A low-cost hybrid heat exchanger uses sheet copper and rigid plastic tubing. Copper is used only where actual heat transfer takes place, adjacent the drainpipe wall. All other components are plastic to lower cost. It pre-heats fresh cold water using waste heat from the drain such as from a shower drain. The heat exchanger comprises an inner copper conduit or drainpipe, a rolled sheet copper cylinder, an outer plastic tube and manifolds, and O-ring. On assembly, inserting the drainpipe results in the O-ring being compressed between the copper cylinder and the plastic tube. The result is a sealed water chamber wherein heat transfer takes place. The ends of the plastic tube have radially spaced water distribution holes into the chamber and inlet and outlet manifolds, each with water connections to the building’s cold water supply. A method of recovering heat from non-shower hot water uses using a separate reservoir is also disclosed.
HYBRID VERTICAL DRAINPIPE HEAT EXCHANGER

FIELD OF THE INVENTION

[0001] The present invention is in the field of heat exchangers and more particularly drainpipe heat exchangers for drainwater heat recovery from vertical drainpipes.

BACKGROUND OF THE INVENTION

[0002] Drainwater is a low-level heat source. As such it requires a low cost heat exchanger in order that home and building owners can recover its cost in a reasonable time.

SUMMARY OF THE INVENTION

[0003] While it may be used in a variety of heat transfer applications, instant heat exchanger’s use in heat recovery from a building’s wastewater drainpipe will be described in detail herein. The instant heat exchanger is suitable for both vertical and horizontal installations. When installed vertically it operates as a falling film heat exchanger where the drainwater flows circumferentially on the inner wall which maximizes the wetted surface area needed for heat transfer. Typically, vertical installations are limited in length by ceiling-to-floor dimensions in buildings which, in turn, limits the wetted surface area.

[0004] By moving the relative locations of its plumbing fittings, it can be used horizontally, where it is preferably made as long as possible to maximize wetted surface area for heat transfer which directly affects performance and cost-effectiveness.

[0005] The heat exchanger comprises a set of concentric cylindrical components. At the center is a conduit such as a standard drainpipe made of copper or other thermally conductive material.

[0006] Around it is a shorter cylinder of sheet copper (or other thermally conductive material). This cylinder is open along its length to define a small gap. Concentric with the cylinder and spaced from it (i.e., of larger diameter) is a outer tube of plastic or other rigid, low-cost material, which has a ring of spaced holes that are covered by a manifold at each end.

[0007] Next is a unique gasket-spacer, such as a common O-ring, that follows the perimeter of the copper cylinder and thereby defines the boundary of a sealed chamber one wall of which is the cylinder and the other the plastic tube. The inner openings of the ring of holes are also enclosed by the gasket.

[0008] The short cylindrical plastic manifolds are sealed to the outside of the plastic tube and have an internal circumferential groove and a water fitting. The fitting opens into the groove within which the outer openings of the ring of hole are located.

[0009] Thus water (or other fluid) for heat transfer with the central drainpipe, enters the sealed chamber at one end and exits at the opposite end of the outer tube.

[0010] Heat transfer takes place in the chamber, either heating or cooling, depending on the relative temperatures of the drainwater and the fresh water. For most uses heating of the freshwater will be the goal. However, for example, a drinking fountain can use the instant invention to cool the delivered water using draining cold water to cool fresh incoming warmer water.

[0011] The diametric dimensions of the components ensures that upon final assembly of the components, the first described drainpipe, which is inserted last, is a press fit into the cylinder which causes the O-ring to compress sealing the chamber.

[0012] Inside the chamber, the building’s normal water pressure exerts enormous force on the cylinder close the gap slightly to create an extremely tight clamping action around the drainpipe for maximum thermal conductivity. For example with water pressure of 50 psi and a cylinder area of 200 square inches, the circumferential clamping force onto the drainpipe is 10,000 pounds.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a cross-section of the heat exchanger also showing the water flow through the fittings, manifolds and chamber;

[0014] FIG. 2 is an exploded view of the outer tube and the manifolds;

[0015] FIG. 3 shows how the O-ring is shaped with its hoop ends and straight runs when installed adjacent the inner wall of the outer tube, and the two opposing O-ring rods located on the opposite wall of the outer tube;

[0016] FIG. 4 shows the central drainpipe and surrounding cylinder with its longitudinal gap;

[0017] FIG. 5 shows the relationship between the drainpipe, cylinder and O-ring and a representation of how the pins work to hold the O-ring. The pins actually protrude through the wall of the outer tube;

