WINTER-16 EXAMINATION

Model Answer Subject Code **17457**

WINTER – 16 EXAMINATIONS

Subject Code: **17457** **Model Answer** Page No: ____/ N

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 judgment 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.

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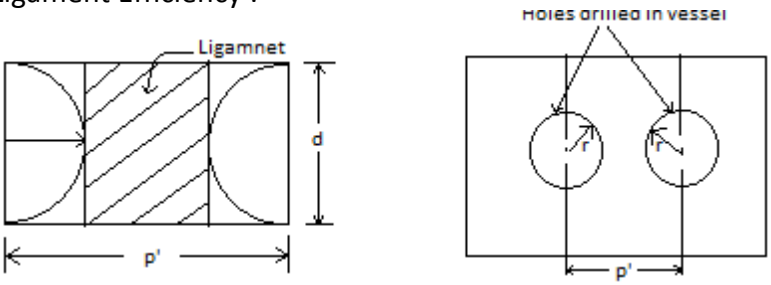
`Q	MODEL ANSWER . NO.	MARKS	TOTAL MARKS
1.	**Attempt any TEN of the following:**		**20**
a)	Ligament Efficiency :  Ligament efficiency is defined as the ratio of area of ligament to the area of normal section. Ligament Efficiency= Area of ligament x 100	**01 mark -dia** **01 mark**	**02 marks**
b)	The boiler mountings are the part of the boiler and are required for proper functioning. In accordance with the Indian Boiler regulations, of the boiler mountings these are essential fittings for safe working of a boiler. Some of the important mountings are: Pressure Gauge, Safety Valve, Fusible Plug, Blow-Off Cock, etc. The boiler accessories are mounted on the boiler to increase its efficiency. These units are optional on an efficient boiler. With addition of accessories on the boiler, the plant efficiency also increases. Some of the important accessories are: Economizer, Super heater, Air pre heater, Feed water pump, Steam injector, etc. Boiler may operate with/without accessories but should not operate without mountings.	**01 mark** **01 mark**	**02 marks**
c)	• Economizer An economizer is a heat exchanger, used for heating the feed water before it enters the boiler. The economizer recovers some of waste heat of hot flue gases going to chimney. It helps in improving the boiler efficiency. It is placed in the path of flue gases at the rear end of the boiler just before air pre-heater. Super heater It is a heat exchanger in which heat of combustion products is used to dry the wet steam, pressure remains constant, its volume and	**01 mark** **01 mark**	**02 marks**

	temperature increase. Basically, a super heater consists of a set of small diameter U tubes in which steam flows and takes up the heat from hot flue gases.		
d)	A pressure vessel is container desined to hold gasws or liquids at a pressure substantially difeerent from ambient pressure The types of pressure vessel are 1) Storage tank 2) Reactor 3) Heat Exchanger 4) Process Vessel	**01 marks** **01 marks (¼ for each)**	**02 marks**
e)	Factors to be considered while calculationg wind load. 1.Wind speed 2.Shape,height and topgraphic location 3.Surface roughness 4. Exposure	**02 marks (any two)**	**02 marks**
f)	Poisson ratio is the ratio of unit lateral contraction to the unit axial elongation and constant within the elastic limit for a given material. It is denoted by μ and for pressure vessel material, assume μ=0.3	**02 marks**	**02 marks**
g)	Design Pressure: It is the pressure used rto determined the minimum required thickness of each vessel shell component.It denoted the difference between internal and external pressure P design = Pintenal – P external (Pexternal is neglible) Therefore, P design = Pintenal	**02 marks**	**02 marks**
h)	Stresses in Cylinder <u>Longitudnal Stress:</u> internal pressure P = Resistive force due to longitudinal stress= σL $P(\pi r^2)= \sigma L*(2\pi r*t)$ $\sigma L= Pr / 2t$ <u>Circumferential Stress</u> internal pressure P= Resistive force due to Hoop/Circumferential stress =σH $P*(2rL)= \sigma H*(2L*t)$ $\sigma H=Pr/t$ $\sigma H=2* \sigma L$	**01 mark** **01 mark**	**02 marks**

