GENERATION-OAHU DIVISION
OPERATOR TRAINEE TRAINING PROGRAM

Section 08
HEAT EXCHANGERS

OBJECTIVES:

1. Describe the function of a heat exchanger.
2. Discuss the two basic types of feedwater heaters and their cycles.
3. Identify and describe the two sides of condensers and their functions.
4. Discuss the theory and operation of plate heat exchangers.

GENERATION-OAHU DIVISION
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Section 08
HEAT EXCHANGERS

Heat exchangers play an important role in the efficient conversion of energy. The term heat exchanger can be applied to any piece of equipment designed to transfer heat. For our purposes, the term will only be applied to power plant auxiliary equipment in which heat is transferred from one fluid to another. The specific heat exchangers which will be discussed are feedwater heaters, condensers and plate heat exchangers. Miscellaneous heat exchangers such as lube oil coolers and fuel oil heaters will also be briefly discussed.

FEEDWATER HEATERS

Many heat exchangers are used in the various plants to raise the temperature of the feedwater. The term feedwater heater only applies to those heat exchangers that raise the temperature by the use of steam extracted from the turbine or reheat piping. To fully understand the gain in thermal efficiency resulting from feedwater heating, it is necessary to study the complete power plant cycle. This study is made in another section of this manual. For the present we can observe the mechanism of the gain by considering two separate conditions. Consider one pound of steam that has passed part way through the turbine. During this passage, it has transferred energy to the turbine blades and its pressure and temperature have been reduced. At this point there are two choices: the pound of steam can be allowed to proceed on through the turbine or it can be extracted from the turbine and used to heat the feedwater. If allowed to expand through the remainder of the turbine, the steam will transfer a portion of its remaining energy to the turbine but most of its energy will be rejected to the circulating water in the condenser. In the other case when the steam is extracted for feedwater heating, most of the steam's energy is transferred to the feedwater and thus returned to the system.

For each plant cycle there is an optimum or most efficient temperature to which the feedwater should be raised prior to entering the boiler. Once this temperature is determined, it is necessary to determine how many feedwater heaters should be used to produce the desired temperature rise. Actually, an improvement almost always results from using more heaters; therefore, economic considerations limit the actual number used. The installation of only one heater produces a significant gain in cycle efficiency. For each additional heater installed, the efficiency gain gets progressively smaller. At some point the cost of one more heater and its installation outweighs the saving from increased efficiency. In general, economic evaluations have led to the following pattern of feedwater heater applications.

TABLE 1

Unit Size	No. of Heaters
20 - 50 MW	4 or 5
50 - 100 MW	5 or 6
100 - 200 MW	5, 6, or 7
Over 200 MW	6, 7, or 8

The total gain in cycle efficiency resulting from utilizing feedwater heating for three typical cycles is as follows:

TABLE 2

Cycle	Gain in Efficiency
7-Heater Reheat	14.4%
5-Heater Reheat	12.8%
5-Heater Non Reheat	16.2%

Regardless of the number of feedwater heaters utilized in the cycle, the most effective use of the heater system requires that an equal rise in feedwater temperature take place in each heater. In practice, it is not possible to achieve this exactly due to the limited number of extraction points available in the turbine. There is one normal exception to this equal temperature rise per heater rule. In a reheat cycle it is most advantageous to take the extraction steam for the top heater from the cold reheat piping. In this instance the temperature rise in this heater should be about 1.8 times as great as the equal rise in the other heaters.

Feedwater heaters are divided into two basic types: (1) *open or contact heaters* in which there is mixing of the extraction steam and the feedwater; and (2) *closed heaters*, in which no mixing occurs. The effectiveness of either type of heater depends on the net loss to the cycle resulting from transferring heat from the steam to the feedwater. In general this heat transfer process becomes more efficient as the temperature difference between the steam in the heater and the feedwater leaving the heater is decreased. This temperature difference is known as the heater *terminal temperature difference* and should be kept as small as possible.

OPEN HEATERS

In the contact heater, extraction steam and feedwater are mixed and discharged from the heater at saturation conditions. This type of heater is usually designed to *deaerate* (remove dissolved gases) the feedwater and act as a storage reservoir for supplying water to the boiler feed pumps. As a heater, the contact heater is highly effective because it has a terminal difference of 0°. It approaches the ideal of a no-loss heater. For this reason a cycle composed entirely of contact heaters is sometimes called an "ideal" feedwater heating cycle. This arrangement is seldom used in practice because of the saturated condition of the feedwater leaving the heater. To prevent the feedwater from flashing, each contact heater must be followed by a pump. From an economic standpoint it is not practical to have this many pumps. A single contact heater, primarily for deaeration purposes, is used in many plants and is always followed in the cycle by a feedwater pump. The contact heater also serves as a convenient point in the cycle to collect moderate pressure drains and leakages. Collecting drains and leakages at this point ensures deaeration of these flows before they are returned to the boiler. Typical deaerating contact heaters

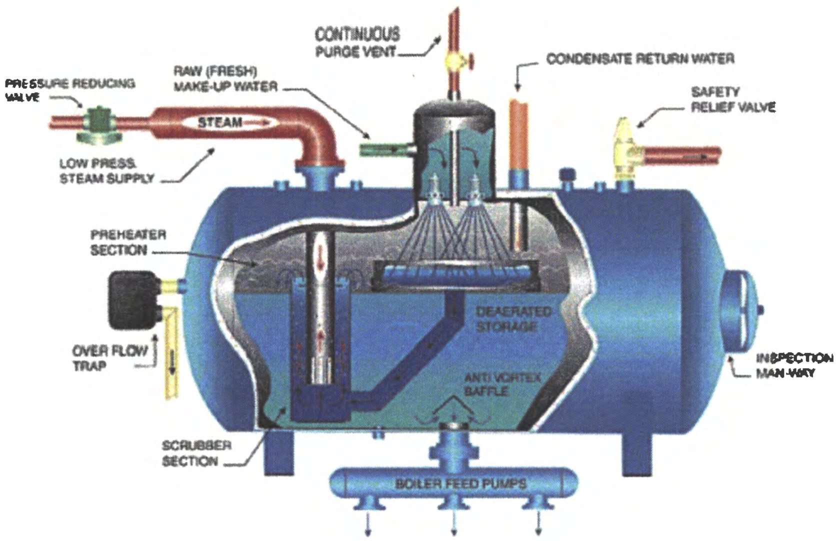


Figure 8.1a - Spray Type Deaerator

are shown in Figures 8.1a and 8.1b. The open heater accomplishes its task of deaeration of the feedwater due to an inherent property of mixtures of gases and liquids. The amount of any gas that can remain dissolved in water depends on the temperature of the water. As the water temperature increases, the amount of dissolved gas decreases. At the saturation temperature, water cannot retain gases in solution. It is not sufficient to just bring the water to its saturation temperature since the small gas bubbles that are released may still be mechanically entrained in the water. Some provision for agitation and turbulence of the water must be provided to thoroughly eliminate gas from the feedwater. In addition, some provision for venting or removing the released air must be made. This is usually accomplished by operating the heater at a slight positive pressure and venting the air and a small amount of steam to atmosphere through a vent condenser.

