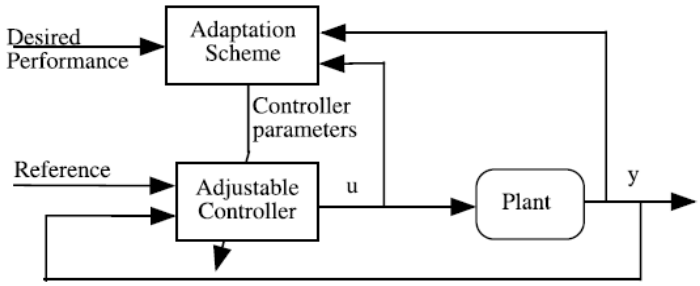
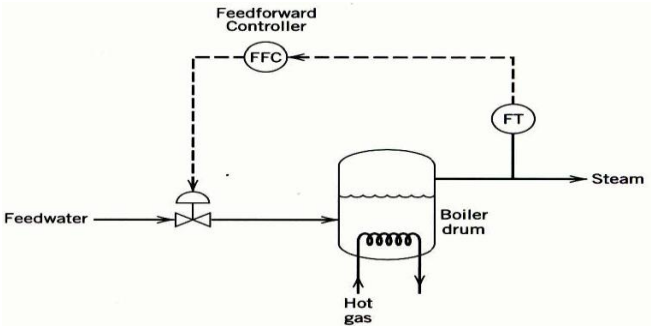
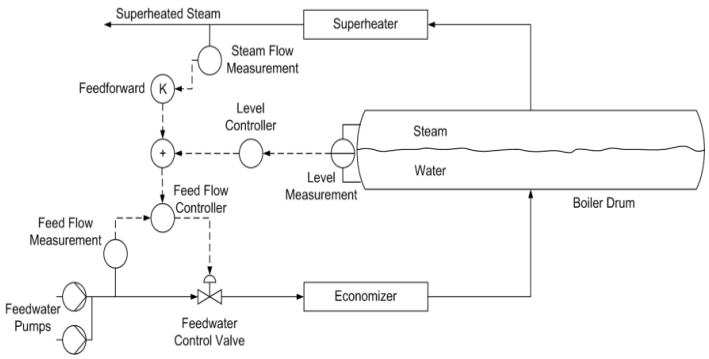
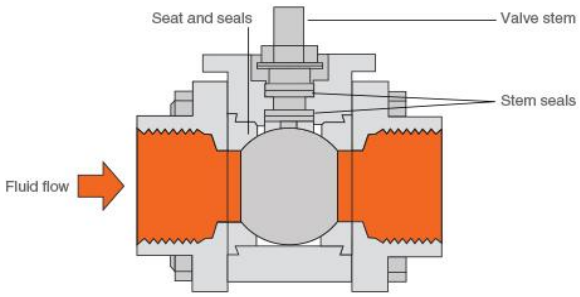
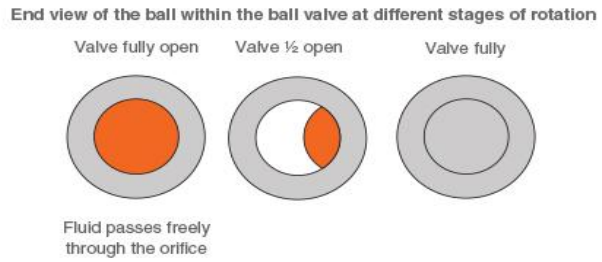
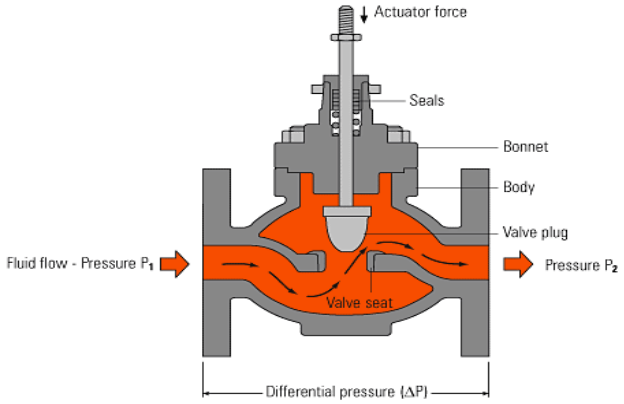
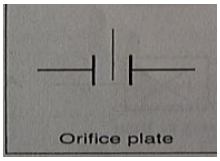
**Important Instructions to examiners:**

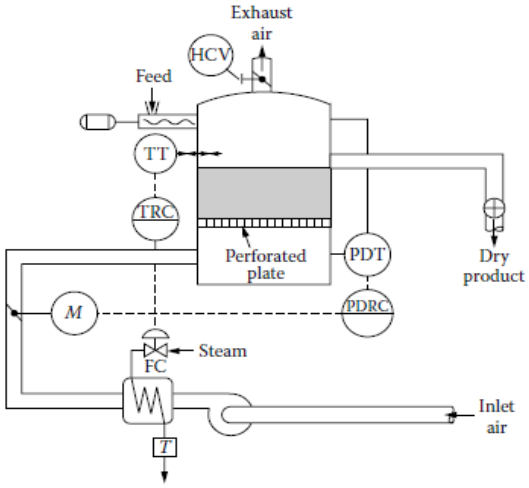
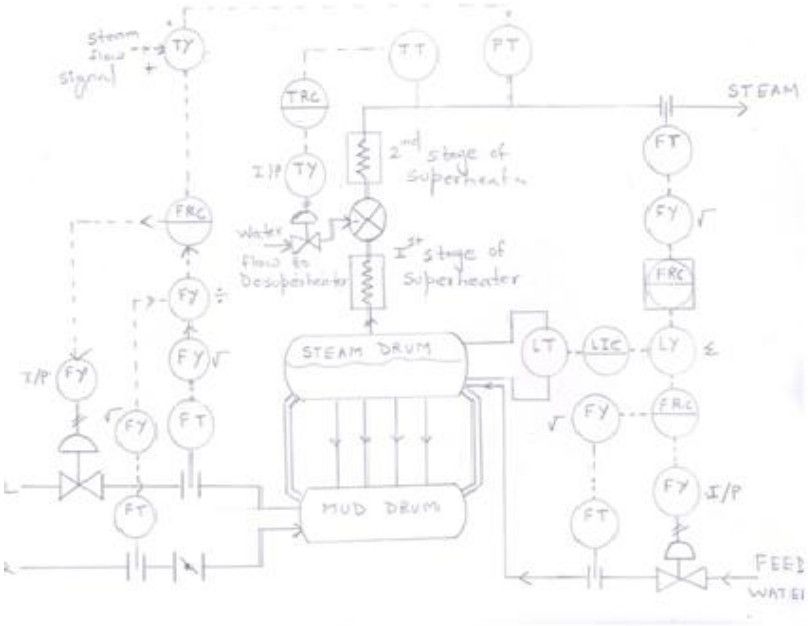
1) The answers should be examined by keywords and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

