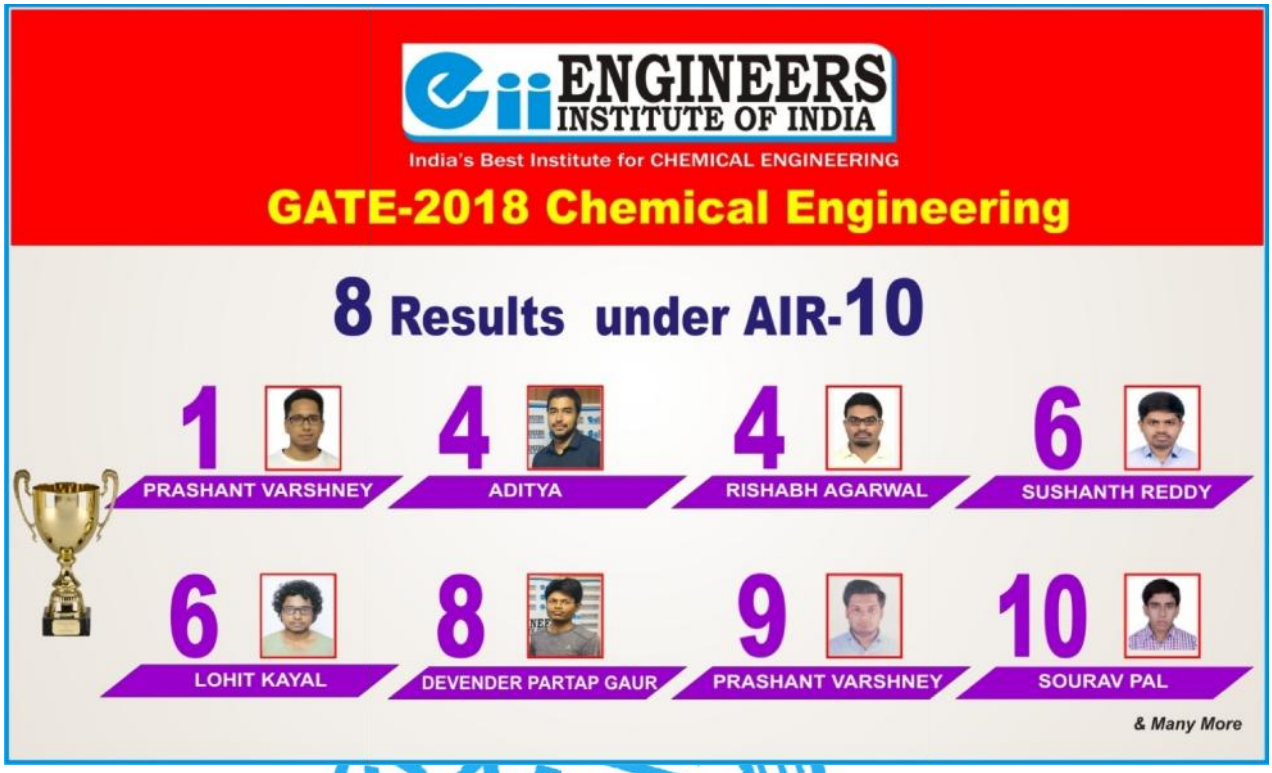

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CONTENT

CHAPTER-1

PRESSURE VESSELS DESIGN

1. Pressure vessels are leak proof containers. They may be of any shape and range from beverage bottles to sophisticated ones encountered in engineering construction.
2. In the latter, high pressures, extremes of temperature and severity of functional performance requirements pose exacting design problems.
3. Pressure vessel design includes
   (a) The reasoning that established the most likely mode of damage or failure.
   (b) The method of stress analysis employed and significance of results.
   (c) The selection of material type and its environmental behavior.

4. These pressure vessels carry, store or receive liquid, gases or steam at pressure above the atmospheric pressure.

Design Pressure:

1. Pressure vessels are designed to with stand maximum working pressure.
2. When pressure vessels are under internal pressure then design pressure can be obtained adding 5 to 10% to the maximum working pressure.
3. If hydrostatic pressure in the column base is significant then it will be added to the operating pressure.
4. If pressure vessel is subjected to external pressure outside and inside vacuum, then maximum difference in pressure between inside and outside of the vessels has to be taken in to account.
5. Specify pressure at top of vessel, where relief valve is located.

