Proceedings World Geothermal Congress 2026, Calgary, Canada, June 8—11, 2026

Development of Key Supporting Tools for Abandoned Well Retrofit into Geothermal Wells

Pengpeng Ma*, Peiyi Wang, Hongyan Li
Sinopec Star Petroleum Corporation Limited, Beijing 100083, China
*E-mail: mpp999@163.com

INTRODUCTION

Oil regions host a significant number of abandoned oil and gas wells. Global statistics indicate the current inventory of abandoned wells ranges between 20 and 30 million. Major oilfields in China also contain numerous idle abandoned wells, representing a substantial wastage of resources. Furthermore, drilling costs constitute 40% to 60% of the total project expenditure for hydrothermal medium-deep geothermal resource development. In non-oilfield geothermal projects, persistent efforts are made to minimize drilling costs to enhance project economic viability.

Consequently, repurposing abandoned wells from major oilfields for geothermal energy development can unlock new economic value from these dormant assets, reduce overall geothermal project costs, improve economic returns, and accelerate the expansion of geothermal energy utilization. This approach offers significant economic benefits alongside social and environmental advantages. This study focuses on the Dongpu Sag within the Zhongyuan Oilfield as a case study. Based on the wellbore structure characteristics and remediation techniques applicable to abandoned wells in the Dongpu Sag, this paper identifies the requisite downhole tools for well conversion. It further details the development of key specialized tools essential for retrofitting abandoned wells into geothermal production wells. This work establishes a technical foundation for subsequent abandoned well conversion projects in the Dongpu area and provides valuable insights for similar initiatives in other oilfield regions.

DOWNHOLE TOOL REQUIREMENTS

A common characteristic of the abandoned wells is that both the technical casing and the production casing extend from the wellhead to the target depth. This results in two to three layers of casing overlapping in the surface section, leading to an excessively small inner diameter of the innermost casing string. This prevents the installation of the multi-stage submersible pumps commonly used in geothermal production. The primary procedures for converting regional abandoned wells into geothermal wells include:

①Plugging the original production zones located below the target geothermal reservoir.

②Cutting and retrieving the original technical casing and production casing of the abandoned well, typically leaving only the surface casing in place, and subsequently sealing the annular communication path created between the cut casing tops and the surface casing.

③Selectively perforating the target geothermal reservoir zone to establish a flow path for geothermal water. For sand-prone reservoirs, installing sand control screens is necessary.

Based on these procedures, the essential tools required for abandoned well conversion primarily include: casing cutting tools, tools for isolating and sealing the wellbore after casing cutting, and sand control completion tools including sand control screen assemblies.

HYDRAULIC JET CUTTING TOOL AND WATER ISOLATION TOOLS

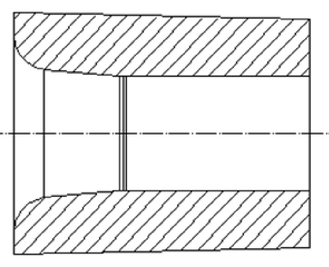
Hydraulic jet cutting technology is an improvement and optimization based on hydraulic sand jet perforation technology. This technology retains the advantages of shaped charge cutting, such as simple operation and low cost, while producing a flatter cut end on the casing and simplifying the overall process. Furthermore, adjusting the surface pump pressure allows for cutting casings of different sizes, offering operational flexibility and a wide application range. The processed hydraulic cutting tool is shown in Figure （Left）.

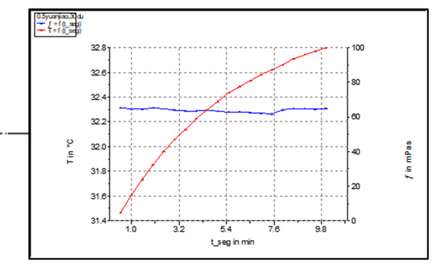
Structural Optimization: Based on nozzle structure analysis, the cone entrance structure was optimized for hydraulic jetting applications. The nozzle flow channel features a smooth conical front section and a cylindrical rear section, as shown in Figure （Middle）.Material Optimization: Tungsten carbide (WC) and boron carbide (B_4C) were selected as the primary materials, along with additives. The sintering process was optimized to develop cemented carbide (WC/Co) and B4C ceramic nozzles.

Calculations indicate that during jet cutting, the fluid velocity through the nozzle ranges from 160 -210 m/s, the maximum nozzle pressure differential is 31.1 MPa, and the resulting thrust force on the nozzle is 5.4 kN, meeting the requirements for casing cutting.

Carrier fluids were prepared with guar gum concentrations of 0.4%, 0.5%, and 0.6%. The abrasive used was quartz sand with a sand concentration of 4%. Suspension and settling experiments were conducted at room temperature for each fluid. Based on the experimental results:The 0.5% guar gum carrier fluid, with a viscosity of 66 mPa·s and a settling time of 4 minutes, offers suitable viscosity and suspension characteristics, meeting the requirements for field casing cutting operations. The viscosity-temperature curves are shown in Figure (Right）.





