Innovative high efficiency closed loop ground coupled heat exchanger (GCHE)

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Scope

✓ Categorization of shallow geothermal energy systems

✓ Short presentation and description of common closed loop GCHEs and its materials

✓ Allocation of standards for GCHEs, drillings and its materials in European and international level

✓ Description and analysis of the innovative high efficiency closed loop GCHE

✓ Advantages of the innovative high efficiency closed loop GCHE
Categorization of shallow geothermal energy systems

The shallow geothermal energy systems are classified in two main categories:

- **Open loop GSHPs**
- **Closed loop GSHPs**
Open loop GSHP

Winter

water table
Production well
Injection well

Pump
Closed loop GSHPs

Heating system

Vertical Ground Coupled Heat Exchanger (GCHE) single U-loop

\[ T_{soil,\text{winter}} = \Theta \degree C \]

Cooling system

Vertical Ground Coupled Heat Exchanger (GCHE) single U-loop

\[ T_{soil,\text{summer}} = \Theta \degree C \]
Closed loop GCHEs

$1.2 < H < 2 \text{ m}$

$H \text{ (m)}$

$50 < H < 150 \text{ m}$

$H \text{ (m)}$

$U\text{-loop}$
## Common materials of closed loop GCHEs

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full name</th>
<th>Material</th>
</tr>
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<tbody>
<tr>
<td>PE</td>
<td>Polyethylene</td>
<td>Polyethylene&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
<tr>
<td>PE-100&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>Polyethylene</td>
<td>Polyethylene&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
<tr>
<td>HDPE</td>
<td>High-Density Polyethylene</td>
<td>Polyethylene&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
<tr>
<td>PE-X</td>
<td>Cross-linked Polyethylene</td>
<td>Polyethylene&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
<tr>
<td>PE-RT</td>
<td>Raised Temperature resistance Polyethylene</td>
<td>Polyethylene&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
<tr>
<td>DXHEs</td>
<td>District EXPansion HEat Exchangers</td>
<td>Copper</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> The Minimum Required Strength (MRS) at 50 years and 20 °C is 10 MPa (100 bar)

<sup>(2)</sup> Different names: polyethene or polymethylene. PE is usually a mixture of similar polymer of ethylene.
Allocation of standards in European and international level

Standards for GSHEs, drillings and for materials of HPs, GSHEs and drillings

- **EU standards**: 13 (54%)
- **International standards**: 9 (38%)
- **National standards in EU**: 2 (8%)
Description of the innovative high efficiency closed loop GCHE

The innovative GCHE is officially protected since January 2014 by a Greek patent \(^{(1)}\), while protection at European level is pending.

The innovative GCHE achieves:

a) higher exploitation degree (%) of the internal thermal energy (U) of the medium,

b) decrease of the manufacturing cost (€),

c) decrease of the installation cost (€),

\(^{(1)}\) Patent number 1008091 in Greek Industrial Property Organization (OBI)
Description of the innovative high efficiency closed loop GCHE

d) solution for the corrosion problems in the case of metallic pipes

e) decrease of the length (m) of the borehole drilling in vertical systems and

f) decrease of the required application area (m²) in horizontal systems.

This invention is achieved better extraction and/or rejection from or to the subsurface or the aquatic environment than any other geometric pattern of closed loop GCHE.
Analysis of the innovative high efficiency closed loop GCHE

(1) Innovative GCHE in helical pattern
(2) Nozzle of the inlet
(3) Nozzle of the outlet
(4) Inflow
(5) Outflow
(6) Polymer plastic pipe
(7) Metallic block
(8) Metallic mechanism
(9) Heat exchange metallic rods
(10) Links
(11) Coils
(12) Polymer plastic block
(13) Borehole
Analysis of the innovative high efficiency closed loop GCHE

This innovation can be applied to horizontal pattern as well as in other variant respectively.
Advantages of the innovative high efficiency closed loop GCHE

The patented GCHE presents, among others, advantages as following:

✓ exploitation of the internal energy of the medium in optimal levels,

✓ higher thermal extraction and/or rejection is achieved by the placement of the particular metallic mechanism which can be mounted to any closed loop GCHE,

✓ equivalent heat extraction and/or rejection to a polymer GCHE, but with a shorter length and a smaller diameter,
Advantages of the innovative high efficiency closed loop GCHE

- the lifetime of the innovative GCHE is much higher compared to those using metallic pipe (DXHEs) and equivalent to those using polyethylene pipes (common GCHEs),

- for horizontal patterns leads to the substantial reduction of required available area ($m^2$) around the application and for vertical patterns to the high decrease of borehole’s depth (m),
Advantages of the innovative high efficiency closed loop GCHE

- noticeable cost reduction for installation and manufacturing in comparison with common GCHEs.
Conclusions

It is expected that the use, production and commercialization of the patented GCHEs may facilitate further diffusion of GSHPs contributing, among others, to the reduction of CO$_2$ and other gas emissions, to environmental protection, to energy savings and to the creation of new jobs.

The installation and further development of the previously described innovative closed loop high efficiency GCHE is recommended considering that GSHP technology is regarded as the future technology for solving the heating/cooling and/or domestic hot water supply needs, facilitating the creation of zero emission communities.
Thank you for your attention

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