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JIWAFlow: A Cloud Computing Wellbore Simulator

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ABSTRACT

Reservoir characterization, well behaviors monitoring and analysis, and forecast of production and injection are the keys reservoir evaluation conducted routinely in the process of managing and optimizing geothermal steam field power production. Wellbore simulation has been one of the main techniques applied by reservoir engineer to support their works. The capability of reservoir engineer to perform their analysis is however limited by how far the wellbore simulator can support their work. This paper described a new generation of wellbore simulator JIWAFLow developed by AILIMA. To support evaluations during field exploration and operations, JIWAFow has been built with capabilities to perform a complete reservoir engineering analysis from permeabilities characterization, well behavior monitoring, production and injection decline analysis, to steam supply and injection capacity forecasting. To honor reservoir uncertainties, JIWAFlow is also coupled with monte carlo simulation to allow probabilistic calculation. JIWAFlow has been developed to make analysis much more time and cost efficient, robust and meet business requirements. JIWAFlow allows cloud computation and is integrated with web-based JIWA applications to perform seamless connection with geosciences, reservoir engineering, and surface monitoring data.

1. INTRODUCTION

Dealing with uncertainty condition in geothermal system is quite challenging, especially during exploration phase where subsurface data information is very limited. Since geothermal project cost is high and site-sensitive, resource capacity become the big question to be revealed in every geothermal project, it will determine development strategy. To lead project more successful, risk and uncertainty must be reduced by improving the understanding of reservoir characterization. Well drilling is the most reliable way to add more information and confirm all interpretations related to the initial conceptual model construction. The information related to reservoir parameters such as reservoir pressure, temperature, and feed zone location, can be obtained through well testing carried out after well drilled. Fluid properties and thermodynamic state that extracted from reservoir to well head surface or vice versa can be calculated using wellbore simulator.

A wellbore simulator performs numerical simulation of fluid flow behavior inside production and injection wells. In geothermal field development, wellbore simulator has been used for various applications including but not limited to:

1. PTS (pressure, temperature, spinner) logging analysis to identify feedzone location and observe the wellbore/reservoir thermodynamic states (pressure, temperature, dan enthalpy)
2. Well capacity estimates: production (output curve) /injection (injection curve) for new make-up
3. Well performance and decline analysis for both production and injection wells.
4. Analyze the causes of production and injection decline
5. Steam supply forecast
6. Identify the occurrence of interzonal flow
7. Assess flash point location related to calcite scaling mitigation
8. Coupled with Monte Carlo simulation to analyze risks and opportunities evaluation related to well output for drilling, acidizing, hydraulic fracturing, workover programs
9. Coupled with reservoir simulation to translate reservoir pressure, enthalpy changes into required number of wells.
10. Support the development/update of conceptual model, etc.

Wellbore simulation has been one of the main techniques applied by reservoir engineer to support their works. **Figure 1** shows key activities during geothermal field evaluation and management that will require wellbore simulator. The capability of reservoir engineer to perform their analysis is however limited by how far the wellbore simulator can support their work. This paper described a new generation of wellbore simulator JIWAFlow developed by AILIMA. Wellbore model concept is actualized by partitioning whole well geometry into small segment and then calculate pressure drop for each segment through iterative method. Normally pressure drop is driven by gravity, friction, and acceleration (Hasan and Kabir, 2010). Pressure drop correlation selection is fundamental in evaluating wellbore profile and production performance. The empirical correlations e.g., Duns and Ros (1963), Hagedorn and Brown (1965), Orkiszewski (1967) and mechanistic model e.g., Hasan and Kabir (1988), Ansari et al. (1994) are still widely used for evaluation and forecast, these correlations basically was adapted from petroleum industry.

