WELL COMPLETION IN EUROPEAN GEOTHERMAL APPLICATIONS - BEST PRACTICE AND PROJECT EXAMPLES

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ABSTRACT

Well completions in challenging geothermal applications require reliable as well as durable equipment and an experienced service on-site. Based on best practices in numerous geothermal projects, the design, material and components of wellheads are modified to the special needs in differing conditions. The equipment should guarantee a maximum of operational availability, while running nearly maintenance-free for many years. All components have to be highly secure and meeting API 6A and permit authority requirements. Furthermore, professional advice and expert service during all project phases is an important success factor. For operators and permit authorities a comprehensive documentation is necessary, in order to assure the traceability of the certified materials used. In the Bavarian Molasse Basin in Germany, several geothermal projects are successfully realized these days. An interesting example is the deepest and most productive German well in Traunreut.

The paper will mention the general purpose of a wellhead as completion component, reflect on new requirements of recent times and describe the technical solutions based on selected examples for geothermal applications. Finally, the advantages in planning and benefits for wellsite operators as a result of these developments in engineering and design will be shown.

1. INTRODUCTION

In general, a wellhead represents the interface between surface and subsurface installations at a wellsite. Its main functions are the suspension of casing and tubing strings, providing pressure control and enable access to the different annuli. These functions are essential and common for all kinds of wellheads, whether they are used for oil or gas production wells, gas storage in caverns, depleted fields or aquifers, or for geothermal applications. Depending on their purpose, wellheads may incorporate a large variety of features in addition to the above mentioned main functions.

This paper will focus on wellheads for geothermal installations with high safety requirements. Commonly these wellheads are designed for a service life of about 20-30 years of constantly fulfilling the highest safety standards.

These circumstances, in addition to the rising complexity of subsurface installations, which also influence the wellhead design, have led to several developments in wellhead technology for geothermal wellheads. Some of them will be mentioned in chapter 3 and presented in detail with a look on geothermal applications in chapter 4.

Picture 1 shows a typical setup for a state-of-the-art geothermal wellhead.

Picture 1: Geothermal Wellhead Freiham

2. REQUIREMENTS AND DEVELOPMENTS IN WELL COMPLETION

Over the last years well completions have become more and more complex, comprising different subsurface equipment. This also reflects on the wellhead design since the operation of these devices mostly has to be conducted via the wellhead. Exemplary the implementation and installation of various cables and control lines for subsurface devices like pumps or safety equipment can be mentioned. These items often demand an easy installation, handling for maintenance, protection against possible damages and shut off functions which have to be ensured by the wellhead equipment or additionally attached parts.

Already in the phase of installation for wellhead equipment different requirements concerning an easy handling and mounting of the single wellhead parts exist. To tackle these challenges, reductions in dimensions as well as the application of studded or even fewer flange connections have been realized. This also bears advantages for maintenance purposes since it may facilitate the replacement of single parts or assemblies.

Further requirements reflecting in wellhead design may be certain demands for executing workover, wireline or coiled tubing interventions. This has led to interface standardized connections, which are necessary especially in geothermal applications where downhole pumps repeatedly get replaced due to maintenance or the change of production and injection well.

Derived by different subsurface completion setups and thereby related installation methods for casing and tubing strings, several technical solutions for their suspension in the wellhead have been developed. Depending on the casing weight, possible pre-stressing or operational issues, a variety of suspensions with rams or bolts can be realized.

Over the last decades, operators of geothermal plants and permit authorities have raised their requirements to reach higher safety standards which in turn can also improve public acceptance for geothermal projects. In the course of these elevated requirements a great amount of developments have been made within the last years. One example is the establishment of metal-to-metal sealing ball valves as standard valves for geothermal wellheads. This not only enhances safe operations, but [it] also allows controlled maintenance.

Meanwhile, the surveillance of internal wellhead areas by different types of control and test ports integrated in wellhead components is state-of the-art and contributes to the operational safety.

The next chapter cites concrete examples of technical solutions which have been developed due to different requirements as mentioned beforehand.

