This invention provides an economical helical polymeric heat exchanger that packages tightly for handling and then is quickly assembled to its full length prior to placement in either the ground or water.
PACKAGED HELICAL HEAT EXCHANGER

BACKGROUND ART

[0001] This invention relates generally to heat exchangers that are used for heating and cooling of buildings or of hot or chilled water for buildings or industrial purposes, and in particular to heat exchangers that are used to extract or discharge heat from and to the ground or large bodies of water, either stable (lakes or oceans) or moving (streams or rivers). Such heat exchangers are typically used in conjunction with closed-loop heat pumps that are able to transfer heat from a colder source to a warmer sink.

[0002] In the prior art, typical installations in the ground use a 6" to 8" diameter, 100- to 200-foot deep bore with a polymeric U-tube (typically of high-density polyethylene, HDPE) grouted in place to maximize heat transfer. These installations are relatively expensive and have the performance liability of allowing a relatively short heat transfer path from the downward supply tube to the upward return tube. Thus, in heat extraction mode, for example, warmer water returning from the bottom is being cooled by water flowing downward a few inches away. A better thermal solution for in-ground applications is a vertical, spiral heat exchanger with a straight supply or return near the center of the spiral. Excavation per foot of heat exchanger is typically much lower for spirals, using auger equipment well-developed for power pole excavation. These relatively shallow bores do not puncture impervious soil layers below 30' deep, thus limiting the dangers of surface contaminants penetrating downward into water supply layers.

[0003] Spiral ground exchangers were pioneered in the US beginning in the 1990's, typically with installations of spirals 18" to 36" in diameter and 20' to 35' deep. The first of these used HDPE pre-wired to cylindrical reinforcing steel cages formed from either reinforcing bars or wire mesh. Beginning in 1997, this inventor developed a "suspender" design that allowed compact packaging of the heat exchanger and elimination of the steel cage. This work was carried out with support from the California Energy Commission, as fully and publicly reported in 1999. No patent application was filed, and subsequently European patent EP1992886A2 was issued in 2008 covering precisely the concept demonstrated in the two California projects summarized in the 1999 reports that apparently were not discovered in connection with the European patent.

[0004] Work on the California ground helix was tabled for business reasons in 2000. Development work was resumed in 2012 on the improved version of the helix described here. The improved design does not rely on gravity to extend the helix into its final, working position, and also allows the heat exchanger to be used in bodies of water where a non-vertical helix working position is advantageous. These helical heat exchangers are typically polymeric but may also be made of soft copper to contain a refrigerant instead of an aqueous liquid.

SUMMARY OF INVENTION

Technical Problem

[0005] Vertical-helix ground exchangers are a cost-effective alternative to deep bores for geothermal heat pump applications, and “suspender” helix designs facilitate compact handling before the exchangers arrive at the jobsite. But the suspender designs require both a support rig to hold them in suspended position for deployment and backfill, and strong, supportive attachments between the rig and the suspenders. This need can be structurally challenging, since in its suspended position the helix may not reach the bottom of the hole. In this case the entire weight of the heat exchanger and the (often considerable) backfill soil or sand that clings to it must be carried by the exchanger and its support rig. Also, the support rig interferes with the backfill operation, and may require installers to lean into a very deep hole to connect and disconnect the helix to/from the suspension rig. Finally, the suspender helix design does not facilitate installation in water where a horizontal position is more stable and better protected from damage.

Solution to Problem

[0006] The solution provided by this invention is to add two-to-four inexpensive vertical supports that intermittently connect to the circumference of the helix and extend it to full length. This solution provides enough rigidity that a helix 20' long (full) can be easily tilted and slid into a deep augured hole. No support rig is required. The assembled helix then rests on the bottom of the hole, so that backfill material is not continuously trying to pull the helix further down. Delivery to the jobsite includes one or more tightly packed helical heat exchangers, and linear compressive members, typically inexpensive rigid PVC pipe that quickly secure to the flexible strips that determine the final coil spacing of the helix. These compressive members provide sufficient rigidity for placing the fully-extended helix either into a bored hole (typically with the axis of the helix vertical), or into a body of water (typically with the axis of the helix horizontal).

Advantageous Effects of Invention

[0007] This invention provides an improved, more versatile geothermal heat exchanger that can be installed more quickly and can better survive installation hazards for ground burial applications, compared to previously-used “suspender” helix designs. The invention also facilitates installation in bodies of water in non-vertical positions where gravity alone would not hold the helix in a fully-extended position. It eliminates the need for placing and removing a holding jig during onsite deployment of the helix, and minimizes the likelihood of damage during placement in the ground, by assuring that the helix is supported at the bottom of the augured hole.

BRIEF DESCRIPTION OF DRAWINGS

[0008] The following description of a principal embodiment of the invention refers to four drawings:

[0009] FIG. 1 is a cut cross sectional view of the assembled helix in a vertical-axis orientation.

[0010] FIG. 2 is a cut top view of the helix of FIG. 1 showing both top and middle segments of the helix.

[0011] FIG. 3 is a close-up view taken from FIG. 1, showing key features at a middle segment of the helix.

