Vapor Compression Distillation

Adding some high tech understanding to natures' process

Water is no longer taken for granted. We live on a water planet, surrounded by water. However of the worlds 1.4 billion cubic kilometers of water only 2.5% is fresh. 69% of that fresh water is locked in our polar caps and mountain glaciers or stored in underground aquifers too deep to tap under current and foreseeable technology.

The real question than is one of renewing or replenishing our fresh water supply. The global hydrologic cycle, **natures' process** is powered by the sun and deposits about 113,000 cubic kilometers of water on the world's continents and islands as rain and snow. Of that, about 72,000 cubic kilometers evaporates back into the atmosphere. Moreover, of the remaining 41,000 cubic kilometers left, more than half flows unused to the sea and another portion falls in areas too far from human habitation. Some water experts suggest that the upper limit of the world's **available** renewable fresh water lies between 9,000 and 14,000 cubic kilometers per year.

What available fresh water we have is becoming increasingly polluted by industrial, municipal and agricultural pollution. In real life terms we must look to what hydrologists refer to as endogenous or internal resources. Looking in a case by case basis some arid countries in the Middle East only get a few millimeters a year. The Kingdom of Saudi Arabia relies on existing ground water to meet 75% of it's water needs. These underground reserves were filled thousands of years ago and have negligible annual recharge.

In the last century, California, a semi-arid state has experienced rapid urban growth and agricultural development. All existing water sources have been tapped and growth is severally limited. Nature needs some help.

Probably the greatest overriding concern is cost to obtain any additional water. The hydrologic cycle is driven by the sun and there the energy is free. As in many situations learning from nature can be valuable. However without the sun as a power source we must consider how much energy is required and the cost of that energy in duplicating natures' process. Distillation is well known and a desirable process, however it has traditionally been known as taking lots of energy.

First the water must be heated to 212° F. As a generalization to heat a gallon of water takes approximately 500 watt- hours. Another 2500 watt-hours is required to turn that gallon of water to steam. The total energy required to evaporate one gallon of water is around three KWH (3000 watt-hours) of electricity.

Along with energy consumption, we must consider capital cost. The market to be addressed helps us determine what is most important. For the home or business POU market where relatively small amounts of water are needed, 5-15 gallons per day, the capital cost is probably most important. Since here only a few gallons are produced a cost of 20 to 25 cents for energy per gallon is still cheaper than available bottled water. There is currently a host of inexpensive single stage distillers on the market. The small size, about the size of a toaster, pure quality and consistent productivity make these desirable.

Most competing water treatment technologies available require constant monitoring, parts replacement and cleaning. Single effect distillers are quite simple where the boiling chamber is a pot with an electric heater and a condensing tube. Condensing is generally done by water cooling or air cooling. The systems using water carry away the heat, but waste some water. The air cooled units put the heat out into the room, but waste little or no water.

 Article appeared in the November, 2006 issue of WC&P International.

Where more water is desired the energy required becomes the most important factor. We can't afford to pay 25 cents a gallon for large quantities. Fortunately for larger production there are higher efficiency distillers.

In multi-stage or multi-effect distillation the steam generated goes to a series of boiler condenser chambers. Each successive boiler stage is held to a lower absolute pressure and lower boiling temperature. The heat energy is reused. The efficiency is then dependent on the number of stages. i.e. 2 stages use 1/2 the energy while 4 stages uses 1/4 the energy. For distilling hundreds of gallons of water distillers using 2 to 6 stages is used. Multi million gallon distillers as used in many Arab countries will use from 16 to 24 stages. To get the higher efficiencies very large systems are built and in the Middle East they are heated with oil or gas.

