

Analysing the Effect of Curing Temperature on Micro-annuli Formation in Existing Wellbore Cement Sheath for Underground Hydrogen Storage

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Abstract

Cement is used in a wellbore to isolate the formation fluids from the adjacent geologic regions. However, the interfaces between cement and casing as well as cement and formation can develop into leakage conduits in the form of micro-annuli. The formation of micro-annuli is a result of poor bonding which can be related to differential stress asserted on the wellbore system due to the changes in temperature and pressure. Micro-annuli are a type of cement sheath failure that can lead to significant leakage depending on the type of fluid and geometry of the micro-annuli. Studies over the years have assumed and simplified the pore geometry to be homogenous and uniform. In contrast, recent studies have revealed the complex nature of the geometry of the micro-annuli. In this experimental work, effort was made to visualise the initial cement bonding in three-dimensional space. X-ray CT scanning was carried out on cylindrical composite samples prepared with sandstone and API class G ordinary Portland wellbore cement. The images were reconstructed and analysed using AVIZO. The effect of different curing temperatures is illustrated through the quantification of micro-annuli and by analysing their geometry.

Keywords: Wellbore integrity, Wellbore cement, Hydrogen storage, Micro-annuli, Porosity