CLOSED HEATERS

In closed heaters, or shell and tube heaters as they are also called, no mixing of the

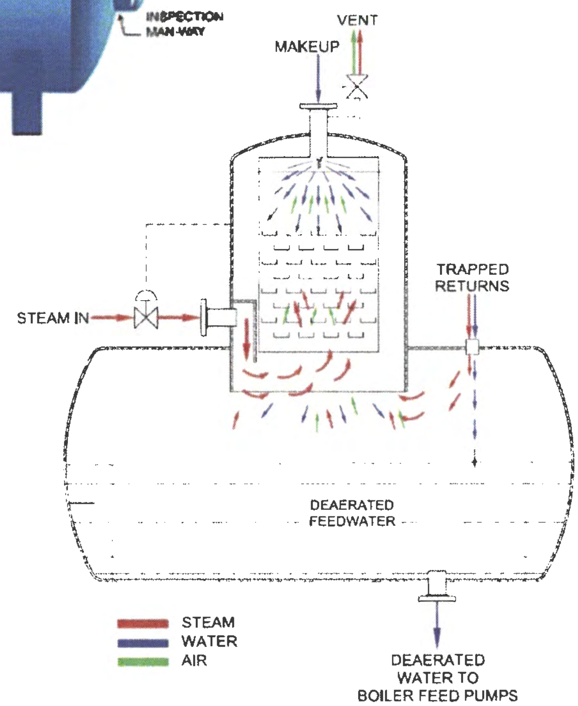


Figure 8.1b - Tray Type Deaerator

extraction steam and feedwater takes place. This arrangement makes it possible to pass the feedwater through several heaters, one after the other, using only a single pump. In these heaters the feedwater always flows through the tubes while the steam is around the outside of the tubes in the shell. With this type of an arrangement, some provision must be made for the differential thermal expansion between the tubes and the shell. This is usually done either by the use of a separate floating head at one end of the tubes (Figure 8.2a) or by using specially bent U tubes. Most of the newer installations use the latter method. A

