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# A Nodal Analysis Based Monitoring of an Electric Submersible Pump Operation in Multiphase Flow

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**Featured Application: This work can be applied in monitoring and predicting ESP failure when it operates in high gas well condition. It can be used to interpret the downhole ESP data such as pump intake pressure (PIP) and pump discharge pressure (Pdis) to diagnose ESP abnormalities related to the multiphase condition. It highlights the importance of using nodal analysis software (e.g., Schlumberger PIPESIM software) to evaluate the ESP operating condition before and after installation. It is strictly applied in the field where gas lock is a major source of the ESP abnormality.**

**Abstract:** Electrical submersible pump (ESP) operation is compromised by free gas, resulting in premature pump failure and production losses in new wells. It is essential to detect the onset of abnormal operations. We develop a model that predicts abnormal ESP operation when the free gas level increases in the pump. The model compares operation parameters with the parameters of normal operating ranges; it shuts down the ESP when necessary. We used a Schlumberger PIPESIM software (version 2017.01) to perform nodal analysis technique; we tested the model using the other multiphase correlation model and field case studies (where the gas problem in ESP was reported). We employ a homogenous model to calculate the differential pump pressures at various gas volume fractions. Nodal analysis of the intake and discharge point predicted the commencement of abnormal ESP conditions and the associated parameters (critical gas fraction, minimum operating pump intake pressure, and pump discharge pressure). The model results were similar to other surging correlation models (e.g., Romero, Dunbar, Turpin, Cirilo, and Zhou models); they were also identical to field case studies. We identify three performance stability phases when an ESP is exposed to free gas. These are the normal and abnormal operating ranges, as well as the ESP shutdown condition. Modeling permits careful monitoring of ESP operations that can be compromised by free gas.

**Keywords:** abnormal operation; electrical submersible pump; gas volume fraction; nodal analysis



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## 1. Introduction

Approximately 60% of global oil production is produced using the artificial lift (AL) pump technique; more than 20% of the pumps used are electric submersible pumps (ESPs) [1,2]. An ESP is an artificial lifting device that features multistage centrifugal pumps, a motor, seals, power cables, and surface controls. Their applications are found in both on- and off-shore production facilities [3]. This efficient downhole pump converts fluid kinetic energy to hydraulic pressure; the developed pressure depends on the pump stages and fluid properties [4,5]. The horizontal well has played a significant role in developing unconventional reservoirs. It increases the contact between the target reservoir and the production well, leading to increased flow rate and recoverable oil [6]. However, when