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REACTION VESSELS

INTRODUCTION

Pressure vessels are used as a reaction vessels for carry out operations such as blending, dispersion, gas absorption, dissolution, heat distillation etc. under controlled conditions. (distributing) The vessel may be open or closed. If open It may have no cover at all. The reaction vessel may require a cover or head that can be secured tightly to the shell so that the reaction can be carried out under controlled pressure and temperature. If the closed vessel is capable of withstanding moderate pressure. It is called as reac Kettle but If the vessel is required t withstand high pressure and temperat that must be maintained at constan values during the reaction proce vessel is called an "autoclave"

Depending on the proce operation the vessel may requir cooling and agitation of the cont ~~[illegible]~~ capacities of reaction vess vary between 100 litres to as large a litres with the shell diamet between 50cm and 250 cm

MATERIALS OF CONSTRUCTION

The number of metals can be used for construction of reaction vessels. The most common metals are low carbon steel stainless steel and other alloy steel. In special cases non-ferrous metals such as copper, nickel, aluminium, titanium are also used. At moderate pressure and temperatures, vessels can be made of glass reinforced polyesters, glass filled furans phenolics and polyvinyl chloride. A saving in cost can be achieved by fabricating vessels from a low cost metals with a corrosion resistant metals like stainless steel. nickel, Inconel, monel, copper etc. vessel can also be lined with lead, rubber, glass and plastics to prevent corrosion.

CLASSIFICATION OF REACTION VESSELS

Reaction vessels may be divided into three main classes. batch reactors, continuous flow reactors and semi batch reactors.

(a) Batch reactors

[illegible] are essentially [illegible] in which [illegible] reactants are [illegible] before [illegible] and products are removed after completion of the reaction. In this system temperature and pressure as well as composition may vary with time.

(b) Continuous flow reactors

In these reactors the reactants flow continuously into the vessel and the products flow out continuously. Under steady conditions, in a well agitated system, a uniform concentration is maintained throughout the vessel.

(c) Semi-batch reactors

In these reactors one of the reactant is initially charged batchwise, while the other reactant is fed into the reactor continuously.

HEATING SYSTEMS

Chemical reactions are accompanied by absorption or liberation of heat. The reaction vessel must, therefore be provided with the means of supplying or removing the heat of reaction. The rate of heat transfer is a function of the physical properties of the agitated liquid and

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HEATING SYSTEMS

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Heating systems for reaction vessels need special consideration. The devices used are either the direct or the indirect type. There are various electrical methods, which heat the vessel directly. The two most common methods are resistance heating/and induction heating. These systems have a low overall efficiency and high operating costs. Indirect heat transfer systems are the most widely used. The heat is received from fluids such as a steam, hot oil, hot water or air, molten salt mixture, mercury and special organic compounds are high boiling point materials, so that the heat transfer systems can operated at low pressure. Both liquid and vapour phase heat transfer systems ~~can be operated at low pressures~~, are used. In liquid systems, the heat transferrid is from sensible heat.

In indirect cooling systems, fluids employed are air, an evaportant [illegible] heat transfer [illegible] [illegible] can be increased by increasing [illegible] fluid velocity, similarly heat transfer coefficient can be increased by increasing agitation of the contents of the vessel. The jacket can be constructed out of cheaper material like mild steel even when the vessel has to be made of an expensive alloy.

JACKETS

A plain jacket consists of [illegible]. The space between the vessel wall and the jacket shell should be narrow for [illegible] heat transfer rate.

(i)

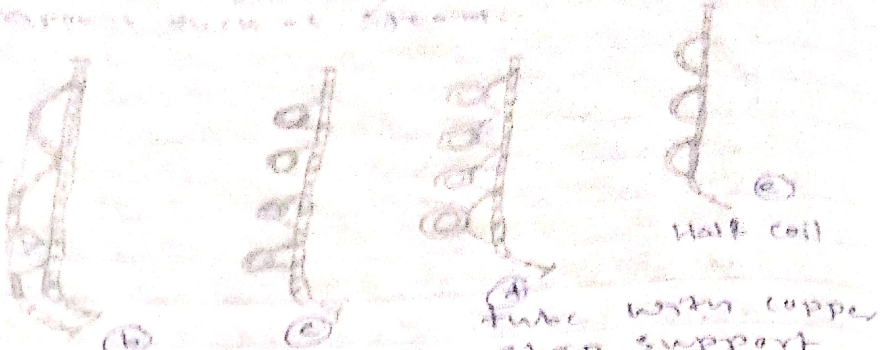
ain Jacket

The dimpled construction shown helps to reduce the thickness of the shell. This construction is particularly suitable for large vessel.