3. EXAMPLES FOR DEMANDS AND TECHNICAL SOLUTIONS REGARDING GEOTHERMAL APPLICATIONS

The following examples give a closer look on some of the latest technical developments in wellhead design and technology, such as counter measurements for the scaling effect, the benefits of the use of modular components, how a pump actuation is realized and why documentation is an essential part of geothermal projects. They are derived from customer's demands which are driven either by their own requirements or restrictions by the regulatory authorities. Reasons for these demands are the achievement of a higher flexibility in installation and operation, the growing challenges of sophisticated well completions, e.g. entirely double barrier connections as well as the increase of safety requirements.

3.1 Scaling - no problem for metal-to-metal sealing Ball Valves

Regarding scaling effects, the ball valve concept has several advantages compared to the use of gate valves in deep geothermal application: The seat ring design of a metal-to-metal sealing ball valve provides an edge which scrapes off possible scaling on the ball surface during opening and closing of the valve (see figure 1). Furthermore, the cavity of the ball valve is in open and in close position encapsulated. Thus, no medium can enter the cavity and scaling build up is impossible. In contrast to that, gate valves usually seal only on one side, which means that the medium can enter the cavity and scaling forms. Split gate valves also seal on both sides, but they are likely to block when the gate expands due to temperature changes. The stem might be ruptured while attempting to open the valves.

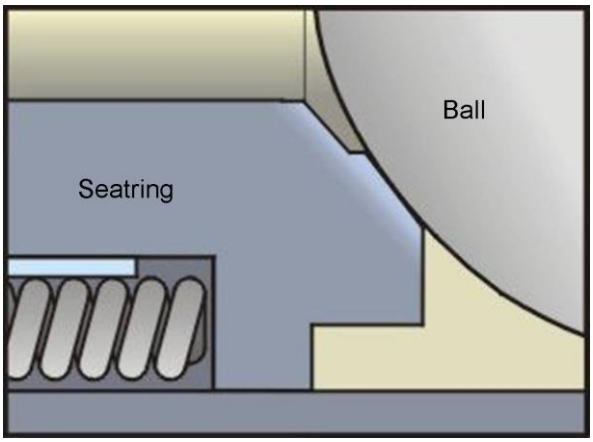


Figure 1: Ball-Seatring Design metal-to-metal Ball Valve

While the sealing area of a gate valve is directly next to the bore, the seat-area of the ball valve is well protected thanks to an adequate overlap between ball and seat.

Another advantage of using ball valves is that the rotating ball does not require additional volume during opening or closing as a gate valve does due to its

shifting. In case this volume is filled with scaling, salt or mud, the gate valve will block.

Moreover, very high safety factors for stem and gearbox allow to overcome the force needed to break occurring scaling. Besides the advantage of a safe closure in case of scaling, ball valves also require considerably less maintenance effort than gate valves.

3.2 Interchangeability through modular components

A geothermal well chosen to be a production well, incorporates an electrical or mechanical pump, unless it is an artesian well. But sometimes a change in geological conditions, like a drop of the downhole pressure or temperature changes after several years of operation, makes it necessary to change from production to injection. This is where the modular make-up of Hartmann components is most practical, since they allow an easy conversion.