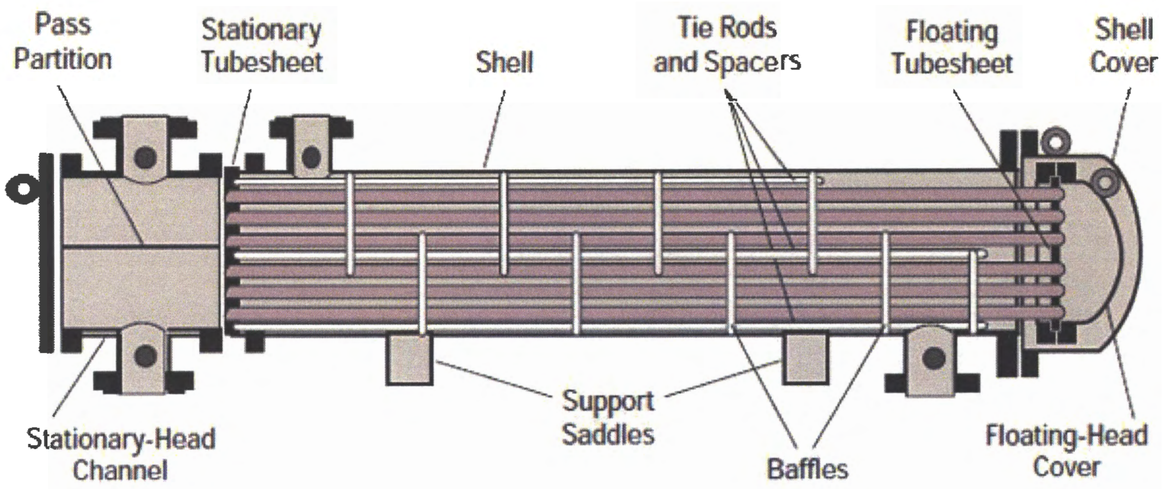


Figure 8.2a - Straight Tube Heat Exchanger

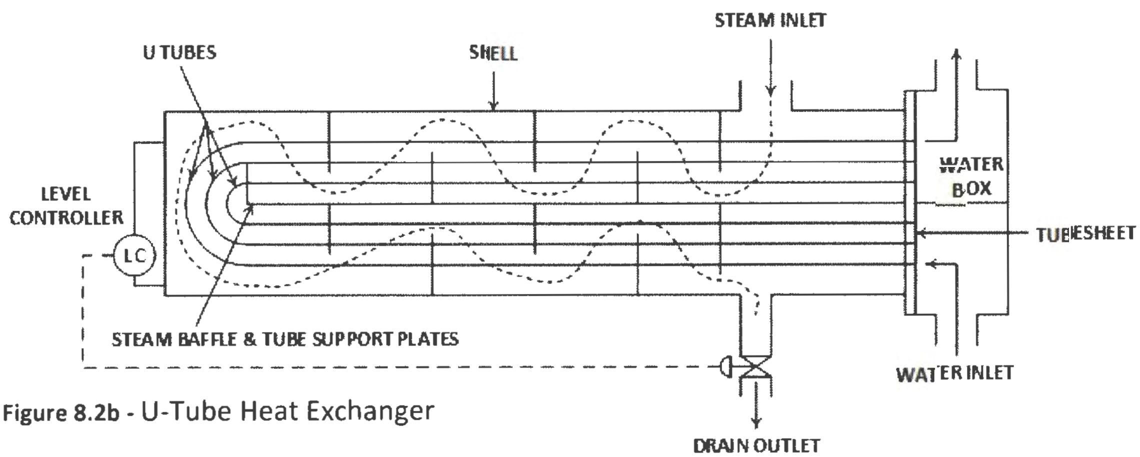


Figure 8.2b - U-Tube Heat Exchanger

simplified drawing of a U tube heater is shown in Figure 8.2b. In this drawing the water in the tubes goes the length of the heater in one direction, then makes the turn and comes back the length of the heater in the other direction. The number of times the water goes the length of the heater is known as the number of passes in the heater. Figure 8.2a & 8.2b are two pass heaters which are the most common. The divided chamber at the inlet end is known as the *water box or channel*. The heavy metal plate that divides the water box from the shell is known as the *tube sheet*. The tubes are rigidly attached to the tube sheet either by rolling (expanding) or welding or both. The steam is directed through the heater shell by baffles to insure maximum use of the heat transfer surface. As the steam transfers heat to the water, it condenses and the condensate is collected in the bottom of the shell. This condensed steam is commonly known as *drips or drains*. A control valve is used in the drain outlet to ensure that a water level is maintained in the shell. If this is not done, steam could blow right through the heater without condensing and result in greatly reduced heat transfer. A level control device is connected to the shell to sense the water level and position the control valve in the drain outlet line.

Note the direction of the steam flow through the heater as compared to the water flow. They are basically in opposite directions; this is known as *countercurrent* flow. It was pointed out earlier in this section that the most effective heater had the lowest terminal temperature difference and transferred heat with the smallest temperature difference. Countercurrent flow accomplishes this purpose by having the hot inlet steam transfer heat to the leaving or hottest feedwater. As the steam loses temperature while flowing through the heater it is transferring heat to cooler feedwater. This flow pattern maintains the minimum temperature difference between steam and water at all times. Unfortunately, at the normal extraction steam pressures and temperatures most of the heat in the steam is latent and is associated with a change of state. There is no change in steam temperature while this heat is transferred; the steam is just condensed from vapor to liquid. This reduces the effectiveness of the heater because the heat must be transferred across a larger temperature difference. This condition can be offset, if steam conditions warrant it, by dividing the heater shell into separate regions. If the extraction steam entering the heater is highly superheated, the heater can be designed with a desuperheating section to utilize this superheat. A desuperheating heater is designed to pass the incoming superheated steam over the tubes containing outgoing feedwater. In this design the temperature of the feedwater leaving the heater may be raised close to, or above the saturation temperature existing in the condensing section of the heater. This results in a small or even negative terminal temperature difference. A desuperheating section is only justified when there is considerable superheat available. This usually limits its application to the highest pressure heaters.

The effectiveness of a heater is affected by what is done with the drains leaving the heater. To get maximum effectiveness the drains should mix with steam or feedwater which is at the same temperature as the steam in the shell of the heater. In the most desirable case the drains would mix with the feedwater leaving the heater. If the drains must be disposed of to some lower pressure point, the maximum effectiveness results from keeping the drain temperature as close as possible to the temperature of the incoming feedwater. This can be accomplished by the use of a *drain cooler section* in the heater. In this design the condensed steam, or drains, are collected and brought into contact with the tubes containing the

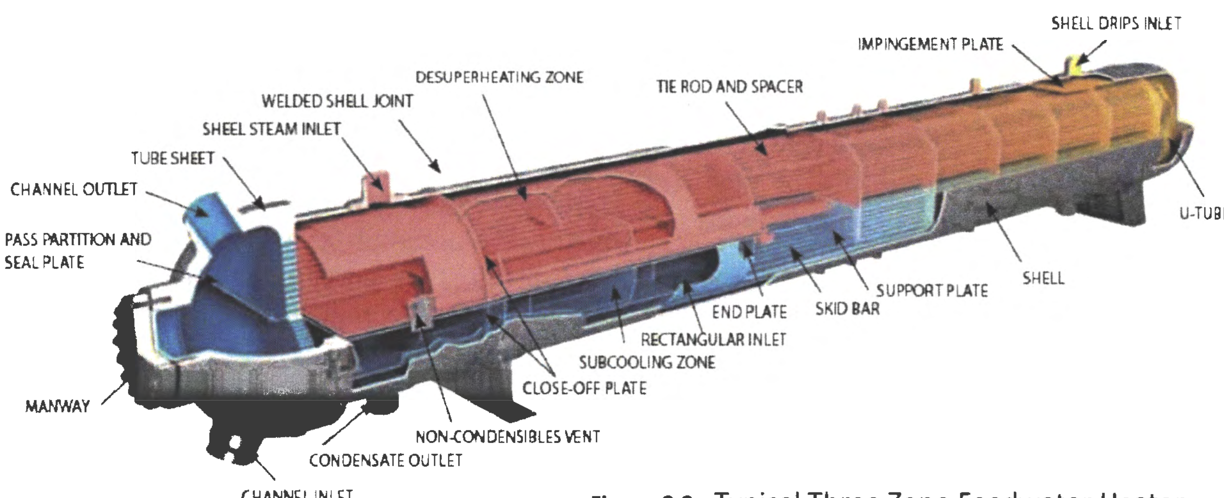


Figure 8.3 - Typical Three Zone Feedwater Heater

incoming feedwater. The temperature of the drains is lowered and made more nearly equal to the incoming feedwater temperature. Figure 8.3 shows a typical high pressure heater with three zones or sections: desuperheating, condensing, and drain cooling. The extraction steam entering the heater usually contains some *non-condensable gases* mixed with it. The origin of these gases is from two major sources:

(1) liberation in the boiler of dissolved gas in the feedwater, and

(2) gas formed by disassociation or breakdown of the chemicals used for boiler water treatment.

These gases flow along with the steam and enter the heaters. It is absolutely essential that these gases be removed and not be allowed to accumulate in the heater shell. There are two major reasons for this:

(1) enough gas can quickly accumulate to blanket the heat transfer surface and greatly reduce the effectiveness of the beater, and

(2) some of the gases if allowed to dissolve in water in the condensing zone can form highly corrosive liquids that can soon damage the tubes.

The gases are normally removed by installing one or more vents on the heater shell. The pressure in the shell forces the non-condensable gases along with some steam out of the heater. The vent is usually located at the opposite end of the shell from the steam inlet. This is done to improve the distribution of steam throughout the shell.

