Distillation Columns - Fractioning Columns

**Distillation** is the process of separating two or more miscible liquids by taking advantage of the boiling point differences between the liquids. For methanol and water, heat is added to the mixture of methanol and water and eventually the most volatile component (methanol) begins to vaporize. As the methanol vaporizes it takes with it molecules of water.

The methanol-water vapor mixture is then condensed and evaporated again, giving a higher mole fraction of methanol in the vapor phase and a higher mole fraction of water in the liquid phase. This process of condensation and evaporation continues in stages up the column until the methanol rich vapor component is condensed and collected as tops product (99.5% recovery / 99.5% pure) and the IPA/Water rich liquid is collected as bottoms product.

**What is Fractionating columns**

SRS Engineering Corporation is premier manufacturer of distillation columns for various applications. Fractional distillation is a method used to separate liquids with similar boiling points. This method relies upon a gradient of temperatures existing in the condenser stage of the equipment.

A vertical condenser is often used in the fractional distillation technique. Extracting products in the liquid stage at the different heights of the column makes it possible for the extraction of liquids that have different boiling points. The greater the distance over which the temperature gradient in the condenser is applied, the easier and the greater separation is.

**Heating under Reflex**

Heating under reflex allows the mixture including volatile materials to be heated for a long time without losing any solvent. If a mixture of liquids forms an azeotrope, then that mixture cannot be completely separated by fractional distillation.
What is Raoult's Law?

If you have studied Raoult's Law you are probably familiar with the graph of vapor pressure vs. composition at constant temperature. You will probably also be familiar with the boiling point/composition diagram (at constant pressure) that is used to explain fractional distillation. What is often absent from the books is the link between the two diagrams. However, here is the explanation that links the two.

As temperature increases, so does the vapor pressure of a liquid. The vapor pressure/composition diagram is plotted at constant temperature; a series of these plots at different temperatures (fig 1 below) is needed in order to obtain a boiling point/composition diagram. The graph shown is for a mixture of hexane and heptane, which forms an ideal liquid mixture. Since vapor pressure does not increase linearly with an increase in temperature, the vapor pressure lines at the different temperatures are not parallel.

Boiling-point composition diagrams are usually plotted at atmospheric pressure, though for an ideal liquid mixture they'd look more or less the same whatever the chosen pressure. The horizontal line is at 1 atmosphere (760 mmHg), and gives the composition of the liquid that gives rise to a vapor pressure of 1 atmosphere at each temperature.

The points thus generated are then transferred to axes having the same composition scale but whose vertical axis is the temperature. The full-size diagram can be seen below.

The boiling point/composition diagram is now completed by putting in the line that represents the vapor composition (shown in red). The vapor in equilibrium with liquid at a given temperature is always richer in the more volatile component. Thus the vapor composition is shown by a point at the same temperature, but whose composition is nearer to the more volatile (lower boiling temperature) constituent.

The link between the vapor pressure/composition and boiling temperature/composition diagrams for non-ideal (azeotropic) mixtures is the same, but such systems give a more complex diagram because of the vapor pressure maximum or minimum.

How Columns Work?

Distillation is a process used to separate a mixture of two (or more) components into its virgin state by heating the mixture to a temperature between their respective boiling points.

For example, at atmospheric pressure, water boils at 212°F and ethanol boils at about 176°F. If the mixture of water and ethanol is heated to about 195°F, the ethanol will boil and be changed into vapor which is then collected and condensed. The water will separate and remain as a liquid.

A fractionating distillation column is used to make this process more efficient. See the picture below to better understand how columns work.
The distillation column is made up of a series of stacked plates. A liquid feed containing the mixture of two or more liquids enters the column at one or more points. The liquid flows over the plates, and vapor bubbles up through the liquid via holes in the plates. As liquid travels down the column, the vapor comes in contact with it several times due to the multiple plates - a critical process in distillation columns. The liquid and vapor phases are brought into contact because as one molecule of higher boiling material converts from vapor to liquid phase by energy release, another molecule of the low boiling material utilizes the free energy to convert from liquid to vapor phase.

The base of the distillation column contains a large volume of liquid consisting mostly of the liquid with higher boiling point (in our example, this would be water). Out of the base flows some of this liquid, some of which is heated in the reboiler and returned to the column. This is called the boil up.

Photo of crude oil fractionating column. Demonstrates the stacked plates

Internals for packed column
Some vapor escapes from the top of the column and is returned to a liquid state in the condenser. Some of this liquid is returned to the column as reflux, and the remainder is the top product or distillate. Vapor and liquid phases on a given plate approach thermal pressure and composition equilibrium to an extent depending upon the efficiency of the plate.

In essence, the hot mixture is pumped into the bottom. The tower acts as a heat exchanger, removing heat from the vapors as they rise. Some of them condense back into liquids and fall back down the column.

The temperature gradually decreases as you go up the column. Different groups of hydrocarbons condense at different heights - the heaviest at the bottom, the lightest at the top. The final product is in its virgin state.

**Distillation Columns**

The **SRXC-Series** is a completely automated chemical distillation column designed to address a high purity chemical purification application in multiple industries. The system is designed to remove water, other chemicals, and or contaminants from the chemical being purified. Low part per million (ppm) levels can be attained for reuse. A specially designed fractionating column with a reflux stream is used to separate the materials in a continuous mode while keeping a flow rate of up to 25-5000 gph on a 24 hour per day basis.

SRS’ distillation/fractionation columns are equipped with a programmable logic controller (PLC) housed in a NEMA 4X enclosure or can be remote located to a customer control room. The PLC monitors a series of relays and sensors to verify proper liquid levels, flows, temperatures and discharge valve position before starting the cycle. Any fault condition is diagnosed and clear status messages are displayed on the touch screen controller panel to ensure operator safety and ease of operation. The system automatically shuts off in the event of a fault condition or at the end of the cycle.

Custom fitted columns and fractionating packing as well as high efficiency heaters and heat exchangers are required to achieve the throughput demands of the application. SRXC-Series Columns are designed to utilize either hot oil, steam, or on occasion electric heaters.
Building a **Greener** Tomorrow… for the Environment and Your Bottom Line!