



SUMMER – 2022 EXAMINATION

Subject Name: Process Control

Model Answer



Subject Code:

22644

Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.
- 8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.



Q. No.	Sub Q.N.	Answer	Marking Scheme
Q.1		Attempt any <u>FIVE</u> of the following :	10-Total Marks
	a)	State the principle of Distillation process.	2M
	Ans:	Distillation Process separates a mixture on the basis of difference in relative volatilities, or differences in boiling points, of the components to be separated. Or Note: Consider Any similar meaning principle	
	b)	Draw P and ID symbol for flow transmitter and Butterfly valve.	2M
	Ans:	  Flow Transmitter symbol Butterfly valve symbol	
	c)	Define cavitation and flashing.	2M
	Ans:	Cavitation: It is the formation and subsequent collapse of vapors cavities or gas bubbles or Void in a flowing liquid in a region where the local static pressure of the liquid falls below its vapor pressure. Flashing: Flashing is the formation of vapor cavities or gas bubbles or voids in a flowing liquid in a region where the local static pressure of the liquid falls below its vapor pressure and the vapor phase continue downstream because the downstream pressure remains at or below the vapor pressure of the liquid.	
	d)	Draw the block diagram of split range control system.	2M

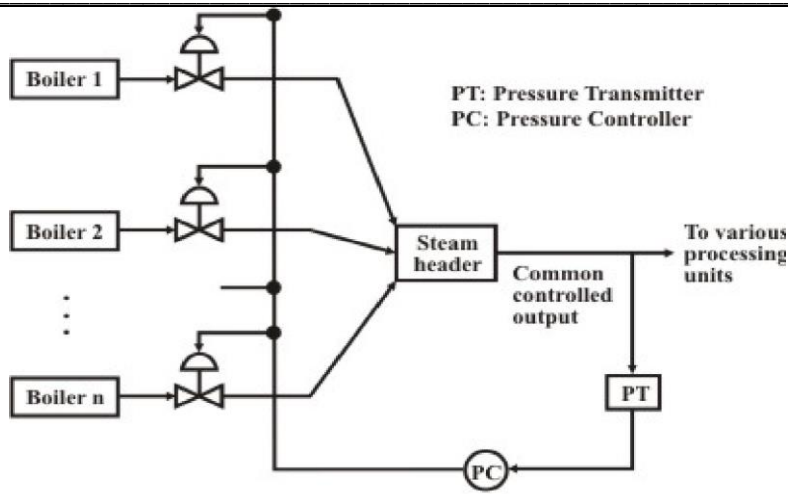
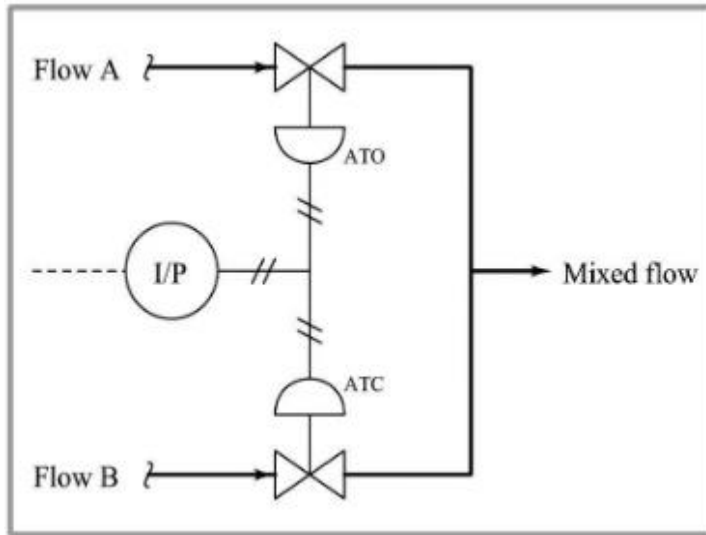


Fig. 7 Steam header with split-range control

Ans:



e)

State scaling concept in ratio control.

2M

Ans:

Scaling is the main function of ratio station. It states the relationship between two variables to provide regulation of a third variable. The scaling can be either additive or subtracting or proportional nature. Two ingredients are mixed with each other in the desired scale as per process requirement

