Pressure Retention Valve for Subsurface Applications

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ABSTRACT

gec-co Global Engineering & Consulting-Company GmbH and the iPAT (Institute of Process Machinery and System Engineering) at the FAU University Nürnberg-Erlangen develop a pressure retention valve for geothermal downhole application. The target of the invention is to avoid and/or to decrease the scaling and degassing of the geothermal fluid.

In advanced binary geothermal power plants the pressure at the re-injection well drops due to low counter pressure of the reservoir. In this case dissolved substances, e.g. solids or gases start to deposit or degas. Then chemical reactions start and the possibility of scaling initiates. Therefore, in most geothermal power plants it is recommended to have a pressure retention installed. State of the art is to install the pressure retention at surface. This has the consequence, that the following pipes, controls and instruments are not protected from scaling caused by depositing or degassing. The conclusion of this experience is that the whole piping and instrumentation has to be protected and the pressure retention should be installed down hole, especially underneath the static water level, to expose the fluid at the outlet to a certain pressure that keeps the fluid from depositing or degassing.

A further critical issue for pressure retention at high pressure and flow levels is cavitation. The invented geometrical feature deals with this problem and guarantees a certain flow speed at the overall length of the valve system. This will avoid partial low-pressure and even protects the valve material from the negative effects of cavitation.

1. INTRODUCTION

In a binary cycle geothermal power plant, it is state of technology to prevent scaling and degassing of the geothermal fluid by the means of pressure retention.

Standard valves are used for this task, placed at surface close to the re-injection well. But cavitation, erosion and pressure surges are damaging these valves over time. Furthermore, this solution will only protect the piping and instrumentation in front of the used valve, but in consequence the following piping and instrumentation cannot be protected as well as the injection well.

The presented invention proposes to relocate the valve from surface to subsurface to allow pressure retention from reservoir to injection point. Moreover a solution is illustrated that makes it possible to evenly release pressure over a defined distance. The invented geometrical feature deals with the problem of cavitation, and guarantees a limited flow speed at the overall length of the valve system. This protects the fluid from partial low-pressure and even protects the valve material from the negative effects of cavitation.

In result, the lifetime of the plant components as well as plant performance increase.

2. MAIN WORKING PRINCIPLE.

Relocation of the valve and subsurface installation as shown in Figure 1 may cause cost intensive replacement if damaged. This can be seen at standard used control valves. These valves need to be repaired or exchanged as a result of damages induced by cavitation.

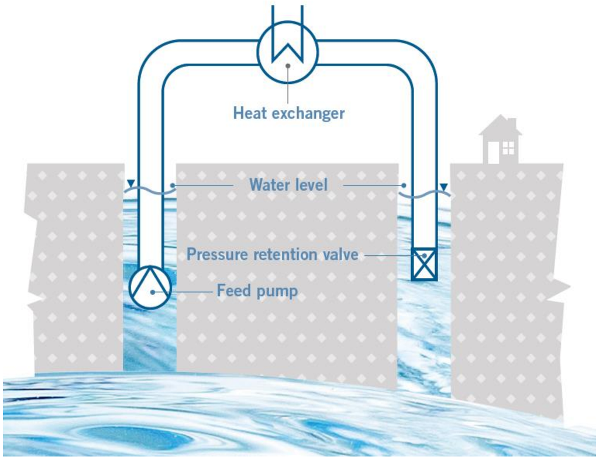

Figure 1: Relocation of the pressure retention valve and installation subsurface.

The phenomenon of cavitation is caused by the formation and subsequent implosion of vapour bubbles, forming an internal pressure lower than the vapour pressure at given temperature. Figure 2 shows an illustration of the phenomenon of cavitation.

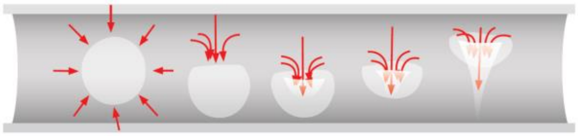

Figure 2: Illustration of the phenomenon of cavitation.

