Hele-Shaw Cell of Varying Thickness for Modeling of Leakage Pathways

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Canada is an important player in the global oil and gas industry and is ranked fourth largest producer of natural gas and crude oil. Alberta and British Columbia are the two largest producing provinces of natural gas with a combined 98\% of the national production. Recent development of the Montney formation, a low permeability unit, has led to a rise in the number of unconventional (horizontal and hydraulically fractured) wells drilled in Western Canada. Recent studies have shown that 28.5\% of wells drilled starting in 2010 in British Columbia have reported an instance of wellbore leakage, and 4.0\% of the wells drilled in Alberta during the same time period have also reported an instance of wellbore leakage resulting in several thousand wells with known leakage issues in these two provinces. Wellbore leakage is the unwanted flow of hydrocarbons from the reservoir, or a formation intersected by the well, through leakage pathways found along the wellbore and discharging to the atmosphere through either the surface casing assembly, surface casing vent flow (SCVF) or a surrounding permeable formation, gas migration (GM). In addition to the greenhouse gas emissions produced by wellbore, groundwater contamination may occur. Provincial regulations state that the remediation of cases of non-serious wellbore leakage, which represents 85.5\% of the cases of wellbore leakage in Alberta and over 94\% of the cases in British Columbia, can be delayed until the time of well abandonment. Less than 30\% of the gas wells in these provinces have been abandoned and both provinces are seeing an alarming number of suspended wells which can be considered ready for abandonment. At which point, wells experiencing wellbore leakage will need to be remediated. Understanding of wellbore leakage, which occurs through leakage pathways such as radial cracks and microannulus, is limited. The model presented in this study relies on flow through a Hele-Shaw cell of varying thickness representing a microannulus. Microannulus thickness data is obtained through experimental data available in the literature. The aim of the model is to determine the flow rate of natural gas through a microannulus of varying thickness and the resulting permeability of the leakage pathways.