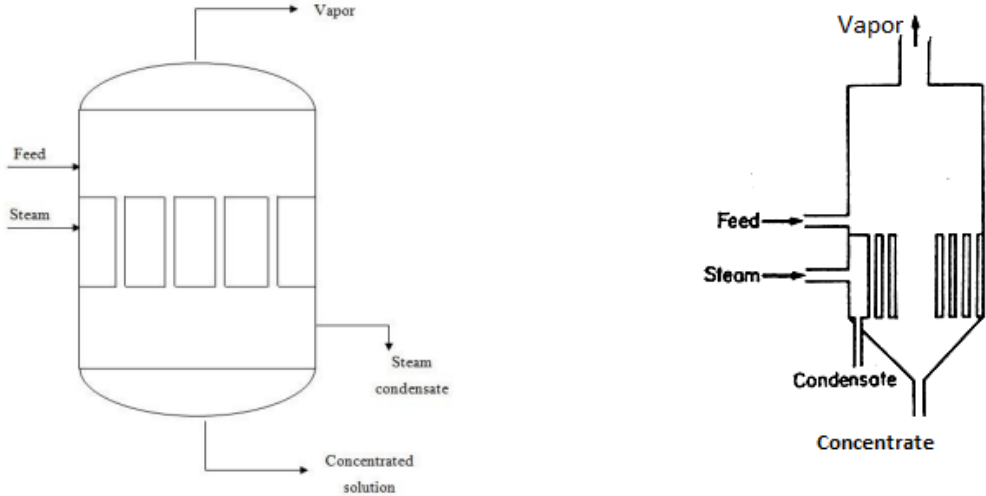
e.g. It is compulsory to mix the air and fuel in 1:1 proportion to ignite desired intensity flame for boiler application. 1:1 ratio is the scaling decided at ratio station.

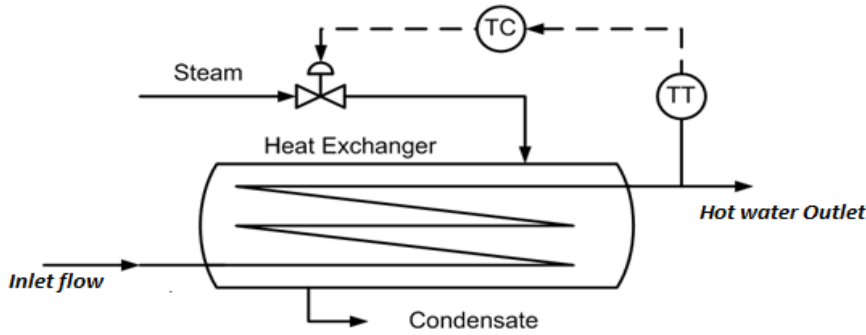
f)

Draw the sketch of single effect evaporator.

2M



<p>Ans:</p>		
<p>g)</p>	<p>List any two safety interlocks of Boiler</p>	<p>2M</p>
<p>Ans:</p>	<ol style="list-style-type: none">1. Purge Interlock: Prevents fuel from entering an unfired furnace until the Furnace has been thoroughly air-purged.2. Low airflow interlock and/or fan interlock: Fuel is shut off upon loss of air flow3. Low Fuel Supply Interlock: Fuel is shut off upon loss of fuel supply4. Loss of Flame Interlock: All fuel is shut off upon loss of flame in the furnace5. Fan Interlock: Stop forced draft upon loss of induced draft fan. (Forced Draft fan forces outside air into the heating system to provide more air for combustion and Induced Draft fan draws flue gases from the system out into the atmosphere ie; produce negative pressure.)6. Low Water Interlock: Shut off fuel on low water level in boiler drum.7. High Combustibles Interlock (optional): Shut off fuel on highly combustible content in the flue gases.	
<p>Q.2</p>	<p>Attempt any <u>THREE</u> of the following:</p>	<p>12-Total Marks</p>
<p>a)</p>	<p>Draw process control diagram for temperature control loop. Describe its functioning.</p>	<p>4M</p>



Ans:

- In the above diagram, feedback control system for heat exchanger is shown, The temperature of the outlet water (process variable to be controlled) at the desired set point, its temperature is measured and given to Temp Transmitter (TT) and Temperature Controller (TC)
 - If the outlet water temperature is too high, the controller will decrease the amount of steam entering the heat exchanger and vice versa.
 - Controller output is given to the control valve through which the steam flows. Accordingly, the steam flow is manipulated.
 - Thus, the temperature of the outlet water (process variable to be controlled) is maintained at the desired set point
- Note: consider any process system showing temperature control scheme either in feedback or feedforward or cascade manner.

b)

Compare single seated control valve and double seated control valve (any four points)

