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Fully Downhole Heat Exchange System on Utilization of Medium-Deep Geothermal Energy

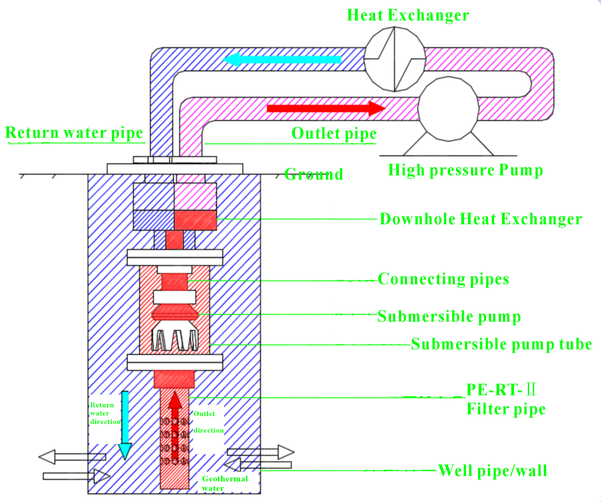
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INTRODUCTION

The utilization of medium-deep geothermal energy has attracted international community since its prospect in the global energy structure transformation and advantage of cleanness and stableness. Heat exchange system has increasingly become an efficient way to develop and utilize medium-deep geothermal energy. However, its popularize applications have been limited in some regions in China due to some strict policies on groundwater and geothermal resources. In order to overcome these limitations and promote the widespread use of heat exchange system, we propose an innovative fully downhole heat exchange system integrating optimized downhole heat exchangers, downhole submersible pumps as well as some wellhead equipment. The features of our proposed system include fetching heat but no water, groundwater staying only underground without coming out of the ground surface, guaranteeing no loss of heat transfer efficiency. This fully downhole heat exchange system paves a way for large-scale deployment of medium-deep geothermal resources, contributing to global decarbonization goals with minimal land use and carbon emissions.

SYSTEM OVERVIEW

The Fully Downhole Heat Exchange System on Utilization of Medium-Deep Geothermal Energy comprises a subsurface high-efficiency heat exchange system, a surface heat exchange testing platform, and a surface monitoring system. This system ensures that geothermal water remains underground during heat exchange, maximizing heat transfer efficiency while minimizing resource depletion and environmental impact. Geothermal water remains entirely underground, with heat extraction occurring without water consumption during the heat exchange process.



DESIGN AND EQUIPMENT

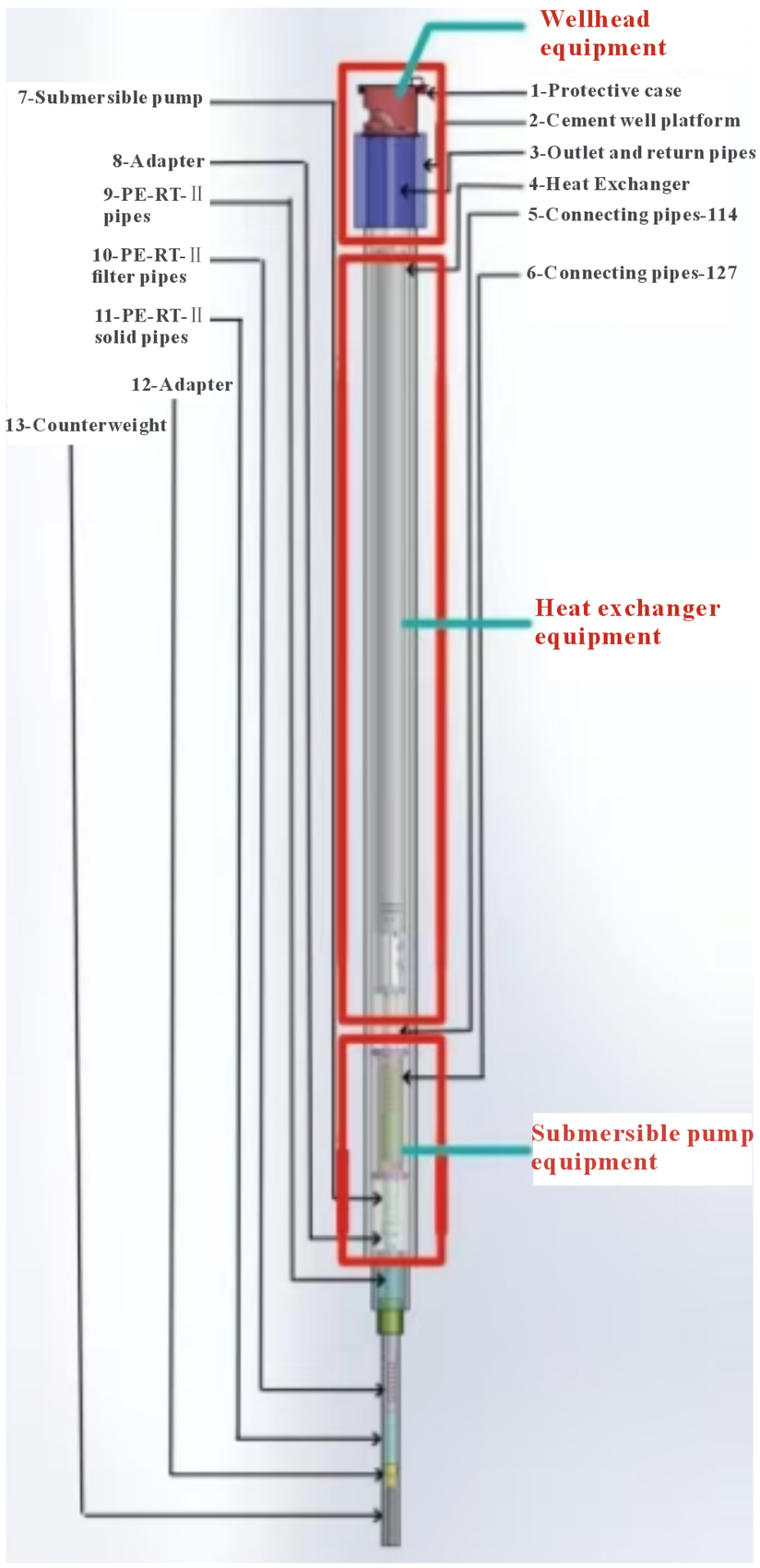
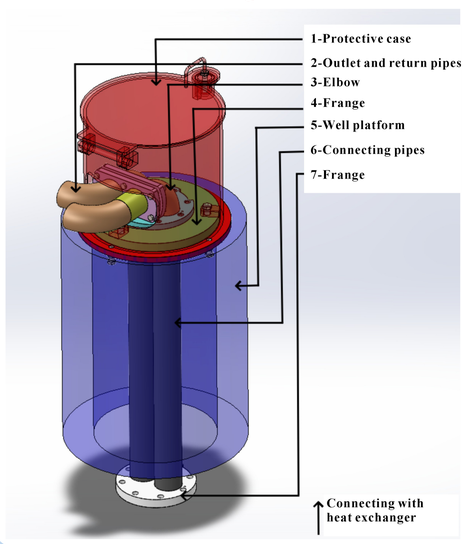