[0018] FIG. 6 shows the concentric layout of the components without the manifolds and showing pins protrude through the outer tube to engage the O-ring until it is secured in place on final assembly;

[0019] FIG. 7 shows how the cylinder could be made from a trapezoidal sheet to provide an angled gap;

[0020] FIG. 8 is schematic drawing of how the instant heat exchanger having a third centre manifold can be used to recover heat during batch water use situations where used hot water is draining from say, a dishwasher, but no cold water if flowing to the faucet or water heater. The separate reservoir will automatically thermostop its water supply through the heat exchanger thereby recovering heat from the drainpipe.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Referring to the drawings, FIG. 1 shows a cross section of the drainpipe heat exchanger 100. The central drainpipe 14 may be a common copper DWV (domestic waste vent) tube or pipe of any suitable diameter from, say, 2 to 6 inches. It may also be rolled and seamed from any suitable sheet material. In FIGS. 1 and 2 outer tube 1 may be of any suitable still material such as a PVC or ABS plastic tube or pipe capable of withstanding pressure from within and sized in accordance with the diameter of drainpipe 14. Outer tube 1 has fluid openings adjacent each end preferably in the form of a ring of holes 9 through the wall for fluid distribution.

[0022] Inlet manifold 4 (lower) and outlet manifold 4o (upper) have inlet 5 and outlet 6 fittings (inlet flow 15r, outlet flow 15b) and an internal circumferential flow channels 10 that communicate with their respective distribution holes 9 in outer tube 1. As shown in FIG. 2 the manifolds arrows indicate they are to be slid on over each end of outer tube 1. The distribution holes may be spaced and/or sized so as to optimize heat transfer performance. That is, more or bigger holes are better the further away they are from the fittings, 5, 6.
The manifolds 4 and 4a are orientated such that the inlet 5 and outlet 6 are positioned opposite to where the gasket O-ring gap 3c will be located on assembly. For horizontal operation, a third centralized manifold 4b may be added for the inlet 5 and the two end manifolds 4, 4a used collectively as outlet 6.

The manifolds can be fabricated from four parts: a short section of plastic tube with two spaced plastic rings 11 inside, and a plastic pipe fitting, all bonded together and defining a circumferential flow channel 10. Alternatively flow channel 10 may be formed internally by machining an internal groove in a piece of thick wall tube or pipe. The manifolds are bonded to seal and secure them to outer tube 1. The manifolds may also be fitted with O-rings (not shown) that seal against the outer wall of outer tube 1. Of course the flow channel 10 may be formed in the outer circumference of outer tube 1 instead of, or in addition to, its indicated location inside the manifolds 4, 4a (not shown). A plurality of flow channels may be formed using a plurality of elements extending between the O-rings.

A third manifold 4b (dashed outline) of the same design may also be added around the middle of the outer tube inclosing a ring of distribution holes (not shown) and with a water fitting. Using manifold 4b as the water inlet the water flow therefrom is both up and down (or left and right if horizontal, with gasket gap 3d downwards). In this way a remote water tank or reservoir can be plumbed inline with the instant heat exchanger to enable thermosiphonic flow therebetween for heat exchange with batch water flow.

Inlet manifold 4 may have a fluid pressure regulator fitted (not shown) to limit the internal pressure in chamber 15.

Cylinder 2 may be least expensive formed from sheet copper which remains open (un-seamed) along its length. Preferably it has at least one longitudinal flange 2a shown in FIGS. 4 and 6 that serves to index cylinder 2 in the O-ring gap 3d (FIG. 3) and prevent its unwanted rotation during assembly. Gap 7 enables cylinder 2 to clamp tightly onto drainpipe 14, first during assembly by means of the compression of O-ring 3, 3a, 3b, 3c, and then when installed, as a result of the enormous force created by the internal water pressure. Gap 7 also serves the important function of providing a vent or fluid path to the ambient in the event of a leak developing in the heat exchanger between the drainpipe 14 and cylinder 2 whereby a visible drip will signal a service requirement.

FIG. 1 shows how a open plastic hoop 20 (dashed outline) can be implemented to prevent erosion of the cylinder 2 from the jets of water that would otherwise impinge directly on the cylinder surface slowly eroding it.

