Computer Simulation of Temperature Distribution around Well and Cavern during leaching

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Introduction

Salt body around a solution-mined cavern loses significant amounts of heat during the leaching process. This results from injecting water of relatively low temperature (as compared with ambient temperature) into the cavern. The range of temperature decrease around the cavern should be known ahead in order to design properly the technological parameters such as gas yield required to withdraw the brine and the duration of the first filling.

The range of temperature decreases while leaching is even more influential during the initial period of gas storage cavern exploitation, thus limiting gas recovery.

The problem of salt body cooling during a leaching process has been studied in the world for years. Quite a few computer models simulating this phenomenon have been developed.

However, these models approach the question in an approximate manner (the same heat exchange mechanism both through the cavern roof and floor as well as through its wall, often no heat exchange through the well casing). The salt body temperature distribution is usually one-dimensional, derived using analytical equations.

All these features result in the models being only an oversimplification of the real thermal process in a storage cavern. Consequently, the thermal prediction obtained from these models can be imprecise.

The authors of this paper propose their own original thermal model TERLUG , developed and used at CHEMKOP , and sponsored by PGNiG Warsaw for Mogilno Project. The model is free from the above-mentioned simplifications.

The salt body is approximated with finite-difference net in cylindrical coordinates. Two-dimensional (in axial symmetry) partial differential heat flow equation with boundary conditions of the first and second kind is solved on this net. Special heat exchange mechanisms have been introduced into the model for the cavern floor (through a thick sump), and for the cavern roof (through an oil blanket). Inside the cavern, two separate thermal zones are considered - above and below the injection level. In the model algorithm, the heat exchange phenomena in successive parts of the well between water, brine and surrounding rocks through pipes, casing and cementation have been taken into account.

Due to such an approach to approximation, the TERLUG model simulations can provide more detailed temperature distribution in different parts of salt body. Thus, precise predictions of initial phases of gas-cavern exploitation become possible.

In salt caverns leached for Mogilno Gas Storage Project, a series of *in-situ* brine temperature measurements along cavern axis has been carried out with a sonar device. The authors have used the measurement results to "gauge" the TERLUG model coefficients by comparing thermal computer simulation results from TERLUG with the *in-situ* brine temperature measurements.

In this way a few coefficients, crucial for the heat exchange process (between the cavern and the surrounding salt rock), impossible to obtain under laboratory conditions, and wrongly estimated from theoretical considerations, have been determined.

The knowledge of these coefficients permits accurate predictions of the first gas filling (SOLGAZ-model) as well as the initial stages of gas storage cavern exploitation (KAGA-model). Both SOLGAZ and KAGA as well as TERLUG are original models developed at CHEMKOP by A. Kunstman and K.Urbańczyk