2.1 Pressure retention valve (PRV-GT)

In order to prevent cavitation, a special geometry was developed in cooperation with the iPAT.

In particular, the theoretical model was developed by Peter Iberl (iPAT) and later iteratively refined and extended by Dr. Mohammad Reza Kariman (gec-co).

Figure 3 shows the PRV-GT body and the unique channel design used for constant pressure release.

Figure 3: Pressure retention valve body with spiralled channel applied along a cylindrical cone.

Due to the geometry of the PRV-GT, the pressure is evenly released over a defined distance, which is directly linked to pressure release. This is done by the use of a spiralled channel which is applied along a cylindrical cone. The channel geometry is thereby designed to widen exactly after the calculated model to avoid cavitation.

The geometry of the valve is depending on the geothermal fluid properties as well as the desired pressure retention and flow rate.

2.2 Downhole installation

It is intended to install the valve PRV-GT below the static water level, downhole in the re-injection well. This allows pressure retention from reservoir to re-injection point. Actuation is possible due to a simple mechanical rod connection to the hydraulic actuator on surface.

The installation depth is only limited by weight of the rod and the increasing size of the hydraulic actuator at surface.

Figure 4 shows an example downhole installation.

It is planned to install the valve as link between casing and production tubing.

The downhole installation is designed according to requirements found in practical use. Therefore it is possible to install the valve with standard American Petroleum Institute (API) tools used by drilling companies worldwide.

The installation consist out of an inlet zone with connection to the API casing, valve inlet, valve seat and body with special geometry for controlled pressure release, outlet diffusor and outlet section with connection to the production tubing. The valve body is connected to surface and actuated by the control rod.

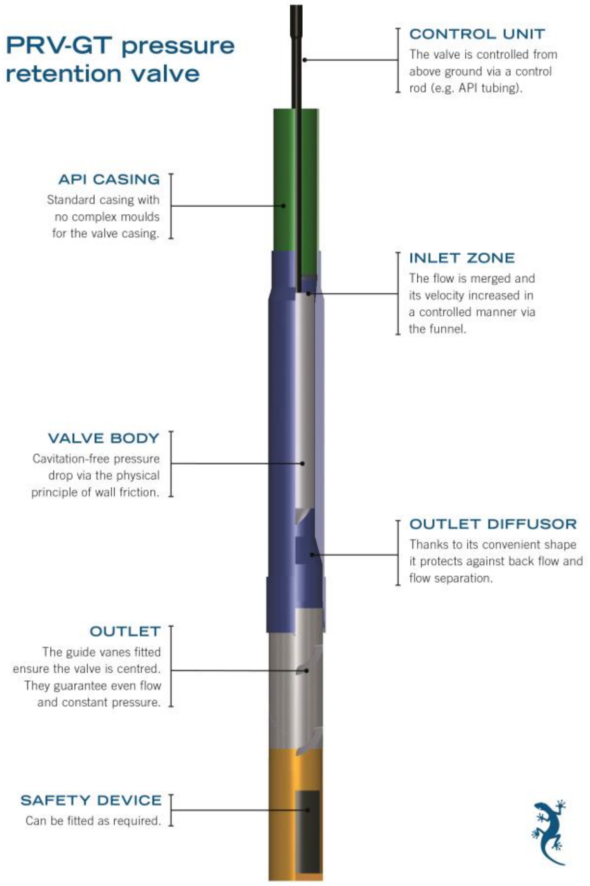

Figure 4: Downhole installation

3. RESULTS FROM PLANT SCALE TEST AND STATUS OF RESEARCH AND DEVELOPMENT

After promising results, a plant scale test was developed and set-up.

The test facility was integrated in the thermal water cycle of the geothermal power plant Traunreut via bypass.

During operation and testing of the valve no cavitation was determined. This was concluded due to the absent of vibration and noise.

Figure 5 shows the characteristic diagram of PRV-GT for the design point of 23.5 m^3/h.