FIG. 3 shows the gasket-spacer component which operates in a marginal area around the perimeter of cylinder 2. An O-ring may be used. It is slightly stretched to hook over pins 16 (FIGS. 2, 5, 6) to create the end hoops 3a separated by the straights 3. Pins 16 are preferably inserted through the wall of outer tube 1 where one end protrudes into chamber 15 and the other end terminates in flow channel 10. Alternatively pins 16 may be attached to cylinder 2. Opposite the O-ring straights 3 are two rear compressors 3c of similar gasket material that act as compression elements to ensure even compression of straights 3 along the length on either side of gap 7 of cylinder 2.

Once assembled the O-ring elements maintain a sealed spacing between cylinder 2 and outer tube 1 which defines a chamber 15 (FIG. 1) through which water flows for heat transfer therewith. Chamber 15 may have inserts to provide turbulent flow, such as plastic mesh, rings, beads and the like. Further this chamber 15 may be made to hold more or less water by altering the O-ring diameter including using large bore tubing or by adding a shaped spacer under the O-ring and bonded to the interior wall of the outer tube. In this way a reservoir is formed to hold a quantity of water. This would be advantageous in applications such as below a sink where a supply of hot water is undesirable due to plumbing or operational costs, as, for example, in a restaurant. With enough volume the instant heat exchanger can provide warm water at no cost and maintain a warm flow by using the draining used water to heat the incoming cold water.

Cylinder 2 may be fabricated with an angled gap 7a as shown in FIG. 7 which will avoid an unbalanced inwards force that would exist along the otherwise axial gap 7 where no water pressure is exerted.

FIG. 6 shows how the components are arranged concentrically, how pins 16 engage O-ring 3, 3a, how flange 2a engages the O-ring gap 3d, and how the O-ring is compressed between cylinder 2 and outer tube 1 defining chamber 15 (FIG. 1) and sealing same.

In FIG. 8 is shown how the instant heat exchanger 100 may be plumbed to include a separate reservoir 110 which is in turn, is plumbed to a water heater 120 (or a faucet, not shown) which supplies hot water via hot water branch 108. Mains water pipe 106 enters a building and splits into two branches: cold water branch 101 and hot water heater supply branch 102. All drainwater leaves via sewer connection 107. Hot water heater supply branch 102 enters the center manifold of heat exchanger 100 and flows both up and down (dashed arrows) to exit via the two end manifolds. The end manifolds are plumbed into reservoir 110 at its top 103 and bottom 104. Due to the physical property of fluids including water, hotter water is lighter or less dense that colder water. Therefore water in reservoir 110 naturally stratifies with the coldest being at the bottom which is continuous with water contained in heat exchanger 100. Any heat in drainpipe 14 will heat water in chamber 15 making it lighter. By natural convection it will therefore be displaced upwards by the heavier, colder water entering below. This thermosiphonic process continues automatically as long as the water in the chamber 15 is warmer than the water at the bottom of reservoir 110, the end result being that the water in reservoir 110 becomes warmer from the top down. Reservoir 110 is plumbed to hot water heater 120 which will therefore receive that warmed water when the next demand for hot water causes cold water from mains 106 to push all the warmed water in heat exchanger 100 and reservoir 110 into water heater 120 and finally into hot water branch 108 and out the opened faucet (not shown).

Note that with this arrangement lower branch 104 can see two way flow at different times (double-ended arrows): if there is cold water flowing through branch 102, flow through branch 104 (and branch 103) is to the left into reservoir 110; if only used hot water is draining, then the flow in branch 104 will be to the right into heat exchanger 100 because of the above described thermosiphonic phenomena.

Although the invention has been shown and described with respect to detailed embodiments thereof, it should be understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the spirit and the scope of the claimed invention.
I claim:
1. A vertical drainpipe heat exchanger for transferring heat from a drainpipe, said drainpipe heat exchanger comprising:
   a conductive layer surrounding said drainpipe;
   a gasket spacer, said gasket spacer having channels to permit flow of fluid therethrough adjacent said conductive layer; and
   an outer cylinder surrounding said gasket spacer, an inlet and an outlet within said outer cylinder to permit fluid access to said channels.
2. The vertical drainpipe heat exchanger of claim 1 wherein said conductive layer has a vertically extending opening therein.
3. The vertical drainpipe heat exchanger of claim 1 wherein said gasket spacer comprises an upper ring, a lower ring, and a plurality of legs extending therebetween.
4. The vertical drainpipe heat exchanger of claim 2 wherein said outer cylinder has a plurality of inlets and a plurality of outlets to permit fluid access to said channels.
5. The vertical drainpipe heat exchanger of claim 3 wherein said conductive layer has a vertically extending opening therein, said conductive layer having a flange adjacent said opening, said legs of said gasket spacer being located adjacent said flange and said opening.