Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

COURSE NAME	:	PRESSURE VESSEL DESIGN
COURSE CODE	:	BNL 40103
PROGRAMMECODE	:	BNL
EXAMINATION DATE	:	DECEMBER 2016 / JANUARY2017
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWERS **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Pressure vessel need to design properly because it involved with extremely high or low pressure and temperature, different from ambient condition. List **FOUR (4)** effect of vessel design failure.

(4 marks)

(b) Explain why welded joint efficiency in pressure vessel is less than unity.

(2 marks)

(c) There are two common geometries of pressure vessel, cylindrical and spherical. The cylindrical pressure vessel shape may be more convenient to fabricate and transport but less efficient compare to spherical shape. Point out **TWO (2)** reasons why cylindrical pressure vessel is less efficient.

(2 marks)

(d) Sketch a horizontal pressure vessel showing its major components. Label each component and the associated joints.

(6 marks)

(e) Pressure vessels are made in all shapes and sizes with restrict internal pressure. List **FIVE (5)** basic steps in the design procedure of pressure vessel.

(5 marks)

(f) The ends of the vessels are closed by heads of various types. List and sketch **THREE (3)** types of pressure vessels heads.

(6 marks)

Q2 (a) List **THREE (3)** industrial application of thin wall pressure vessels (TWPV).

(3 marks)

(b) A 7/8 in diameter bolts, having a diameter at the root of the threads of 0.731 in., is used to fasten two timbers together. The nut is tightened to cause a tensile stress of 124 kPa in the bolt. Compute the shearing stress in the head of the bolt and in the threads. Refer **Figure Q2(a).**

(10 marks)

(c) Determine the outside diameter of the washers if their inner diameter is 9/8 in. and the bearing stress is limited to 5500 kPa. Refer **Figure Q2(a)**.

(5 marks)

(d) The strength of longitudinal joint of the cylindrical tank in **Figure Q2(b)** is 150 kN/m, whereas for the girth is 85 kN/m. Calculate the maximum diameter of the cylinder tank if the internal pressure is 350 kPa.

(7 marks)

Q3 (a) Investigate **THREE (3)** purposes of openings in pressure vessels.

(3 marks)

(b) Point out **TWO (2)** major considerations during designing of openings and nozzles.

(4 marks)

(c) Point out **ONE (1)** disadvantage of reinforcement method

(2 marks)

(d) Determine the reinforcement requirements for a 300 mm diameter opening in a cylindrical pressure vessel 1 m in diameter subjected to an internal pressure of 5 MPa. The shell and the nozzle allowable stress is 120 MPa. The shell and nozzle thickness are 25 mm and 32 mm, respectively. Refer **Figure Q3(d).**
Determine

(i) The minimum required thickness, t_s

(2 marks)

(ii) The minimum required nozzle thickness, t_n.

(2 marks)

(iii) The limit parallel to the surface of the shell.

(3 marks)

(iv) The limit normal to the surface of the shell.

(3 marks)

(v) The reinforcement area required, A_r.

(1 marks)

(vi) The reinforcement area available in the shell, A_1.

(2 marks)

(vii) Total area available for reinforcement, A_t.

(3 marks)

Q4 (a) Investigate **TWO (2)** major problems on designing of support skirts.

(4 marks)

(b) In order to design large vessel containing liquid, the 'sloshing' effect must be considered. Explain the so-called 'sloshing' effect.

(1 marks)

(c) Sketch **TWO (2)** types of vessel support commonly used in process industries.

(6 marks)

(d) A skirt support for a pressure vessel with a total vertical load of 720 kN, and an overturning moment of 2050 kN.m. The bolt circle diameter of the support may be assumed to be 4.5 m. Assume a thickness of 10 mm for the support skirt and the mean diameter of the support as 4.25 m. Given N = 12 bolts. Determine

(i) The stress in the skirt, σ

(3 marks)

(ii) The load on a single bolt, P

(3 marks)

(e) For good sealing performance, the ASME code recommends the residual stress at operating conditions be at least two to three times the contained pressure. The relationship between the initial seating stress and the residual seating stress is indicated by the gasket stress versus deflection plot.

(i) Sketch the relationship plot.

(2 marks)

(ii) Explain the plot based on the sketch.

