Supplementary file

Use of Controlled Fractures in Enhanced Geothermal Systems

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Introduction

This supplementary file discusses the comparative study of the two slot-drill doublet cases presented in Figures 5b and 5c. It also compares the performance of the 14 slot-drill fracture (SDF) doublet parallel and series configurations. The last section summarizes the evaluation of the effect of a constant-temperature (instead of an insulated) boundary on the outer faces of the simulation domain.

S-1. Six SDF doublet

This section presents the simulation results for the six SDF doublet series and parallel configurations. The simulation domains are shown in Figure S-1. The 50-year simulation results for these two cases are presented in Figure S-2. The results show that the SDF doublet parallel configuration yields slightly lower cumulative thermal energy and produced fluid temperature than the series configuration. In contrast, the SDF doublet parallel configuration yields a marginally higher thermal recovery fraction than its corresponding series configuration. This SDF series configuration's slightly higher produced fluid temperature could be due to the pressure-volume work, as evidenced by the increase in the injection and near-fracture pressures (up to 1.5 times the initial reservoir pressure). From equation 15, the higher produced fluid temperature in the SDF series configuration results in increased wellhead enthalpy and cumulative thermal energy. Conversely, we observed that the volume-weighted average temperature after 50 years of heat extraction is 428 and 427 K for the SDF doublet series and parallel cases, respectively. The observed higher thermal recovery fraction of the SDF doublet parallel case is consistent with equation 12, which indicates that the case with the lower average temperature yields a higher recovery fraction.

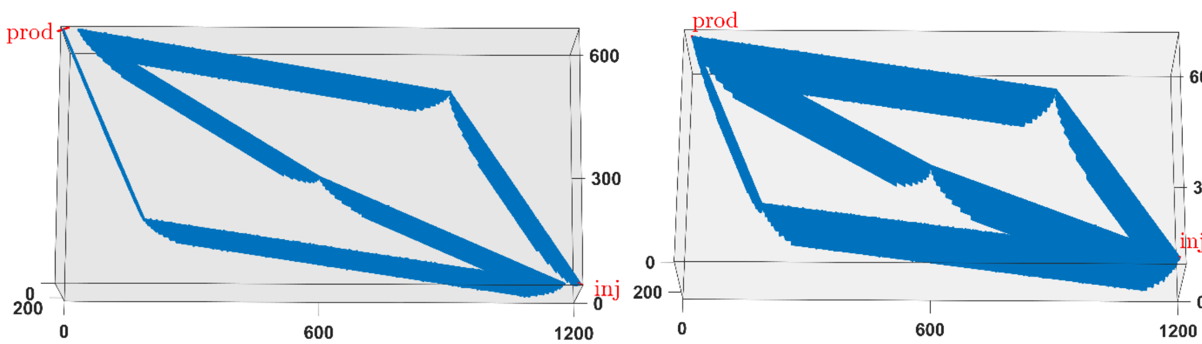

Figure S-1— Simulation domains for the coupled thermal and hydraulic simulation of (a) doublet of six SDF-series, and (b) doublet of six SDF-parallel