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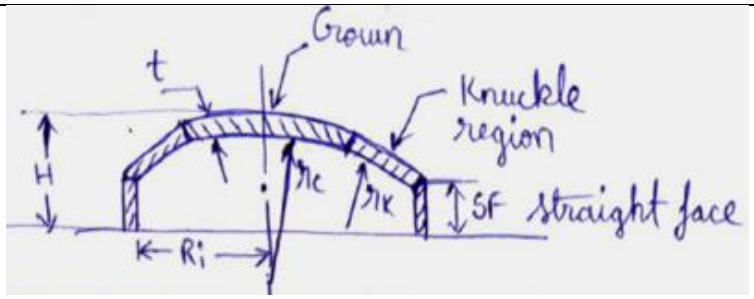
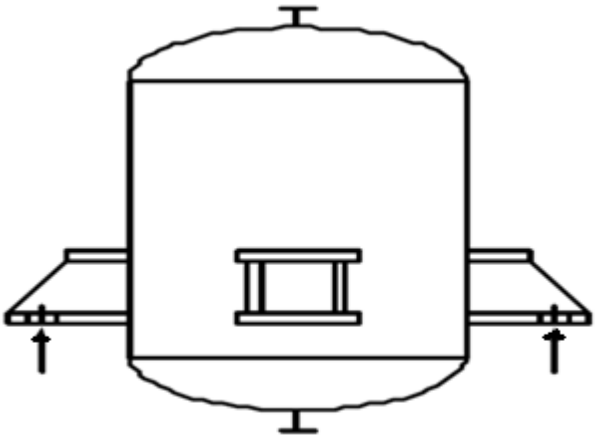
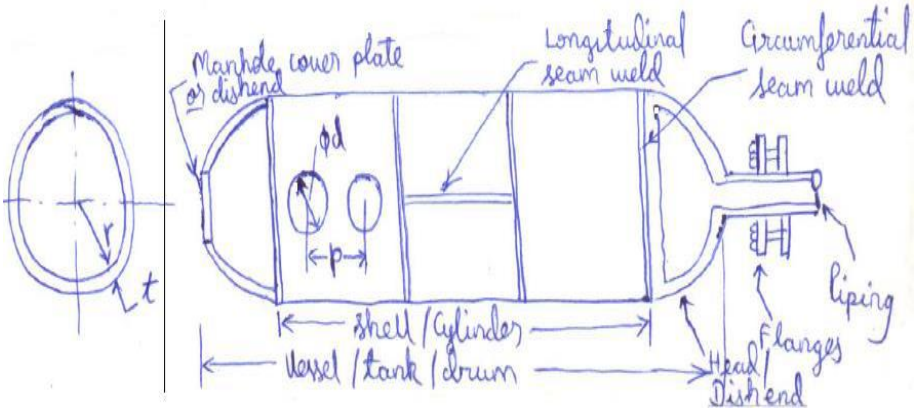
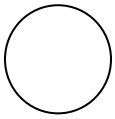
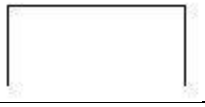
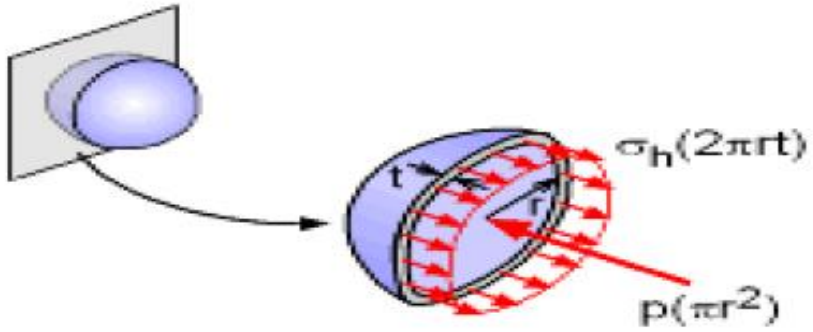
l)	 Torispherical Head	**02 marks**	**02 marks**
j)	**Support Lugs:** 	**02 marks**	**02 marks**
k)		**02 marks**	**02 marks**
l)	Stress concentration: Whenever in a part there is a change in the shape of its cross-section, then the stress distribution changes. This irregularity in the stress distribution caused by the abrupt changes of form is called as stress concentration. It reduces the strength, durability, stress resistance of a component.	**02 marks**	**02 marks**