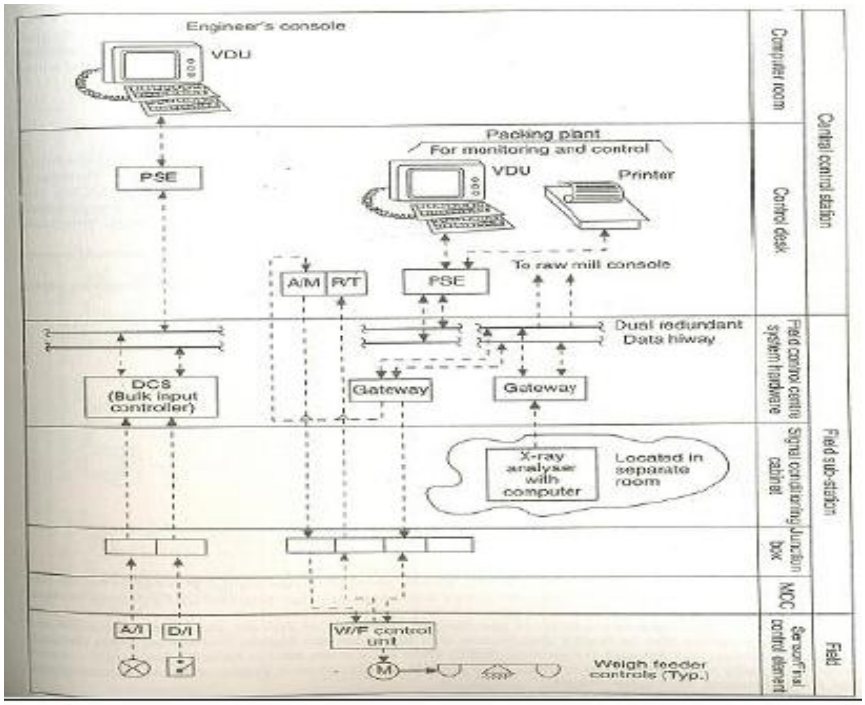
| Q. No. | Question & its Answer | Remark | Total Marks |
|---|---|---|---|
| 01(A) (a) | **Draw the block diagram of Adaptive Control system and describe its working** | | 04 |
| Ans. | **Diagram:**<br>  <br><br>In Adaptive control, the parameters are automatically adjusted to meet the corresponding variation in the parameters of the process being controlled in order to get the desired response of the control loop. Unlike the conventional control system where the parameters are fixed and outputs are variable, in adaptive control system, the parameters re adjusted.<br>In the diagram shown above, a closed loop controller is shown whose parameters can be changed to change the response of the system. The output of the system is compared to the desired performance and based on this error, the controller parameters are | **Block diagram- 2M**<br><br>**Description -2M** | |

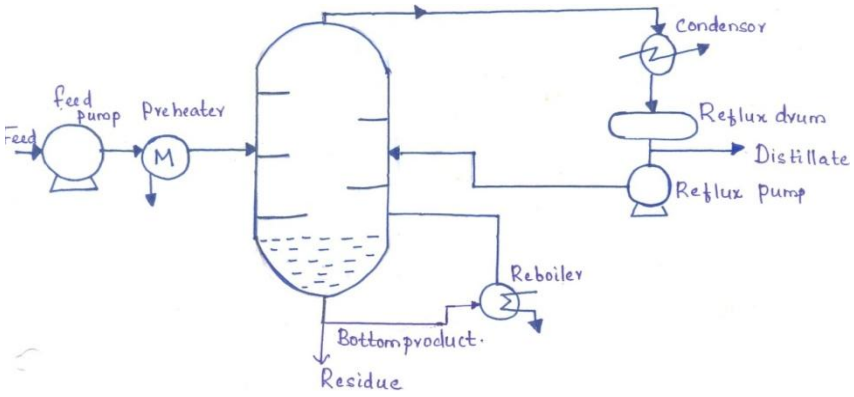
| | | | |
|---|---|---|---|
| | adjusted | | |
| **b)** | **Draw feed forward control scheme for drum level of boiler and write its working in brief.** | | **04** |
| **Ans** | **Feed forward Control Scheme for drum level control of Boiler**<br>  <br><br>In Feedforward control scheme, instead of measuring the controlled variable directly, disturbance is measured to maintain the controlled output at the desired value.In case of boilers, changes in the steam flow indicates the variation in demand and hence will affect the boiler drum level. Thus, the steam flow rate ismeasured, and the feed forward controller adjusts the feed water flow rate to maintain the boiler drum level at the set point.<br><br>**OR**<br>**3 Element Boiler Drum level Control**<br>  <br><br>Similar to feed flow, changes in steam flow can also cause large deviations in drum level, and could possibly trip the boiler. Changes in steam flow rate are measurable and this measurement can be used to improve level control very successfully by using a feed forward control strategy.For the feed forward control strategy, steam flow rate is measured and used as the set point of the feed water flow controller. In this way the feed water flow rate is adjusted to match the steam flow. Changes in steam flow rate will almost immediately be counteracted by similar changes in feed | **Diagram-2M**<br>**Working-2M** | |

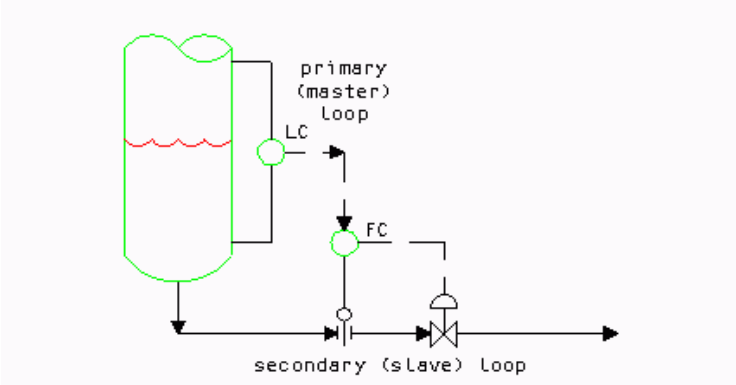
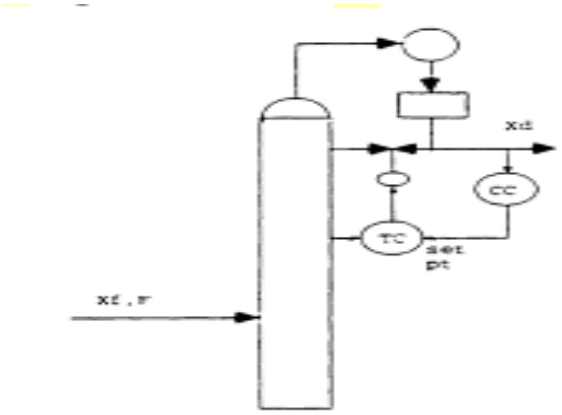
| | | | |
|---|---|---|---|
| | water flow rate. To ensure that deviations in drum level are also used for control, the output of the drum level controller is added to the feed forward from steam flow. | | |
| **c)** | **Draw the neat labeled diagram of (i) Ball Valve & (ii) Globe Valve** | | **04** |
| **Ans** | **i) Ball Valve ( Any other figure should also be considered)**<br>  <br>**Following diagram optional for Ball valve**<br>  <br>**ii) Globe Valve(Any other figure should also be considered)**<br>  | **Ball Valve Diagram- 2M**<br><br>**Globe Valve Diagram- 2M** | |
| **d)** | **Draw P & ID symbols for (i) Orifice meter (ii) Venturimeter (iii) Temperature Transmitter) (iv) Rotameter** | | **04** |
| **Ans** | **i) Orifice meter:**<br>  | **1 M each for correct symbol** | |