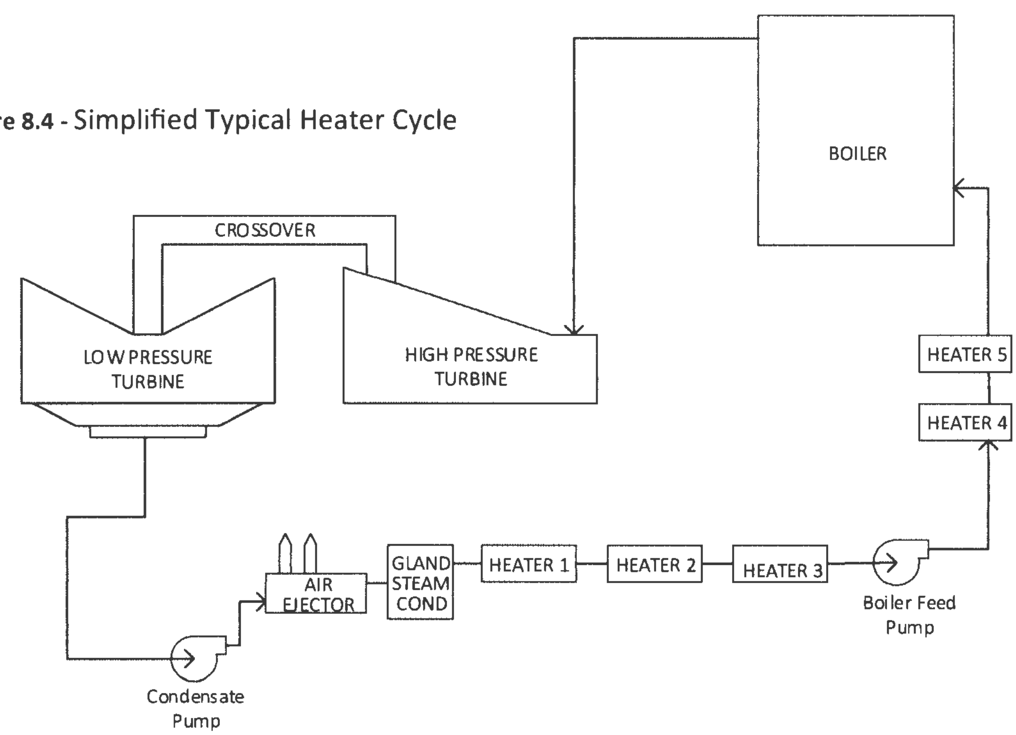
HEATERS AND THE CYCLE

The same numbering system for feedwater heaters is used throughout all plants. The heaters are numbered in reverse order in which steam is extracted from the turbine. This means that No. 5 Heater has the highest steam pressure, No. 4 the next lowest, and so forth. The feedwater flows through the heaters in the same order as the numbering system. This numbering system will be used in the following discussion. As mentioned earlier, the manner in which the drains from a closed heater are handled has a considerable effect on heater performance. The best method is to collect the drains and pump them into the feedwater leaving the heater. This requires a drain pump, or as it is more commonly known, a *drip pump* for each closed heater. In most cases this number of pumps cannot be economically justified. Usually the drains from one heater will be sent to the next lower pressure heater where, due to the lower pressure, some of the drains will flash to steam. A system where the drains from each heater are flashed to the next lower pressure heater is known as a *cascading drain system*. This type of system is used in practically all plants. Since the drains will always be a wet mixture of steam and water, they always enter a heater in the condensing zone and not in the desuperheating zone. An example of this can be seen in Figure 8.3. As we proceed down the feedwater heater chain, the drain flow from each heater gets larger and larger. Each heater not only has the drains due to its own extraction steam, but also the drains from all the heaters above it in the cascade. If this were continued down to the lowest pressure heater, the accumulated drain flow would be so large that unreasonably large size heaters would be required to handle the flow. To get around this problem, the cascade is usually stopped at some intermediate point in the heater chain, usually about half way through. If the cycle uses one open heater, the cascade is automatically stopped at this point since the extraction steam, drains, and feedwater all mix together and discharge directly to the boiler feed pump. In cycles where there is no open heater, the cascade is also stopped, and the drains are collected and pumped into the feedwater system. Regardless of the cycle, the point where the cascading drains are stopped will be before the main feed pump. This allows the drip pump to be smaller since it doesn't have to develop a head sufficient to overcome the feed pump discharge pressure. The cascade of drains is started again with the heaters below the collection point. The drains from the lowest pressure heater are either dumped to the condenser or pumped into the feedwater system. Figures 8.4 shows a simplified typical heater cycle.

An alternate method of drain disposal for each heater must be provided. If this were not done, removal from service of one heater for maintenance would stop the drain flow and therefore deactivate all heaters above it. To alleviate this condition each heater is provided with an alternate drain disposal route, usually directly to the main condenser. This alternate route is commonly known as the *high level dump*. These drains are automatically opened whenever high water level is detected in the heater shell. This alternate drain disposal route not only increases reliability by allowing maintenance but also protects against high level in a heater resulting from any source such as a ruptured tube. If high level were not protected against in this manner, a heater could completely fill with water and even back up into the extraction line and eventually into the turbine. The consequences of this could be disastrous. Additional protection against this and other turbine associated troubles is provided in the extraction line.

Disposal of the heater vents does not pose as great a problem as the drains due to the small steam flow involved. In some cases the heaters are vented directly to atmosphere. In most cases, however, the heater vent system is a closed system. Frequently, the vents are cascaded just like

Figure 8.4 - Simplified Typical Heater Cycle



the drains. In this manner the heat contained in the small amount of steam that is vented along with the gas can be reclaimed in the next lower heater. The gain from doing this is quite small and it is better to run the vent from each heater directly to the condenser. This eliminates the possibility of building up a large gas inventory in the lower pressure heaters which can happen with cascading vents.

Despite their apparent size and strength, feedwater heaters must be handled carefully to prevent thermal or hydraulic shock. When placing a heater in service, it should be warmed up slowly to its normal operating temperature. At no time should there be extraction steam supplied to a heater unless there is a flow of water through the tubes. When removing a heater from service the steam should always be secured first, and when returning a heater to service the steam supply should be opened only after a flow of water has been established. In many plants, it is not possible to remove a single heater from service. Heaters can only be cut out and bypassed in groups of two or three. When cutting out heaters in this type of installation, the steam to the highest pressure heater should always be secured first. This method produces the smallest upset in feedwater temperature.