[0012] FIG. 4 is a close-up view taken from FIG. 1, showing key features at the top and bottom of the helix.

[0013] FIG. 1 shows a wound helix 1 held in its final configuration by flexible straps 2, holding clips 3 and 4, and compression members 7. The helix 1 performs as a closed loop heat exchanger with liquid entering through inlet tube 5 to enter helix 1 at one end (typically the bottom for vertical in-ground applications). Liquid flows upward through helix 1...
to emerge through exit 6. Contact with the ground or water causes the liquid to be heated or cooled as it passes through the helix. (In water applications the helix will most often be positioned with its axis approximately horizontal, so the assembly rests on the bottom of either a stationary or flowing body of water.) Horizontal ground applications are also possible.

[0014] For illustrative convenience these drawings show four sets of straps 2, compression members 7, and clips 3 and 4 at 90 degree spacing around the circumference of helix 1. Since each set adds additional material and labor costs, the only rationale for more than three sets is redundancy; one strap could fail during backfill and the helix could still maintain fairly uniform coil spacing.

[0015] In a typical embodiment, helix 1 of continuous high density polyethylene (HDPE) tubing has diameter of approximately 24" and the outside tubing diameter is 0.625" or 0.75", with total helix length approximately 20', and helical coil spacing of about 6". These dimensions provide effective heat exchange performance with modest pressure drop for the heat exchange liquid, which is typically water or an anti-freeze/water solution.

[0016] As in prior designs, the helix 1 arrives at the jobsite with the helical coils tightly packed to facilitate handling. Flexible straps 2 allow the coil to be compressed for tight packing, with clips 3 and 4 pre-secured intermittently at intersections of the helix 1 and straps 2. Clips 3 have through holes that allow compression members 7 to slide through, as further shown with reference to FIG. 2 and FIG. 3. Clips 4 at both ends may be with or without through holes, as further discussed with reference to FIG. 2 and FIG. 4.

[0017] FIG. 2 shows, in upper/right half and lower/left half, respectively, how clips 3 and 4 respectively interact with helix 1, strap 2, and compression member 7. Clips 3, located on middle coils of helix 1, are spaced approximately every 6 coils. Clip 3 is a short polymeric channel that can either be cut and drilled from an extrusion, or injection-molded. At its inner edge it is secured, preferably by adhesive, to strap 2 and to helix 1. In a preferred embodiment, strap 2 wraps both ways around helix 1 as further described with reference to FIG. 3. Compression member 7, typically a 20' long nominal ½" PVC pipe that is 0.84" diameter, inserts through holes 8 in clips 3. While clips 4 at the top and bottom of helix 1 may be identical to clips 3, and fastened to compression members 7 as further described with reference to FIG. 4, they may also, as shown, be without holes so that compression members 7 dead-end against the middle surface of channel clip 4. Since helix 1 favors its compacted position when first extended, members 7 tend to “stretch” the coil when they dead-end against closed clips 4.

[0018] FIG. 3 provides additional detail on the assembly at middle coils that use clips 3. A preferred embodiment of strap 2 is shown as a two-layer assembly surrounding helix tube 1. Both straps are adhesive-coated tapes, and are deployed with adhesive face-to-face. Each clip 3 has a middle segment 3a, a long leg 3b, and a short leg 3c. The outside of leg 3b adhers to strap 2a to help hold the helix 1 in position, and strap 2b adhers to the inside of leg 3b to further secure clip 3 to strap 2a. Compression member 7 inserts through slighly oversized hole 8 in middle segment 3a, and leg 3c helps retain an orthogonal relationship between clip 3 and member 7. Above and below clip 3, strap 2a is continuous, and cover straps 2b extend over approximately five coils to either the next clip 3 or to a clip 4 at the top or bottom of the helix, as shown with reference to FIG. 4.

[0019] FIG. 4 provides additional detail on the assembly at the end coils, where end clips 4 are adhered to main strap 2a before helix 1 is wound. Each clip 4 has a middle segment 4a, a long leg 4b, and a short leg 4c. The outside of leg 4b adhers to strap 2a such that middle segment 4a is just outside the last coil of helix 1, and strap 2b adhers to the inside of leg 4b to further secure clip 4 to strap 2a. Compression member 7 dead-ends against middle segment 4a, and leg 4c helps retain an orthogonal relationship between clip 4 and member 7. To prevent possible separation during handling and placement, self-drilling screw 9 may be driven through leg 4c into member 7. While FIG. 4 shows the top of a vertical-axis helix, it should be clear that turned upside-down, it also represents the bottom; or sideways, either end for a horizontal deployment in either earth or water.

1. A helical liquid-to-ground or liquid-to-water heat exchanger of continuous tubing with at least two flexible straps that securely hold the tubing, establish a maximum helical pitch, and allow compact packaging before installation, with at least two linear compression members that secure to the straps just prior to installation, where the compression members cause the heat exchanger to be installed in its extended position.

2. Claim 1 where the compression members secure to clips along the straps.

3. Claim 1 where the compression members insert through openings in clips along the straps.

4. Claim 1 where the compression members are retained with fasteners to the clips at both ends of the helix.