(ii)

Dimpled construction

[illegible] reduction in weight, [illegible] Jackets are generally used for condensing vapours such as steam.



High velocities of circulating fluids can be obtained by use of different types of Jacket constructions such as channel or Coiled Jacket.

COILS

Coils are used for heating or cooling by immersing them in contents of the vessel. Such coils are formed from a tubing by shaping them in the form of a helical or double helical coil. A pancake type of coil, which is a spiral rolled in a single plane so as to lie horizontally near the bottom of the vessel is also used to transfer heat by free convection. Tubes can

Also designed [illegible] vessel which serves the dual purpose of heat transfer and holding

DESIGN CONSIDERATIONS

Design of the reaction vessel is based on pressure and temperature conditions. It is essentially a pressure vessel with heads and nozzles. A jacket constructio is an additional feature, involving operatio of external pressure on the vessel wall. The reaction vessel is jacketed designed for bo internal and external pressure operating independently and the higher value of the wall thickness is accepted as satisfactory. The vessel shell is subject to external pressure and care must be taken in the design to prevent collaps

The methods ~~are~~ adopted are

(a) Making the shell thick~~ness~~ enoug in proportion to its diameter and le so that it is self supporting.

(b) Using stay bolts for attaching Inne shell to the outer jacket.

(c) Using stiffing ring or corrugations the shell of the vessel.

are different [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] and [illegible]

DESIGN CONSIDERATIONS

Design of the jacketed vessel [illegible] under an pressure and simultaneously [illegible] It is essentially a pressure vessel [illegible] [illegible] [illegible] It needs consideration than ordinary because considering action of external pressure on the inner shell. The inner vessel is jacketed designed for internal and external pressure separately independently and the highest value of the wall thickness is accepted as satisfactory. The vessel shell is subjected to external pressure and care must be taken in the design to prevent colla

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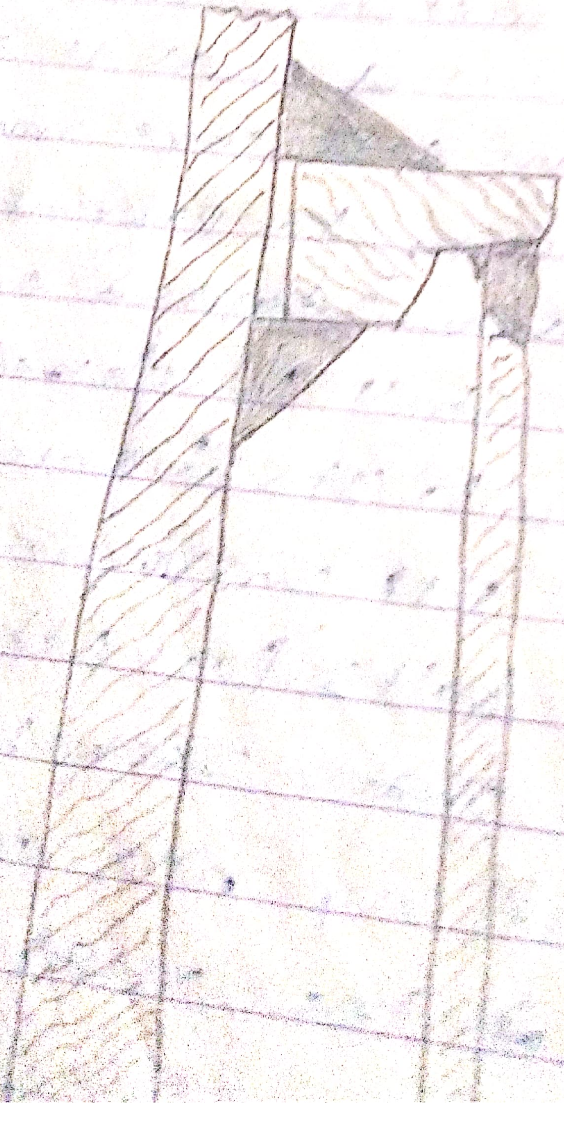
JACKET DESIGN

A plain jacket is the simplest arrangement for heating or cooling. The jacket is generally made of [illegible] carbon steel & is designed for maximum operating pressure of the heating fluid as well as operating temperature. Various methods are adopted to attach the jacket to the shell. A common method is to use a ring of square or rectangular section, one at the top and the other at the bottom, to which jacket and the vessel shell are securely welded.