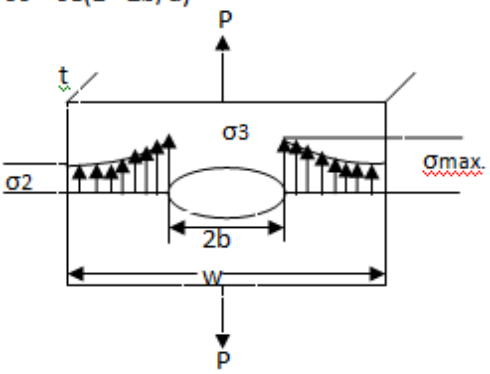
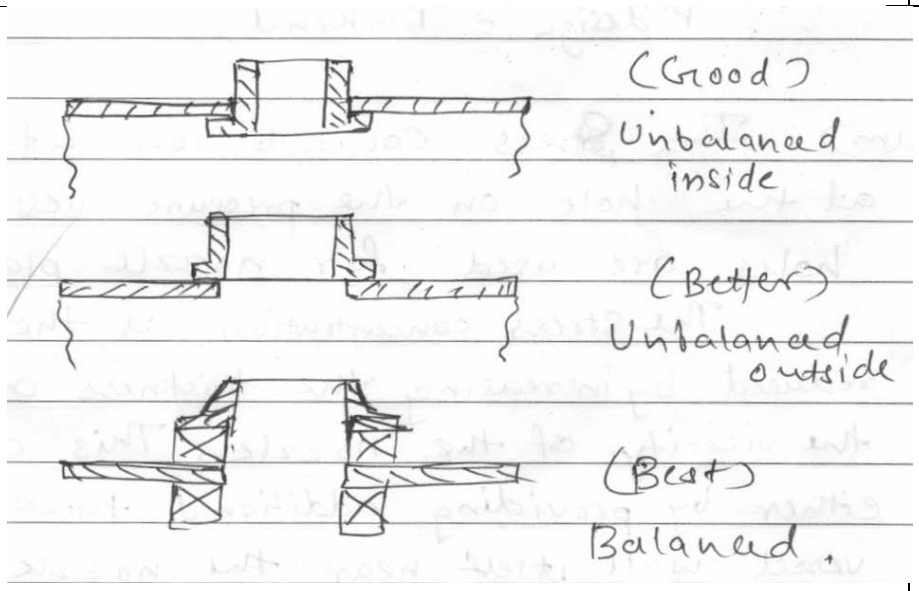
	It occurs because of stresses in the presence of notches, fillets, holes, keyways, splines, surface roughness, shoulders, scratches, etc		
m)	Stress contration is formed at the hole on the pressure vessel.These holes are used for nozzle placement. The stress contraction at the hole can be reduced by inceasing thr thickness of the vessel in the vicinity of the nozzle.This can be done either by providing additional thickness to the vesse wall itself near the nozzle or by use of separate reinforcing p;ate attachmened to the vessel wall covering an area surrounding the hole.Sometimes the nozzle wall at base can be made sufficiently thickn to act as reinforcement.	**02 marks**	**02 marks**
o) i	Spot Weld 	**01 mark**	**02 marks**
ii	Plug Weld 	**01 mark**	
p)	The factors considered for selection of material for hydrogen services: 1) Temperature 2) Hydrogen pressure 3) Time 4) Composition of material	**02 mark (any two)**	**02 marks**
2.	**Attempt any TWO of the following:**		**16**
a) i	General design criteria for pressure vessel: For cylinders under internal pressure, three principal stresses are generated, a) Hoop stress, b) Radial stress and c) Longitudinal stress The latter is due to the thrust of pressure on the heads of the cylinder. The value of the Hoop and Radial stresses are not constant through the cylinder walls, whereas longitudinal stresses are in fact constant. In the design phase it is therefore necessary to consider the stresses of the tri-axial state and to derive the ideal stress via. one of the theories of failure. Assuming that the ideal stress is equal to the basic allowable stress, we can then obtain an equation to compute the minimal required thickness for the pressure vessel.	**04 marks**	**08 marks**

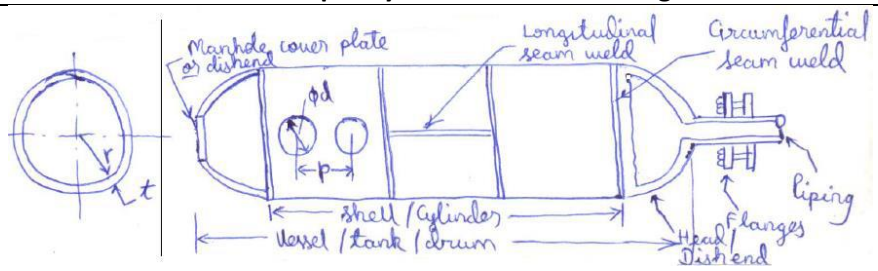
2.a) ii	Stresses in flanges and flanged joints: Correct assembly of the flanged joint requires the flanged joint requires the flange to be analyzed and the correct bolt load established to seat joint. Criterion, adopted for flange design and stress analysis, is carried out according to ASME code, in which following assumption have been adopted. 1. For hub and shell sections of flange local pressure acting on surfaces is neglected. 2. The effect of the external moment applied to the flange, equal to the product of the bolt load and the lever are independent of the location of the bolt- loading circle and of the forces balancing the bolt load. 3. Creep and plastic yield do not occur.	**04 marks**	
b)	Ferrous metals used for corrosive services in pressure vessel construction: • Steel a. Low carbon steel b. Medium carbon steel c. High carbon steel d. Alloy steel Low alloy steel viz. Carbon Molybdenum steels High alloy steels viz. Chromium steels, Chromium nickel steels also called as Stainless steels Commonly used material is Low carbon steels or also called Mild steels: Properties: • Good strength and ductility • Good weldability, machinability and fabricability • Rolled, forged and drawn • Low corrosion resistance • etc. Application: Used in normalised condition for; • Pressure vessel components, • Pipes and fittings, • Machine components, • Structural sections	**04 marks-** list **04 marks-** properties	**08 marks**
c)	Most common weld defects found are: 1. Misalignment of parts being welded 2. Cracks 3. Pin holes 4. Slag inclusion 5. Porosity 6. Incomplete fusion 7. Undercut groove 8. Insufficient penetration	**04 mark (any four)**	**08**

