Homebrew Heat Exchanger

Bert Echt

A single-wall, tube-in-tube heat exchanger can easily be built from readily available parts.

Most solar hot water systems that operate in freezing conditions use a heat exchanger. A heat exchanger is a device that allows a hot fluid to heat a cooler fluid without the two fluids mixing. I am a plumber by trade, but basic soldering skills are all you need to construct your own simple heat exchanger. In this article, I'll show you how to build a simple, single-wall, tube-in-tube heat exchanger for use with drainback solar domestic hot water (SDHW) systems.

Heat exchangers are used in both closed loop antifreeze and drainback type SDHW systems. I have also used them in wood-fired heating systems, radiant floor house heating systems with a domestic water heater, and custom-built spas. For more information on all types of heat exchangers and their use in solar domestic hot water systems, refer to *HP92*, "Heat Exchangers for Solar Water Heating."

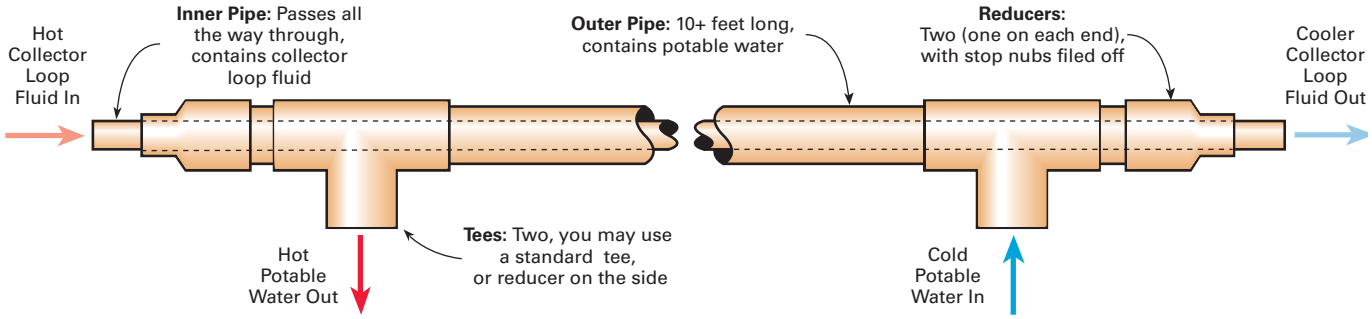
A Pipe Inside a Pipe

The tube-in-tube exchanger described here is simply "a pipe inside a pipe." This is accomplished by a very small and easy modification to a standard copper pipe fitting.

The fitting is called a "reducing coupler" or "coupling" (sometimes called a "bell reducer" because of its shape). But it must have the right kind of "stops." Normally this fitting is used to join two pipes of different diameters, and there are "stops" to prevent the smaller pipe from going too deep into its socket.

Bert Echt ready to solder together a heat exchanger.

Typical Tube-In-Tube Heat Exchanger



Some manufacturers create a ring or tiny shelf all the way around inside the smaller socket—you do not want this kind of stop. Other manufacturers just stamp two little dimples on the outside of the small socket to create two tiny bumps on the inside of the socket. This is what you must look for. Then just use a round file to remove these little inside bumps.

That's the secret! Now the smaller pipe can slide all the way inside the bigger pipe—a pipe inside a pipe. A tee at each end, on the large side of the bell reducer, connects the outer pipe to your cold water source. See the diagrams for different configurations.

Design

The design of a heat exchanger depends on its intended use. Obviously, the longer the pipes, the more heat will be exchanged. For a domestic hot water system, experience has taught me that 10 feet (3 m) is the minimum. To heat a house requires a *big* exchanger. Don't skimp on the exchanger—if undersized, it will be "choked" or bottlenecked, and not enough heat will be transferred. The greater the difference in temperatures (ΔT) between the liquids, the greater the exchange of heat. A ΔT on the order of 20°F (11°C) is typical. The exchanger configuration can be straight (vertical or horizontal), or in a coil if soft copper is used.