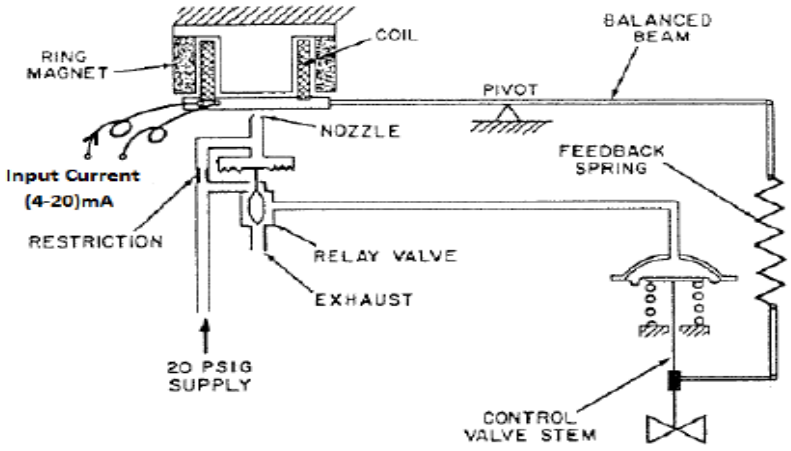
| | | | |
|---|---|---|---|
| | **ii)**  Venturi Meter<br>**iii)**  Temp Transmitter OR with a line/ or dashed line in the center<br>**iv)**  Rotometer OR  | | |
| **1(B) (a)** | **Enlist Types of Drying Process. Describe any one drying process with neat diagram** | | **06** |
| **Ans** | **Types :-**<br>1) Fluid- Bed Dryer ii) Spray Dryer iii) Direct Fired Rotating Kiln Dryer iv) Double Drum Dryer<br>OR<br>1) Adiabatic and Non-adiabatic Drying<br>2) Continuous and Batch Drying<br>Continuous Fluid –Bed Dryer<br><br>The continuous fluid-bed dryer shown in the following figure. It uses a temperature controller on the air leaving the bed to manipulate the flow of steam to the air heater. A second controller maintains bed density by holding a constant differential pressure across it. Hot air is passed up through the perforated plate, which comes in contact with the falling solid which is to be dried . The dried material is discharged through the side-arm.In this dryer, rapid circulation of the solids means that the average moisture content in the bed is approximately the same as that of the product being discharged..As a consequence, the rate of drying is essentially that of the product. An increase in either feed rate or moisture will lower the outlet-air temperature, causing the controller to increase steam flow to return it to set point. However, the addition of more heat to the air also raises its wet-bulb temperature, thereby raising the level of moisture in the product. Therefore, this system works only on temperature and is not sensitive to humidity. | **Any 4 types list OR classification as given-1M Diagram( Any 1 type)-3M Description-2M** | |

| | | | |
|---|---|---|---|
| |  **(Any other type with relevant diagram may also be considered)** | | |
| **b)** | **Draw P & I diagram for boiler Instrumentation and describe its operation** | | **06** |
| **Ans** |  Boiler Instrumentation involves control of the following parameters:<br>1) Boiler Drum level control<br>2) Combustion Control<br>**3)** Steam Temperature control<br><br>**1)Boiler Drum level control**<br>A 3 element boiler drum level control scheme is shown in figure above. Steam flow signal is added with drum level signal to form | **Diagram-3M**<br><br>**Descriptio n-3M** | |

| | | | |
|---|---|---|---|
| | the set point of Flow Recorder and Controller(FRC). The actual feedwater flow signal is compared with this set point and if there is any error, Feed water flow is manipulated.<br>**2) Combustion Control**<br>A Ratio control scheme for combustion is used to control the fuel flow rate. Steam flow and Steam Pressure are combined to form set point for FRC. The ratio of actual fuel flow rate and Air Flow rate are measured and given to FRC. Any change in the staem demand will generate actuating signal for the fuel control valve which is suitably adjusted to manipulate the combustion rate.<br>**3) Steam Temperature Control**<br>To control the temperature of steam, cold water is directly injected in the steam with the help of attemperator device. It can be mixed at any one of the following 3 locations<br>i) At the outlet of Boiler Drum<br>ii) Between the successive stages of Superheaters<br>iii) After the last stage of superheaters<br>The second option is widely used and is shown in the figure above.Steam temperature is measured and after comparing it with the set point, the TRC generates actuating signal for the Desuperheater water flow valve.<br>**(Any other type with relevant diagram may also be considered)** | | |
| **2.** | **Attempt any TWO:** | | **16** |
| **a)** | **Draw the block diagram of DCS in process Industry and describe its working** | | **08** |
| **Ans** |  | **Diagram-4M** | |

| | | | |
|---|---|---|---|
| | Steps involved in process operation:<br>It has the following units<br>• Crusher section<br>• Raw mill section<br>• kilin and coal mill section<br>• Cement mill section<br>• Packing & dispatch<br>Each unit will have its own local control room, which are monitored bya central control room. Raw mill automation is mainly to control theblending system. Being the heart of the plant kiln should haveoptimum control to maintain kiln fuel level, kiln speed, calciner fuel, cooler speed, oxygen content and cooler fan speed. In packing anddispatch section, automatic bag filling to certain weight and automaticloading in trucks are implemented.<br>**(Any other type with relevant diagram may also be considered)** | **Description-4M** | |
| **b)** | **Describe the working of distillation column with neat diagram. Draw cascade control scheme for any two variable in Distillation column.** | | **08** |
| **Ans** |  <br>**Explanation :**<br>Distillation is a process used for separating mixtures having two or more liquid component mixed with each other based on the difference in boiling points. Fig. above shows a typical distillation column. It consists of cylindrical shell, reboiler and condenser. The liquid mixture to be separated enters the cylindrical shell through the feed inlet. The section above feed plate is rectifying section, in which vapours are washed to remove the less volatile component. The section below feed plate is stripping section, in which liquid is stripped off from more volatile component by the rising vapours. | **Diagram-2M**<br>**Working-2M** | |

| | | | |
|---|---|---|---|
| | The vapoursgenerated in the reboiler are fed to the bottom of the column. Liquid removed from the bottom of the column is called bottom product. The vapours from top of the column are fed to condenser. The condensed component is taken from the top as top product.<br>**i) Cascade control of bottom level**<br>  <br><br>**ii) Cascade control of distillate composition (top product)**<br>  <br><br>**(Any other type with relevant diagram may also be considered)** | **Control schemes diagram- 2M each for 2 variables.** | |
| **c)** | **State the necessity of Valve Positioner. Draw the neat diagram of electro-pneumatic valve positioned. Write its working.** | | **08** |
| **Ans** | **Necessity:**<br>1. To overcome friction on valve stem through high open loop gain.<br>2. To increase speed of response when the distance between controller and valve is large by dead ended controller.<br>3. To achieve faster response speed.<br>4. To provide reverse action of signal pressure.<br>5. To provide split range application.<br>6. Delaying or slowing valve action.<br>7. Reduces valve hysteresis | **Necessity, Any 4 points- 2M Diagram- 3M, Working- 3M** | |




Electropneumatic force balnce type valve positioner

**Working:** **A**bove figure shows an electro-pneumatic valve positioner. It has a force balance mechanism consisting of electromagnetic coil, flapper-nozzle system, relay, balanced beam, and feedback spring. As an electrical control signal is applied to the coil placed in a ring magnet changes its position. Higher the electrical signal , more is the repulsive force between the magnet and the coil. This causes the nozzle back pressure to increase and is applied to the actuator through the relay valve. The change in stem position causes change in the position of the balance beam, which thereby increases the nozzle back pressure and consequently more control signal is supplied to the control valve. This process is continued until the opposite force across the pivot is balanced.