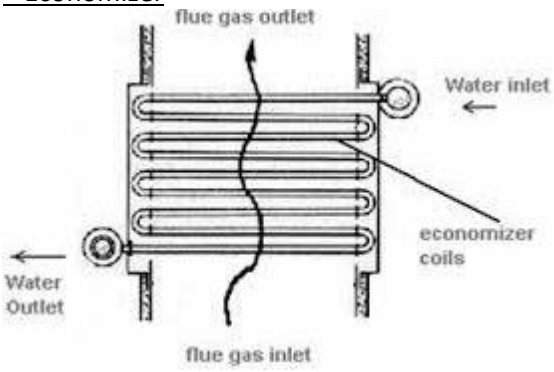
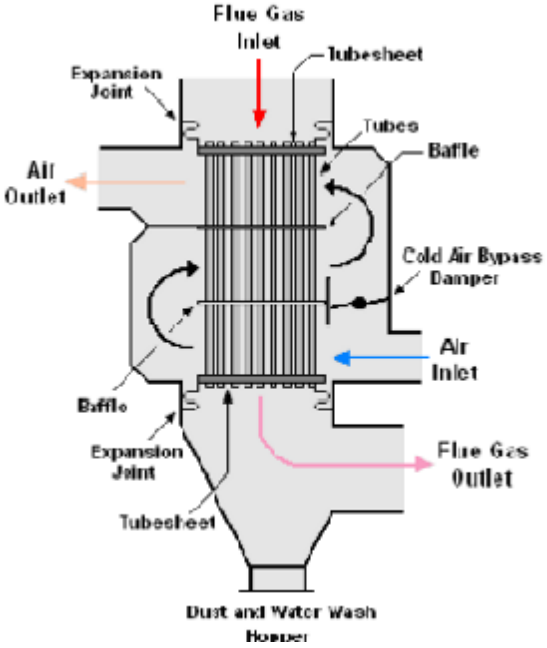
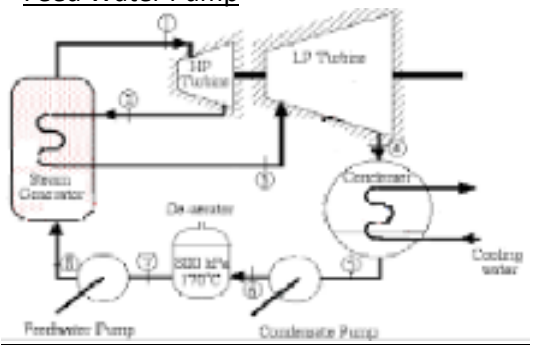
	Misalignment: Poor weld shape of weld occur due to misalignment of parts being welded. this also reduces the strength of weld Cracks: Cracks in welds occur due to thermal shrinkage after the fused molten metal cools down. Pin Holes: Pin holes on weld surface due insufficient flux covering or dirt on the parent metal. Slag Inclusion: Slag inclusion occurs when slag covering a run is not totally removed after every run before the following run. Porosity: Porosity occurs in the form of voids (cavity) when gases are trapped in the solidifying weld metal. Incomplete fusion: Incomplete fusion between the weld and base metal resulting from too little heat input and / or too rapid traverse of the welding torch (gas or electric). Undercut groove: Undercutting groove adjacent to the weld left unfilled by weld metal due to incorrect settings / procedure may make the weld weak. Insufficient penetration: Insufficient penetration of the weld metal in joints arises from too high heat input and / or too slow traverse of the welding torch (gas or electric).	**04 mark-e(any four)**	
3.	**Attempt any TWO of the following:**		**16**
a)	Stresses in Sphere:  Spherical Pressure Vessel Cut in Half	**04 Marks dia**	**08 Marks**

