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MECHANICAL STABILITY OF A CAVERN SUBMITTED TO HIGH-FREQUENCY CYCLES

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Abstract

Summary

Storage of natural gas in salt caverns had been developed mainly for seasonal storage, resulting in a small number of yearly pressure cycles and moderate gas-production rates. The needs of energy traders are changing toward more aggressive operational modes. Gas temperature changes and additional stresses generated by high-frequency cycling in a storage cavern are discussed. It is proved that, when short-period gas pressure cycles are performed, the thickness of the thermally disturbed zone at the cavern wall is relatively small. Refined meshes of the disturbed zone are required when performing numerical computations. The case of an actual cavern is discussed. In addition to the Munson-Dawson constitutive law, “reverse” creep is considered. The no-tension and dilation criteria are used to discuss numerical results. It is proved that tensile stresses may develop when cavern pressure is low. The evolution of the state of stresses in the $-\left(I_1/3, \sqrt{3J_2}\right)$plane; i.e., the “bumble-bee flight”, as suggested by Kurt Staudtmeister and Zapf (2010) [1] is discussed, and it is proved that the dilation criterion is met at an early stage.

Key words: Cycling loading, gas cavern design, rock mechanics, numerical analysis