**3.** **Attempt any FOUR:** **16**

**a)** **Discriminate human aided and automatic process control.** **04**

**Ans**

| **Human aided control:** | **Automatic process control:** |
|---|---|
| Human being are required in control operation | No human being is required in control operation |
| Human cant not work beyond certain time if efficiency is less | Efficiency is excellent in this sysytem |
| More errors occurs.Hence accuracy is less. | Less error exist.Hence accuracy is more. |
| They are easy to install | They are difficult to install |
| They cannot be used in hazzardous | It is used in hazzardous area. |

**Any four point 1 mark each**

| | | | |
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| | | | |

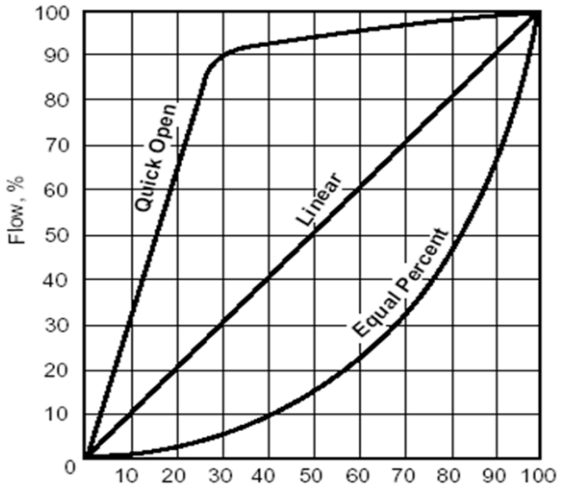
| | |
|---|---|
| Safety of human is major concern | Machine can work safely. |
| Quality of product is not good. | Quality of product is good. |

**(Any other relevant point may also be considered))**

| | | | |
|---|---|---|---|
| **b)** | **Differentiate between heat exchanger process and evaporation process.** | | **04** |
| **Ans** | | **Any four points 01 mark for each** | |

| Heat exchanger process | Evaporator process |
|---|---|
| It is device for efficient heat transfer from one medium to another. | It is device used to turn liquid form of solution into gaseous form. |
| It can be used as heater, cooler, condenser, reboiler. | It is the separation of liquid mixture into thick liquor & vapour. |
| It is used in power plant, Chemical plant & Petrochemical plant. | It is used in sugar, salt & milk powder industry. |
| Types of heat exchanger can be double pipe type & shell tube type. | Types of evaporation process can be single stage & multistage evaporator. |

**(Any other relevant point may also be considered)**

| | | | |
|---|---|---|---|
| **c)** | **Draw control valve flow characteristics. Give the meaning of one of them.** | | **04** |
| **Ans** |  | **2 mark for diagram** | |

| | | | |
|---|---|---|---|
| | • Linear - flow rate changes linearly with valve travel or stem position.<br>$$\frac{Q}{Q_{max}} = \frac{S}{S_{max}}$$<br>$S$ is the stem position, $Q$ is the flow rate.<br>• Equal percentage - flow rate changes exponentially with stem position. A given percentage change in stem position produces equal percentage changes in the flow.<br>Rangeability $R = \frac{Q_{max}}{Q_{min}}$<br>• Quick opening - provides large changes in flow rate for very small changes in stem movement. Since it has very high valve gain, it is not used in modulating control. Therefore it is used in on-off service, such as sequential operation in either batch or semi-continuous processes. | **Any one meaning: 2 marks** | |
| **d)** | **Compare feedback and feedforward control system (any 4 points)** | | **04** |
| **Ans** | | **Any four points 01 mark for each** | |

| Feedforward | Feedback |
|---|---|
| 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. |
| Good for slow system | Unsatisfactory for slow processes |
| Does not introduce instability in the closed loop response. | Create instability in the closed loop response |
| Requires identification of all possible disturbances and their direct measurement. Thus requires good knowledge of process model. | Does not require identification and measurement of any disturbances |
| Sensitive to unmeasured disturbances | Insensitive to unmeasured disturbances |
| Sensitive to process parameter variations | Insensitive to parameter changes |

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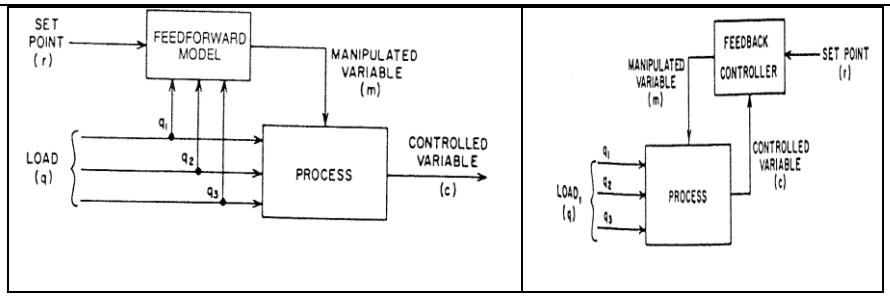
| |  | | |
| **e)** | **Name the different DCS communication methods. Describe any one.** | | **04** |
| **Ans** | • Different communication methods of DCS are<br>1) MODBUS<br>2) PROFIBUS<br>3) ControlNet<br>4) Ethernet<br>**1) <u>MODBUS</u>**<br>• MODBUS is a serial communications, application-layer protocol based on client/server or request/reply architecture for process control systems. It was published by Modicon (now Schneider Electric) in 1979.<br>• Modbus is used for <u>Supervisory Control and Data Acquisition (SCADA)</u> type network communication between devices. It is used to connect a supervisory computer with a remote terminal unit (RTU) in SCADA systems.<br>• The Modbus protocol follows a <u>master and slave architecture</u> where a master transmits a request to a slave and waits for the response. It provides up to 247 slaves for one master. Only the master initiates a transaction giving the master full control over the flow of information. For example a system that measures temperature and humidity and communicates the results to a computer.<br>• Here, transmission medium is not defined. The user can therefore choose between RS-232C, RS-422 or 20 mA current loops, all of which are suitable for the transmission rates which the protocol defines.<br>• Certain characteristics of the MODBUS protocol are fixed, such as frame format, frame sequences, handling of communications errors, and exception conditions and the functions performed. Other | **Name of the methods: 2 marks, any one explanation in brief: 2 marks** | |

characteristics are user-selectable. These are transmission medium, transmission characteristics, and transmission mode (RTU or ASCII).

