

Instrumentation Questions & Answers

List any four objectives of process control.

Suppressing the influence of external disturbances, Optimizing the performance, Increasing the productivity, Cost effective.

Define process

Any system comprised of dynamic variables usually involved in manufacturing and production operations. It is defined as a series of operations during which some materials are placed in more useful state.

What is manipulated variable

It is a variable which is altered by the automatic control equipment so as to change the variable under and make it conform with the desired value.

Define Controlled variable

It is the quantity of control system which is directly measured and controlled.

What do you mean by self regulation?

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The output will move from one steady state to another for the sustained change in input. This means that for change in some input variable the output variable will rise until it reaches a steady state (inflow = outflow). It is the tendency of the process to adopt a specific value of controlled variable for nominal load with no control operations.

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Why do we need mathematical modeling of process?

The physical equipment of the chemical process we want to control have not been constructed. Consequently we cannot experiment to determine how the process reacts to various inputs and therefore we cannot design the appropriate control system. If the process equipment needs to be available for experimentation the procedure is costly. Therefore we need a simple description of how the process reacts to various inputs, and this is what the mathematical models can provide to the control designer.

Name different test inputs.

Step, Ramp, Impulse, Sinusoidal, Pulse inputs

Name a process giving inverse response

Drum boiler system, in which the flow rate of the cold feed water is increased by a step the total volume of the boiling water and consequently the liquid level will decreased for a short period and then it will start increasing.

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Define interacting system and give an example.

Load changes in first process affects the second process and vice versa when both are connected in series nature is called interacting system. Eg. Two level tanks are connected in series.

A tank operating at 10ft head, 51pm outflow through a valve and has a cross section area of 10 sq f calculate the time constant.

$$T=R/A, R=H/Q=10/(5 \times 5.885 \times 10^{-4})$$

What is meant by non-self regulation?

A system that grows without limit for a sustained change in input (constant outflow or outflow independent of inflow condition).

Write any two characteristics of first order process modeling

The smaller the value of time constant the steeper the initial response of the system. A first order lag process is self regulating the ultimate value of the response equal to K_p (steady state gain of the process) for a unit step change in the input.

Distinguish between continuous process and batch process.

A process in which the materials or work flows more or less continuously through a plant apparatus while being treated is termed as continuous

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process. The problem of continuous process is due to load changes. (e.g.) storage vessel control.

A process in which the materials or work are stationary at one physical location while being treated is termed as batch process. (e.g.) furnace.

Explain the function of controller.

The element in a process control loop that evaluated error of the controlled variable and initiates corrective action by a signal to the controlling variable.

What is the purpose of final control element?

Components of a control system (such as valve) is used to directly regulates the flow of energy or materials to the process. It directly determines the value of manipulated variable.

Define Process control

It is the scheme that describes how much the manipulated variable should change in order to bring the controlled variable back to the setpoint.

List the two types of process control.

Direct process control

– Controlled variable directly indicates the performance of the process
Eg. Water heater system

InDirect Process control the performance of the process.

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- Controlled variable indirectly indicates Eg. Annealing

What is Servo operation and Regulatory operation.

If the purpose of the control system is to make the process follow the changes in setpoint as quick as possible, then it is servo operation.

What is mathematical modeling.

Set of equations that characterize the process is termed as Mathematical Modelling.

Define an non-interacting system.

The dynamic behaviour one tank is affected by the other, but the reverse is not true, then it is non-interacting system. Here the liquid heads are independent of each other.

Define an interacting system.

The dynamic behavior one tank is affected by the other, but the reverse is also true, then it is non-interacting system. Here the liquid heads are dependent of each other.

Mention two drawbacks of derivative action

- (i) The output of controller is zero at constant error condition.

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(ii) It will amplify the noise present in the error signal.

What are the steps involved to design a best controller?

Define appropriate performance criterion (ISE, IAE, ITATE). Compute the value of the performance criterion using a P, PI, or PID controller with the best setting for the adjusted parameters K_p , T_i , T_d . Select controller which give the best value for the performance criterion.

Define proportional control mode

A controller mode in which the controller output is directly proportional to the error signal $P = K_p e_p + p_0$ P-controller output $K_p =$ Proportional gain, $e_p =$ error in percent of variable range, $P_0 =$ Bias.

Define proportional band.

Proportional band is defined as the change in input of proportional controller mode required to produce a full-scale change in output

Write the relationship between proportional band and proportional gain

The reciprocal of gain expressed as a percentage is called proportional band.
 $K_p = 100/PB$

Define offset.

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It is the steady state deviation (error) resulting from a change in value of load variable.

Define error (deviation)?

It is the difference at any instant between the value of controlled variable and the set point. $E = S.P - P.V$

Sketch Pneumatic P+I controller

Refer Curtis Johnson, Page No.418, and Fig. 10.17.

Why is the electronic controller preferred to pneumatic controller?