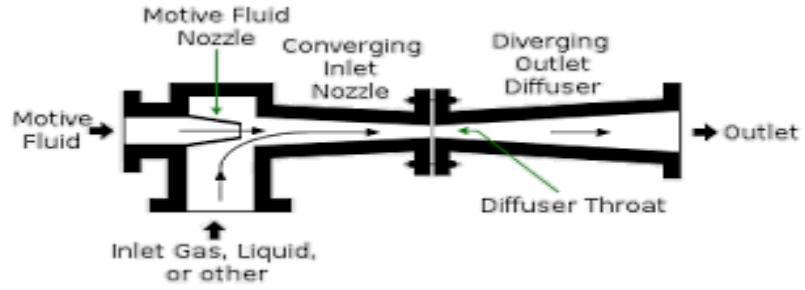
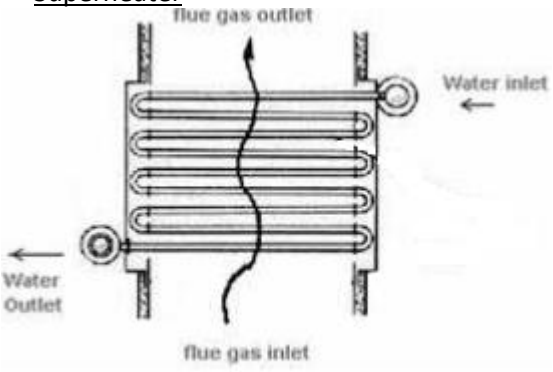
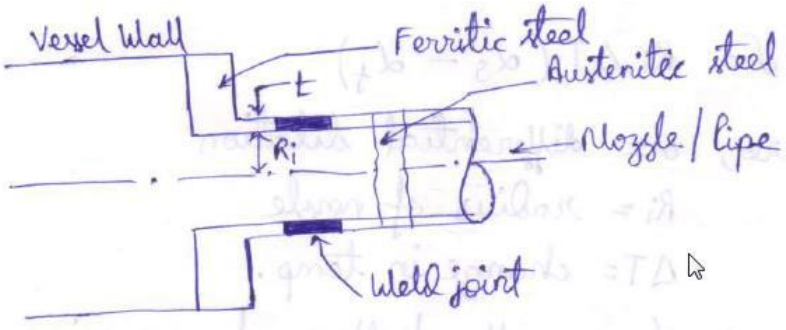
	A spherical pressure vessel is really just a special case of a cylindrical vessel.No matter how the sphere is cut in half, the pressure load perpendicular to the cut must equal the shell stress load. This is the same situation with the axial direction in a cylindrical vessel. Equating the two loads gives; $p(\pi r^2) = \sigma h (2\pi rt)$ This can be simplified to: $\sigma h = \sigma a = pr / 2t$ (Notice, the hoop and axial stress are the same due to symmetry)	**04 Marks**	
b)	Visual inspection: Visual-weld-inspection represents the immediate critical observation of the external features visible on all welds. It is the first and most important assessment of quality to be performed as soon as the welding operations are accomplished. Other inspection procedures may be required to detect discontinuities not visible to the eye or present below the external surface. Whatever additional non destructive inspection methods are applied, they are performed only after visual inspection is successfully completed. The List of NDT methods: 1) Liquid Penetrant Testing 2) Magnetic Particle Testing 3) Ultrasonic Testing 4) Radiographic Testing	**04 Marks** **04 marks**	**08 Marks**
c)	Methods of attaching protective coatings: 1. Integral cladding Low carbon steels or low alloy steels (base plates) also called as backing plates and corrosion resistant steel (liners) are welded at the edges. This is then passed through steel mills for hot rolling operations. The high temperature and high pressure creates a solid bond between the plates. Thickness of the liners is about 2mm to 4mm or 8% to 20% thickness of base metals. 2. Sheet lining The corrosion resistant layer is attached to a vessel shell by welding. Thickness of sheet is 2mm to 4mm. Types are; i) Strip type lining of 3' to 5' *3" to 6" wide strips are welded on base material by spot welding. ii) Sheet type lining of several feet in length and width are welded on base materials by spot, plug or seam welding. The linings are attached to the vessel after the vessel is entirely completed. Sometimes sheets are attached to the base plates before rolling or forming. Carbon steel surfaces (base plates) are ground to provide suitable surface for application of the liner.	**04 Marks each (Any two)**	**08 Marks**

