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Evolutionary automated radial basis function neural network for multiphase flowing bottom-hole pressure prediction

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ABSTRACT

Accurate multiphase flowing bottom-hole pressure prediction within wellbores is a critical requirement to improve tube design and production optimization. Existing models often struggle to achieve reliable accuracy across the full range of operational conditions encountered in oil and gas wells. This can lead to misallocating resources during well design, inefficient production strategies resulting in lost revenue, increased risk of wellbore damage, and poorly informed investment decisions. This research presents a data-driven hybrid approach that uses a Radial Basis Function Neural Network and a Particle Swarm Optimization algorithm to construct an automated hybrid machine learning model. The proposed model was compared with several well-established machine learning models in the literature using the same computational framework. The modeling results demonstrated the superiority of the hybrid approach. The model achieved superior performance with lower errors, as evidenced by a Relative Root Mean Squared Error (RRMSE) of 0.055. Furthermore, the model exhibited a low level of uncertainty throughout the analysis, indicating its high degree of reliability. These findings suggest the proposed data-driven approach offers a robust and practical solution for FBHP prediction in oil and gas wells.

1. Introduction

Multiphase flow in circular pipes is a common phenomenon across various engineering disciplines [1]. Within the petroleum industry, it is particularly relevant in wellbore environments such as drill-pipe/casing annuli, oil and gas production wells, and hydrocarbon transportation pipelines [2]. This type of flow involves the simultaneous movement of multiple components, forming mixtures like oil-water, gas-liquid, or even more complex combinations like oil-water-gas and gas-liquid–solid [3]. The presence of these distinct fluid phases and their varying properties makes multiphase flow significantly more intricate compared to single-phase (liquid or gas) flow. This complexity arises from the difficulty in establishing readily applicable flow standards, unlike single-phase scenarios [4]. Consequently, accurately estimating Flowing Bottom-Hole Pressure (FBHP) in multiphase flow presents a significant challenge.

Accurate prediction of flowing bottom-hole pressure (FBHP) is a critical aspect of optimizing oil and gas well operations, ensuring safe and efficient production, and maximizing profitability [5]. FBHP represents the pressure at the bottom of a wellbore, a crucial parameter that governs numerous aspects of well management [6]. Precise FBHP estimations are vital for well design, production optimization, and risk mitigation [7].

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