Electronic signals operate over great distance without time lags. Electronic signals can be made compatible with digital controllers. Electronic devices can be designed to be essentially maintenance free. Intrinsic safety techniques eliminate electrical hazards. Less expensive to install. More energy efficient. Due to the above said properties electronic controllers are preferred to pneumatic controller.

Explain the function of controller.

The element in process control loop that evaluates error of the controlled variable and initiates corrective action by a signal to the controlling variable.

Write any two limitations of single speed floating control.

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The present output depends on the time history of errors and such history is not known, the actual value of controller output floats at an undetermined value. If the deviation persists controller saturates at either 100% or 0% and remain there until an error drives it towards opposite extreme.

Sketch the input – output characteristic of single – speed floating controller.

Refer Curtis Johnson, Page No. 368, and Fig.9.7.

Why derivative mode of control is not recommended for a noisy process?

The series capacitor in the derivative controller will amplify the noise in the error signal.

Define integral (reset) windup?

The over charging in the presence of a continuous error of the integral capacitor which must discharge through a long time constant discharge path and which prevents a quick return to the desired control point.

What are the two modes of controller.

Discontinuous and continuous mode are the two modes of controller.

Define Discontinuous mode of controller

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If for only two values of error, control action is taken, it is Discontinuous mode of controller.

Define Continuous mode of controller

If for every value of error, control action is taken, it is Discontinuous mode of controller.

Give an example for Discontinuous and Continuous mode of controller.

Discontinuous-ON-OFF controller.

Define cycling.

Oscillations of error about zero is called cycling.

Define controller turning.

Deciding what values to be used for the adjusted parameters of the controller is called controller turning.

What is reaction curve.

In process controller, the reaction curve is obtained by applying a step change (either in load or in set point) and plotting the response of the controlled variable with respect to time.

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What performance criterion should be used for the selection and turning of controller?

Keep the maximum error as small as possible. Minimize the integral of the errors until the process has settled set Point.

Define ultimate gain

The maximum gain of the proportional controller at which the sustained oscillations occur is called ultimate gain (K_u).

What is ITAE and when to go for it?

ITAE means Integral Time Absolute Error. To suppress the errors that persist for long time, the ITAE criterion will tune the controllers better because the presence of large t amplifies the effect of even small errors in the value of integral.

What are the parameters required to design a best controller?

Process Parameters ($K, \hat{\theta}$), Controller parameters (K_p, T_i, T_d), performance criterion (ISE, IAE, IATE)

Write any two practical significance of the gain margin

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It constitutes a measure of how far the system is the brink of instability. Higher the gain margin (above the value of one), the higher the safety factor we use controller turning.

Typically, a control designer synthesizes a feedback system with gain margin larger than 1800.

Why is it necessary to choose controller settings that satisfy both gain margin and phase margin?

The gain margin and Phase margin are the safety factors which is used for the design of a feedback system. Beyond the phase margin and gain margin the system goes to unstable position.

What is turning a controller based on quarter – decay ratio?

It is the procedure in which adjusting the proportional gain of controller upto $\frac{1}{4}$ th decay ratio waveform is obtained.

Name the time integral performance criteria measures.

Integral Square Error (ISE), Integral of absolute value of error (IAE), Integral of time weighted absolute error.

Define Integral Square Errors (ISE)

If we want to suppress large errors, ISE is better than IAE Because errors are squared and contribute more to the value of integral.

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Define Integral Absolute Errors (IAE)

If we want to suppress small errors, IAE is better than ISE. Because when we square small numbers, they even become smaller.

Define Integral of Time weighted Absolute Error (ITAE)

To suppress errors that persist for long times, ITAE criterion will tune the controllers better because the presence of large t amplifies the effect of even small errors in value of integral.

Define One-quarter decay ratio

It is a reasonable trade off between fast rise time and reasonable settling time.

Give the satisfactory control for gas liquid level process.

Proportional Control is the satisfactory control for liquid level process.

Give the satisfactory control for gas pressure process.

Proportional Control is the satisfactory control for liquid level process.

Give the satisfactory control for vapour pressure process.

PI Control is the satisfactory control for vapour pressure process having fast response.

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Give the satisfactory control for temperature process.

PID Control is the satisfactory control for temperature process.

Give the satisfactory control for composition process.

PID Control is the satisfactory control for composition process.

Define ratio control

Ratio control is a special type of feed forward control where two disturbances are measured and held in a ratio to each other.

Define cascade control

Cascade control is defined as a control system composed of two loops where the set point of one loop (the inner loop) is the output of the controller of the other loop (the outer loop)

When cascade control will give improved performance than conventional feedback control?

In some process the secondary variables in it introduce disturbance throughout the system is measured and controlled by a separate loop.

Explain the purpose of cascade control for heat exchangers?

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In heat exchangers, the control objective is to keep the exit temperature of stream. But the flow rate of the stream creates the low disturbance throughout of its a function. The secondary loop is used to compensate the flow rate of the stream.

What is meant by auctioneering control?