(6 marks)

Q5 An ellipsoidal head having an inside radius 380 mm is subjected to an internal pressure of 29 MPa. The allowable stress of SA 515-70 plate is 160 MPa for both heads and shell. Efficiency factor of joints of shell and head to shell is 0.85, while joint efficiency of seamless heads is 1.00. Assume corrosion allowance, CA is 4 mm.

(a) Calculate the inner height of the ellipsoidal head.

(2 marks)

(b) Calculate the thickness of the cylindrical shell and the maximum allowable working pressure in a new condition, if any.

(10 marks)

(c) Calculate the thickness of the seamless ellipsoidal head and the maximum allowable working pressure in a new condition, if any.

(10 marks)

(d) Illustrate and label the vessel with the dimensions calculated in previous questions.

(3 marks)

-END OF QUESTIONS -

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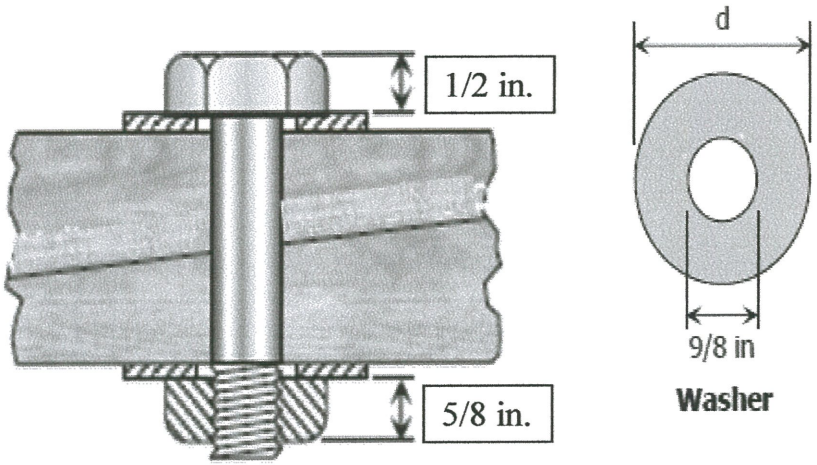

Figure Q2(a)

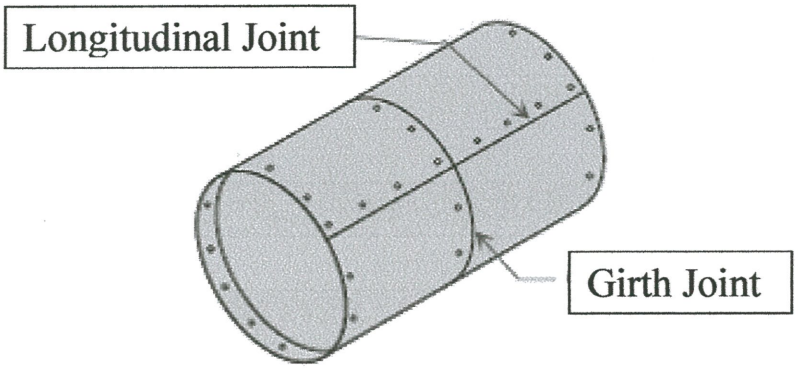

Figure Q2(b)