4M

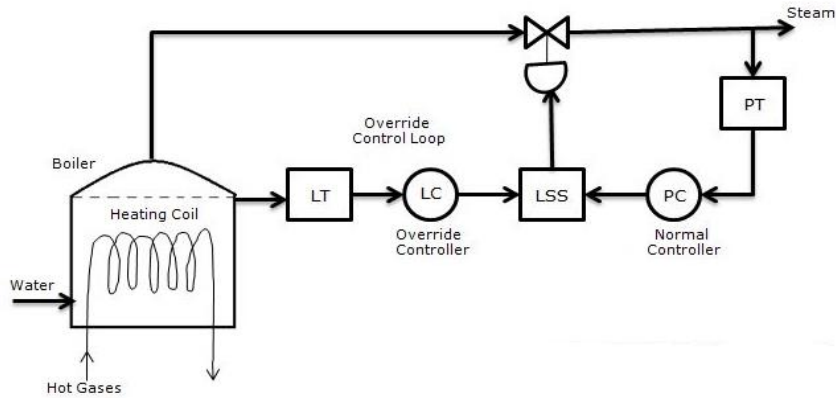
Ans:

single seated control valve	double seated control valve
1. It has only one plug	1. It has two plugs
2. It is used for sizes 2 inches and below	2. It is used for sizes 2 inches and above
3. It has low flow capacities	3. It has high flow capacities
4. Unbalanced forces on the plug; therefore, requires large size of actuators	4. Forces are balanced on the plug; therefore, requires smaller size of actuators
5. More force required to drive stem	5. Less force required to drive stem

c)

Describe working of selective control with diagram

4M



Ans:

- In the boiler shown above, the steam pressure is controlled through the use of a pressure control loop in the output line (loop 1).
- The water level in the boiler should not fall below a lower limit which is necessary to keep the heating coil immersed in the water to prevent its burning out. Here, override control system is used with a low switch selector (LSS).
- Under normal circumstances, the selector switch selects the pressure control loop for control.
- But as soon as the level of water in the boiler falls below a set value, the selector switch LSS switches to level control mode from pressure control mode and the second loop takes over the control action and closes the valve in the output line.

d)

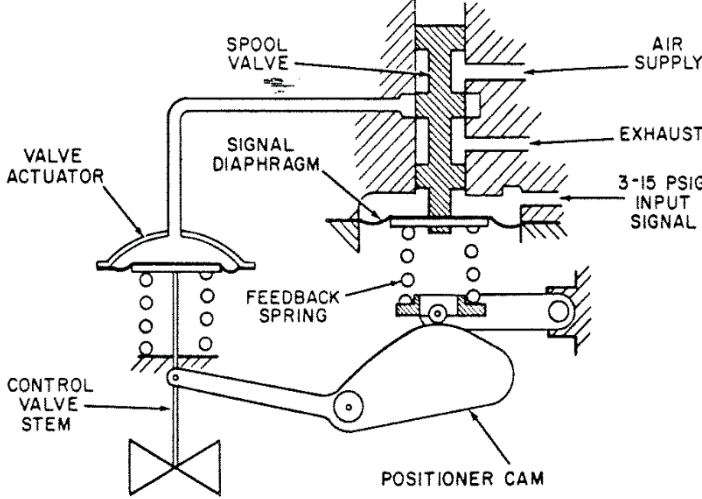
Write any four advantages of DCS system.

4M

Ans:

1. Overall cost of the installation is lower
2. Less wiring required due to serial communication.
3. Panel space is reduced.
4. Allows inter-controller communication
5. Flexible and relatively easy to expand
6. Quick response.
7. High reliability
8. Can be programmed without knowing a high-level programming language
9. Interface with the process is improved
10. Advanced control technique.
11. Provision of redundancy.
12. Optimum utilization of available man-power

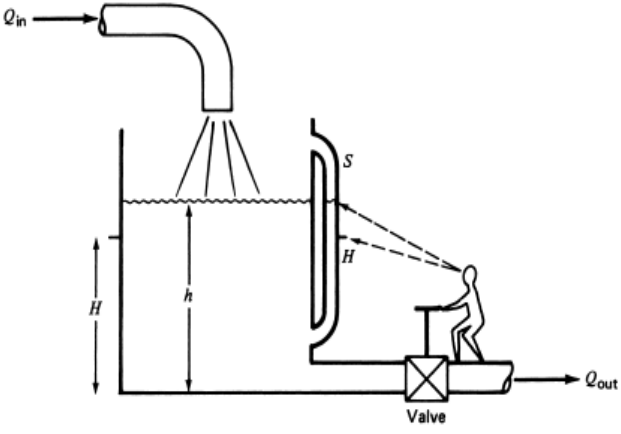
Note: consider any four points

Q.3	Attempt any THREE of the following:	12-Total Marks
a)	<p>Explain working of force balance type valve positioner with neat sketch.</p>	4M
Ans:	 <ul style="list-style-type: none"> ● Force-balance positioner has a diaphragm element that compares the force generated by the input signal from the controller with the force generated by the feedback spring connected to the valve stem. ● The controller signal of 3-15psig acts on the diaphragm which creates a signal force that is opposed by a feedback spring connected to the valve stem. ● The feedback derived from the valve position provides a force to balance the input signal. ● A spool valve is attached to the other side of diaphragm to provide the supply air to the actuator. Thus, the air supply flows to the actuator. ● The resultant stem motion is sensed by a lever that rotates a cam. ● The cam displacement is converted by a lever arrangement into comparison of feedback spring which will produce a force to match the signal. 	4M
b)	<p>State any four advantages of feed forward control over feedback control.</p>	4M