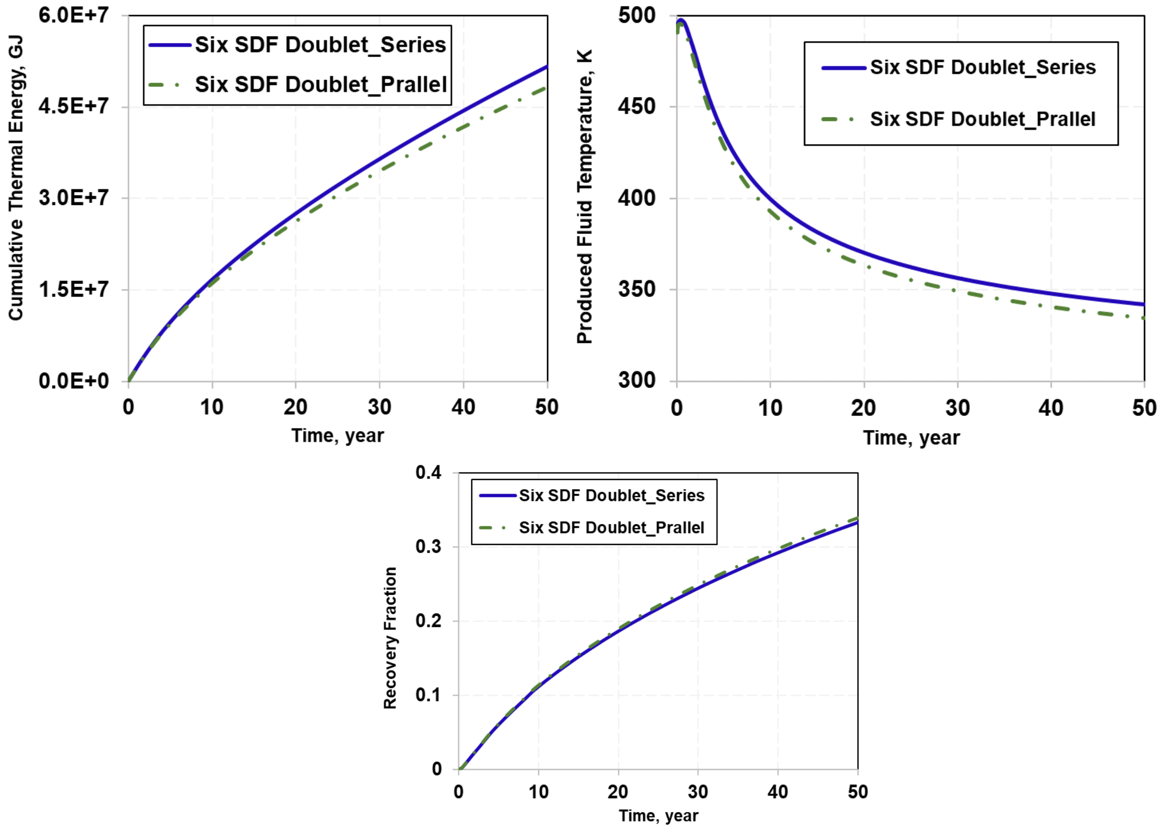

Figure S-2— Comparison of performance between two configurations of the SDF doublet case. (a) comparison of the produced fluid temperature. (b) comparison of cumulative thermal energy (c) comparison of recovery fraction

S-2. Fourteen SDF doublet

This section presents the result of the extended doublet case with fourteen slot drill fractures. The grids for the corresponding series and parallel configurations are shown in Figure S-3. Both systems were simulated for 50 years and summarized in Figure S-4. Although the cumulative thermal energy and produced fluid temperature are higher in the series configuration, its thermal recovery fraction is lower. The artificially higher cumulative thermal energy and produced fluid temperature in the series configuration is because the injection pressure increases to two times the initial reservoir temperature in the series configuration. These high-pressure values induce pressure-volume work, resulting in higher cumulative thermal energy and fluid temperature. However, the average temperatures of the 14 SDF doublet series and parallel configurations are 386 and 382 K, respectively, after 50 years of thermal energy production. So, the thermal recovery fraction, as described by equation 12, is still higher in the parallel configuration than in the series configuration.