OR

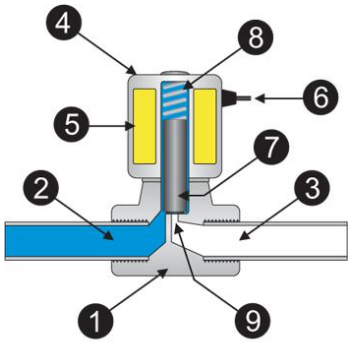
**2) PROFIBUS**

- 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, 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.

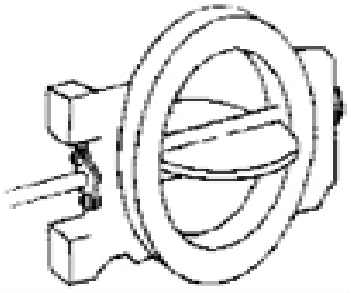
OR

**3) ControlNet**

- ControlNet is an open industrial control network protocol for real-time industrial automation applications.
- ControlNet is a member of the CIP (Common Industrial Protocol) network family.
- ControlNet has good real-time capabilities providing high-speed deterministic transmission for time-critical I/O data and messaging data.
- ControlNet is highly deterministic (the ability to reliably predict when data will be delivered) and repeatable (ensures that transmit times are constant and unaffected by devices connecting to, or leaving, the network) and thus meets critical requirements for synchronized and coordinated real-time motion control applications.
- ControlNet was developed by Rockwell Automation and today, it is managed by the ControlNet International User organization.
- ControlNet products are certified by the ControlNet International user organization, guaranteeing worldwide compatibility
- It has the built-in support for fully redundant cables,

| | | | |
|---|---|---|---|
| | and communication on ControlNet can be strictly scheduled and highly deterministic. These are its features.<br>• ControlNet is standardized in the European standard series EN 50170. It uses coax cables and a transmission speed of 5 Mbit/s. The Media Access method allows multiple controllers to control I/O on the same wire.<br>OR<br>**4) Ethernet**<br>• Ethernet is the most widely-installed local area network (LAN) technology.<br>• It is specified in IEEE 802.3 standard.<br>• Ethernet was originally developed by Xerox from an earlier specification called Alohanet (for the Palo Alto Research Center Aloha network) and then developed further by Xerox, DEC, and Intel in 1976.<br>• An Ethernet LAN typically uses coaxial cable or special grades of twisted pair wires to connect the devices.<br>• Ethernet is also used in wireless LANs.<br>• The most commonly installed Ethernet systems are called 10BASE-T<br>• It provides transmission speeds up to 10 Mbps.<br>• It uses a Carrier Sense Multiple Access with Collision Detection (CSMA/CD ) protocol to handle simultaneous demands.<br>• Ethernet uses a bus or star topology. | | |
| **4. (A)** | **Attempt any THREE.** | | **12** |
| **a)** | **Describe working of solenoid control valve with diagram** | | **04** |
| **Ans** |  <br>1. Valve Body<br>2. Inlet Port<br>3. Outlet Port<br>4. Coil / Solenoid<br>5. Coil Windings<br>6. Lead Wires<br>7. Plunger<br>8. Spring<br>9. Orifice | **02 marks for Diagram** | |

| | | | |
|---|---|---|---|
| | • A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid. It is used for controlling liquid or gas flow.<br>• It consists of the valve body, a magnetic core attached to the stem and disc(plug) and a solenoid coil. The magnetic core moves in a tube that is closed at the top and sealed at the bottom. A small spring assists the release and initial closing of the valve.<br>• The valve is electrically energised to open. It is controlled by electrical current, which is run through a coil. When the coil is energized, a magnetic field is created, causing a plunger ( movable core) inside the coil to move. Depending on the design of the valve, the plunger will either open or close the valve.<br>• When electrical current is removed from the coil, the valve will return to its de-energized state. Reversing the valve plug causes reverse action (open when de-energized).<br>• In direct-acting solenoid valves, the plunger directly opens and closes an orifice inside the valve.<br>• The solenoid valve has two ports: an inlet port and an outlet port. | **02 marks for explanation** | |
| **b)** | **Write purpose of instrument index sheet and process flow sheet.** | | **04** |
| **Ans** | **Purpose of Instrument Index sheet:**<br>Instrument index is a document containing list of instrument devices within a plant. Instrument index shall include tag number of all physical instruments. This document contains list of instruments coming under each TAG No., there functions, locations, etc. This document contains all the information about instrumentation which is shown on the P & ID.This document also contains nos. of other documents for crossreference. Therefore this document is considered as a live document which should be kept updated even though the plant has been operated.<br><br>**Purpose for Process flow diagram:**<br>A process flow diagram (PFD) is a diagram commonly used in chemical and process engineering to indicate the general flow of plant processes and equipment. The PFD displays the relationship between major equipment of a plant facility.<br>Process flow diagrams of a single unit process will include the following: | **02 marks**<br><br>**02 marks** | |

| | | | |
|---|---|---|---|
| | • Process piping<br>• Major equipment items<br>• Control valves and other major valves<br>• Connections with other systems<br>• Major bypass and recirculation streams<br>• Operational data (temperature, pressure, mass flow rate, density, etc.), often by stream references to a mass balance.<br>• Process stream names. | | |
| **c)** | **State the advantages of DCS (Any four)** | | **04** |
| **Ans** | **Advantages of DCS:**<br>1. Overall cost of the installation is lower.<br>2. Less wiring required due to serial communication.<br>3. Panel space is reduced.<br>4. Allows inter-controller communication. Hence programming can be done from any location.<br>5. Flexible and relatively easy to expand.<br>6. It allows duplicate storage of data.<br>7. High reliability.<br>8. Application program can be easily developed.<br>9. Interface with the process is improved.<br>10. Advanced control technique.<br>11. Provision of redundancy.<br>12. Optimum utilization of available man-power.<br>13. Minimum data losses & errors.<br>14. Reduces manpower requirement. | **Any 4 Points, 1 Mark Each** | |
| **d)** | **Draw the neat diagram of butterfly valve and describe its working.** | | **04** |
| **Ans** |  <br>• In this valve, the plug is in the form of a disc. The "butterfly" is the metal disc mounted on a rod. The disc is positioned in the center of the pipe.A rod connected to an actuator on the outside of the valve is passing through the | **02 marks for Diagram**<br>**02 marks** | |