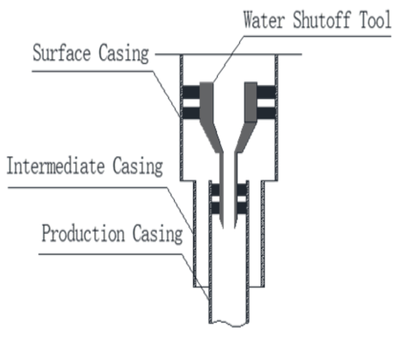


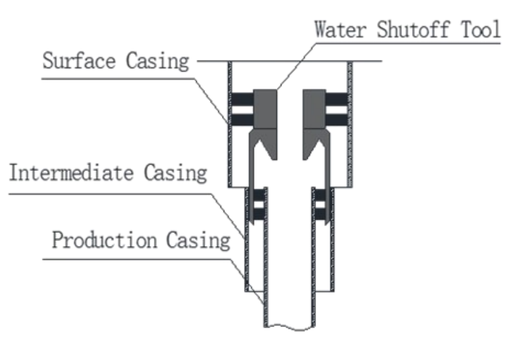
After casing cutting is completed, the annular space between the cut casing string and the adjacent outer casing becomes connected. To prevent shallow surface water from mixing into the wellbore through this connection during production (which would affect geothermal water temperature) and also to prevent geothermal production water from infiltrating and contaminating shallow freshwater aquifers, two sets of casing end sealing/water isolation schemes and corresponding tools were developed.

Insertion Seal Scheme: The isolation tool comprises two sections of water-swelling rubber packers. The upper section, with a larger diameter, seals against the surface casing. The lower section, with a smaller diameter, seals inside the bore of the innermost cut casing string, as shown in Figure （Left）.

Encapsulation Seal Scheme: The sealing tool features an integrated design for sealing both the surface casing and the cut casing string. It consists of an inner sealing rubber and an outer sealing rubber. The guide shoe at the tool's front end directs the cut casing end into the interior of the isolation tool. The outer rubber seals against the inner wall of the surface casing, while the inner rubber seals against the outer wall of the innermost cut casing string, as shown in Figure （Middle）.

Based on Scheme 2 (Encapsulation Seal) and the selected swelling rubber, a water isolation tool was manufactured and subjected to laboratory application tests to verify its reliability. The physical water isolation tool is shown in Figure (Right）.







SAND CONTROL TECHNOLOGY AND SCREEN DEVELOPMENT

Based on the analysis of sand samples from regional geothermal wells, a precision micro-porous composite screen for geothermal well sand control was developed, the structure is shown in Figure (Left). A schematic diagram of the sand control completion is shown in Figure (Right). Operational Procedure:

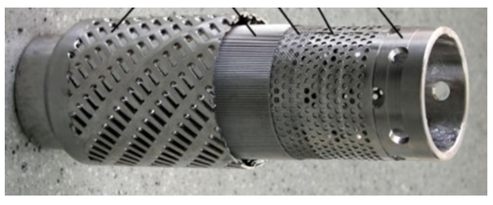
①Assemble the drop-off hanger packer and sand control screen onto the work string and run in hole to the designed depth.

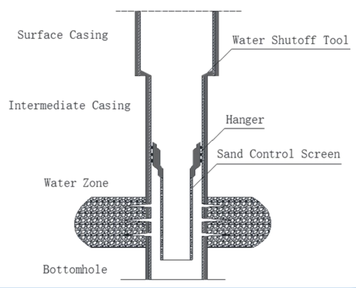
②Drop a ball and allow it to seat. Apply pressure (15-18 MPa) inside the work string to set the packer.

③Maintain pressure for 5 minutes. Continue increasing pressure to 20-22 MPa until a sudden pressure drop to zero occurs, indicating the drop-off mechanism has released.

④Pull the work string up 3-5 meters, then slowly lower it, applying a set-down weight not exceeding 30 kN, to verify the packer is securely set.

⑤Retrieve the work string, completing the operation.





CONCLUSION

(1) The Dongpu Sag area of the Zhongyuan Oilfield contains a large number of abandoned wells. Their common structural characteristic is that both the technical casing and production casing extend from the wellhead to the target depth, resulting in overlapping casing strings in the surface section and an excessively small innermost diameter, preventing the installation of standard multi-stage submersible pumps used in geothermal production. Converting these wells into geothermal wells requires the development of specialized downhole tools.

(2) Two sets of casing cutting solutions with corresponding tools, two types of water isolation tools for sealing the tops of cut casing strings, and sand control technology including specialized screens for the converted geothermal wells were developed. Tool designs were finalized, prototypes manufactured, and laboratory tests were conducted to verify their reliability, thereby establishing a technical reserve for regional abandoned well conversion projects.

(3) The key tools developed for converting abandoned wells into geothermal wells are based on the current state of abandoned oil and gas wells in the Dongpu Sag. The technical principles of these tools are applicable to abandoned well conversions in other major oilfields. However, the specific manufacturing parameters of the tools need further verification and optimization based on the characteristic parameters of abandoned wells in other oilfield regions.

Acknowledgements

This research was financially supported by the Sinopec Science and Technology Project (Grant Nos. P25205).

REFERENCES

GUO Xusheng. Discussion and Research Direction of Future Onshore Oil and Gas Exploration in China[J]. Earth Science,2022,47(10):3511-3523.

WANG Jiyang, QIU Nansheng, HU Shengbiao, et al. Advancement and developmental trend in the geothermal of oil fields in China[J]. Earth Science Frontiers,2017,24(03):1-12. DOI:10.13745/j.esf.2017.03.001.

LI Desheng, LI Bohua. Towards a new era of diversified energy development: Innovation in theoretical petroleum geology to meet “dual carbon target”[J]. Earth Science Frontiers,2022,29(06):1-9. DOI:10.13745/j.esf.sf.2022.8.57.

WANG Peiyi, MA Pengpeng, LIU Jinxia, et al. Research of processing technology for transforming abandoned wells into geothermal wells[J]. Geology and Exploration,2017,53(04): 788-793. DOI:10.13712/j.cnki.dzykt.2017.04.019.

WANG Dengfeng, WANG Peiyi. Scheme of acid washing to heat reservoirs in geothermal wells reconstructed from abandoned wells in oil fields[J]. Geology and Exploration,2021,57(02):430-438.