RINGKASAN

PERBANDINGAN *X-GRADIENT BOOSTING ALGORITHM* DAN *RANDOM FOREST ALGORITHM* TERHADAP SENSITIVITAS PARAMETER *SURFACTANT FLOODING* DALAM MENINGKATKAN *RECOVERY FACTOR* PADA LAPANGAN LANGGAK

Peningkatan efisiensi perolehan minyak (*enhanced oil recovery*/EOR) menjadi tantangan penting dalam pengelolaan lapangan *crude oil* seperti Lapangan Langgak. Salah satu metode yang menjanjikan adalah injeksi surfaktan (surfactant flooding), yang bertujuan menurunkan tegangan antarmuka antara minyak dan air serta meningkatkan mobilitas minyak. Namun, keberhasilan metode ini sangat bergantung pada kondisi *reservoir* dan formulasi surfaktan yang tepat, sehingga diperlukan evaluasi sensitivitas parameter-parameter kunci untuk mendukung desain strategi injeksi yang optimal.

Dalam penelitian ini, dilakukan simulasi numerik menggunakan perangkat lunak reservoir simulator dan analisis sensitivitas berbasis algoritma pembelajaran mesin, yaitu X-Gradient Boosting (X-Gradient Boosting) dan Random Forest (RF). Data input mencakup variasi parameter fisik dan kimia yang mempengaruhi kinerja surfaktan, seperti suhu, salinitas, adsorpsi, interfacial tension (IFT), dan konsentrasi. Performa masing-masing algoritma dievaluasi menggunakan metrik statistik seperti R^2 dan root mean square error (RMSE), sekaligus dibandingkan kemampuan keduanya dalam mengidentifikasi parameter yang paling berpengaruh terhadap peningkatan recovery.

Hasil perbandingan X-Gradient Boosting dan Random Forest menunjukkan bahwa X-Gradient Boosting berhasil mengidentifikasi suhu dan salinitas sebagai parameter paling dominan, serta memberikan hasil prediksi yang lebih akurat (R^2 = 0,972; RMSE = 2,71) dibandingkan Random Forest (R^2 = 0,965; RMSE = 3,08). Selain itu, X-Gradient Boosting memberikan distribusi kepentingan parameter yang lebih seimbang dan representatif, sehingga direkomendasikan sebagai kerangka utama dalam analisis sensitivitas dan optimasi injeksi surfaktan di Lapangan Langgak.

Kata Kunci : *surfactant flooding, x-gradient boosting, random forest, machine learning*

ABSTRACT

COMPARISON OF X-GRADIENT BOOSTING ALGORITHM AND RANDOM FOREST ALGORITHM ON PARAMETER SENSITIVITY OF SURFACTANT FLOODING FOR IMPROVING RECOVERY FACTOR IN THE LANGGAK FIELD

Improving oil recovery efficiency remains a critical challenge in managing mature oil fields such as the Langgak Field. One promising method is surfactant flooding, which aims to reduce the interfacial tension between oil and water and enhance oil mobility. However, the success of this method is highly dependent on reservoir conditions and the proper surfactant formulation, making it essential to evaluate the sensitivity of key parameters to support the design of an optimal injection strategy.

In this study, numerical simulations were conducted using a reservoir simulator, coupled with sensitivity analysis based on machine learning algorithms namely X-Gradient Boosting (X-Gradient Boosting) and Random Forest (RF). Input data included variations in physical and chemical parameters affecting surfactant performance, such as temperature, salinity, adsorption, interfacial tension (IFT), and concentration. The performance of each algorithm was evaluated using statistical metrics such as R^2 and root mean square error (RMSE), while their ability to identify the most influential parameters was also compared.

The comparison results of X-Gradient Boosting and Random Forest show that X-Gradient Boosting successfully identified temperature and salinity as the most dominant parameters, and provided more accurate prediction results ($R^2 = 0.972$; RMSE = 2.71) than Random Forest ($R^2 = 0.965$; RMSE = 3.08). Furthermore, X-Gradient Boosting provided a more balanced and representative distribution of parameter importance, making it the recommended framework for sensitivity analysis and surfactant injection optimization in the Langgak Field.

Keywords : *surfactant flooding, x-gradient boosting, random forest, machine learning*