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| | disc. Rotating the actuator turns the disc either parallel or perpendicular to the flow.<br>• The disc is always present within the flow, therefore a pressure drop is always induced in the flow, regardless of valve position.<br>• A butterfly valve is from a family of valves called quarter-turn valves. In operation, the valve is fully open or closed when the disc is rotated a quarter turn. When the valve is closed, the disc is turned so that it completely blocks off the passageway. When the valve is fully open, the disc is rotated a quarter turn for the passage of the fluid.<br>• Butterfly valves are less costly and lighter in weight, therefore less support is required. It is used for isolating or regulating flow. | **for working** | |
| **(B)** | **Attempt any ONE:** | | **06** |
| **a)** | **Describe different remedies to avoid problem of cavitation and flashing in control valve.** | | **06** |
| **Ans** | Remedies to avoid the problem of cavitation<br>1. Revised process condition:<br>a) Reduction of operating temperature can lower vapour pressure.<br>b) Increase in upstream and downsteam pressure with Δp. unaffected.<br>2. Revised valve<br>Type of valve in terms of pressure recovery characteristics.<br>3. Revised installation<br>Two or more control valves installed in series as multistage control valve to handle huge pressure drop.<br>4. Gas injections<br>Introduction of non condensable gas or air into the region where cavitation is anticipated.<br><br>Remedies to avoid the problem of flashing<br>1. The damage from flashing can be minimized by reducing velocity by using reduced port angle valve discharging directly into vessel or flash tank.<br>2. Using erosion resistant material such as ceramic material lining provided at downstream of control valve. | **Any two points 1 ½ mark for each**<br><br>**Any two points 1 ½ mark for each** | |
| **b)** | **Draw the block diagram of batch processes and continuous process. Describe processes with example.** | | **06** |
| **Ans** | **Continuous process:**<br><br>The continuous process is one in which inputs are fed into the system at a constant rate and at preset ratios (raw materials, | **03 marks (02 marks** | |

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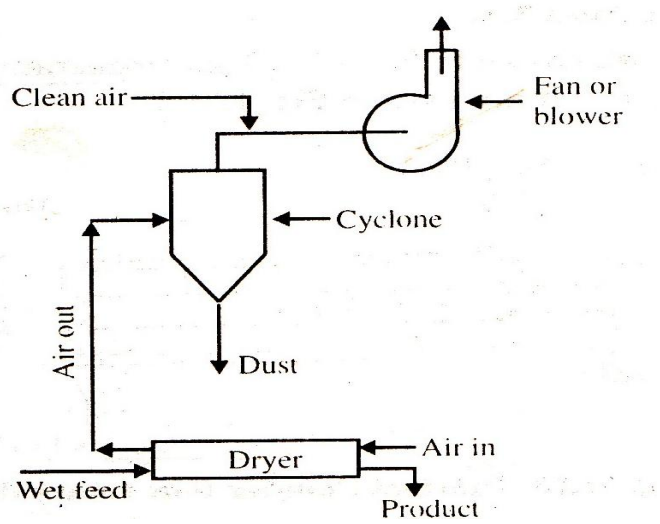
| | auxiliary materials, energy, etc.), and at the same time a constant extraction of outputs is done (products, by-products, energy, etc.). This process is characterized by a constant process taking place in each section of the facility and during the time of its action a constant process takes place. Thus, the concentration of reactants and products at every location in the system is in a durable state and control of the process is done by maintaining these concentrations.In a continuous process, such as the distillation of crude oil or the manufacture of bulk chemicals and fertilizers and rotary dryer in cement industry, the product is manufactured on a continuous basis.<br><br>  <br><br>Fig. Rotary dryer with dust collector(cyclone)<br><br>**Batch process:**<br><br>It is a process that manufactures a finite quantity of material by subjecting measured quantities of raw materials to a sequential order of processing actions using one or more pieces of equipment.<br>In batch process material is fit to the equipment at a time and then it is processed to obtain finished product. During the process operation there is no other material added or taken out.<br>Batch processes used in the food, pharmaceutical and fine chemicals industries and fluidized bed dryer in chemical industry, products are manufactured in batches. Batch processes are sequential, where the control actions, such as charging, mixing, heating, cooling, and testing are performed in an ordered fashion. | **for description and 01 mark for diagram)**<br><br>**03 marks (02 marks for description and 01 mark for diagram)** | |

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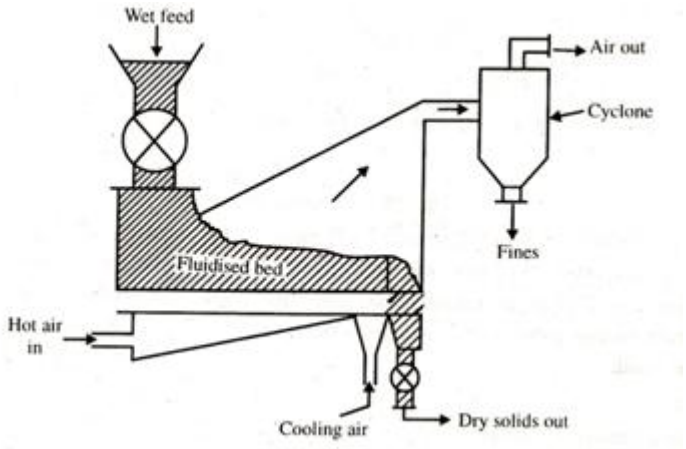
| |  Fig. Fluidised bed dryer **(Any other relevant diagram of above process to be considered.)** | | |
| **Q.5** | **Attempt any TWO:** | | **16** |
| **a)** | **Describe the working of ratio control system with example.** | | **08** |
| **Ans** | **Ratio control system:**<br>• Ratio control is a special type of feed-forward control.<br>• The objective of a ratio control scheme is to keep the ratio of two process variables at a specified value.<br>• The two process variables are usually flow rates of a manipulated stream(m) and a disturbance stream(d).Here, the disturbance stream is also referred to as wild or load stream.<br>• Thus, the ratio (R) of two variables ( m& d),**R = m / d** is controlled rather than controlling the individual variables.<br><br>There are two ways to implement ratio control scheme.<br>**i) Ratio control scheme using Divider**<br>**ii) Ratio control scheme using Multiplier** | **(Any one scheme) 2 Marks** | |

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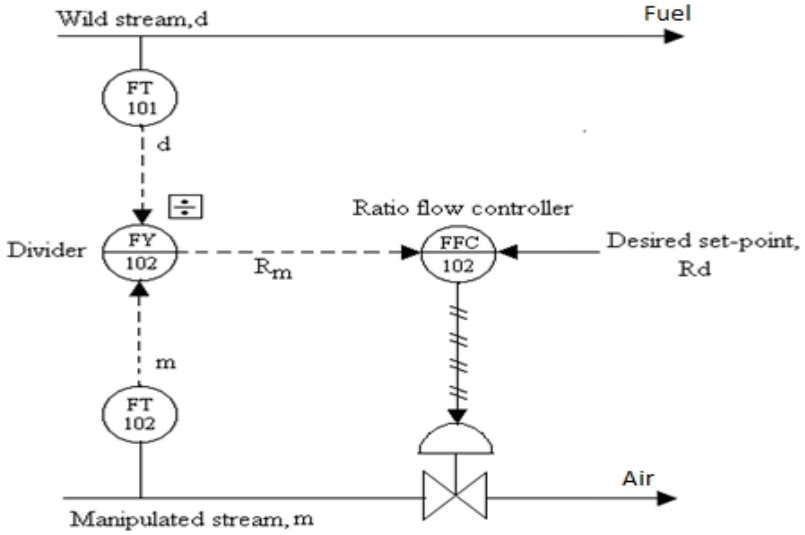
| | **Dia. of ratio control:**<br>  <br><br>Ratio control scheme using Divider<br><br>Here the manipulated stream (m) is under standard feedback control. The flow of the wild stream(d) is measured using flow transmitter(FT-101) and sent to a 'multiplier' (FY-102 ) which multiplies the signal by the desired ratio(Rd) yielding the set-point for the flow controller(FC-102).The flow controller then adjusts the flow rate of manipulated stream(m).The main advantage of this method is that the process gain remains constant because divider is not used.<br><br>**Ratio control system in boiler process:** In boiler process for proper operation of furnance heating maintenance the fuel to air ratio to furnace at its optimum value is essential for most efficient combustion that can achieved by ratio controller as in above figure.<br><br>**(Any one of the system may be considered.)** | **2 Marks**<br><br>**2 Marks**<br><br>**2 Marks** | |
| **b)** | **Enlist the documents required for instrumentation in project engineering. State role of instrumentation engineer in project engineering.** | | **08** |
| **Ans** | **Documents required for instrumentation in project engineering:** | | |