Design temperature:

1. Temperature used in the design should not be less than mean metal temperature expected under operating conditions because metal strength decreases as temperature increases.
2. The design temperature shall be at least 25^0C or more than the maximum temperature expected where vessels are in direct internal heating or severe exothermic reaction takes place.

Maximum Allowable Stress:

1. Maximum allowable stress is required for design purpose.
2. Maximum allowable stress is calculated by applying a suitable safety factor to the maximum stress.
3. The maximum stress of material could be expected to withstand without failure under standard test conditions.
4. From standards and code used for designing pressure vessels we can obtain values of maximum allowable stress for different material.

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Materials:

1. Suitable material of construction for process vessel have to be selected from the lift of acceptable material available in codes and standard.
2. Selection of material depends on
   a. Suitability of material for fabrication.
   b. Suitability of material with process environment.
3. Process Environment includes:
   - Material must have sufficient strength at design condition.
   - Material must be able to with stand variation (or cycling) in process condition.
   - Material must have corrosion resistance to survive in service between inspection interval.

Weld joint efficiency factor (J):

1. Weld joint efficiency factor (J) is the ratio of strength of an arbitrary strength of welded joint to the strength of plate welded.
2. Weld joint efficiency factor depends on joint type and radiography amount required for the design code.
3. Joint efficiency is 100% for seamless heads.
4. Joint efficiency :
   Spot radiography: 85% No radiography: 70%

Corrosion allowance:

1. Additional thickness of metal provided to allow for material loss by corrosion and erosion during the expected life of the vessel is called corrosion allowance.
2. Unless a protective lining is employed a minimum corrosion allowance of 1.5 mm should be provided.
3. Pressure vessels may be partially or fully lined with corrosion resistant material.
4. Corrosion allowance should not be provided against internal wastage of the base material.
5. These lines are provided to exclude contact between base material and corrosive agent.
6. These lining may be intermittently attached loose to the vessel base material. These lining may be internally banded to the vessel base material.

MATERIALS OF CONSTRUCTION

Iron and Steel:

(1) Low carbon steel is most commonly used engineering material.
(2) Low carbon steel is also known as mild steel.
(3) Low carbon steel has good tensile strength and ductility.
(4) Low carbon steel can be easily welded.
(5) Iron and carbon steels are not resistant to corrosion, except in certain specific environments, such as concentrated sulphuric acid, and caustic alkalies.
(6) Iron and carbon steels are suitable for use with most organic solved except chlorinated solvent.
(7) Mild steel is susceptible to stress corrosion cracking in certain environments.
(8) High silicon iron (14 to 15% Si) are particularly suitable for handling sulphuric acid at all concentration and temperature.

Stainless Steel:

1. Stainless steel is the most frequent used corrosion resistant material in process industry.
2. Nickel is added to improve the corrosion resistance in non oxidizing environment.
3. Chromium is added to impart corrosion resistance in oxidizing conditions.
4. Chromium content should be above 12 percent.
5. Stainless steel can be divided into three types based on their micro structure:
   a. Ferritic : 13-20% Cr, less than 0.1 % C, No Nickel
   b. Austenitic: 18- 20% Cr, greater than 7% Ni
   c. Martensitic: 12- 10% Cr, 0.2 to 0.4% C, up to 2% Ni.
6. The austenitic stainless steels have greater strength than the plain carbon steels, particularly at high temperature.
7. Important grades of austenitic steels are given below:
   (i) Type 304: It is most widely used stainless steel. Type 304 is also called 18/8 stainless steel. Type 304 have minimum Cr and Ni which provides a stable austenitic structure.
   (ii) Type 304L: Type 304L is the low carbon version of type 304. Type 304L is used for thicker welded section.
   (iii) Type 321: Type 321 is stabilized with Ti to prevent carbide precipitation during welding.
   (iv) Type 347: Type 347 is stabilized with niobium.
   (v) Type 316: Type 316 have molybdenum which improve the corrosion resistance in reducing conditions such as in dilute sulphuric acid.
   (vi) Type 316L: Type 316L is a low carbon version of type 316.