CONDENSERS

The main condenser in a power plant serves two major functions. It creates a vacuum or low absolute pressure at the turbine exhaust, and it reclaims and collects high purity condensate for reuse in the cycle. Most condensers are designed to accomplish many other functions as well, but the above two are the major ones common to all condensers. The amount of heat transferred in the condenser is tremendous. Each pound of steam exhausted from the turbine must reject approximately 950 BTU to the circulating water in order to condense from a vapor to a liquid. Large quantities of circulating

Figure 8.5a - Single Pass Condenser

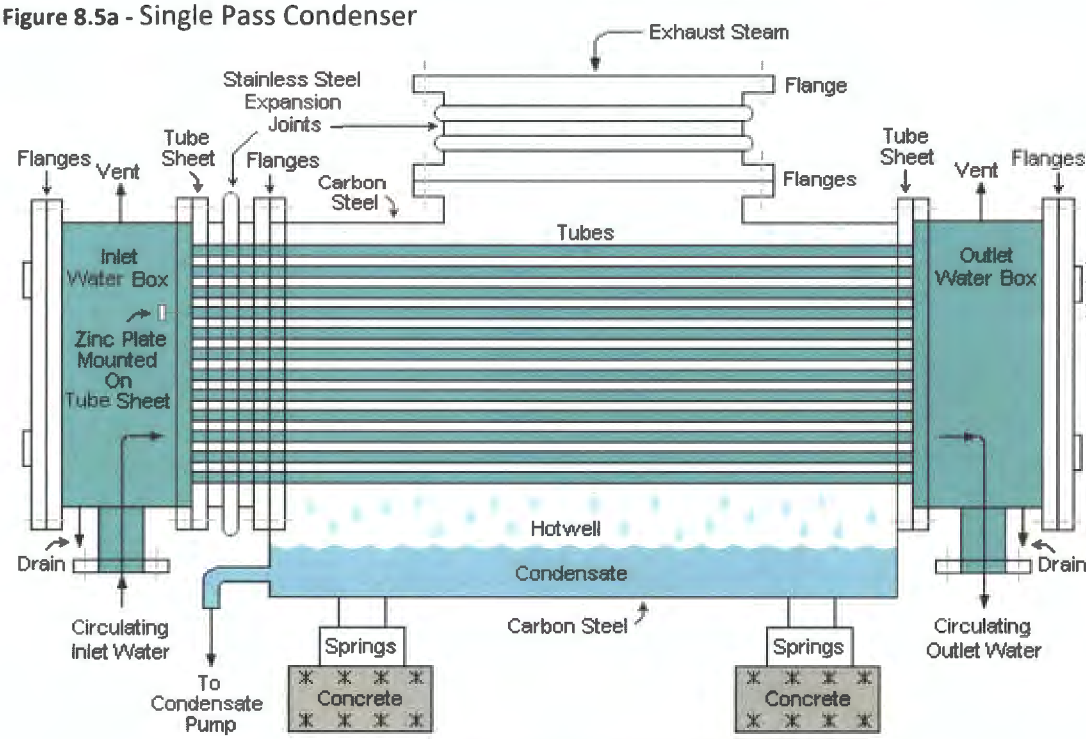
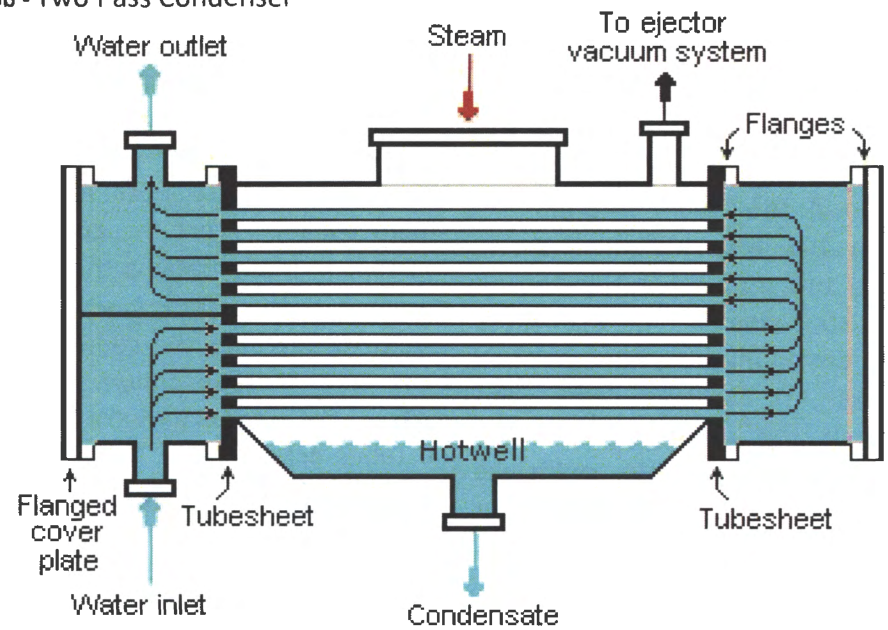


Figure 8.5b - Two Pass Condenser



water are required to remove this heat. In addition, in order to minimize thermal pollution and for other considerations, the temperature rise of the circulating water is usually limited to approximately 15°F and is never more than 20°F. From these considerations it can be shown that for each 1000 pounds per hour of steam entering the condenser, a circulating water flow of approximately 130 gallons per minute is required. Another way of stating this relation is that each megawatt of turbine capacity requires approximately 600 gallons per minute of circulating water.

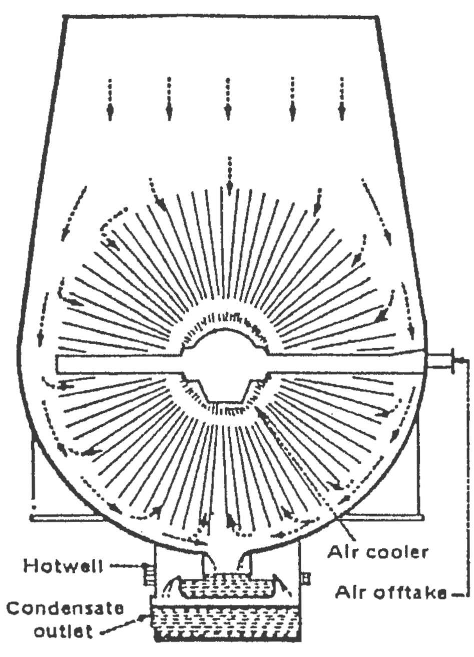
The condenser is a shell and tube heat exchanger with the circulating water passing through the tubes and the condensing steam in the shell. The condenser is located as close as possible to the turbine in order to minimize the pressure drop experienced by the steam in flowing from the turbine exhaust to the condenser. This consideration usually results in the condenser being located directly below the turbine exhaust. Some provision must be made for differential expansion between the turbine and the condenser. There are two normal methods of accomplishing this; an expansion joint may be installed in the connecting piece between the two, or they may be solidly connected with the condenser mounted on springs to allow for expansion.

