# Recovery of Waste Heat

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ONE of the important problems which a chemical engineer has to face is the efficient utilisation of large amounts of heat that is being otherwise wasted as secondary heat in any chemical operation. Any process which demands heat, gives rise to a secondary heat which may be present in one or more secondary heat carriers. For example, in the fruit juice industry, where steam is used for sterilisation of fruit juice, the secondary heat carrier is the hot sterilised juice itself. The recovery of these large amounts of heat, whether of high or low value, effects a considerable saving in the overall cost of the process concerned.

*Factors Affecting the Utilisation of Secondary Heat:*

The recovery of the secondary heat is brought about in heat exchangers. For economical utilisation of the secondary heat the cost of recovery should be less than that of transferring heat from other sources. Various factors influence the cost of transmission of secondary heat.

Firstly, the temperature of the heat carrier; higher the temperature, higher the value of heat transmission coefficient and hence, larger is the amount of heat transferred per unit area of heating surface.

Secondly, the nature of the heat carrier; for the same temperature, the overall heat transfer coefficient for water or steam is much higher than that for gases.

The cost of materials of construction, maintenance and operational costs and the periodicity of the heat source are some of the other factors which have to be taken into consideration. A heat source available only during short periods evidently requires a more expensive equipment, than if the heat source should deliver a regular quantity per hour, thereby allowing continuity of operation.

Of late, quite a number of new processing problems have cropped up. Process pressures and temperatures are higher, process fluids are more dangerous and more corrosive and various forms of energy cost more than they did a decade ago. These problems have resulted in the revision of old concepts in the equipment design and even the design of entirely new devices. For recovery of low-grade heat (i.e. of secondary heat at a relatively low temperature level). different types of modern heat exchangers have been designed which differ considerably from the various types of traditional tubular heat exchangers in that they are generally built of steel or metal sheets instead of tubes. Installation costs have been lowered by this trend towards more compact designs. Low cost heat transfer equipments have led to the increased recovery of what was previously considered waste heat in many industries.

It is not intended to describe in this article all the different designs of modern heat exchangers. An attempt is made to delineate one of the more important designs in the field the spiral plate heat exchanger, especially because of the unique nature of its design.

*Spiral Plate Heat Exchanger:*

The spiral heat exchanger was originally introduced by Rosenblads in 1930

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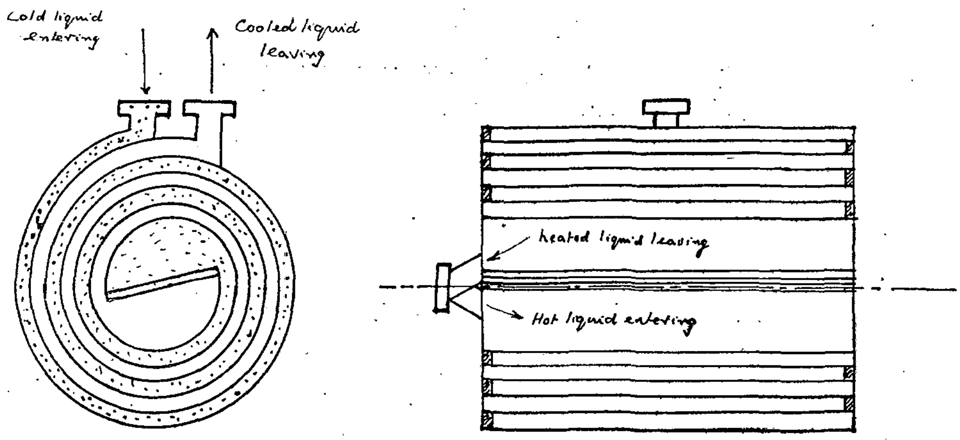
to obtain more efficient recovery of heat in the wood pulp processes of Scandinavian countries, where fuel costs are relatively high.

It consists of a pair of long plates rolled in a spiral arrangement to provide two relatively long, narrow, continuous channels with media in counter-current flow. A fluid flowing through one passage is subjected to heat inter-change with a fluid in the other channel. Figure I shows the scheme of operation of this exchanger. The cross section of




these passages can be of varying dimensions (the passage width may be anything from 3/16 of an inch to one inch) to suit specific flow conditions. Exceptionally long passes obtainable make the spiral heat exchanger suitable for services requiring wide temperature changes and low terminal temperature differences.