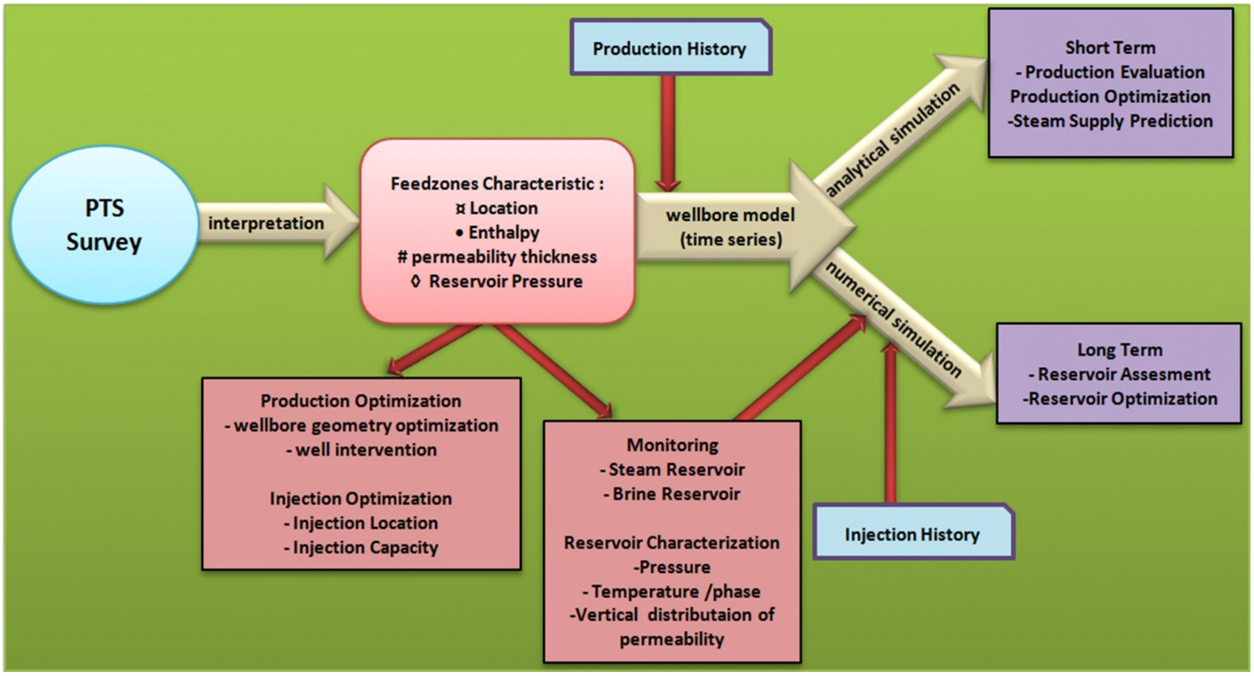

Figure 1: Wellbore simulator is vital to support geothermal field management

2. JIWAFLOW

To support evaluations during field exploration and operations, JIWAFlow wellbore simulator has been built with capabilities to perform a complete reservoir engineering analysis from permeabilities characterization, well behavior monitoring, production and injection decline analysis, to steam supply and injection capacity forecasting. JIWAFlow functions has been developed to be able to simulate multi-component (H_2O- CO_2-NaCl) as well as Heat Loss effects. The effect of CO_2 to pressure drops inside wellbore and heat loss to well production output simulated using JIWAFlow are presented in **Figure 2** and **Figure 3** respectively.