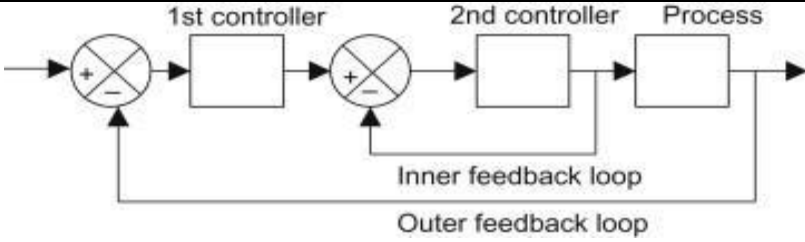
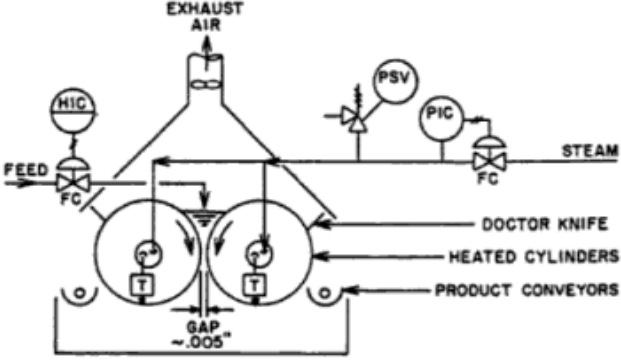


Ans:	No.	Feed forward	Feedback
	1	Acts before the effect of a disturbance is felt by the system, thus acts in anticipatory manner	Waits until the disturbance affects the system, thus acts in compensatory manner.
	2	Good for slow system	Not satisfactory for slow processes
	3	Does not introduce instability in the closed loop response.	Create instability in the closed loop response
	4	Requires identification of all possible disturbances and their direct measurement.	Does not require identification and measurement of any disturbances
	5	Sensitive to modelling errors	Insensitive to modelling errors
	6	Sensitive to process parameter variations	Insensitive to parameter changes
	7	Reduces the effect of load variation on process variable	Does not reduce the effect of load variation on process variable
c)	Describe working of spray dryer with neat diagram		4M
Ans:	<ul style="list-style-type: none"> ● The inlet feed is given to a chamber where there is a large flow of hot air. ● In order to make the inlet temperature high, fired heaters are used to heat the air. The feed is introduced by high pressure pump. ● The air flow is regulated. ● The process conditions are maintained by temperature control near outlet. ● The temperature controller regulates air-fuel ratio through the fuel control unit. 		



	d)	State the purpose of Instruments index sheet and process flow sheet.	4M
	Ans:	<p>Instrument index Sheet: it is a document containing list of instrument devices within a plant. Instrument index shall include tag number of all physical instruments (e.g. field instrument, physical alarm and indicator) and pseudo instruments which commonly named “soft tag” (e.g. DCS indication, alarm, and controller).</p> <p>Instrument index is used for purposes as follow:</p> <ul style="list-style-type: none">• As a basis to prepare the I/O list by extracting only the tag number which has I/O point• Searching, Listing, Filtering a tag number <p>Process flow Sheet: A process flow sheet/diagram (PFD) is a diagram commonly used in chemical and process engineering to indicate the general flow of plant processes and equipment. <u>The PFD displays the relationship between major equipment of a plant facility.</u></p> <p>Process flow diagrams of a single unit process include Process piping, Major equipment items, Control valves and other major valves, Connections with other systems etc.</p>	
Q.4		Attempt any THREE of the following:	12- Total Marks
	a)	Describe Human aided control system with neat diagram.	4M
	Ans:	<p>Here, human being is involved in the operation, measurement and control of process variable. Human being can regulate the value of the process variable to find out and rectify the error. Human being takes the corrective action to reduce the error.</p> <p>Example of human aided level control system is given here. Human operator checks the level with scale and operates the control valve accordingly to maintain the level at setpoint.</p> 	
	b)	Describe working of cascade control system with neat diagram.	4M