Plain Jacket welded to shell by ring

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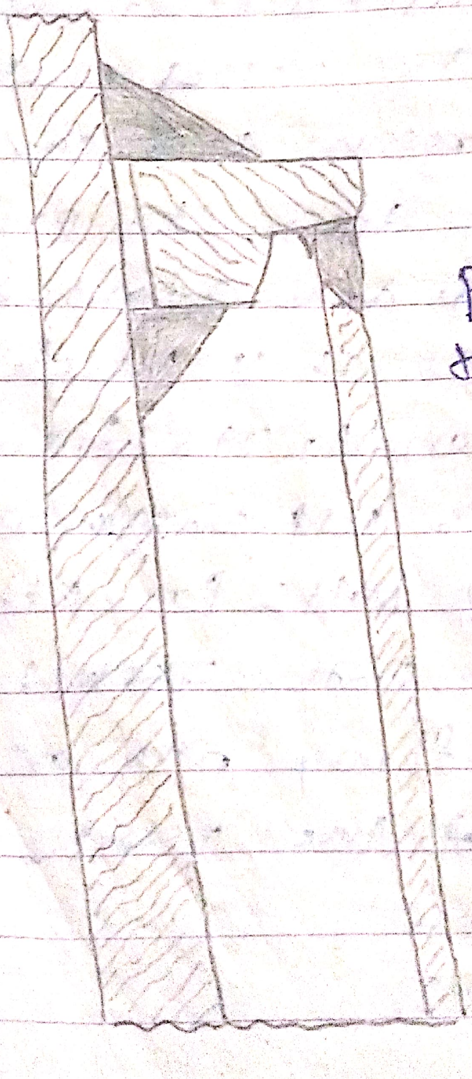

Plain Jacket wel
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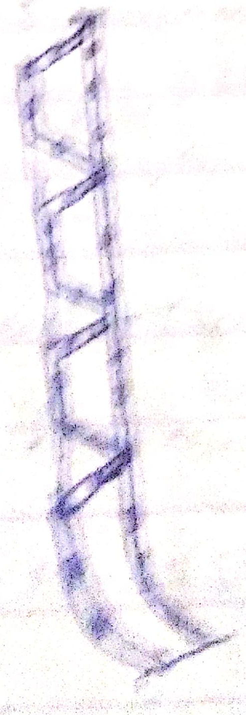
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] channel [illegible] through [illegible] [illegible] [illegible] [illegible] for higher [illegible] [illegible] [illegible] [illegible] preferable to the channel types of jacket designs. [illegible] [illegible] will have to be taken [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

COIL AND CHANNEL DESIGN

The half coil or channel construction shown in fig as



Channel

Half Coil

It is formed by a continuous spiral of half pipe or channel section welded to the vessel shell [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] consequently. Heat transfer coefficients are also higher than for jacket construction. The half coil or the channel coil is also known as limpet coil

DESIGN OF VESSEL SHELL WITH HALF COIL

A half coil is a part of a torus for which the circumferential stress occurs at the junction with the shell, and is given by