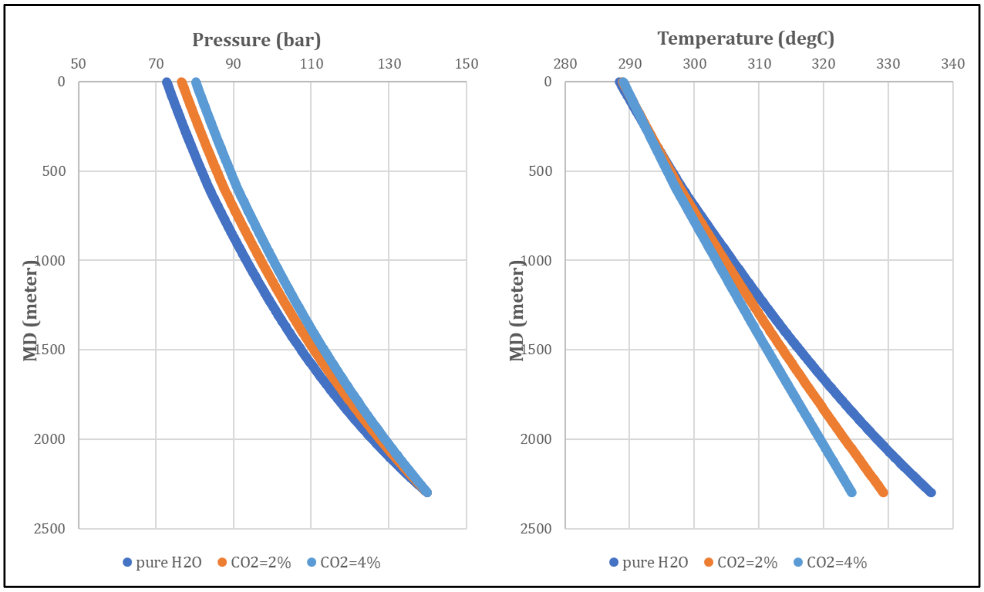

Figure 2 Simulated wellbore pressure under different CO2 contents using JIWAFlow

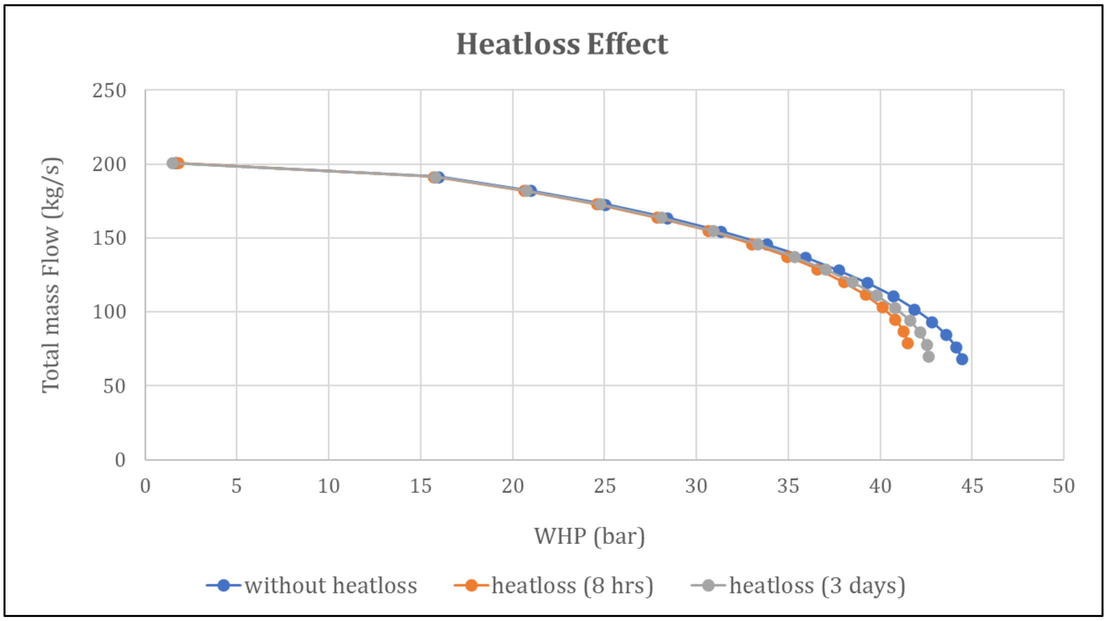

Figure 3: The effect of heatless to well output simulated using JIWAFlow

A total of six empirical pressure drop correlations have been introduced including Homogenous, Hagedorn Brown, Mechanistic, Drift Flux, Orkiszewski, Duns Ross. This will serve engineers with many options while trying to obtain the best match during model calibration against measured data. **Figure 4** shows simulated temperatures along the wellbore comparing six different empirical pressure drop equations