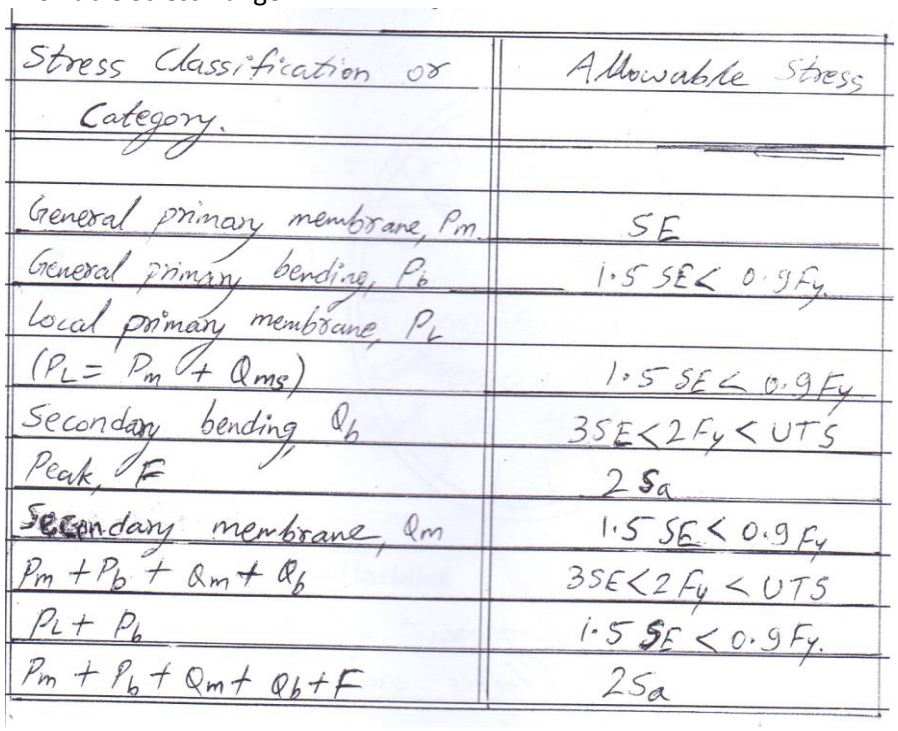
	3. Protective coatings Coatings should be applied only on clean surfaces free from grease, oil, dirt, scale, etc. i) Metallic coatings – Common methods are electroplating, mechanical cladding (most important), metal spraying, cementation, hot dipping, and condensation of metal vapors. ii) Inorganic coatings – Chemical dipped methods are used to create protective oxide films on iron, steel, stainless steel, copper, aluminum and some of their alloys. Such films are very thin and colored. e.g. Electrolytic coating iii) Organic coating – Different synthetic resins, pigments, oils and solvents are used in coating formulations. A continuous adherent inert film is formed between the metal and environment. They change the appearance of the metal e.g. paint enamel, lacquer.		
4.	**Attempt any TWO of the following:**		**16**
a)	Given ID=350mm,r=350/2=175mm P=13.5n/mm2 σcy=55Mpa σdish=65Mpa Solution Assume joint efficiency of pressure vessel as 100% 1.Shell t=Pr/(SE-0.6P) ={13.5 x175}/{(55 x1)-(0.6 x13.5)} =50.37 = 52mm Flat head t=CD √(P/S) C=0.5Constant assume t=0.5 x 350 √(13.5/65) =79.75 = 80mm	**04 Marks** **04 Marks**	**08 Marks**
b)	Stress concentrations produced by irregularities are damaging in case of fluctuating stresses. All failures as a result of fatigue are in the areas of high localised stresses. Hence all stresses including localised stresses should be taken into account when designing the pressure vessel.	**02 marks- def.**	**08 marks**

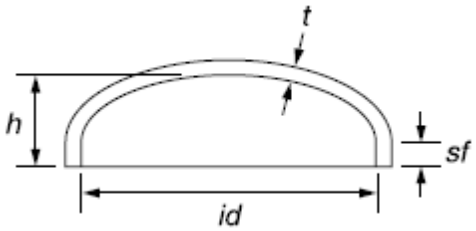
	Stress concentration for circular and elliptical holes: $K_t = \sigma_3 / \sigma_{av}$; where $\sigma_{av} = P/t(w-2b)$ $\sigma_1 = P/tw$ $\sigma_3 = \sigma_1(1+ 2b/a)$  Where, b/a = 1 refers to circular opening b/a = 1/2 refers to vertical ellipse with least stress concentration, Kt	**02 marks dia** **04 marks**	
c)i	 Stress contration is formed at the hole on the pressure vessel.These holes are used for nozzle placement. The stress contraction at the hole can be reduced by inceasing thr thickness of the vessel in the vicinity of the nozzle.This can be done either by providing additional thickness to the vesse wall itself near the nozzle or by use of separate reinforcing p;ate attachmened to the vessel wall covering an area surrounding the hole.Sometimes the nozzle wall at base can be made sufficiently thickn to act as reinforcement.	**02 marks dia** **02 marks**	**04 marks**
ii	Nozzle can be classified as follows	**02**	**04**

