Abstract

Convergence calculations during operations and their intended minimisation are based on precise knowledge of the interior cavern pressure and its reduction or build-up rate. The continuous usage of pressure instrumentation in the cavern to establish these parameters would exceed financial and technical limits. On behalf of Ruhrgas AG, PLE GmbH and Hagoort & Associates have therefore further developed a thermodynamic program which can be used to determine cavern parameters such as pressure, gas temperature and salt temperature with a high degree of accuracy on the basis of measured wellhead pressure and temperature as well as calculated or measured volume rates.

In contrast to the relatively precise determination of wellhead pressure, a high error rate is encountered in measuring the volume rates at the cavern wellhead due to the measurement principle involved. The new "GSTMAN" thermodynamic program has been designed in the history match mode so that the measured wellhead pressure is matched by numerically varying the volume rate. If the calculated and measured wellhead pressure values concur, this means that the volume rate has been established up to the stipulated accuracy factor.

The availability of working gas as well as the short-term to long-term thermodynamic capacity of individual caverns through to cavern clusters can be rapidly and accurately determined by calculations in the prediction mode.

Further options and advantages featured by the thermodynamic program are as follows:

- Calculation of optimum gas volume rates for individual caverns and cavern clusters for a stipulated overall rate (maximi sation of working gas)
- Determination of the latest juncture for re-injection
- Consideration of constraints, such as, for example, minimum wellhead temperature, minimum and maximum wellhead pressure, hydrate formation conditions
- Consideration of "cold zones" in salt rock
- Consideration of pressure and temperature losses from the cavern up to the manifold
- Calculation of pressure equilibrium in the manifold for cavern clusters.