	 <p>Ans:</p> <ul style="list-style-type: none"> • Cascade control involves the use of two (or more) controllers in series. It has one manipulated variable and more than one measurement. • Output of first controller is the set point of another controller. • The controller which uses the set point given by the operator is called the <u>primary, outer, or master controller</u>. • The controller which is receiving the set point is called the <u>secondary, inner or slave controller</u>. • The output of the secondary controller is used to adjust the manipulated variable. • Thus, the primary controller maintains the primary variable at set point by adjusting the set point of secondary controller. 	
c)	<p>Draw schematic diagram of double drum dryer. Explain its services.</p>	4M
Ans:	<p>Schematic diagram: 2M</p>  <p>Its services are: 2M</p> <ul style="list-style-type: none"> • Double drum dryer has two heated cylinders. The inlet feed is given into the valley between the heated cylinders. • Double drum dryer is used in the drying of liquids and pastes of sticky and highly viscous products. It is used under vacuum for drying temperature-sensitive products such as vitamins, proteins, yeasts, pigments, malt extracts, hormones and antibiotics 	
d	<p>State limitations of butterfly valve when used in throttling services.</p>	4M



	Ans:	The disc is always present within the flow, therefore a pressure drop is always induced in the flow, regardless of valve position. The recovery factor for a butterfly valve is generally poor compared to a control valve. Therefore, these valves tend to have more problems with cavitation and permanent pressure drop when they are throttling flow.	
	e)	State the feature of profibus communication methods in DCS system.	4M
	Ans:	The feature of profibus communication methods in DCS system are: <ul style="list-style-type: none">● The Process Fieldbus, PROFIBUS, is a German standard. PROFIBUS specifies Layers 1, 2, and 7 in accordance with the OSI model.● It provides high-Performance communications system for simple and inexpensive equipment.● Its functionality and data transfer capabilities ensure transparency to higher network levels.● Communication with simple field instrumentation with immediate response, master-slave access with central polling and broadcast messages PROFIBUS uses a hybrid access method combining a centralized master-slave system with decentralized token passing.	Each point 1 M
Q.5		Attempt any TWO:	12-Total Marks
	a)	State types of actuators. Describe any one type of actuator with neat diagram.	6M



The following are the two types of actuators

2M

- Pneumatic
- Electric

1. Pneumatic Diaphragm actuators

3M

- Diaphragm actuators have compressed air applied to a flexible membrane called the diaphragm.
- The operating force is derived from compressed air pressure, which is applied to a flexible diaphragm. The actuator is designed so that the force resulting from the air pressure, multiplied by the area of the diaphragm, overcomes the force exerted (in the opposite direction) by the spring(s).
- Actuator shown in fig. is single acting, in that air is only supplied to one side of the diaphragm, and they can be either direct acting (spring-to-retract) or reverse acting (spring-to-extend).

Direct-acting—air pressure is applied above the diaphragm and pushes the stem downwards

The direct acting actuator is designed with the spring below the diaphragm, having air supplied to the space above the diaphragm. The result, with increasing air pressure, is spindle movement in the opposite direction to the reverse acting actuator.

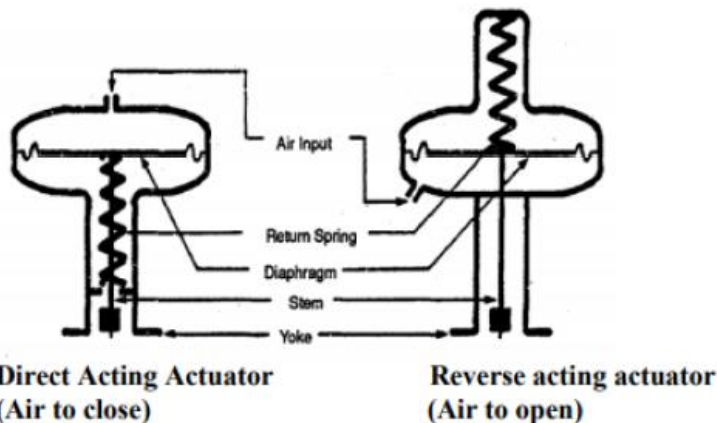
Reverse-acting — air pressure is applied below the diaphragm and pushes the stem upwards.

Ans:

Air to close: Direct acting actuator will cause the actuator stem to be pushed downwards as a result of applying signal air to the top of the diaphragm.

Air to open: Reverse acting actuator will push the actuator stem upwards as a result of applying signal air applied to the bottom of the diaphragm.