	(A)By the fuse 1.Single 2.Multiple 3.Non radial (B)By make 1.Integral nozzle 2.Fabricated nozzle 3.Formed nozzle	marks 02 marks	marks
5.	**Attempt any FOUR of the following:**		**16**
a)	 Pressure vessel consists of basic parts such as; Cylinders/shell:- it is the container which holds the fluid under pressure and temperature Rings: - these are used so that leakages at the joints in the pressure vessel are avoided. Baffle plates: - these used to increase the pressure in boiler or pressure vessel. The position of these plates varies the pressure in vessel. Curved shape dish ends/ heads/ closure ends:- these are ends which provides closure to the vessel. The shape of the ends varies according to the use. Nozzles: - these are the outlets/inlet hole which is used for the supply of the fluid. Flanges: - these are used to connect the pipes with the vessel so that minimum loses are achieved. Piping: - these are used so that the fluid can be transferred from the vessel	02 marks dia 02 marks expl	04 marks
b)	Pressure Vessel Accessories:	04	04

	• Economizer  • Air Pre-heater  • Feed Water Pump  • Steam Injector	marks dia (any one)	marks

	 • Superheater 		
c)	Thermal stress: Stresses which result from contraction or expansion of a material due to temperature change are called as thermal stress. $\sigma T = \pm (\alpha E \Delta T/ (1-\mu)$ where, σT = Thermal stress α = Co-efficient of thermal expansion E = Modulus of elasticity ΔT = Change in temperature μ = Poisson's ratio (± sign indicates that the material is in expansion/contraction)	**02 Marks** **02 Marks**	**04 marks**
d)	Stresses induced in bi-metallic joints:  Special conditions often require that a pressure vessel be constructed of several materials of different metallurgical and physical properties, whose	**02 Marks** **02**	**04 marks**

	incompatibility induces stresses when the vessel is subjected to its operating environment. This occurs in the piping (nozzle) of boilers and turbines where austenitic steels such as 18-8 (18%Cr and 8%Ni) are required in the high temperature zones whereas in the cooler zones the more economical ferritic steels are used. Local discontinuity stresses are produced in the region where these dissimilar materials are welded together, due to the fact that the coefficient of thermal expansion of the austenitic steels is 50% greater than that of the ferritic steels.	**Marks**	
e)i	1.The type of gasket depend upon ➢ Type of fluid being seated ➢ Service temperature 2.Therfore depending upon properties ans shpe gasket are following types ➢ Flate ring gasket ➢ Serrated gasket ➢ Laminted gasket ➢ Corragated gasket 3.material used for gasket are plastic,cork,asbesticos,fibre,etc	**02 marks**	**04 marks**
e)ii	Allowable Stress Range: 	**02 marks**	
f)i	Fatigue concentration: Stress concentrations produced by irregularities are damaging in case of fluctuating stresses. All failures as a result of fatigue are in the areas of high	**02 marks**	**04 marks**

	localized stresses. Hence all stresses including localized stresses should be taken into account when designing the pressure vessel.		
f)ii	Notch sensitivity factor,q is defined as q=(Kf-1) /(Kt-1) The value of q lies between 0 and 1 If q= 0 and kf=1 this indicates no notch sensivity If q=1,Kf=Kt this indicates full notch sensitivity	**02 marks**	
6.	**Attempt any FOUR of the following:**		**16**
a)	Membrane stress analysis of Semi ellipsoidal head  These heads are developed by rotation of a semi-ellipse. Heads with a 2:1 ratio of major axis to minor axis are most frequently used end closures in vessel design, particularly for internal pressure above 150 psi and for bottom head of tall, slender column. Thickness of head: t=[pr / SE- 0.1p] x K where, K= constant = 1 for 2:1 ratio i.e. 1 for a/b = 2 i.e. 1 for a=2b	**01 mark dia** **01 mark** **02 mark**	**04 marks**

b)

