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Heating Arrangements to a Vessel

For reactors and process vessels many times the temperature inside the contents has to be kept at some required values. For these the heating or cooling is done by means of circulating a heat transfer fluid through inside coils and/or outer jackets.

Inside coil is of the types: helical coil, spiral coil, or vertical tubes.

Outer jackets are of the types: plain jacket, half-pipe jacket, or dimpled jacket

Thickness of jacket and vessel are designed using pressure vessel deign codes such as ASME Section VIII Division 1 and IS 2825.

Design of Pressure Vessels

Thickness of Shell

(a) Cylindrical vessel

Longitudinal stress:

$$t = \frac{pd}{4fJ}$$

Circumferential stress:

$$t = \frac{pd}{2fJ}$$

where t = thickness of shell
d = inside diameter of cylinder
p = design pressure
f = allowable stress
J = joint efficiency (max: 1)

Circumferential stress is the controlling stress; and cylindrical shell is designed based on the circumferential stress formula.

(b) Spherical vessel

$$t = \frac{pd}{4fJ}$$

If cost of fabrication were not a prime consideration, the most economical shape for a vessel would be a sphere. However, the fabrication cost of spherical vessels are so great that their use is limited to special considerations. Cylindrical vessels are more easily fabricated, in the majority of cases are considerably simpler to erect, are readily shipped, and are therefore more readily used in the process industries. From the viewpoint of material savings and uniform distribution of stresses in the material of walls from loads, a spherical shape is most favorable. A spherical geometry provides minimum surface area per unit volume, and its wall thickness is minimum for a given pressure.

Allowable stress decreases with increase in temperature.

Joint efficiency (J):

No radiography : 70%
Spot radiography : 85%
100% radiography : 100%
Joint efficiency is 100% for seamless heads.

A cylindrical vessel under internal pressure tends to retain its shape in that any out of roundness or dents resulting from shop fabrication or erection tend to be removed when the vessel is placed under internal pressure. Thus any deformation resulting from internal pressure tends to make an imperfect cylinder more cylindrical. However, the opposite is true for imperfect cylindrical vessels under external pressure, and any imperfection will tend to be aggravated with the result of possible collapse of the vessel. For this reason, a given vessel under external pressure in general has a pressure rating only 60% as high as it would have under internal pressure.