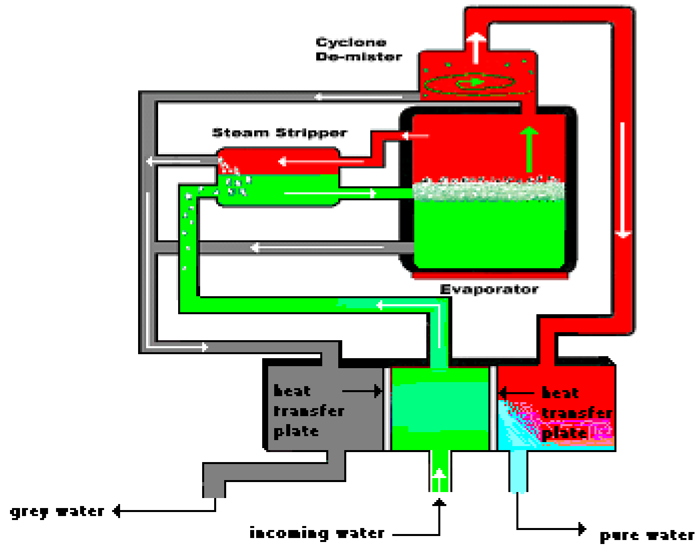
There is another and more efficient distillation process. It is now possible to do that same work, heat one gallon of water, evaporate, condense and cool it back down to within one degree of the original feed water, for the amazingly low energy consumption of 10 to 15 watt hours. This process is called vapor compression distillation. The boiler and condenser are recycling the heat necessary to turn the incoming water to steam. A quick explanation may be helpful here.

Normally in nature we are used to getting water hot to make it boil and cooling the steam down to get it to condense.

The problem here is, how do we recycle the heat? Heat always goes from hot to cold, never cold to hot. It turns out that pressure and temperature are interchangeable in the sense that as pressure decreases water will boil at a lower temperature and conversely as pressure increases steam will condense at a higher temperature. We are reversing what we normally see in nature by using this vapor compression technology. We use a compressor to draw steam from the boiler side creating a lower pressure. Now we are able to boil at a lower temperature. The steam passes into and through the compressor and is blown into the condensing chamber creating higher pressure. Now the steam will condense at a higher temperature because it is under higher pressure.

The chambers are separated by thin plates creating alternating chambers with the boiler on one side and the condenser on the other side. As the pressurized steam coming from the compressor touches the plate, as it is relatively colder, it condenses. To condense it must give off its' latent heat, which passes through the plate and into the water that is at a lower pressure on the other side and turns that water to steam. This allows us to virtually recycle almost all the energy required to turn the hot water to steam and since we can't have a perpetual motion machine and there is some loss, the make up heat is supplied by the compressor. The compressor is doing work and that heat /energy is continually added to the steam.

The beauty of this system is that we then have a process that duplicates nature, evaporating water, then condensing it to give us pure water for only the energy that the compressor uses. This allows us to clean virtually any water on site for less cost than pumping water down from the mountains. This is exciting because almost all available water is spoken for and the real question is where can we find more make up water as our need increases?



The technology I have developed and written patents for incorporates several well known processes and it is the combination of these technologies that allows us to finally have pure affordable fresh water almost anywhere!

The technology will purify feed water with a very broad range of contaminants, including virus and bacteria, minerals, chemicals, gasses, radiation, and salts.