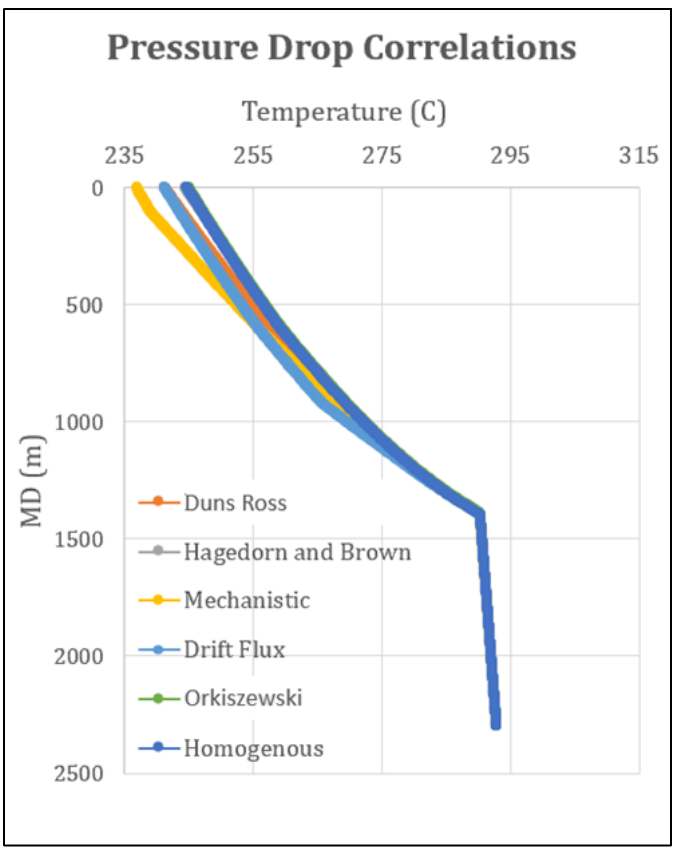

Figure 4: JIWAFlow wellbore simulation comparing six different empirical pressure drop equations