$$f_{pc} = \frac{p d_i}{2 t_c} \quad (1)$$

and the longitudinal (axial) stress is given by

$$f_{ac} = \frac{p d_i}{4 t_c + 2.5 t_s}$$

when

p → design pressure inside the half coil

d_i → Internal diameter of the half coil

t_c → thickness of half coil

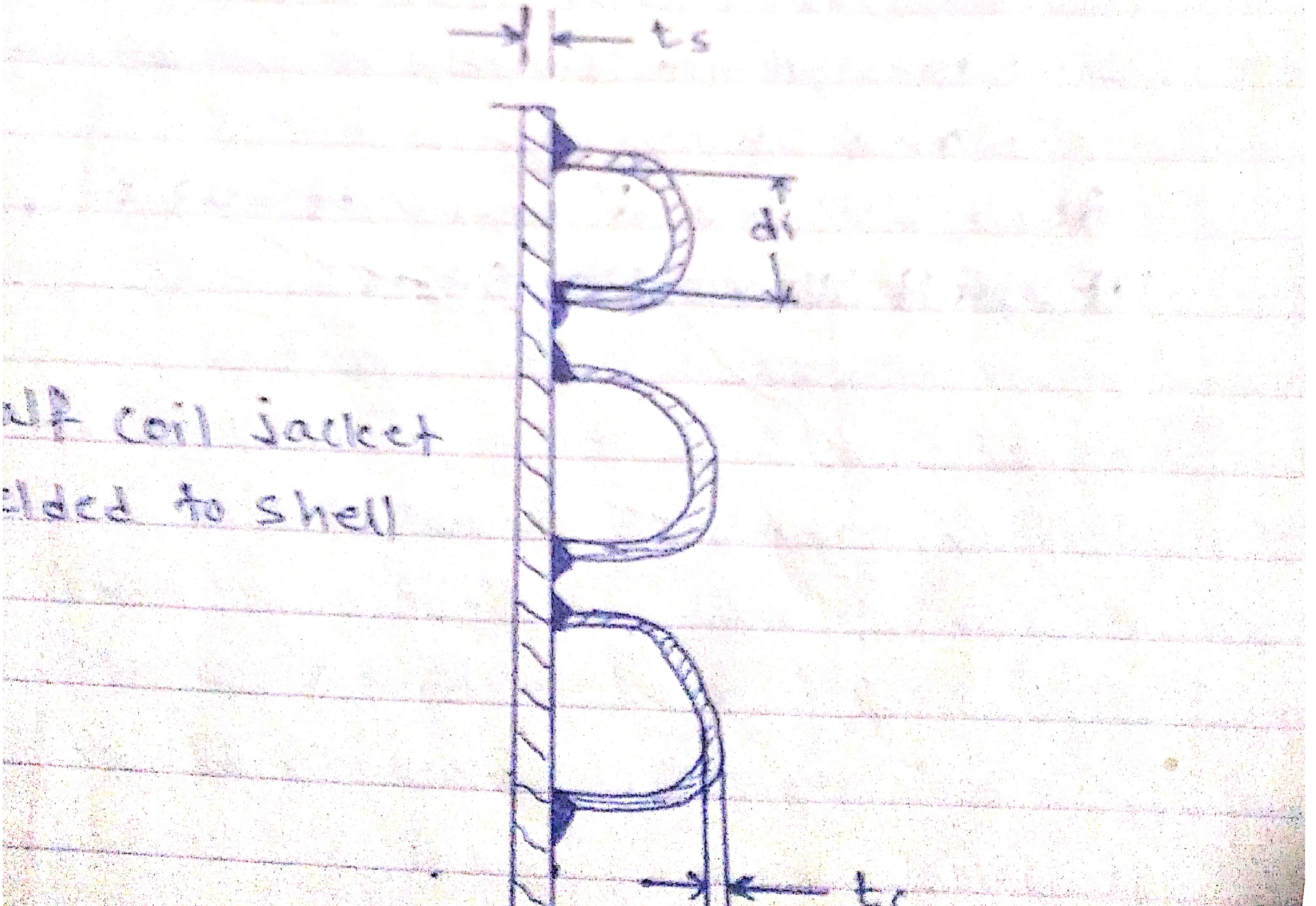
t_s → thickness of shell

The thickness of the half coil is calculated from equation (5) which also [illegible] of [illegible] corrosion allowance.

The total circumferential stress f_{pt} in the shell is the sum of the circumferential stress f_p due to pressure in the vessel and the longitudinal stress f_{ac} in the coil caused by coil pressure.

$$f_{pt} = f_p + f_{ac}$$

$$= \frac{pDi}{2ts} + \frac{p\,di}{4tc + 2.5ts}$$



The total longitudinal (axial) stress, f_{as} in the vessel shell is made up of

(1) Longitudinal stress due to pressure in the vessel

(2) Longitudinal stress f_{ac} due to coil pressure

(3) The bending stress caused by the distortion of the shell at the junction with the coil

$$f_{as} = f_a + f_{ac} + f_b$$

$$= \frac{P D_i}{4 t_s} + \frac{p d_i}{2 t_c} + \frac{2 \Delta p d_o^2}{3 t_s^2}$$

Where
P — Internal pressure in the shell

D_i → Internal diameter of shell

Δp → maximum differential pressure between coil and shell.

d_o → External diameter of half coil.

~~DESIGN OF VESSEL SHELL~~