Most condensers are single pass units (Figure 8.5a); however, some of the older installations use two pass condensers (Figure 8.5b). The circulating water usually enters the inlet water box from the bottom and passes through the tubes into the outlet water box from where it is discharged. The water side of the condenser is divided into two separate halves. This may be accomplished by having separate water boxes for each half or by using a common water box with an internal dividing plate. Regardless of the method, this division permits removal from service of one half of the condenser for cleaning, maintenance, or testing for tube leaks while the unit is in operation. Load must be reduced whenever one half of the condenser is out of service.

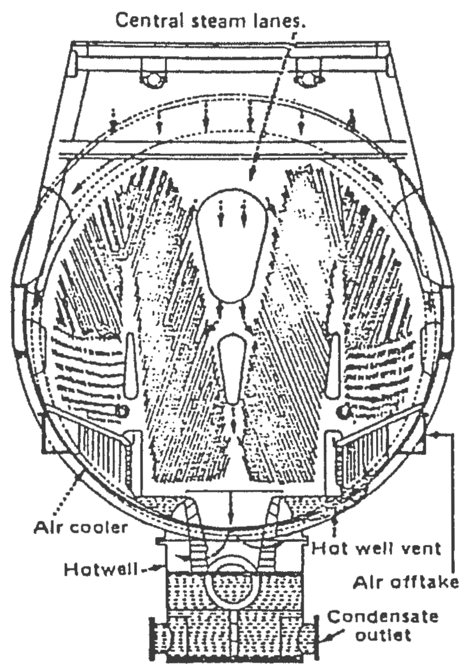
The steam side or shell of the condenser must be leak tight since any leaks will allow air to enter and result in loss of vacuum. The steam enters the condenser at the top and contacts the cold tubes. Heat is transferred from the steam through the tube wall to the water. The steam is condensed by this process of transferring heat. Drop condensation is the most effective condensing method; however, this is impractical to achieve and film condensation is the usual process. This process results in a lower overall coefficient of heat transfer and requires more tube surface. With practical tube materials, water velocities, and water temperatures, thousands of tubes are required to provide sufficient surface area for the required beat transfer rate.

The layout of the condenser tubes must be such that the steam can quickly and easily come into contact with the greatest number of tubes. This makes a much larger surface available for heat transfer. There are two usual methods of accomplishing this purpose. As previously mentioned, the steam usually enters the condenser from the top. In many designs the tube bank is designed with *steam lanes* which allow steam to flow into the center of the tube bank and thereby utilize more of the surface. The steam lanes are areas in which no tubes are installed. These open spaces or lanes permit the steam to penetrate the tube bank before contacting the cold tubes and condensing. The tube layout is such that the area of the steam lanes is largest at the top or outside of the tube bank and decreases as the lane proceeds toward the center of the tube bank. This design helps

Figure 8.6 - Typical Condenser Layouts



Deaeration and heating take place as steam rising from bottom comes in contact with falling condensate. Air is removed from the center of the condenser.



A venturi-shaped center lane allows heating and deaerating steam to pass. Note open arrangement of tubes to give steam access to all portions of the surface.

to distribute the steam and therefore the heat transfer load evenly over all the tubes.

The other common method of distributing the steam is used on the newer, larger units which have separate water boxes. In this design there are two separate tube banks, one for each condenser half. The steam completely surrounds each tube bank and flows radially inward toward the center. The tubes are arranged in a radial pattern which automatically provides more flow area at the outside of the tube bank and progressively smaller flow areas as the steam approaches the center of the tube bank.

Air and other non-condensable gases enter the condenser with the steam and from leakage. These gases must be continuously removed or a loss of vacuum will result. Most condensers have a particular section, usually near the center of the tube bank where air removal takes place. The tubes in this air removal section are placed very close together to insure that all the steam is condensed and not removed with the gas. The gases leave this section of the condenser through an *air removal line* to the *air ejectors*. The air removal line inside the condenser is usually baffled to assist in separating any entrained moisture from the non-condensable gases. When one half of a condenser is out of service for any reason. it is advisable to shut off the air removal from this half. With no cooling water through the tubes considerable steam can be drawn into the air ejector which may cause overloading and loss of vacuum.

In plants which have no deaerating heater, this function is performed in the condenser. As the steam condenses, it drips down through the tube bank and is collected in the hot well which is located directly below the condenser. Some of the incoming steam is directed around the tube bank to the bottom from where it flows upward into the tube bank. This steam heats the downward flowing condensate to its saturation temperature and releases any dissolved gases. Due to the high vacuum or low absolute pressure in the condenser, the saturation temperature is quite low and the condensate can be easily heated to this temperature. The condensate is already broken up into small drops due to its dripping through the tube bank In some designs, however, an additional agitation or break-up is provided for insurance. This is usually a form of trays similar to those used in a deaerating feedwater heater. The gas liberated by this process is carried off by the air removal system. Figure 8.6 shows some typical condenser layouts.

PLATE HEAT EXCHANGERS

A *plate heat exchanger*, or *plate and frame heat exchanger*, uses thin corrugated metal plates installed in a frame and compressed together to transfer heat between two fluids. The metal plates have gaskets for sealing around the outer edge and ports which allow fluid to flow between pairs of plates while preventing mixing of the fluid flows. The primary and secondary fluids enter through ports in the fixed cover and are directed counter-currently through adjacent channels formed by the gasketed plates (see Figure 8.7). The plates are pressed from a sheet of metal, typically stainless steel but titanium is also a common material. The gaskets can be clipped or glued to the plates depending on the service and pairs of plates can be welded instead of gasketed for high pressure or other special applications.