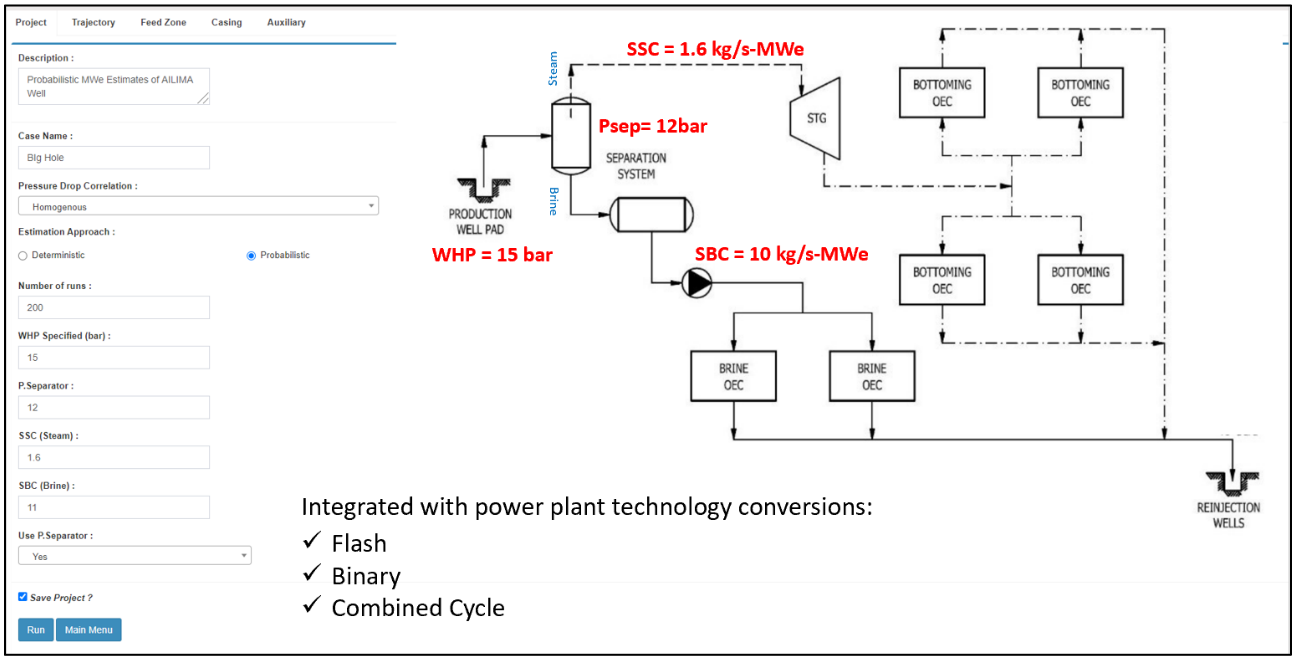

Figure 5: JIWAFlow is integrated with power plant technology conversions

Option is available in JIWAFlow to convert from mass flow rate into MWe capacity. To calculate the MWe capacity, the user will be required to assign separation pressure and the power plant fuel consumptions. In the case of flash system, specific steam consumption is used to calculate MWe from the produced steam. When combined cycle is installed, both steam and brine specific consumptions are required. **Figure 5** shows the user interface in JIWA to perform the MWe calculation.

3. PROBABILISTIC SIMULATION

To support decision making during Drilling, Workover, Acidizing, Feasibility Study (estimate well requirement), well deliverability estimation is required in a form of probability. The uncertainties of reservoir fluid enthalpy, productivity index (PI, a measure of reservoir permeability), reservoir pressure, can be addressed in JIWAFlow probabilistic modeling. To perform the calculation, Monte Carlo simulation is coupled with wellbore modeling. **Figure 6** shows the output of production output probability estimates resulted from JIWAFlow.

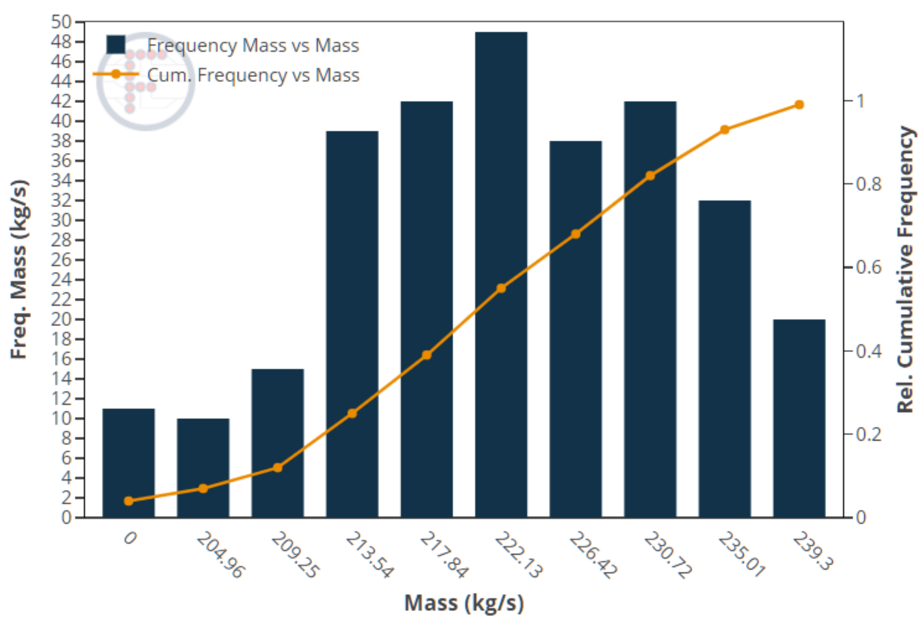

Figure 6 JIWAFlow estimates production capacity probability as it is coupled with Monte Carlo Simulation

4. CLOUD COMPUTING SYSTEM

JIWAFlow allows cloud computation and is integrated with web-based JIWA applications to perform seamless connection with geosciences, reservoir engineering, and surface monitoring data. The architecture of JIWA cloud computing system is presented in **Figure 7**. The system can be accessed through https://jiwa.ailima.co.id.

