JRED3048

PRODUCTION ALLOCATION IN A MULTI-LAYERED WATERFLOOD RESERVOIR USING A PHYSICS-EMBEDDED MACHINE-LEARNING WORKFLOW

Cristian Di Giuseppe, Mercedes Castellanos, Isabel Cano, Nicolás Crevani, Santiago Fernández
Pan American Energy
cdigiuseppe@pan-energy.com; mcastellanos@pan-energy.com; icanofre@pan-energy.com; ncrevani@pan-energy.com; sfernandez@pan-energy.com;
Carlos Calad, Guadalupe Castano Pallav Sarma, Javad Rafiee, Tachyus
carlos.calad@tachyus.com; guadalupe.castano@tachyus.com; pallav.sarma@tachyus.com; javad.rafiee@tachyus.com;
Manuel Albaytero, Mariano Muniategui Luciana Poveda, Micaela Podesta, Silvia Etienot, Darío Baldassa, Javier Gómez, Pan American Energy
malbaytero@pan-energy.com; mmuniategui@pan-energy.com; lpoved@pan-energy.com; mpodesta@pan-energy.com; setienot@pan-energy.com; drbaldassa@pan-energy.com, jegomez@pan-energy.com

Resumen

Allocation of production in a multi-layered reservoir presents a significant challenge to reservoir engineers, particularly in scenarios where injection and production occur without selectivity, rendering traditional methods ineffective. Complicating matters further, the presence of artificial lift completion equipment precludes the use of production logging tools to obtain individual layer contributions. Moreover, the reliance on radioactive tracers from the injector's perspective, adds time and cost to the overall process.

This paper explores an innovative solution aimed at overcoming the limitations of traditional allocation methods, providing insights into achieving dynamic and accurate production allocation in a multi-layered reservoir in the west sector of the Cerro Dragon field using a physics-embedded machine learning workflow with the intent of providing accurate dynamic allocations in reduced period of time.

The Cerro Dragon field is located in the Gulf of San Jorge basin, in the south-east of Argentina. The field has over 4000 producing wells and more than 1000 injectors and it has been operated by Pan American Energy (PAE) since 1997.

The proposed methodology involves a two-step process for each time step within the production period. Initially, we establish an initial state for each layer, encompassing pressure and saturations, then employ Darcy's law and material balance equations to update the layer states for the subsequent time step. This process dynamically allocates phase production to the reservoir layers and is adaptable to the primary production period, where no injection occurs in the reservoir.

In the first step of each time step, we utilize reservoir layer and bottom-hole pressures, along with the well index incorporating effective phase permeability, viscosity, and thickness in Darcy's equation, to compute phase rates for each layer. These rates are then normalized for each well to match the observed well-level rates for each phase. Subsequently, in the second step, we conduct a material balance at the layer level, accounting for the volumes produced and injected during the time step to determine new state variables, namely pressure and saturations. We employ a fully implicit approach to solve the system of equations, comprising two equations for two-phase water-oil systems and three equations for three-phase water-oil-gas systems. These steps iterate until the final production data.

As a result of the implementation, it was possible to solve the production/injection allocation problem taking into account not only the production and petrophysical parameters but also the reservoir pressure, saturation and the corresponding recovery factors aligned with the observed in analogous reservoirs.