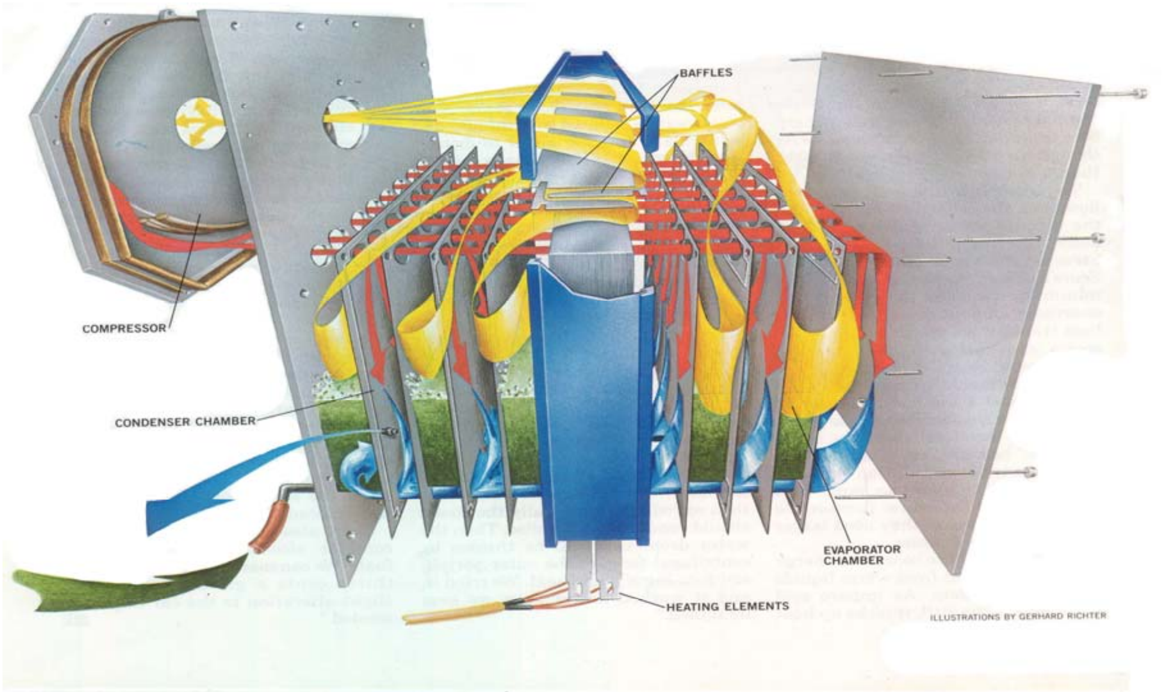
The incoming feed water flows through a three liquid counter flow heat exchanger that heats the incoming water to within one degree of boiling. These are just stacked plates with no moving parts, no friction, no wear, and has a very long life expectancy, and very inexpensive to make.

Secondly the heated water passes through a counter flow steam stripper that removes all the gasses, odors and smells, then enters the boiling chamber where part of the water is turned to gas. The remaining water is waste and carries away all the impurities that were in the feed water. These systems are a continuous flow process.

In the boiling chamber the rising gasses are centrifuged to spin off any droplets prohibiting any carry over. Only dry gas is pulled into the compressor and blown into the condensing chamber.

The boiling and condensing chambers are formed by stacking plates so as to create alternating chambers. One side of a plate is boiling the feed water while the other side is condensing the steam.

To understand the difference in recycling energy, this system has a coefficient of performance, "COP" of 200 to 1.
This is the equivalent of a 200 stage multi effect distiller.(Note; They don't make those!)



This system does not rely of filters or chemicals to clean the water . It is made of high grade stainless steel and the pure fresh water is separated from the impure feed water by solid stainless steel barriers. Also the high pressure is on the pure water side so should there be a leak the water could only go from the high pressure side or pure water side to the low pressure side or the impure side. A leak would only mean that you would be getting less product water out, but not impure water. This then is a true fail safe system.

Additional value of the vapor compression distillation process is that they are constructed of high grade stainless steel, with virtually no moving parts except the compressor. There are no membranes to degrade or filters to fill up.

They are continuous flow so all the contaminants flow out in the waste and don't build up in the machines.

Built for long life out of solid stainless steel cleaning in place is possible should a build up of deposits happen over time. They are relatively inexpensive to build resulting in a low capital cost. They take very low energy consumption which makes them inexpensive to run and make very pure water, generally less than 1 ppm purity.

The combination of all these benefits means affordable pure fresh water at virtually any source.

Footnotes;

1. (Igor A. Shilomanov.1993. "World Fresh Water Resources," in Peter H. Gleick, ed., Water in crisis: A Guide to the World's Fresh Water Resources. New York: Oxford University Press.)

2. (Robin Clarke. 1993. Water: The International Crisis. Cambridge: MIT Press)

3. (Sandra Postel. F1992. Last Oasis: Facing water Scarcity. World Watch Institute. New York: W.W. Norton.)