geoconvention
Calgary • Canada • May 15-17 2023

Optimization of SAGD well elevation utilizing a score of horizontal layers in multi-realized reservoir models

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Summary

The steam-assisted gravity drainage (SAGD) well-pair is commonly placed at the bottom of reservoir to maximize SAGD-able pay thickness. However, low-permeable zones disturb the thermal communication between steam injector and oil producer, and steam chamber expansion above the injector. It causes low SAGD performance in oil sands fields. The SAGD performance can be improved by avoiding low-permeable zones, which needs to evaluate the impact of low-permeable zones in each horizontal layer of 3-D reservoir model. The reservoir model, which is not characterized by production history, is highly uncertain to specify distribution of the low-permeable zones in initial development stage. Therefore, multi-realized models are necessary to suggest the optimal well elevation probabilistically. This study develops an optimization method of the SAGD well elevation utilizing a score of each horizontal layer in multi-realized reservoir models.

The reservoir modeling was conducted using facies and petrophysical properties of 46 cored wells from an oil sands field in Athabasca, Canada. Total 50 realizations were generated utilizing the field data, then three sub-models of SAGD well-pairs were extracted from the individual realizations. Numerical simulations were conducted for the three SAGD well-pairs changing the well elevation in 50 realizations individually. The net present value by 10-year SAGD operation was compared to determine the optimal well elevation as ground truth.

The facies can indicate the high-permeable or low-permeable rock type qualitatively. The score of high-permeable rock type (i.e., sand) was assumed to 100, and score of low-permeable rock type (i.e., shale, mud, muddy IHS, densely packed breccia) was assumed to 0. There were moderate-permeable rock types such as sandy IHS and loosely packed breccia in the studied oil sands field. The score for the facies were examined by sensitivity analysis. The score was allocated to all grid-blocks corresponding its facies for the extracted sub-models. The score of grid-blocks were averaged at each horizontal layer. A cut-off value was used to screen promising intervals in the averaged score curve, which consisted of highly scored horizontal layers. The cut-off value was also examined by sensitivity analysis. A base elevation of the thickest promising interval was determined as the optimal well elevation. The procedure was iterated for three sub-models of 50 realizations. Lastly, the R-squared value between optimal well elevation by numerical simulation and scoring method was calculated. The R-squared values were compared by changing the score for sandy IHS, loosely packed breccia, and cut-off value in the sensitivity analysis. The result showed that 15 and 10 for the score, and 70 for the cut-off were proper values with R-squared of 0.73. The developed method was applied to each sub-model of 50 realizations, and it could suggest the optimal well elevation probabilistically.