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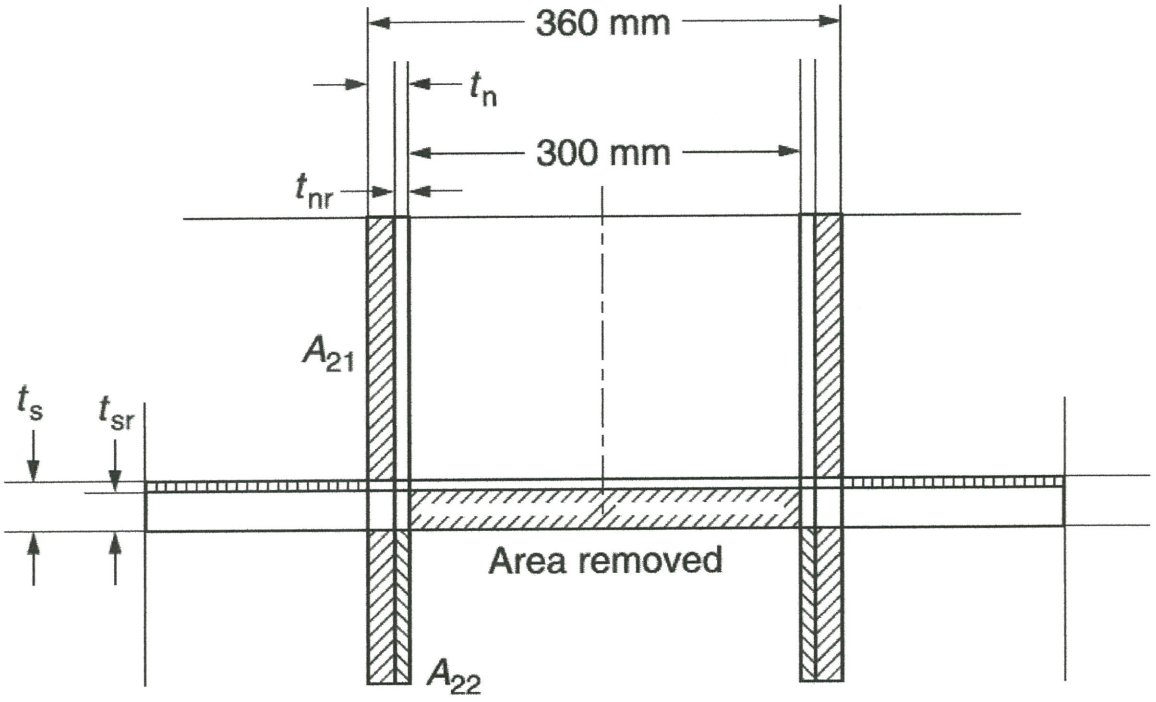

Figure Q3 (d)

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Formula

Shell thickness, t_s

$$t_s = \frac{PR_S}{S - 0.6P}$$

Nozzle thickness, t_n

$$t_n = \frac{PR_n}{S - 0.6P}$$

Reinforcement area, A_r

$$A_r = dt_{rs}$$

Shell Area

$$A_1 = (2d - d)(t_s - t_{sr})$$

Skirt Stress, σ

$$\sigma = \frac{-W}{A} \pm \frac{M}{Z} \quad \text{or} \quad \sigma = \frac{-W}{\pi Dt} \pm \frac{4M}{\pi D^2 t}$$

Bolt load, P

$$P = \frac{-W}{N} \pm \frac{4M}{ND}$$

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Supplementary design formulas for heads and shell

Item	Thickness (t)	Pressure (P)	Stress (S)	Notes
Cylindrical shell	$\frac{PR}{SE-0.6P}$	$\frac{SEt}{R+0.6t}$	$\frac{P(R+0.6t)}{t}$	$t \le 0.25$ D; $P \le 0.385$ SE
Hemispherical shell (or head)	$\frac{PR}{2SE-0.2P}$	$\frac{2SEt}{R+0.2t}$	$\frac{P(R+0.6t)}{2t}$	$t \le 0.178$ D; $P \le 0.685$ SE
Flat Flanged head	$D\sqrt{0.3P/S}$	$PS/0.3D^2$	$0.3D^2P/t^2$	
Torispherical Head (a)	$\frac{0.885PL}{SE-0.1P}$	$\frac{SEt}{0.885L+0.1t}$	$\frac{P(0.885L+0.1t)}{t}$	r/L = 0.06; $L \le D+2t$
Torispherical head (b)	$\frac{PLM}{2SE-0.2P}$	$\frac{2SEt}{LM+0.2t}$	$\frac{P(LM+0.2t)}{2t}$	$M = 3 + (L/r)^{1/2}/4$
2:1 Semi-elliptical head (a)	$\frac{PD}{2SE-0.2P}$	$\frac{2SEt}{D+0.2t}$	$\frac{P(D+0.2t)}{2t}$	$\frac{h}{D} = 4$
Ellipsoidal head (b)	$\frac{PDK}{2SE-0.2P}$	$\frac{2SEt}{DK+0.2t}$	$\frac{P(DK+0.2t)}{2Et}$	$K = [2 + (\frac{D}{2h})^2]/6$; $2 \le \frac{D}{h} \le 6$
Toriconical head	$\frac{PD}{2(SE-0.6P)\cos\alpha}$	$\frac{2SEt\cos\alpha}{D+1.2t\cos\alpha}$	$\frac{P(D+1.2t\cos\alpha)}{2t\cos\alpha}$	$\alpha \le 30^\circ$