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The Synergy of Wind Power and Hydrogen Stored in Salt Caverns

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Abstract

Solar, tidal and wind energies are inherently intermittent with continual fluctuations in electricity production. Because the availability of wind is time-dependent, whereas the need of electric power is continuous, there is a requirement for an intermediate storage of wind power which may be achieved by using hydrogen to facilitate storage of large quantities of energy.

Hydrogen energy storage in underground salt caverns is an optimum solution in addressing the balancing problems in electricity grids resulting from the planned increase in wind power in the UK.

The technological concept of hydrogen storage in salt caverns is well established and hydrogen has been successfully stored in salt caverns for decades. To date, hydrogen has been stored in three salt caverns since 1972 in Teesside, UK, currently operated by SABIC, and in three salt caverns near the US Gulf Coast since 1983.

The relevant technology and the design of hydrogen storage salt caverns are typically based on the existing experience in the design and operation of salt caverns for natural gas storage.

This paper presents the results of the detailed geomechanical analysis of a salt cavern in Teesside, UK, which may be used for the large-scale storage of hydrogen as part of a hybrid system of wind power and energy storage facility. The employed analysis was complicated by the fact that the Zechstein III evaporites in Teesside are characterised by a persistent layer of Carnallitic Marl (known locally as Rotten Marl) which, as result of its proximity to the cavern's roof, is influencing the cavern's geomechanical stability.

In this paper we present the results of the geomechanical analysis employed to evaluate the anticipated creep response of the investigated hydrogen storage cavern. The investigations enabled us to better understand the long-term volumetric closure of caverns used for the storage of hydrogen and to define the most significant parameters affecting the integrity of such storage facilities.

With respect to the geomechanical response of the investigated salt cavern, it was ascertained that the creep of Zechstein III Upper Main Salt did not give rise to excessive cavern closure rates. Additionally, the geomechanical analysis identified the structural significance of the Mercia Mudstone and the Sherwood Sandstone strata. These competent formations, which overlay the Zechstein III beds, have a thickness, which when combined, act as an enormous thick plate with built-in-ends that contributes significantly to the stability of the hydrogen storage cavern.

Key words: Bedded salt deposits, Caverns for hydrogen storage, Computer modelling, Geology, Rock mechanics, Salt properties, United Kingdom, Zechstein.