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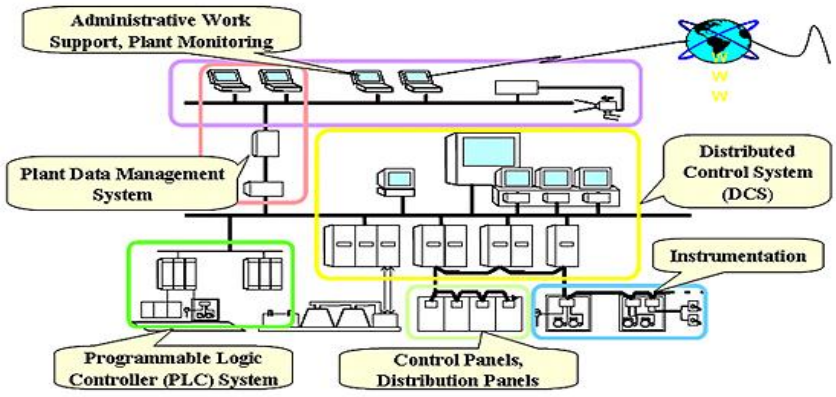
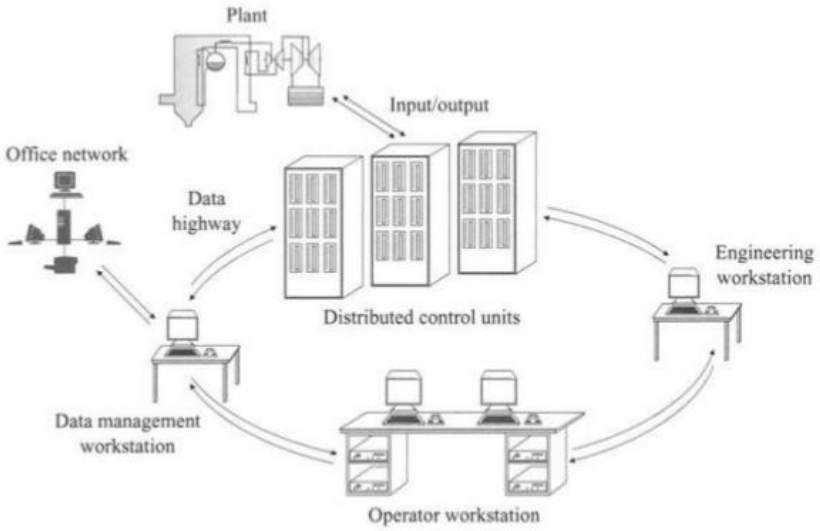
| | 1) Instrument index sheet<br>2) Data sheet/ instrumentation specification sheet<br>3) I/O list<br>4) P & ID diagram<br>5) Loop wiring diagram<br>6) Process flow sheet<br>7) installation diagram<br>8) control panel wiring diagram.<br><br>**Role of Instrumentation engineer in Project engineering:**<br>• designing and developing new control systems<br>• testing, maintaining and modifying existing systems<br>• analyzing data and presenting findings in written reports<br>• managing operations<br>• working collaboratively with design engineers, operation engineers, purchasers and other internal staff<br>• liaising with clients, suppliers, contractors and relevant authorities (e.g. the Nuclear Decommissioning Authority)<br>• project management within cost and time constrained environments<br>• understanding and ensuring compliance with relevant health and safety regulations and quality standards<br>• providing advice and consultancy support<br>• purchasing equipment<br>• writing computer software and test procedures<br>• Developing new business proposals. | **02 mark for listing**<br><br>**6 marks**<br><br>**01 mark for each point** | |
| **c)** | **Draw the block diagram of DCS in thermal power industry and describe its working** | | **08** |
| **Ans** | **DCS system architecture:**<br>  | **4 marks for diagram** | |

(OR)




**Description of the system:**

Managing a power plant involves the following activities,

1. Raw Material Transportation and Processing
2. Boiler Combustion (Pulverization of Coal / CFB)
3. Turbine (Steam Turbine and Heat Recovery) Monitoring and Control
4. Generator and Plant Electrical System Monitoring and Control
5. Waste and Exhaust Treatment.

Like any other industrial control application, the subsystem of DCS are interconnected through network, using the standard Ethernet, serial line or point to point multidrop. In dual configuration, they may support high reliability networking using dual ethernet network topology. The automation and control logic are typically distributed among the various stations. The human machine interface functions are provided by DCS HMI operator stations. The connection to external systems is guaranteed by the OPC or MODBUS gateway functions.

DCS used to control entire plant operation from CCR following major variables are measured and controlled.

**4 marks For description**

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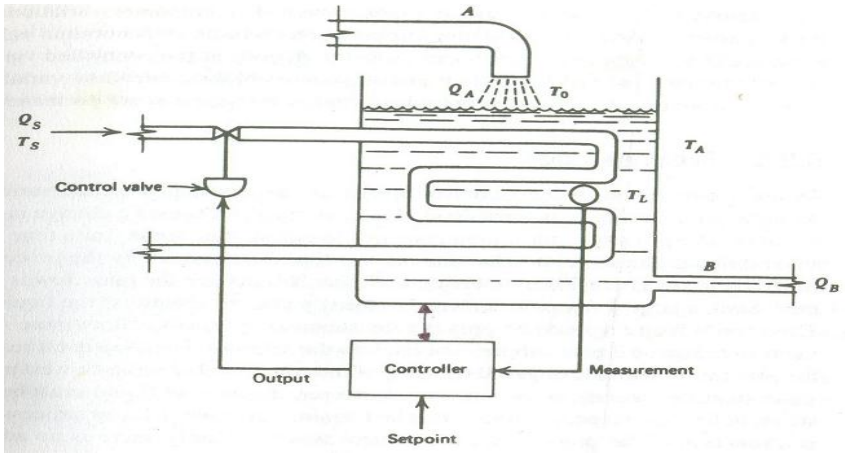
| | Input variables<br>• Fuel flowrate<br>• Combustion air.<br>• Feed water flow<br>• Steam flow / pressure<br>Control variables:<br>• Drum level<br>• Steam pressure<br>• Furnace draft<br>• Waste gases composition<br>Above variables are continuously monitored and controlled on DCS using different DCS displays such as<br>• Graphic display<br>• Group display<br>• Trend display<br>• Alarm display<br>• Log and repeat display etc.<br>**(Any other relevant diagram may also be considered.)** | | |
| **6** | **Attempt any FOUR:** | | **16** |
| **a)** | **Draw the diagram of temperature control system and state the functions of each element.** | | **04** |
| **Ans** | **Temperature control system**<br>  <br><br>Fig. shows a temperature control loop, in which the temperature $T_L$ of the liquid in a tank is controlled. Liquid is heated using steam flowing through a pipe inside the tank. The objective is to maintain | **2 Marks for diagram**<br><br>**2 Marks for description** | |

