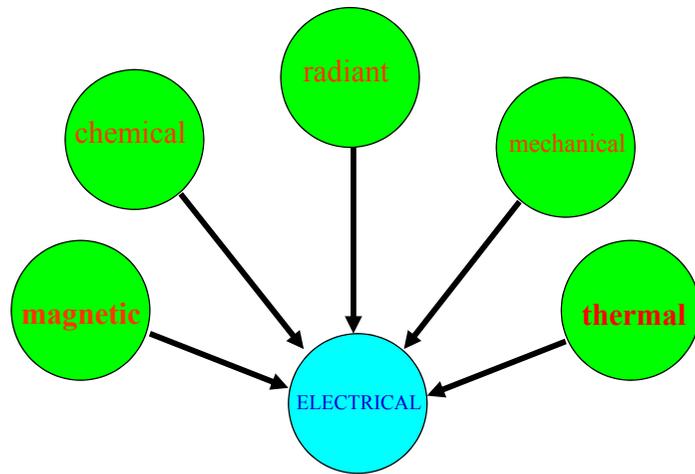
Sensor, Transmitter & Transducer

- ❑ **Sensor**
 - Primary sensing element
 - Converts the physical quantity to signal that can be recognized by other component such as display, transmitter
- ❑ **Transmitter**
 - Generates an industrial standard signal from the sensor output
 - Standard instrumentation signal levels
 - Voltage: 1 – 5 VDC, 0 – 5 VDC, -10 – +10 VDC, etc.
 - Current: 4 – 20 mA
 - Pneumatic: 3 – 15 psig
- ❑ **Transducer**
 - Changes one instrument signal value to another instrument signal value
 - Signal conversion
 - I/P or P/I transducer: current-to-pressure or vice versa
 - P/E or E/P: pressure-to-voltage or vice versa

Sensor electrical output signal

- ❑ **Current**
 - Example: some humidity sensors
- ❑ **Voltage**
 - Example: sensors based on the seebeck-effect
- ❑ **Charge**
 - Example: piezoelectric based sensors

Interrelation of the energy domain



SIGNAL ENERGY DOMAIN

❑ Mechanical

- length, area, volume, linear velocity, angular velocity, acceleration, mass, flow, force, torque, pressure, acoustic-wave speed, viscosity

❑ Thermal

- temperature, (specific) heat, heat flow, state of matter

❑ Electrical

- voltage, current, charge, resistance, inductance, capacitance, dielectric constant, polarization, electric field intensity, dipole moment

SIGNAL ENERGY DOMAIN

❑ Magnetic

- magnetic field intensity, flux density, permeability

❑ Radiant

- color, intensity, reflectance, transmittance, refractive index

❑ Chemical

- composition, concentration, reaction rate, pH, humidity

Sensor Types

❑ Flow rate

• Orifice, venturi, ultrasonic, etc

❑ Pressure

• Bellows, bourdon tube, diaphragm

❑ Liquid level

• Displacement, float, differential pressure

❑ Temperature

• Thermocouple, RTD, thermistor

❑ pH

• pH electrode