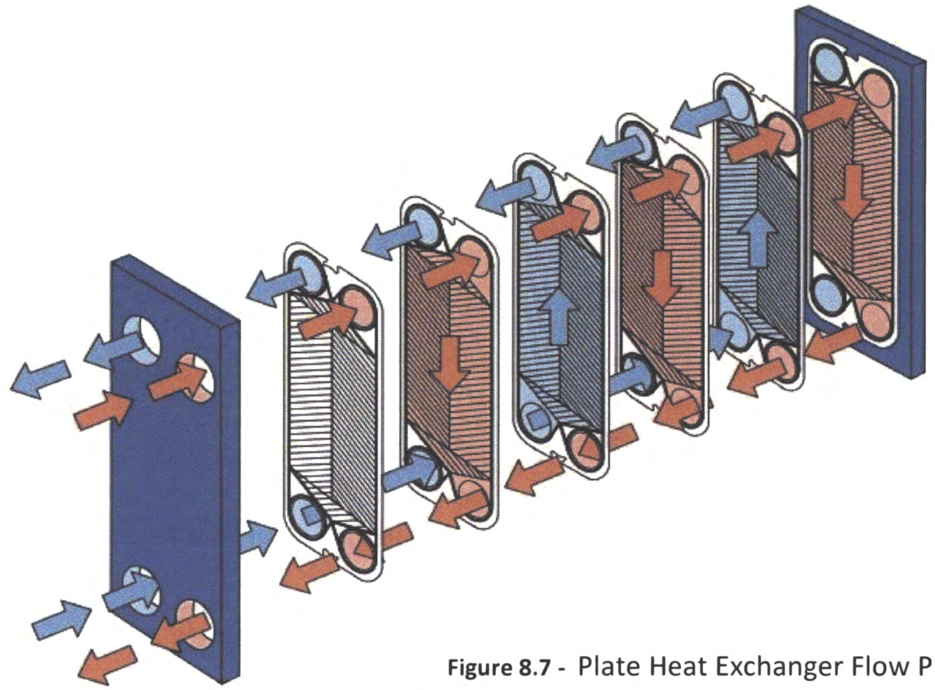


Figure 8.7 - Plate Heat Exchanger Flow Principle

Plate heat exchangers have a major advantage over shell and tube heat exchangers in that the fluid is spread out over a large surface area in a thin layer between the plates. The narrow spacing promotes turbulent flow at low velocities which results in a higher heat transfer coefficient which can allow approach temperatures to reach as low as 2°F. Because of the higher heat transfer coefficients, for the same amount of heat exchanged, the plate heat exchanger will be smaller than a shell and tube heat exchanger. Additionally, if adjustments are required in heat transfer capacity, plates can be added or removed with minimal disruption to operation.

The main components of a plate heat exchanger can be seen in Figure 8.8. These include:

Fixed Cover - Also called *Stationary Cover* or *Head*. The fixed cover has connections for the inlet and outlet piping of both fluids and provides a surface against which, the plates can be compressed.

Carrying Bar - Also called *Top Bar* or *Upper Guide Bar*. The carrying bar is what the plates and moveable cover hang from.

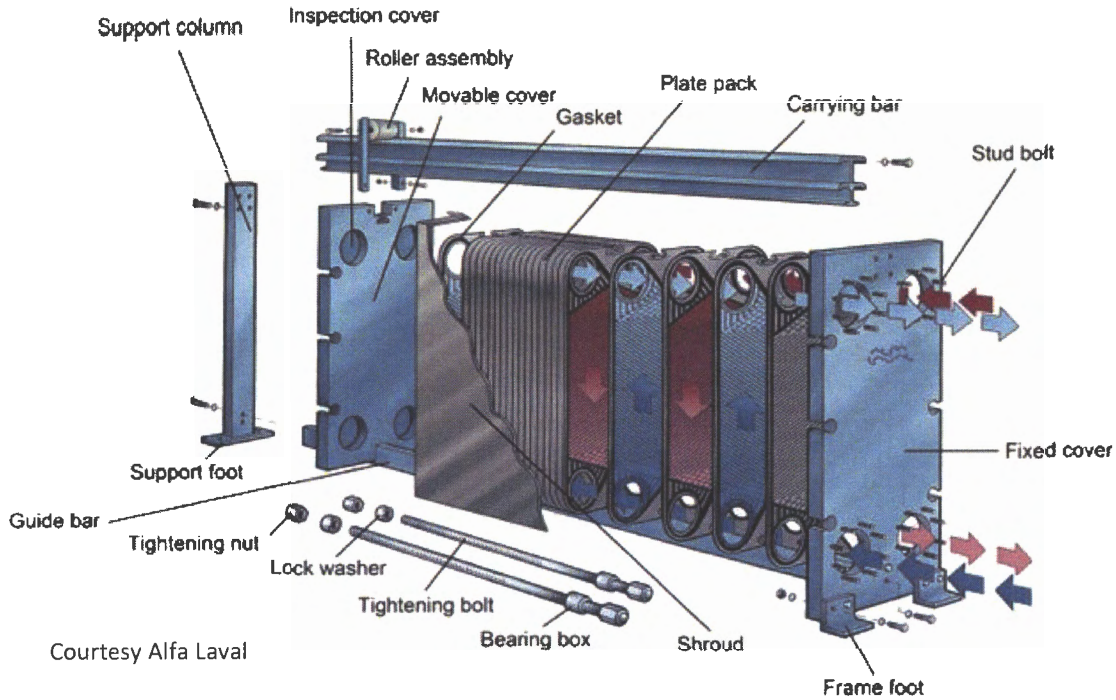
Guide Bar - Also called *Bottom Bar* or *Lower Guide Bar*. The guide bar keeps the plates aligned at the bottom.

Support Column - Also called *End Support* or *Guide Bar Support*. The support column forms the frame of the heat exchanger along with the frame plate, carrying bar and guide bar.

Moveable Cover - Also called *Follower* or *Moveable Frame*. The moveable cover hangs from the carrying bar and is allowed to move back and forth to compress the heat exchanger plate.

Tightening Bolts - Also called *Tie Bars*. The tightening bolts are used to compress the heat exchanger plates between the fixed cover and the moveable cover.

Heat Transfer Plates - The heat transfer plates transfer the heat from one fluid to another. The plates are pressed to form



Courtesy Alfa Laval

Figure 8.8 - Typical plate heat exchanger components

corrugations which create flow channels and provide additional strength.

Gasket - The gasket is used to seal between two plates to help form the flow channels for fluid movement. The gasket can be made from different material depending on fluid temperatures.