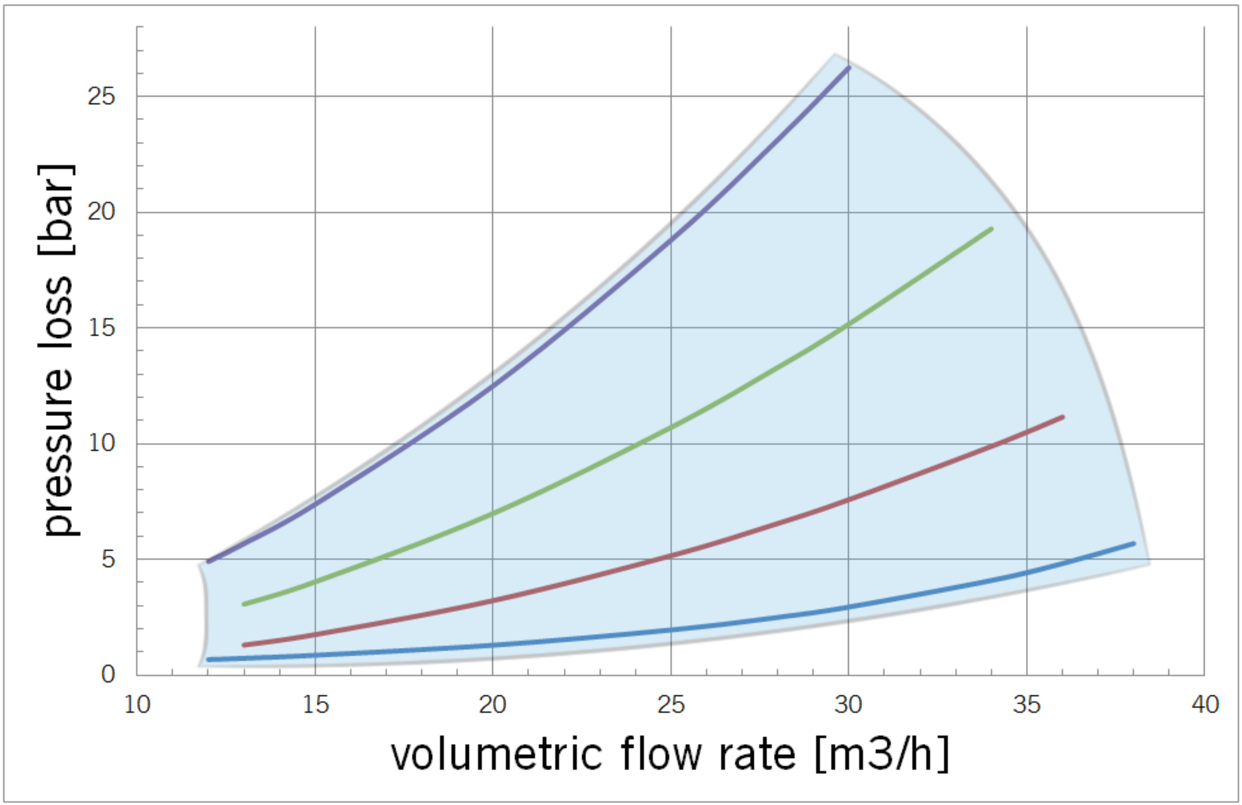

Figure 5: The figure shows the characteristic diagram of the pressure retention valve PRV-GT for design point 23.5 m3/h as measured. The lines are indicating different valve positions from fully open to close.

3. CONCLUSIONS

The presented novel approach shows that pressure retention is technically feasible for the complete binary cycle.

Reliable pressure retention is achieved by the use of the special designed helix for defined pressure release in combination with installation of the valve below static water level.

This new technology will increase overall plant performance due to better heat transfer at the heat exchangers. No precipitation or scaling at the surface of the heat exchangers ensure an unobstructed heat transition and enhance power extraction. No need to acidify the cycle and no need to exchange damaged control valves, in conclusion less downtime and more uptime.

Acknowledgements

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