Diagram optional



OR

2. Electric Actuators

3M

Electric actuators for quarter turn valves are a type of rotary motorized valve actuators. Electric rotary actuators convert electric energy into rotary force, so a quarter turn electric actuator can only turn 90 degrees. The electric motor generates torque, which is transmitted to turn the valve



	through an output drive. The motor voltage options are either AC (alternating current), DC (direct current), or they are able to operate on either one. The motor is housed in a robust, compact housing that also contains other components of the actuator such as gearings, limit switches, wiring, etc. The whole assembly is connected to a valve through a compatible connection interface.	
b)	State types of process displays. Explain any two displays with diagram	6M

Different types of DCS displays

1. Group display,
2. Overview display,
3. Detail display,
4. Graphic display,
5. Trend display

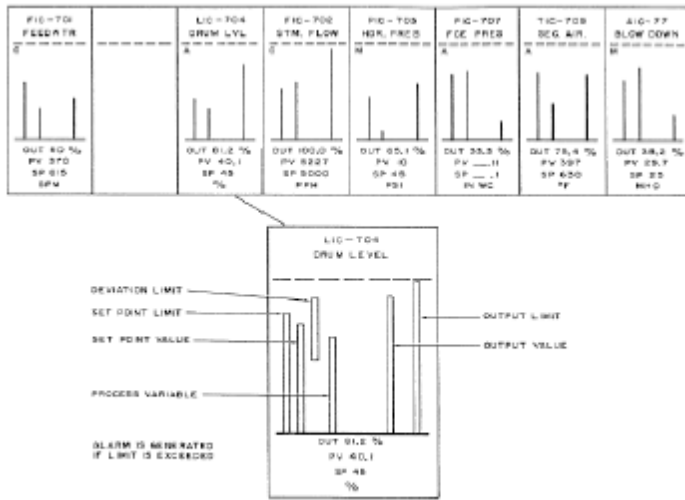
**Types
(Any 4)**

1 M

Group Display

It shows the operating parameters of 8, 12 or 16 control loops, arranged in rows so that they look like faces of instruments on an instrument panel. Each of the control loops is represented by a rectangle with bar graphs to indicate values of process variable, set-point, output signal and their limits

Ans:

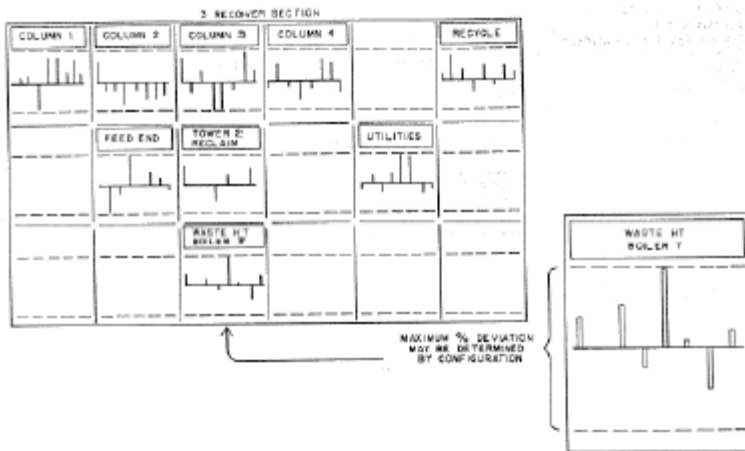


1) Group display

**2 M each
for any 2
display
descripti
on with
diagram**

Overview display

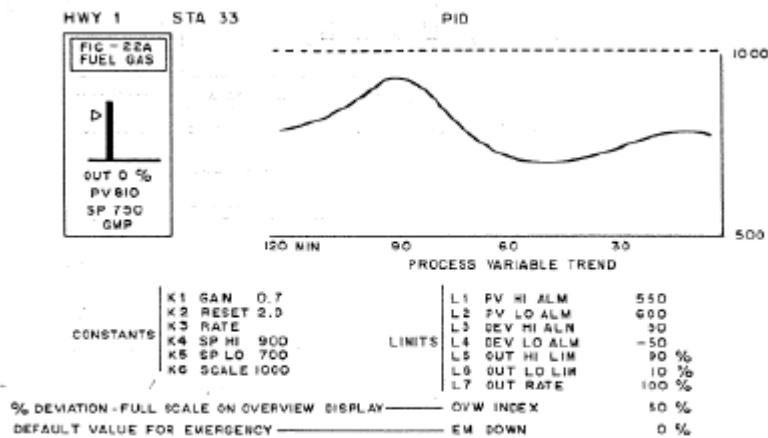
It shows the bare essentials of a number of groups, each group in a separate rectangle. The set-point is shown as a straight line and deviation of process variable from set-point appears as vertical bar