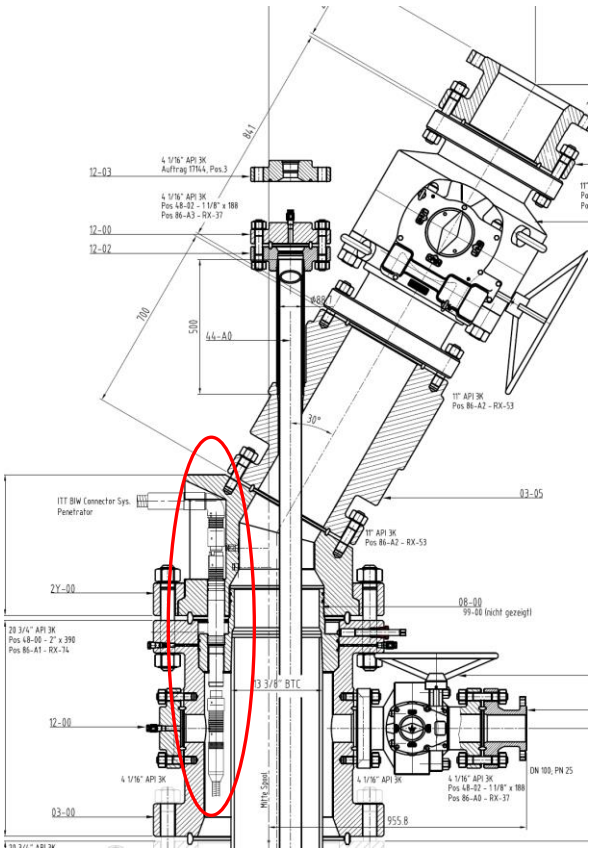
Another modular component is the actuator. It can easily be converted from a conventional gear box to an electric driven actuator. They can easily be fitted subsequently at any time to a ball valve of an existing wellhead in operation. Currently there are upgrades like this realized in several projects. In case of future demands for equipping geothermal wellheads with quick closing ball valves for safety reasons, an upgrade with suitable pneumatic or hydraulic spring return actuators is possible.

3.3 Pump Actuation – Where to put the Cable?

In case of a low downhole pressure or flow rate an electrical pump is required to stimulate the flow in a well. To power that pump an electrical cable needs to go down hole and conduct through the wellhead. Since the cable is clamped to the tubing string and not running inside of it, the wellhead design needed to be changed for this application to have an extra entry for the cable. Instead of a centred tubing, it is necessary to have a design with an eccentric tubing to have enough space next to it to fit the cable. This space may also be used for fiber optic cables or other control and measurement units, depending on the customer's or operator's needs.

As an example the geothermal plant in Traunreut in the Bavarian Molasse Basin in Germany may be mentioned. The key to success of the project was to ensure a high flexibility during the planning phase. The design of the cable conductor changed repeatedly due to changing perceptions for the appropriate downhole pump. Drawing 1 (below) shows a typical cable feed through for the pump cable.

Furthermore, additional accessories like pressure loading valves or small tubings to inject inhibitor fluids had to be implemented. Therefore the respective connections had to be foreseen at the wellhead equipment.



Drawing 1: Geothermal Production Wellhead Traunreut – Pump Cable Connection feed through marked

3.4 Documentation as Basis for Approval and Acceptance

Not only the reliability of the components themselves is a crucial factor in geothermal projects, but also the experience, service and competence of the involved suppliers is important. An efficient cooperation between manufacturer, engineering partner and operator during all project phases has a high influence on the project's success. This cooperation has been highly appreciated by all involved parties in recent projects.

Furthermore, operators and permit authorities require comprehensive documentation which allows a traceability of the certified materials used. Thereby a consistent documentation about the whole manufacturing process of all components is ensured. It comprehends all material and test certificates as well as technical drawings of the complete installation including all components. These documentation services are also performed by Hartmann Valves interface-free at first hand. Meeting those official requirements consistently is as important for the authorities as it is for the public's acceptance of this form of renewable energy.

5. ADVANTAGES AND BENEFITS

The aforementioned examples give insight in recent developments in wellhead design and technology. They reveal the current challenges for the design criteria of wellhead components and show that even complex technical solutions can be found.

Innovative developments and designs of wellheads and their components dedicated to recent requirements enable operators to realize their ideas of wellhead installation and operation. This results in higher flexibility in planning processes for installation, over the whole equipment's service life and in turn also for the complete geothermal well site.

Raised safety standards driven either by operators or regulatory authorities can be implemented with new technical solutions and thereby fulfill the safety requirements. This also supports initiatives to gain or maintain public acceptance for geothermal projects.

Higher investment costs connected with advanced wellhead systems will pay off during operations, since they provide higher flexibility and facilitate well intervention. Furthermore, improvements for maintenance and replacement may reduce standstill times and help to save costs.

It can be assumed, that the technical development will proceed due to a growing amount of requirements. Still fulfilling their general purposes, wellhead systems will incorporate more and more new technical features and functions encountering these new demands by creative solutions.