Figure 1. Schematic diagram of the fully downhole heat exchange system as well as the equipment.

WELLHEAD EQUIPMENT



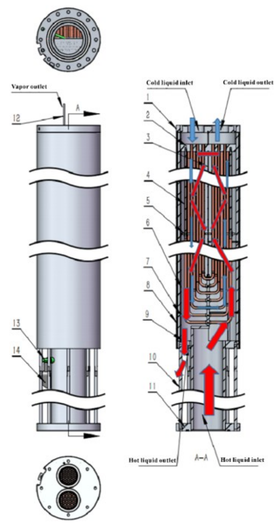
The wellhead equipment is an important component of the fully downhole high-efficiency heat exchange system. It can secure the inner heat exchange tube, connect the downhole equipment with surface equipment, and simultaneously serve as an innovative wellhead protection device.

The wellhead equipment consists of a top cover, cylindrical body, connecting plate, connecting flange, fastening bolts, and specialized lock and key. The top cover is made of 10mm thick steel plate, formed in a single piece using a laser cutting machine, ensuring precise dimensions and smooth edges. The cylindrical body is made of a 10mm thick seamless steel pipe and is assembled with the top cover through welding and pins.





HEAT EXCHANGER EQUIPMENT



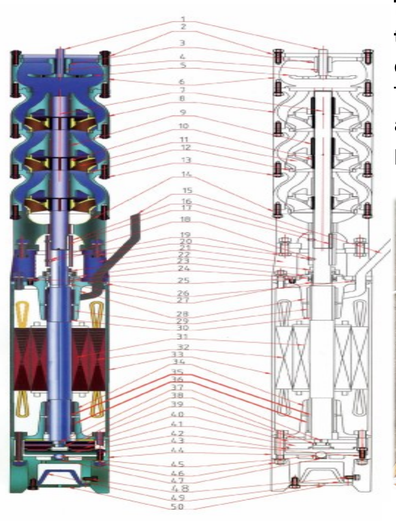
No.	Name
1	Flange
2	Iron tube
3	Partition plate
4	Heat exchanger tube
5	Baffle plate
6	230 Barrel
7	Reinforcement plate
8	260 Barrel
9	Flange
10	Connecting Bolt
11	Flange
12	Vapor outlet
13	Temperature sensor
14	Flow meter sensor

This new type of shell-and-tube heat exchanger is designed for vertical use within the borehole. It mainly consists of highly conductive copper tubes, stainless steel tube sheets, a shell, and baffles.

Geothermal water enters through port C. After entering the shell, the hot water flows through the gaps formed outside the heating copper tubes. With the enhanced turbulence provided by the baffles, the hot water and the cold water inside the copper tubes undergo thorough heat exchange, and finally, the water exits the heat exchanger through port D. Cold water flows in through port B, is distributed by the upper tube sheet and the distribution plate into each copper heat exchange tube, and eventually flows upward through the upper tube sheet and exits from port A. The copper tubes carrying hot and cold water act as intermediaries, completing the heat exchange through counterflow.



SUBMERSIBLE PUMP EQUIPMENT



The submersible pump equipment is designed to meet the needs of geothermal water extraction and circulation in the fully downhole heat exchange system. It can ensure the normal operation of the system and improve heat exchange efficiency.

The equipment is divided into the pump core and the pump casing. The pump core is researched and designed, opting for a variable frequency, high-temperature-resistant submersible pump; the pump casing is researched and designed, choosing Belay insulated steel pipes.





CONCLUSION

Our work focused on the high-efficiency of heat exchange systems for utilization of medium-deep geothermal energy, making a series of achievement in design, equipment development, and construction methods. These achievements could provide technical support for the application of heat exchange systems in medium-deep geothermal utilization, especially in the regions with strict policies on the extraction of groundwater and geothermal water.

We have successfully designed, developed, and manufactured the key equipment for the fully downhole heat exchange system, including wellhead equipment, heat exchanger equipment, and submersible pump equipment. These equipment have been tested, and the relevant parameters meet design requirements, possessing the corresponding performance capabilities. They can achieve functions such as safety, protection, connectivity, as well as efficient downhole heat exchange and safe, efficient utilization of geothermal water, ensuring the smooth operation of the fully downhole heat exchange system for the utilization of medium- deep geothermal energy.

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