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| | temperature of process to desired value by regulating steam flow rate in line.<br><br>**Elements & functions**<br><br>1) Temperature transmitter – To measure and transmit the temperature to the controller<br>2) Temperature controller - To manipulate the error signal, generate and transmit control signal to the control valve<br>3) Control Valve – To control the steam flow rate according to the control signal<br>4) Tank (Process vessel), flow & Steam pipes – Parts of the process.<br>**(Any other relevant diagram may also be considered.)** | | |
| **b)** | **Find the proper valve size in inches and centimeter for pumping the liquid flow rate of 600 gal/min with maximum pressure difference of 55 psi. liquid specific gravity is 1.3. find valve size.** | | **04** |
| **Ans** | **Data given:**<br><br>Q = 600 gal/min, ΔP = 55 Psi, G = 1.3<br><br>Equation for flow rate, $Q = C_V\sqrt{\frac{\Delta P}{G}}$<br><br>Therefore, $C_V = Q\sqrt{\frac{G}{\Delta P}}$<br><br>Substituting we get, $C_V = 600\sqrt{\frac{1.3}{55}}$ = 92.24<br><br>For a $C_V$ of 92.24, the required valve size is 3 inches. ( Refer table)<br><br>The valve size in cm = 3x2.54 = 7.62 cm | **2 Marks for formula & substitution**<br><br>**2 Marks for answer** | |
| **c)** | **List the features of typical DCS (eight points).** | | **04** |

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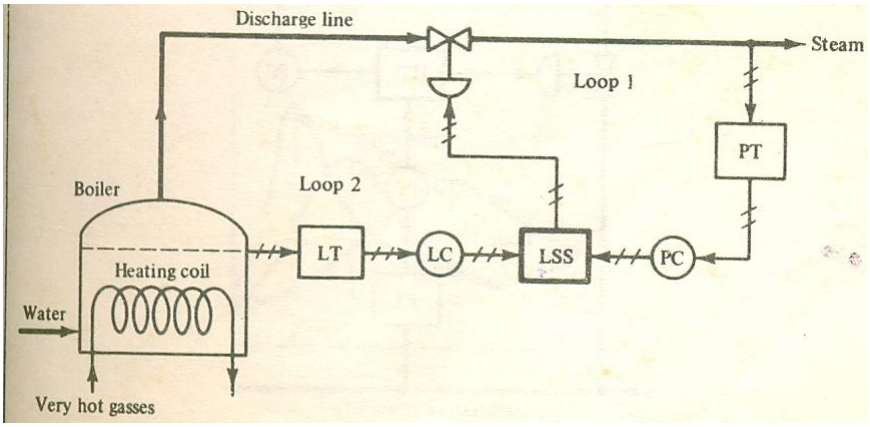
| **Ans** | **Features of DCS:**<br><br>1.Modular system development capability<br>2. Build schematic display develop control program<br>3. Interoperability.<br>4. Support for standards.<br>5. Location independence<br>6. Increased service reliability and support for Fallback.<br>7. Optimized throughput.<br>8. Monitoring and Instrumentation capability.<br>9. Redundancy and other fail safe techniques.<br>10. Data highway and transmission, communication capability. | **04Marks. Any eight points (½ marks for each )** | |
| **d)** | **Draw the diagram of selective control with example. Describe its working.** | | **04** |
| **Ans** | **Dia. for selective control system:**<br><br>  <br><br><br>**Override control to protect a boiler system**<br><br>**Description:** Selective control is the name given to the application of signal selectors in a control strategy. Signal selectors are the devices that choose the lowest, highest or median signal from among two or more signals. Selective control have variety of applications,<br><br>1) Guarding against exceeding equipment or operating constraints(overrides)<br>2) Automatic start-up and shut-down<br>3) Protection against instrument failure<br>4) Selection of extreme values. | **2 marks for diagram**<br><br>**2 marks for working** | |

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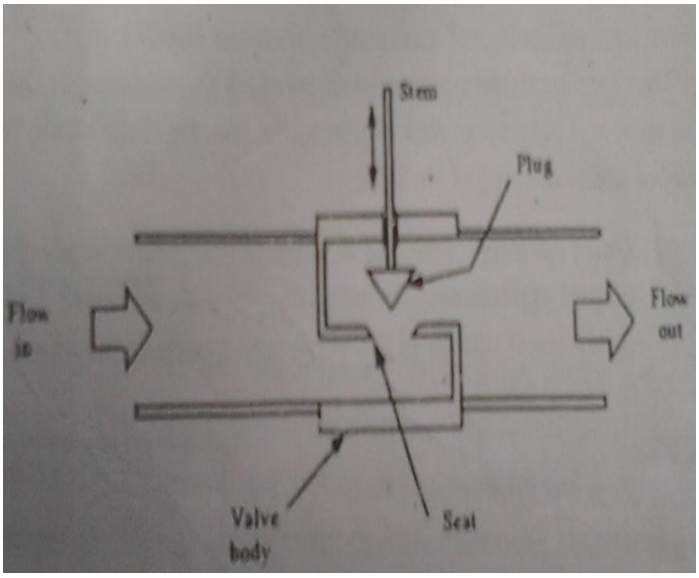
| | The override control system shown in fig. uses a low selector switch(LSS). According to the system whenever the liquid level falls below the allowable limit, the LSS switches the control action from pressure control to level control(loop1 to loop2) and closes the valve on the discharge line, preventing burning out of the heating coil. | | |
| **e)** | **Explain the principle of control valve in brief. State criteria of valve selection and sizing.** | | **04** |
| **Ans** | **Principle of Control valve:**<br>A control valve is a final control device which is used to regulate the flow rate of fluid flowing through pipes in the system. This is accomplished by placing variable size restriction in the flow path as shown in following fig.<br>The control valve (final control element) manipulates a flowing fluid, such as gas, steam, water, or chemical compounds, to compensate for the load disturbance and keep the regulated process variable as close as possible to the desired set point. It works by fully or partially opening or closing in response to signals received from controllers. The opening or closing of control valves is usually done automatically by electrical, hydraulic or pneumatic actuators.<br>**Diagram:**<br>  <br> | **02 marks for explanation** | |

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| | **Selection criteria for control Valve:**<br><br>1. Body pressure rating: It must be as per the ANSI pressure classes.<br>2. Temperature considerations: It includes strength of body materials as well as relative thermal expansion of various paths.<br>3. Material selection: Body materials are to be decided depending on temperature range and erosive qualities of fluid.<br>4. Flow characteristics: Characteristics may have strong influence on stability of process. Accordingly, choice may be quick opening, linear or equal percentage.<br>5. Rangeability: Wide rangeability may be required according to the process load change.<br>6. Pressure drop: Maximum pressure drop a valve can tolerate at fully shut off and partly open or fully open.<br>7. Cost Vs capacity: For larger lines, over size valves are required and cost increases. | **02 marks for selection criteria (1/2 mark for each point)** | |