Nickel and Its Alloys:

1. The important use of nickel alloy is for equipment handling caustic alkalies at temperature above $70^{O}C$.
2. Important Ni-Cu alloy is monel which contain metal in ratio of 2:1.
3. Monel alloy has good mechanical properties up to $500^{O}C$.
4. Monel alloy has good resistance to dilute mineral acid.
5. Monel alloy used for equipment handling alkalies, organic acid and salt and sea water.
6. Inconel have 76% Ni, 7% Fe and Cr 15%.
7. Inconel is used primarily for acid resistance at high temperature.
8. Inconel is resistant to furnace gases if S free.
9. Hastelloys composition are given below:
   a. Hastelloys B: Ni=65% Mo=28% Fe=6%
   b. Hastelloys B: Ni=54% Mo=17% Fe=5% Cr=15%
10. Hastelloys is useful for corrosion resistant to strong mineral acid particularly HCL.

Aluminum and Its Alloys:

1. Pure Al has a higher resistance to corrosion than its alloys.
2. Pure Al has less mechanical strength in compare to its alloy.
3. Aluminum –Copper alloy (Composition: - 4% Cu, 0.5% Mg) is main structural alloy of aluminum.
4. Aluminum-Copper alloy has tensile strength equivalent to that of mild steel.
5. Pure aluminum can be applied as cladding on aluminum plate alloy. These combine corrosion resistance of pure metal and alloy is useful for concentrated nitric acid 80%.
6. These are widely used in textile and food industries where use of mild steel would lead contamination.

Lead:

(1) Lead metal is a soft, ductile material and is mainly used in the form of sheets or pipe.
(2) Lead has a resistance to acid specially to sulphuric acid.

Copper and Its Alloy:

(1) Copper is used for small bore pipe and tubes.
(2) The important alloy of copper are the brasses and bronze.
(3) Brasses is alloy of Zinc and copper.
(4) Bronze is alloy of copper and tin.
(5) The important use of these alloy in process industry for valves and other small fittings, and for heat exchanger tube and tube sheet.
(6) The copper Ni alloy have a good resistance to corrosion –erosion.
(7) The copper – Ni alloy are used for heat exchanger tube specially where coolant is sea water.

Titanium:

(1) Titanium has a good resistance to chloride solution, including sea water and wet chlorine.
(2) Titanium is used for sea water equipments and replacing for cupro-nickel alloy.

Pressure vessel design codes:

(1) ASME BPV code is the legally required standard for pressure vessel design, fabrication, inspection and testing.
(2) The code is consensus best practice
(3) It is usually required by law.
(4) Code rules are often applied even for vessel that don't require construction to code.
(5) Storage tanks are usually not designed to BPV code.
   - API standard 620, Large low pressure storage tanks, pressure 0.5 to 15 psig.
   - API standard 650, welded storage tanks pressure upto 0.5 psig.
(6) Fittings are covered by other ASME codes
   - ASME B 16.5, pipe flanges and flanged fittings.
   - ASME B 16.9, factory-made wrought butt welding fittings.
   - ASME B 16.11 Forged fitting, so cket welding and threaded.
   - ASME B 16.47, large diameter steel flanges NPS 26 through NPS60.
(7) Piping is covered by a different ASME code ASME B 16.3, process piping.
(8) Heat exchangers have additional codes set by TEMA.

Practice Problems

1. Which of the following can be a reason for using horizontal vessel:
(a) Easier to distribute fluid (b) Smaller plot space
(b) To promote phase separation (d) None of these

2. Which of the following is/are welded joints:
(a) Butt weld (b) Single fillet lap weld
(c) Double fillet conrner joint (d) All of the above

3. Which of the following is not true for Nozzles?
(a) Nozzles are usually on side of vessel, away from weld lines.
(b) Nozzles may or may not be flanged.
(c) Nozzles are not used for not and weld utilities.
(d) Vessel needs nozzle for relief valves.

