Schulz, R.[1], Denzau, H.[1] and Benke, K. [2]

[1]Pipeline Engineering GmbH, Kallenbergstr. 5, 45141 Essen, Germany.

[2]Ruhrgas AG, Huttropstr. 60, 45138 Essen, Germany.

Introduction of a Continuum Damage Method (CDM) for FEM Calculations of Fracture Mechanisms in Rock Salt

1) Abstract

Conventionally, fracture mechanisms in rock salt differ with respect to the velocity of deformation. For high deformation rates, brittle fracturing is usually assumed; for low deformation rates, creep fracturing can occur. For medium rates of deformation, there are hardly any models known that correctly describe this process. By using the CDM method, it is possible to overcome the limitations of these assumptions and to introduce a concept that makes it possible to determine brittle, brittle-viscous, and viscous fracturing in rock salt.

We herewith present a formulation of the CDM method that offers the possibility of correctly describing the primary, secondary and tertiary creep phases in conventional creep experiments on rock salt samples. Additionally, we can use this formulation to determine the amount of damage (or continuity) in the rock sample and the time of rupture. The damage parameter is a measure of microcracking in the surrounding area of a cavern. By comparing the damage parameter with permeability, and with ultrasonic measurements in the laboratory, it was possible to derive initial assumptions about the area affected by microcracking. Because of the simple formulation of the CDM method used, only six rock parameters are introduced. These rock parameters were determined from several special laboratory experiments that incorporated the tertiary creep phase. By including the CDM as the visco-plastic part in PLE's FEM program MAUS (=Mechanical Analysis of Underground Storage), we calculated the rock-mechanical behaviour of rocks surrounding gas caverns. For comparison, we calculated the displacement, strain and stress for a low-pressurised gas cavern by applying a conventional creep law (Lubby2) and the new CDM method. The possible three-dimensional extent of the resulting damage in the surroundings of such caverns was confirmed by several other well-known theoretical analyses.