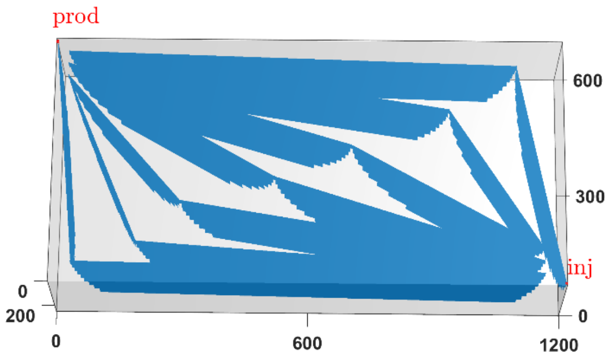

Figure S-3— Simulation domains for the coupled thermal and hydraulic simulation of (a) doublet of fourteen SDF-series, and (b) doublet of fourteen SDF-parallel

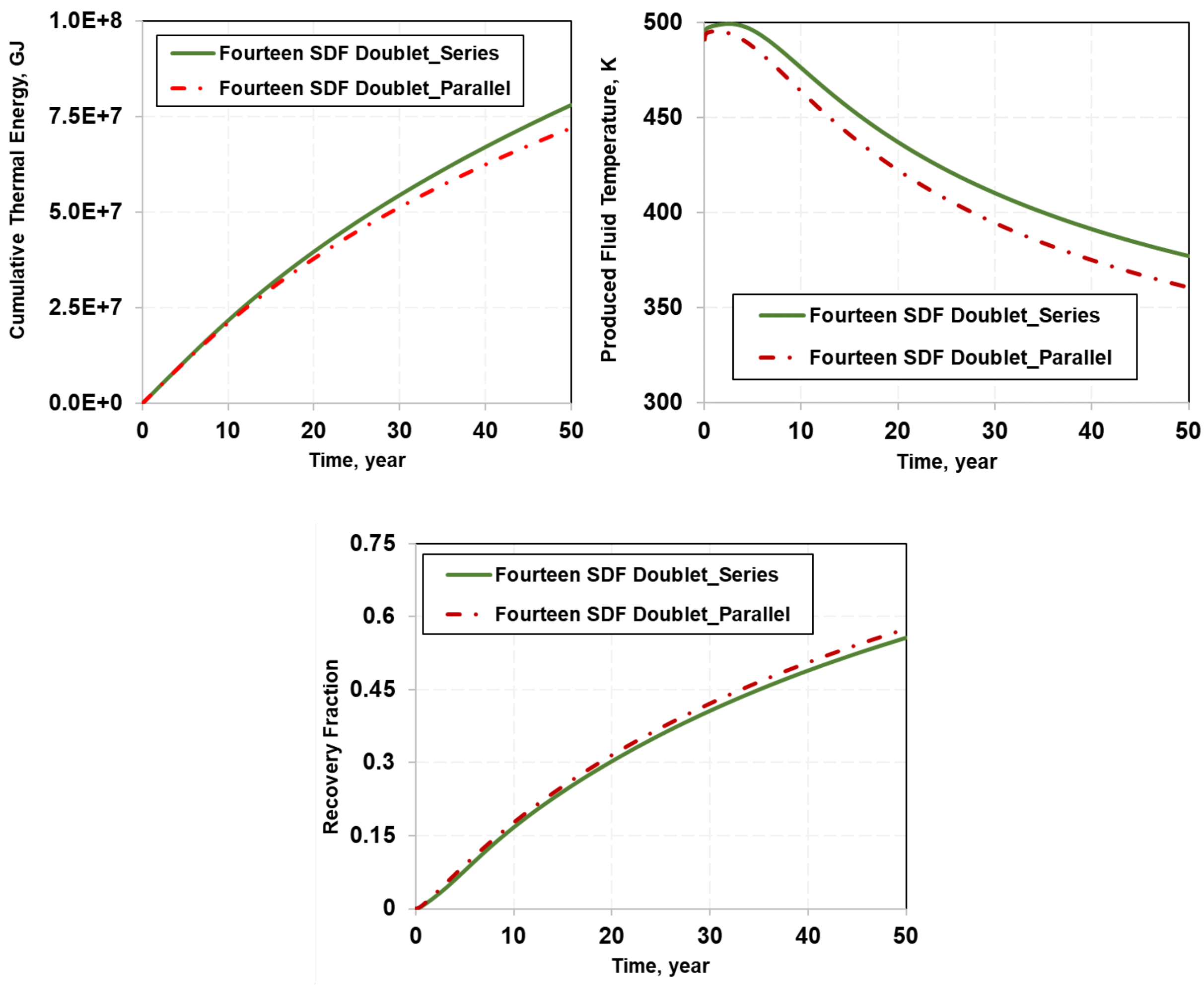

Figure S-4— This figure presents line plots that compare the performance of the series and parallel configurations of the 14 SDF doublet case. It presents a (a) comparison of the produced fluid temperature, (b) cumulative thermal energy, and (c) thermal recovery fraction.

S-3. Evaluation of EGS Performance Under Constant Temperature Boundary Conditions

Although all simulations presented in the manuscript used no-flow and fully insulated boundary conditions, the trend in the results remains unchanged if the temperature is instead maintained constant on the outer faces