Such control configurations select among several measurements the one with the highest value and feed it to the controller. Thus it is a selective controller which possesses several measured outputs and only one manipulated input.

Give any two types of selective control system.

Override control for the protection of process equipment, auctioneering control.

What is limit switch?

In some cases it is necessary to change from the normal control action and attempt to prevent a process variable from exceeding an allowable upper or lower limit. This can be achieved by the use of special type switches called limit switches.

Mention the types of limit switches.

High Select Switch (HSS), Low Select Switch (LSS).

What is HSS?

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High Select Switch (HSS) is a limit switch which is used whenever a variable should not exceed an upper limit.

What is LSS?

Low Select Switch (LSS) is a limit switch which is used whenever a variable should not exceed an lower limit.

What is override control?

During the operation of the plant, it is possible that some of the process variables exceed the limit. In such cases it is necessary to change from the normal control action and attempt to prevent a process variable from exceeding an allowable an allowable upper or lower limit. This can be achieved by the use of special type switches called limit switches called limit switches (HSS and LSS). This type of protective control is called override control.

What is split-range control?

To control A single process output can be controlled by co-coordinating the actions of several manipulated variables all of which have same ef f ect on controlled output. Such systems are called split-range control systems.

Differentiate split-range control and selective control.

Split-range control system involves one measurement and more than one manipulated variables but sele ctive control system involves one manipulated variables and several controlled outputs.

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Why are fuel and air sent at a specified ratio into a combustion chamber?

To obtain the most efficient combustion.

What are decouplers?

The special element introduced in a system with two strongly interacting loops to cancel the interaction effect between the two loops and thus render two non-interacting control loops is called decoupler.

When is inferential control used?

It is used in some cases where the output of the process and the influence of the disturbance cannot be measured.

What are the advantages of feed forward controller

Acts before the disturbance is felt by the process. It is good for slow systems.

What are the disadvantages of feed forward controller

Requires identification of all possible disturbances and their direct impact. Cannot cope with unmeasured disturbances.

What are the advantages of feedback controller.

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It does not require identification and measurement of disturbance.

What are the disadvantages of feed forward controller

It is unsatisfactory for slow processes with significant dead time.

What is flashing in control valve?

When a liquid enters a valve and the static pressure at the vena contracta is less than the fluid vapour pressure and the valve outlet pressure is also less than the fluid vapour pressure the condition called flashing exists.

When do you use a valve positioner?

If the diaphragm actuator does not supply sufficient force to position the valve accurately and overcome any opposition that flowing conditions create a positioner may be required.

Give two examples for electric actuator

Motor, Solenoids.

What is the need of I/P converter in a control system?

In some process loop the controller is electronic and the final control element is electronic one. To interconnect these two we need a device that should linearly convert electric current into gas pressure (4-20mA-315 psi). Such a device is called I/P converter.

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Why installed characteristics of a control valve is different from inherent characteristics?

Inherent characteristics is which the valve exhibits in the laboratory condition where the pressure drop is held constant. Installed or resultant characteristics is the relationship between flow and stroke when the valve is subjected to pressure conditions of the process.

Explain the function of pneumatic transmission lines.

Used to transmit the input signals into standard instrumentation pneumatic output signals (3 to 15 psi or 20 to 100 KPa).

What is the purpose of final control element.

Components of a control system (such as valve) is used to directly regulates the flow of energy or materials to the process. It directly determines the value of manipulated variable.

What is meant by cavitations in control valve?

When a liquid enters a valve and the static pressure at the vena contracta drops to less than the fluid vapor pressure and the recovering to above fluid vapour pressure, this pressure recovery causes an implosion or collapse of the vapour bubbles formed at the vena contracta. This condition is called cavitation.

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What is “equal percentage” in the equal percentage valve?

For equal increment of stem travel at constant pressure drop an equal percentage change in existing flow occurs.

What are the characteristics of control valve?

Inherent characteristics, Installed characteristics.

Differentiate inherent characteristics and installed characteristics.

Inherent characteristics is which the valve exhibits in the laboratory condition where the pressure drop is held constant. Installed or resultant characteristics is the relationship between flow and stroke when the valve is subjected to pressure conditions of the process.

What is “quick opening” control valve.

For smaller movement of the stem, there is maximum flow rate.

What is “Linear” control valve.

If stem position varies linearly with flow rate, then it is linear.

Define Control Valve sizing.

$Q = C_v \cdot \sqrt{P/Sg}$ Q-Flow rate

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Cv-Valve coefficient

P-pressure difference across valve. Sg-Specific gravity of liquid.

Name any one final control element.

Control Valve.

What is the function of control valve in a flow control system.

The function of control valve in flow control system is to regulate the flow.

Name one application of electrical actuator

Solenoid coil used to change gears.

Name the two types of plugs.

Single-seated and double-seated plug type control valves.

Define Rangeability

It is the ratio of maximum controllable flow to minimum controllable flow.

100. **What is rotating shaft type control valves.**

Rotating-plug valves

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Butterfly valves

Louvers.