ii) Overview display

Detail display

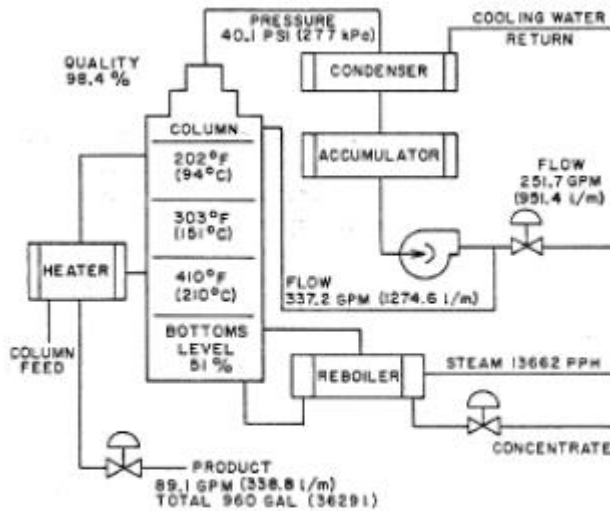
It is specific to single control loop. It shows the same bar graph representation like group display, but it includes additional information defining controller parameters, alarm limits and other characteristic of control loop



iii) Detail display

Graphic display

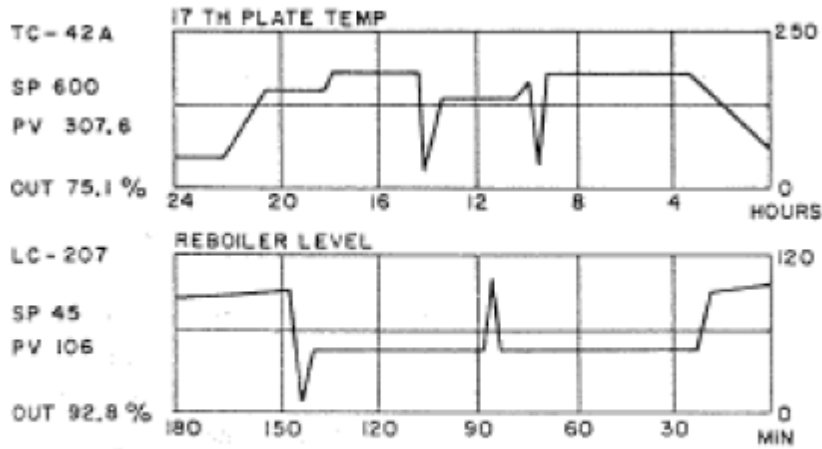
It shows pictorial representation of plant under control. This display includes process and control information and it can be interactive and real time information. Some displays are capable of showing movement in pipeline, tank and reactors as well



iv) Graphic display

Trend display

It shows real-time trend graphs of process variable, set-point, and controller output over a period of time



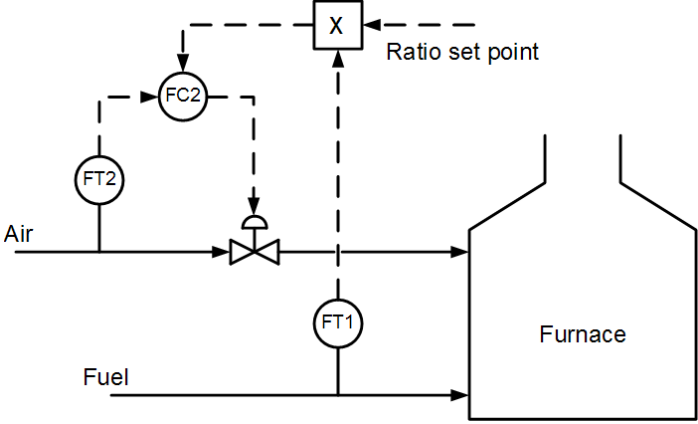
v) Trend display

c)

Draw diagram of Ratio control system for air to fuel control in Boiler Process and explain it.

6M



	Ans:	<p>Diagram:</p>  <p>Air to Fuel Ratio should be maintained for optimum combustion in Boilers.</p> <p>As shown in the diagram Fuel is the “Wild” Flow and Air is the “Controlled” Flow. Changes in the Fuel flow rate are measured and transmitted with the help of FT1 and multiplied by the desired ratio. This signal then acts as set point for the flow controller FC 2 which is compared with the actual air flow, sensed and transmitted by FT2. The error signal acts as the actuating signal for the control valve to manipulate the air flow rate.</p>	
Q.6		Attempt any TWO:	12-Total Marks
	a)	Describe working principle of override control system. Compare override control and selective control.	6M Example- 2 M Comparison -2 M(Any 2 points)

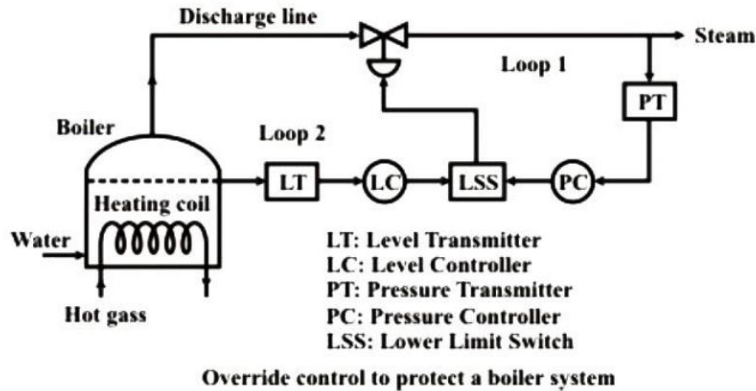
Principle

2 M

Override control system is a type of multi loop selective control system in which the control action is transferred from one loop to another according to the need. Switching between the controlled and manipulated variables can be easily done with selective devices called signal selectors. Signal selectors are devices that choose the lowest, highest or median signals among two or more signals .