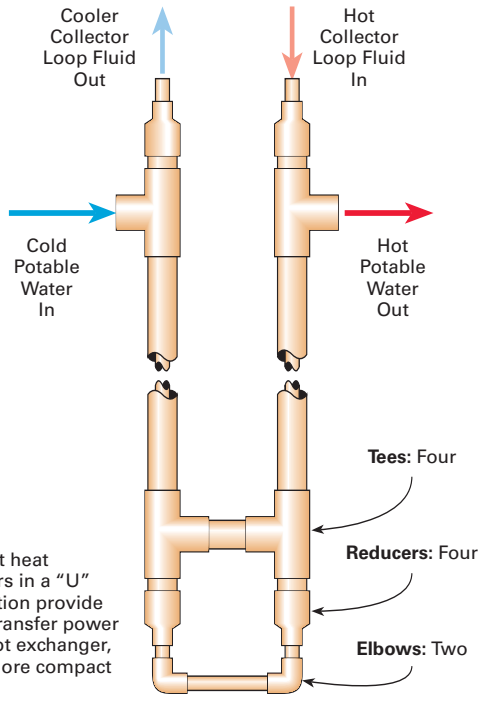
There are other considerations as well. Is the system circulated by thermosyphon or by pump? With thermosyphon systems, larger pipes are needed to make fluid flow easier. I recommend a $1^1/_2$ inch outside pipe with $^3/_4$ inch inside pipe for thermosyphon systems. With circulating pumps, 1 inch outside and $^1/_2$ inch inside works. The hotter fluid usually runs through the smaller pipe in the center, with the cooler domestic water running between the two pipes. This keeps the outer surface temperature cooler to minimize heat loss.

Single vs. Double Wall

Heat exchangers may be classified as either double wall or single wall. Double-wall heat exchangers have two layers of separation between the two fluids. The space between the two walls is usually vented, so any leak will become visible. Double-wall heat exchangers are usually required by code when a toxic heat transfer fluid such as ethylene glycol is used.

Single-wall heat exchangers only have one wall of separation between the two fluids. A single wall is more efficient than a double wall, since only one layer of thermally conductive material is between the two fluids. However, a failure in that wall will allow one fluid to mix with the other. For that reason, use only potable water (distilled is best) as the collector loop fluid in single-wall exchanger systems for heating domestic hot water. *Never use automotive antifreeze!*

"U" Configuration



Two 5 foot heat exchangers in a "U" configuration provide the heat transfer power of a 10 foot exchanger, but in a more compact space.

Materials & Tool List
for a U-shaped Heat Exchanger

Materials
- ❑ One, 1 inch by 10 foot, type L copper tube
- ❑ One, 1/2 inch by 10 foot, type L copper tube
- ❑ Four, 1 inch by 1/2 inch reducing couplers (with "dimple" stops)
- ❑ Four, 1 inch tees
- ❑ Two, 1/2 inch elbows
- ❑ Insulation, lead-free solder, flux, Mapp gas,

Tools
- ❑ Propane torch
- ❑ Flint box or sparker
- ❑ Abrasive cloth
- ❑ Flux brush
- ❑ Tubing cutter
- ❑ Water spray bottle
- ❑ Leather work gloves
- ❑ Round file
- ❑ Small fire extinguisher

The collector fluid is usually at a lower pressure than the potable water, so if an internal leak develops, the domestic water will move toward the collector fluid, and the pressure relief valve on the solar loop (set at 30 psi) will open. Of course, you should pressure test your exchanger with air at 60 psi for 24 hours, so there will be little chance of leaks.

External heat exchangers are common in small SDHW systems using conventional tanks. Internal coil-type heat exchangers are available with some commercially available tanks, but they are expensive. Large drainback tanks can be easily fitted with an internal coil-type heat exchanger. In smaller systems that use conventional hot water tanks for storage, it is easier to use an external heat exchanger. Standard practice for heat exchangers calls for two-pump, "counter-flow" operation—meaning that the hot fluid flows in the opposite direction from the cooler fluid.

Cost Effective Heat Exchanger

The cost of a 10 foot (3 m), U-shaped (5 feet; 1.5 m long) exchanger for a pumped system is approximately US$50. For a thermosyphon system, the cost is approximately US$100 or more, since larger tubes often come only in 20 foot (6 m) lengths.

These liquid-to-liquid heat exchangers can be easily made from standard copper plumbing tubing and fittings. But you need to know how to solder or "sweat," as plumbers call it. For a crash course, see the sidebar in *HP94*, page 55, "Soldering Copper Pipe."

Heat exchangers are a key element in a solar hot water system. With a few simple tools and some basic soldering skills, you can build your own from this homebrew design. It is efficient, durable, and inexpensive.

Access

Bert Echt, green builder, plumber, licensed master electrician, 63 Strong Rd., Ferndale, NY 12734 • 845-295-9221