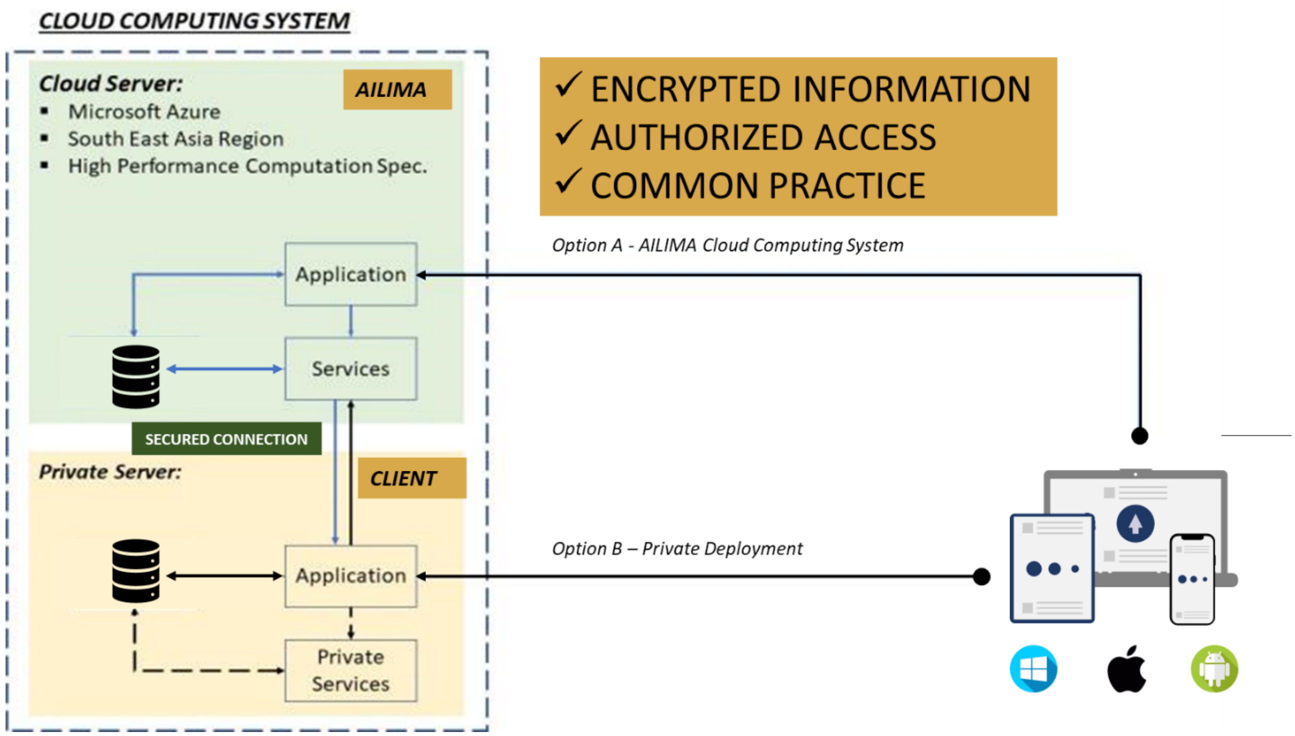

Figure 7 The architecture of JIWA cloud computing system

5. CONCLUSIONS

The wellbore simulator JIWAFlow has been developed in AILIMA. It is developed in a cloud computing system to perform seamless connection with geosciences, reservoir engineering, and surface monitoring data. JIWAFlow wellbore simulator enables well characterization, well capacity estimation and optimization. Moreover, the reservoir uncertainties are honored through Monte Carlo probabilistic calculation which resulted to more decisive opportunities and risks identification during drilling, acidizing, workover and well performance evaluation.

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