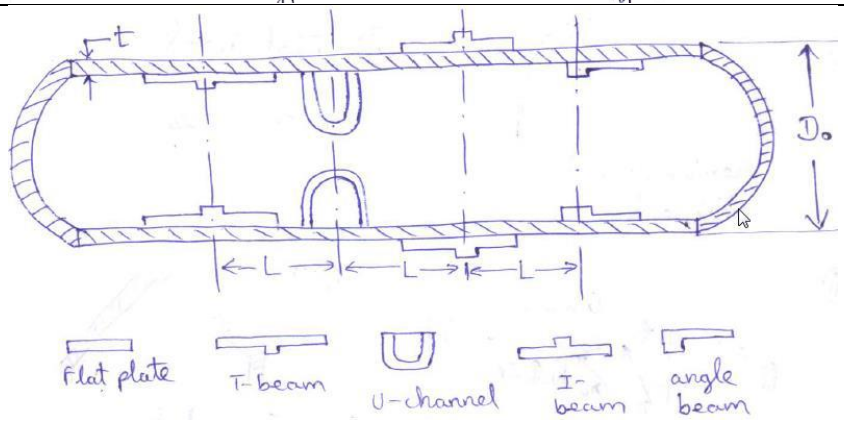
Sr. No.	Parameters	Cylindrical pressure vessel	Spherical pressure vessel
1	Stress	$\sigma L = \frac{Pr}{2t}$ (Put unit values for P, r, t) $\sigma L =$	$\sigma L = \frac{Pr}{2t}$ (Put unit values for P, r, t) $\sigma L =$
		$\sigma h = \frac{Pr}{t}$ (Put unit values for P, r, t) $\sigma h =$	$\sigma h = \frac{Pr}{2t}$ (Put unit values for P, r, t) $\sigma h =$
2	Thickness	$t = Pr/(S\varepsilon - 0.6P)$ (Put unit values for P, r, S, ε) $t =$	$t = Pr/(2S\varepsilon - 0.2P)$ (Put unit values for P, r, S, ε) $t =$
3	Dilation	$\delta = \frac{Pr^2(2-\mu)}{2tE}$ (Put unit values for P, r, μ, t, E) $\delta =$	$\delta = \frac{Pr^2(1-\mu)}{2tE}$ (Put unit values for P, r, μ, t, E) $\delta =$
4	Storage capacity	$V = \prod r^2 h$ (Put unit values for r, h) $V =$	$V = \frac{4}{3}\prod r^3$ (Put unit value for r) $V =$
5	Surface area	$A = 2\prod rh + 2\prod r^2$ (Put unit values for r, h) $A =$	$A = 4\prod r^2$ (Put unit value for r) $A =$

6 4/5 $\frac{V_{cyl}}{A_{cyl}} =$ $\frac{V_{sph}}{A_{sph}} =$

04 marks (any four point)

04 marks

c)



Stiffners:
Considerable saving in weight and material can be made by use of stiffening rings (reinforcing rings). Stiffening rings are attached on the inside or outside surface of the shell.

02 Marks dia

02 marks

04 marks

	These rings extend over the whole circumference and serve the purpose of end supports. T- beams, flat plate rings, I-beam, U-channel, angles, etc. bolted/ riveted/welded to the shell can be used as stiffening rings.		
d)	Design of anchor bolts: 1. Number of bolts; n = D /600 where, n = number of bolts D = Outer diameter of skirt = Outer diameter of shell + 2 * thickness of skirt The number of bolts will be even number and minimum 04 nos. 2. Size of bolts; $W = \prod/4 * dc^2 * fc * n$ where, W = Weight of vessel with its content dc = core diameter of bolt fc = crushing stress of bolt material n = number of bolts Now, Size of bolt, d = dc / 0.84 The size of bolts will be even number and minimum of M24	**02 marks** **02 marks**	**04 marks**

6.e)	Pressure Vessels are classified as:- Function:- Storage tank, Process Vessel, Reactor, Heat Exchanger etc. Geometry:- Cylindrical, Spherical, Conical, Horizontal, Vertical, Non-circular etc. Construction:- Monowall, Intersecting, Multishell, Cast, Forged etc. Dimensions:- Thin Shell = Wall thickness is less than 1/10 dia. of shell. Thick Shell - Wall thickness is greater than 1/10 dia. of shell. End Construction:- Open End Vessel, Closed End Vessel. Service:- Cryogenic, Steam, Vacuum, Fired/Unfired, Stationary/Mobile, etc. Examples of Pressure Vessel are:- Beverage bottles, any sophisticated vessels like steam generators, nuclear power plant, oil refineries, boiler drum, etc.	**04 marks**	**04 marks**
f)	Factors to be considered in determining ligament efficiency are: -Pitch of the holes(P). -Diameter of the hole. -Stresses in ligament. -Area of the Ligament.	**04 marks**	**04 marks**

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