of the simulation domain. To achieve this, the domain shown in Figure 8 was padded with a few more matrix cells in the x- and y- directions. Without this padding, the SDF production wells will be on the constant temperature boundary cell, leading to artificially high temperatures throughout the simulation duration, which is not representative of what to expect in the subsurface. The enlarged domain (in the x- and y-directions) is shown in **Figure S5**. **Figures S6** and **S7** show the results for the cases with insulated and constant-temperature boundaries, respectively, and the results show that the SDF case still outperforms the MHF case.

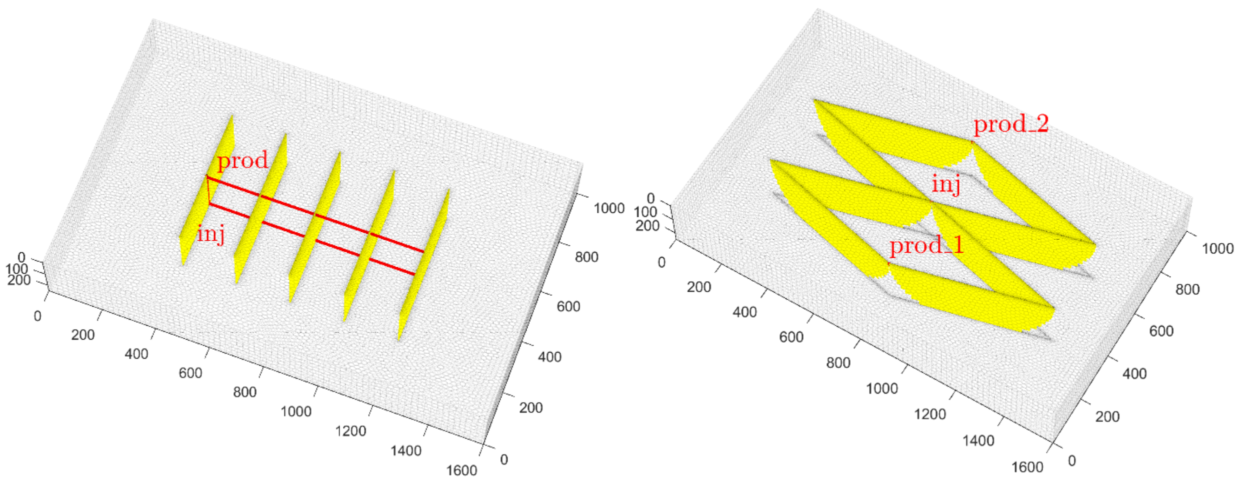

Figure S5. Extended grid for the MFHW case and the SDF triplet case with and without constant temperature boundary conditions