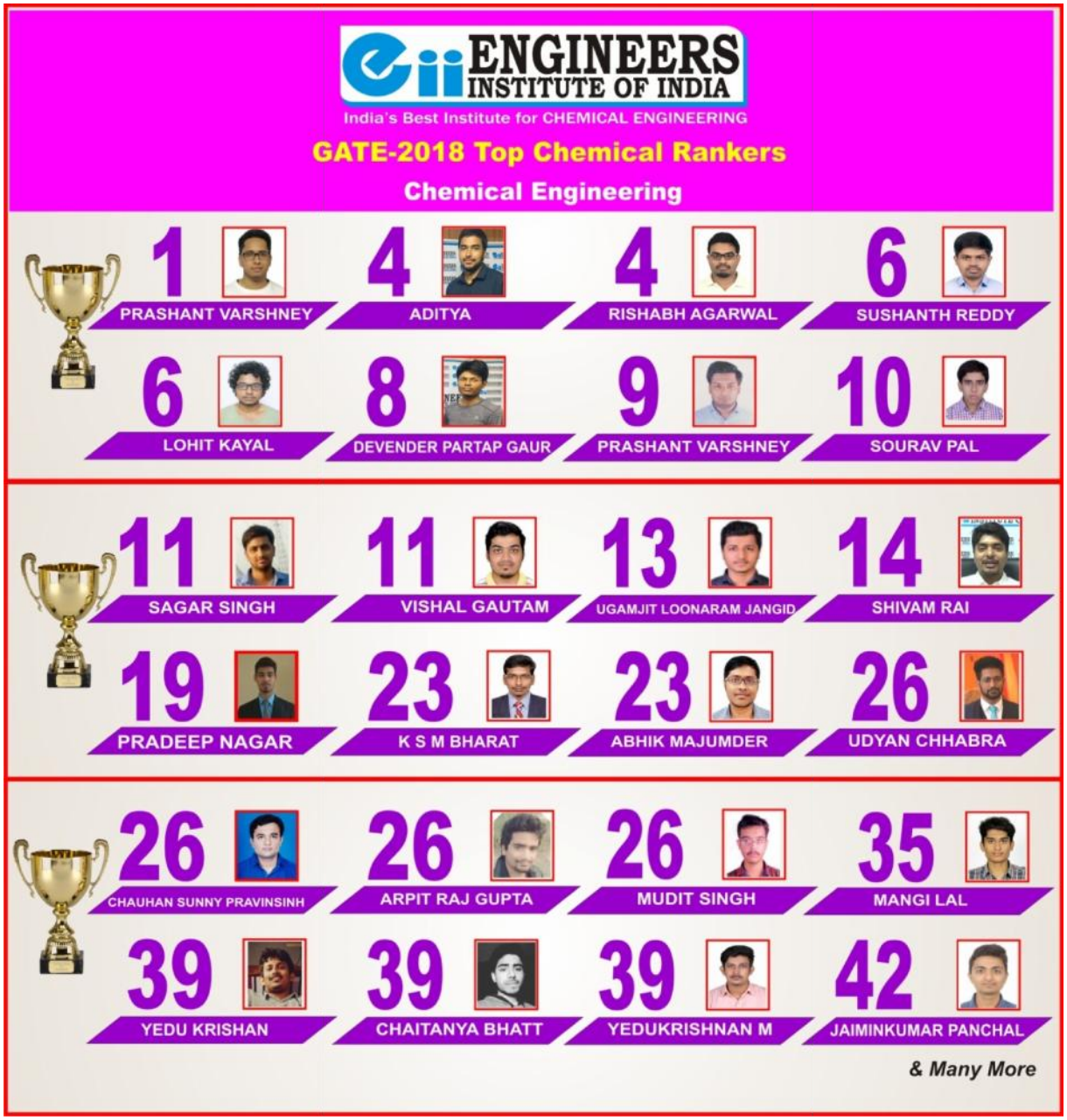
4. Which of the following alloy should be used in high temperature oxidizing environment?
(a) Inconnel (b) Monnel (c) Brass (d) Bronze

5. Type 304 or type 316 are grades of :
(a) Carbon steel (b) Austenitic steel (c) Copper (d) Nickel

6. API standard 650 is used for :
(a) Large low pressure storage tanks (b) Welded storage tanks
(c) Both (a) and (b) (d) None of these

7. Which of the following code is used for process piping
(a) ASME B 16.5 (b) ASME B 16.9 (c) ASME B 16.11 (d) ASME B 16.3

8. Code used for pipe flanges and flanged fitting
(a) ASME B 16.5 (b) ASME B 16.47 (c) ASME B 16.11 (d) ASME B 16.9



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