If operating conditions require, one of the two passages is welded tight at one side while the other passage is welded at the opposite side. Sealing is completed with gaskets and flat steel covers, bolted to the flanges on the heat exchanger. These covers are easy to remove for inspection or cleaning of the heating surface. Certain modifications in design are effected according to the nature of fluids used in the exchanger.

For example, when used for steam or a steam gas mixture, the steam passage is sealed at the bottom and closed at the top by a steam distribution device and an outer cover. This distribution device supplies to the passage an inlet of steam sufficient to bring about a constant suitable velocity in the passage. The liquid passage is sealed at the top and closed at the bottom by packing and a flat cover. When used for vacuum steam, the liquid passage is sealed both at bottom and top. The vacuum steam passage is open at both ends and steam passes in cross flow downwards. This provides a sufficient cross-sectional area of the steam passage so that the pressure drop is limited and at the same time good heat transfer is obtained.[3]

*Advantages of Spiral Heat Exchangers:*

Exhaustive tests have been carried out by K. W. Coons *et al.*,[4] on the heat transfer characteristics of the spiral heat exchanger under varying conditions when heating or cooling oil, water, brine and steam. Their conclusions were:

(1) Turbulence becomes definitely established at lower values of $R_e$ in a spiral exchanger than it does in tubular units. Turbulance begins at values of $R_e$ between 1400 and 1800.

(2) At any given value for $R_e$, the spiral channels offer less resistance to *the flow than do circular cross-sectional* tubes. Thus the pressure drop through the spiral channels at a given value of $R_e$ is consistently lower than in smooth tubing.

(3) At any given value of $R_e$, the heat transfer coefficient in a spiral exchanger will be at least 35 per cent higher than would be anticipated in a tubular exchanger.

Using a spiral with 30 sq. ft. of surface, steam to water, overall heat transfer coefficients of 700 were obtained at water velocities of 6.5 ft/sec. In the same unit, exchanging from water to water, coefficients of 325 were obtained at water velocities of 5 ft/sec.

Other advantages of the equipment can be summarised as follows:—

Both the passages can be dimensioned for the most economic velocities. The continuous flow eliminates flow reversal and the accompanying wasted pressure drop. Both passages are accessible for inspection and cleaning by removal of the respective covers except in a special case where one passage is sealed at both sides. As the cold fluid enters at the periphery (see Fig.) and flows along under the shell, the need for insulation is less.

The spiral design is also compact. One thousand square feet of heating surface with a pass on each side 100 ft. long can be contained in a unit having a 42 in. diameter and 60 in. length. Overall dimensions would be 48 in. at the cover diameter and 72 in. from face to face of the nozzles. Spirals have been designed for operating pressures in stages up to 150 psi. Any metal that can be cold formed and welded can be used for fabrication. The rate of scaling is, as experience has shown, considerably less than in tube and shell type heat exchangers operating under similar conditions. Mixture of the two media is not possible, as they are completely isolated from each other, and mixing is in no way dependent upon packings.

*Performance and Applications of Spiral Heat Exchangers:*

In a sugar mill in Sweden,[3] a spiral heater for sugar juice is said to have performed the same duty as two tubular heaters together, the heating surface being 260 and 860 sq. ft. respectively and similarly for ammoniacal liquor in a gas works.

Thus, we see that modern heat exchangers in many cases are considerably more efficient and consequently cheaper than the traditional shell and tube exchangers. Even in cases where special materials of construction are to be used, spiral exchangers are recommended since sheets or plates are cheaper per square foot of surface than tubes.

The spiral heat exchanger can be used in all types of heat recovery problems, except where the apparatus is exposed to a very high pressure. This pressure limit is somewhere around 200 psi. Consequently, only few applications are excluded by the working pressure required. In fact, spiral heat exchangers are nowadays being extensively used for recovery of heat from waste liquors and vapours, for heating and cooling of vegetable, fruit and sugar juices and certain chemicals such as oleum, acids and distillery mashes. There is little doubt that the field of their application will widen further.

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