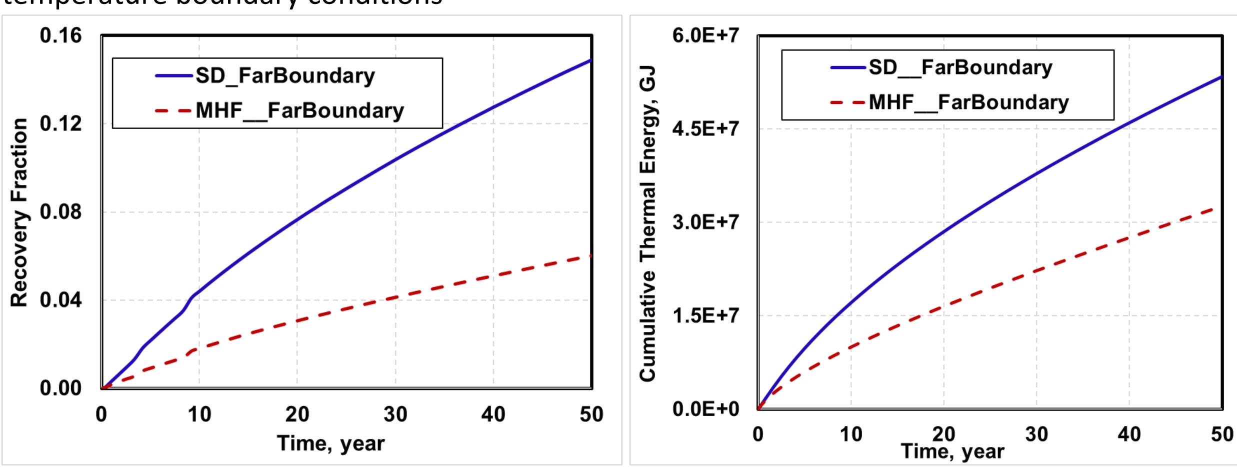

Figure S6. Thermal recovery fraction and cumulative thermal energy plots for the expanded grid cases that have no-flow and insulated boundary conditions.

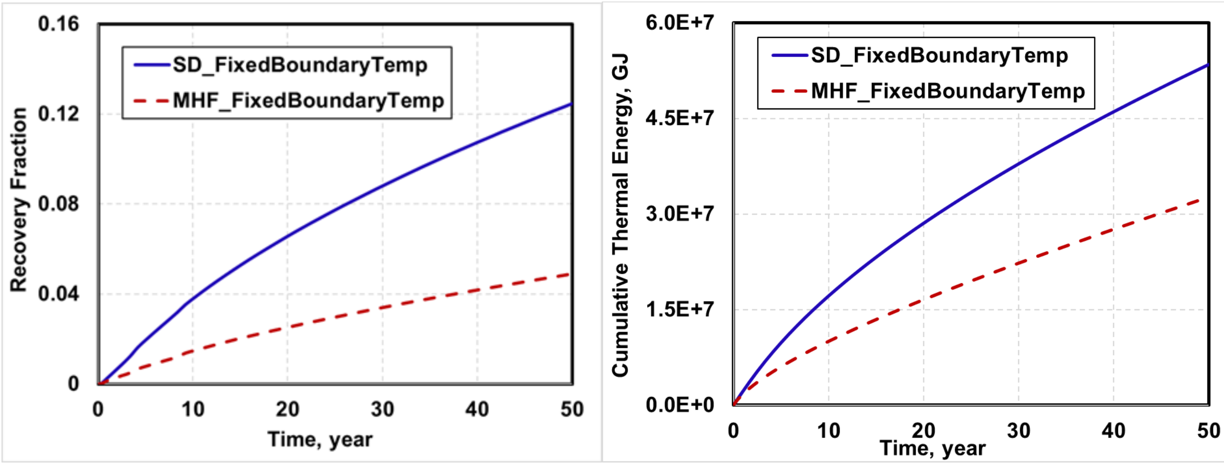

Figure S7. Thermal recovery fraction and cumulative thermal energy plots for the expanded grid cases that have no-flow and constant-temperature boundary conditions.