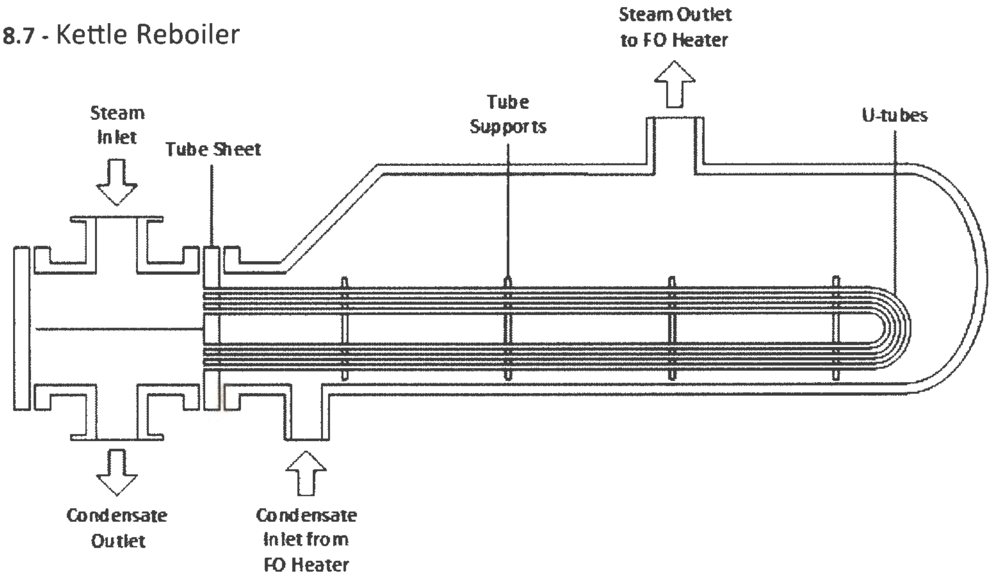
MISCELLANEOUS HEAT EXCHANGERS

Heat exchangers are used for many applications in power plants. They include: lube oil coolers, fuel oil heaters, and auxiliary cooling water heat exchangers. Most of these are shell and tube heat exchangers, but plate heat exchangers are used more widely now. Countercurrent flow is practically always used since it provides the most efficient heat transfer. In most of these applications it is necessary or desirable to control the temperature of one of the fluids exiting the heat exchanger.

There are several methods available for doing this. The primary problem is one of controlling the rate of heat transfer. Consider a fuel oil heater in which steam passes through the tubes and fuel oil is in the shell. It is desired to maintain a constant fuel oil temperature leaving this heater. This can be accomplished in several ways: The steam pressure to the heater can be varied thereby varying its temperature, or the water level in the heater can be varied which in effect changes the effective heat transfer surface. In other applications it may be possible to vary the flow rate of one of the fluids in order to control the temperature of the other fluid.

Gases are less efficient than liquids for heat transfer applications. In order to keep the size of liquid to gas heat exchangers reasonable it is frequently necessary to increase the heat transfer area by unusual means. The most common method of providing more surface in a small volume is to use tubes equipped with fins. The use of

Figure 8.7 - Kettle Reboiler



fins greatly increases the surface area. These are seldom used with liquids since the higher density of the liquid would produce a very large pressure drop through a finned tube bundle.

REBOILERS

Steam may also be used to evaporate (or vaporize) a liquid, in a type of shell and tube heat exchanger known as a reboiler. These are typically used in the petroleum industry to vaporize a fraction of the bottom product from a distillation column. These tend to be horizontal, with vaporization in the shell and condensation in the tubes (see Figure 8.9).

In power plants, the reboiler provides an isolated supply of steam for use in the fuel oil system to heat fuel oil to the correct viscosity for firing. This type of fuel oil heating system ensures that no oil leaking from the fuel oil heater can contaminate the main condensate or feedwater systems.

Some of this steam is also used for steam tracing. Steam is fed through tubing that is wrapped around fuel oil piping to prevent the oil from cooling and causing a cold plug.

In a forced circulation reboiler, the secondary fluid is pumped through the exchanger, while in a thermosyphon reboiler, natural circulation is maintained by differences in density. In kettle reboilers there is no circulation of the secondary fluid, and the tubes are submerged in a pool of liquid.

REHEATERS

In conventional plants reheating is accomplished in the reheat section of the boiler. High pressure turbine exhaust steam is reheated, mainly to remove the moisture. This reduces turbine blading erosion in the low pressure turbine.

Section 08
HEAT EXCHANGERS
Study Questions

1. The term heat exchanger can be applied to any piece of equipment designed to

   ____.

2. Feedwater heaters raise the temperature by the use of steam extracted from the turbine or reheat piping. True \ False

3. In open or contact heaters, extraction steam and feedwater are mixed, while in closed heaters, no mixing occurs. True \ False

4. Open heaters are designed to ________________________ (remove dissolved gases) from the feedwater.

5. At the saturation temperature, water cannot retain gases in solution. True \ False

6. The most effective heater has the lowest terminal temperature difference and transfers heat with the smallest temperature difference. True \ False

7. The closed heater contains which of the following features? (Circle answer)
   a. U-tubes
   b. Drain outlet
   c. Water box
   d. All of the above

8. Open heaters are more economical than closed heaters because each heater does not have to be followed by a pump to prevent the feedwater from flashing. True \ False

9. The effectiveness of a closed heater is affected by what is done with the drains leaving the heater. True \ False

10. Briefly explain the cascading drain system.

11. The cascading drain system always has to include one open heater that automatically stops the cascade. True \ False

12. Why is each heater provided with an alternate drain disposal route, and where is this route usually directed?

13. To prevent thermal or hydraulic shock in feedwater heaters during startup, the extraction steam should be supplied to the heater to warm it up before the water begins to flow through the tubes. True \ False

14. List the two major functions common to all condensers.

    a.

    b.

15. The condenser is a shell and tube heat exchanges. True \ False

16. The condenser is usually located ______________________

    a. directly after the main feed pump.
    b. directly below the turbine exhaust.
    c. as close as possible to the boiler.
    d. None of the above.

17. Why is the water side of a condenser divided into two separate halves?

18. How are non-condensable gases able to enter the condenser?

19. Describe the main components of the plate heat exchanger.

20. How is the heat exchange accomplished in a plate heat exchanger?

21. Name at least two (2) features of a plate heat exchanger that are not found in a shell and tube heat exchanger.

22. When would it be advantageous to use a plate heat exchanger instead of a shell and tube heat exchanger?