Efficient - Sustainable - Economical

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Material selection key challenges for CO2 transport and underground storage

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Nowadays, carbon capture, transport, and underground storage (CCUS) rises like one of the technologies for mitigating climate change and meeting one of the most challenging targets of the Paris agreement: 14% of the total CO2 emissions reductions by 2060 must come from CCUS. Moreover, in the Net Zero Emissions (NZE) scenario, it is called a CO2 storage capacity objective of 1200 Mt of CO2 per year by 2030.
Similarly to other types of wells, a CO2 injection well must be designed for the long term and with operational design lives of typically 40+ years followed by the need for continued integrity for a planned abandonment for over 10000 years. As a conclusion, it becomes clear that correct design, particularly in terms of the selected materials for well components is very critical.
In this context, the CO2 injection and sequestration in underground sites differs from the experience with relative pure CO2 injection due to the presence of impurities related to the CO2 source and the capture technology used. These impurities are mainly H2O, H2S, CH4, O2, SOx, NOx…Their type and quantity are key to the material selection of tubes for the transport and injection of the impure CO2.
It is especially critical to determine the solubility of H2O in the fluid to limit the risk of presence of liquid water. On the contrary, several chemical reactions with the rest of impurities likely occur giving rise to strong acids (H2SO4, HNO3, S0…) that provoke different types of corrosion in the CCUS systems: stress corrosion cracking (SCC), sulfide stress corrosion cracking (SSC) and localized corrosion (pitting and crevice).
For a long-term exposure in wet CO2, the recommended materials are corrosion resistant alloys (CRAs). Then, duplex stainless steels with high pitting resistance equivalent number (PREN) are very suitable to avoid the very frequent localized corrosion. In general, compositions with high content of Chromium, Molybdenum and Nitrogen are firm candidates for CCUS. At a higher level of impurities, Nickel content is also a key element and austenitic solid solution Nickel based alloys enter directly into this application.
Apart from the corrosion resistance, the requirements in mechanical properties depend on the CO2 state in each part of the CCUS chain. It is usually ship transported as liquid, as a dense phase fluid when is transported by pipelines or in its supercritical phase to be stored in saline aquifers or hydrocarbon reservoirs. Therefore, working conditions require very high pressures, and risks of sudden depressurizations introduce the high probability of supporting very low subzero temperatures related to the Joule-Thompson effect. Consequently, ductile to brittle transition temperatures shall be also considered in the material selection, thus austenitic CRAs have the advantage in this point. In parallel, the injection well requires high yield strength, so minimum values of 80 ksi, 110 ksi and even 125 ksi are usually demanded, which implies the use of cold hardened finished tubes.
As a main conclusion, CCUS systems integrity implies important material considerations and, in this sense, CRAs appear to be the most suitable and reliable materials for increasing their lifetime and therefore, for contributing to accomplish the targets expected by the global decarbonization strategy. In addition, chemical composition optimization is a must for sustainability and one of the key elements in these alloys is the Molybdenum.

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