For e.g. Override control system for protection of Boiler equipment

2M



Ans:

In the boiler shown above, the steam pressure is controlled through the use of a pressure control loop in the output line (loop 1). The water level in the boiler should not fall below a lower limit which is necessary to keep the heating coil immersed in the water to prevent its burning out. Here, override control system is used with a low switch selector (LSS). Under normal circumstances, the selector switch selects the pressure control loop for control But as soon as the level of water falls below a set value, the selector switch LSS switches to level control mode from pressure control mode and the second loop takes over the control action and closes the valve in the output line.

Comparison of selective and override control

2M

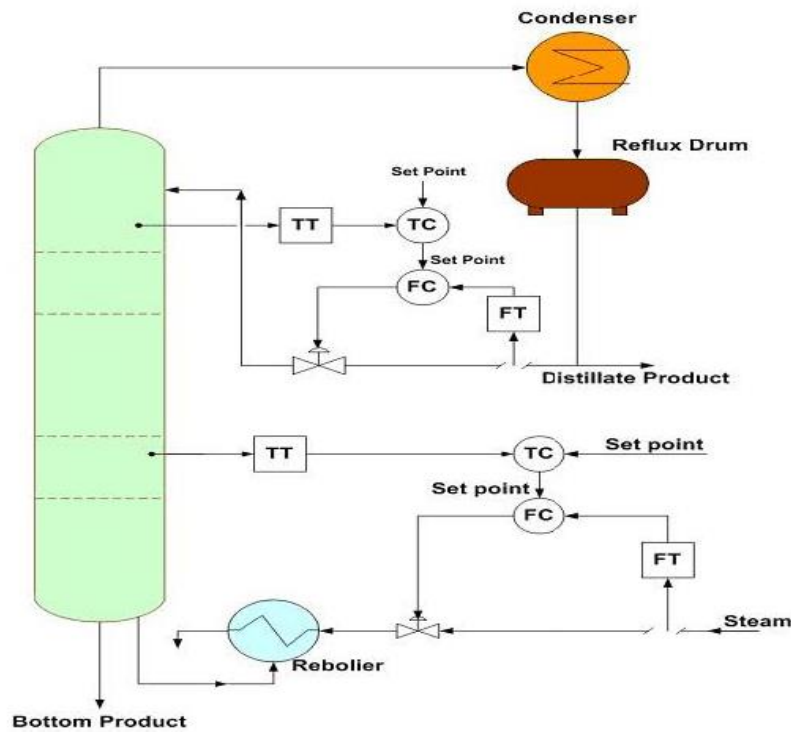
Sr.no.	Selective control	Override control
1	It is a multi loop control systems that have 1 manipulated variable but has more than 1 controlled variable or Measured variable	It is a type of selective control scheme in which there are many controlled variables but only one manipulated variable



			2	There are 2 types of selective control schemes-Override and Auctioneering	Control is switched between the loops with the help of Low selector switch(LSS) or high selector switch (HSS)	
			3	The purpose is for Protection as well as for providing control action based on highest value of measured variable	The purpose is for protection of Process equipment	
	b)	Draw cascade control scheme for distillation column. Explain it.				6M



Diagram:



Ans:

Explanation:

3M

- It is used to regulate the temperature at the top or bottom of the distillation column.
- For regulating the temperature of the top of the column, temperature of the overhead output is measured and controlled by TT and TC. This is the primary loop.
- Output of TC (primary controller) is given as the set point of the FC.
- The flow rate of the distilled product is measured and controlled by FC (secondary controller), whose set point is set by TC.
- Thus the secondary loop consists of FT, FC and control valve. This is given back as the reflux flow input to the column. Thus the temperature of the top of the distillation column is regulated

Diagram
4 M

Explanati
on-2 M

c)

Draw feed forward control scheme for heat exchanger. Explain it.

6M



	Ans:	<p>Diagram:</p> <p>The objective of feed forward control is to measure the disturbances and compensate for them before the controlled variable deviates from the set point. In heat exchangers if the major disturbance is the inlet temperature, following scheme can be used to implement feedforward controller.</p>	<p>3M</p> <p>Diagram-3 M</p> <p>Explanation-3 M</p>
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