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An Integrated Production Modelling workflow for CSG production forecasting and optimisation

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A B S T R A C T

An Integrated Production Model (IPM) predicts the coupled response of the reservoir, producer wells and surface facilities ensuring that proper boundary conditions are honored at all times. Traditional IPM approaches typically employ time-dependent type curves for modelling the reservoir-well behavior to reduce computational effort and time. However, these approaches have limited accuracy and applicability because changes in the reservoir pressure or well production variations as a function of the surface network back pressure are ignored. This paper presents the implementation of an automated workflow to replace time-dependent type curves by pressure-dependent reservoir-well models for honoring pressure and flow constraints, controlling the IPM optimizer and efficiently generating a fully constrained CSG production forecast. The automated workflow approach provides a framework for reducing simulation time, improving accuracy and handling scenario analysis being tested using field data of two real integrated production systems of increasing complexity involving 250 wells (single compressor station) and 500 wells (multiple compressor stations), respectively, with pre or post dewatering periods. The results show the time required to manually generate long-term production forecasts is reduced by up to 68% model whereby the system was accurately solved to meet demand or to maximize production by satisfying hydraulic constraints and boundary conditions. This approach has been applied for Optimisation and Debottlenecking of which case studies are presented.

1. Introduction

An Integrated Production Model (IPM) is used to analyse the response from reservoirs, wells and surface facilities ensuring that proper boundary conditions are honored at all times (Bartolomeu and Abdrakhmanov 2014; Tleukhabyluly et al., 2012). Previous reported approaches modelled the reservoir using time dependent type curves which did not take into account changes in the reservoir pressure or well production variations as a function of the surface network back pressure or constraints (Sharma et al., 2013). Type curve based reservoir models could not be solved by a surface network modelling tool automatically without human intervention (Sharma et al., 2013). This was not possible due to the size and complexity of the surface network and because of the lack of time and pressure-dependent reservoir-well models suitable for Integrated Production Modelling process (Belushko et al., 2014; Correa Feria, 2010; Nazarov et al., 2014).

This paper presents the implementation of an automated workflow that converted the forecasted profile from time dependent type curves, iteratively found main reservoir parameters (i.e., initial pressure, drainage radius and permeability), reproduced the production profile into the equivalent CSG well model which included the reservoir and well performance response and replaced the existing well source models with newly created CSG wells. After CSG Well models were created a series of workflows were developed to control the optimizer of the integrated production model and efficiently generate a fully constrained production forecast.

This proposed approach used a combination of techniques to incorporate type curve based reservoir models into two large integrated production models. The first model consisted of 250 wells and a single compressor station and the second model consisted of 500 wells and multiple compressor stations. Different techniques were applied for wells that were pre or post dewatering and incorporated into a surface network modelling tool. This allowed production forecasts to be generated automatically for the single compressor station model and semi-automated for the multiple

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compressor station model whereby the system was solved to meet demand or to maximize production taking into account constraints.

2. The integrated production system

In the context of CSG production, the Integrated Production System (IPS) typically consists of the following components as per Fig. 1. For a long term CSG production forecast, the gas and water production systems can be segregated as one does not significantly affect the other over the forecast period and the complexity of modelling would not be worth the value gained (Ali Al-Shabibi et al., 2013; Ozdogan et al., 2008). For example, periods of low gas demand would reduce gas production which operationally would need be managed by choking or shutting in low Water to Gas ratio (WGR) wells whilst allowing higher WGR wells to continue to produce, thus having minimal effect on overall water production and dewatering. On the other hand, being unable to dispose of water due to ambient effects or plant availability will result in higher WGR wells being shut in whilst continuing to produce low WGR wells with minimal water.

3. The integrated production model

An Integrated Production Model (IPM), also referred to as an Integrated Asset Model, is a representation of each of the IPS components and typically combines a reservoir model and simulator, well models and a surface-network model in a single higher-level model as shown in Fig. 2. The main purpose is to compute multiphase flow rates, pressure and temperature through each IPS

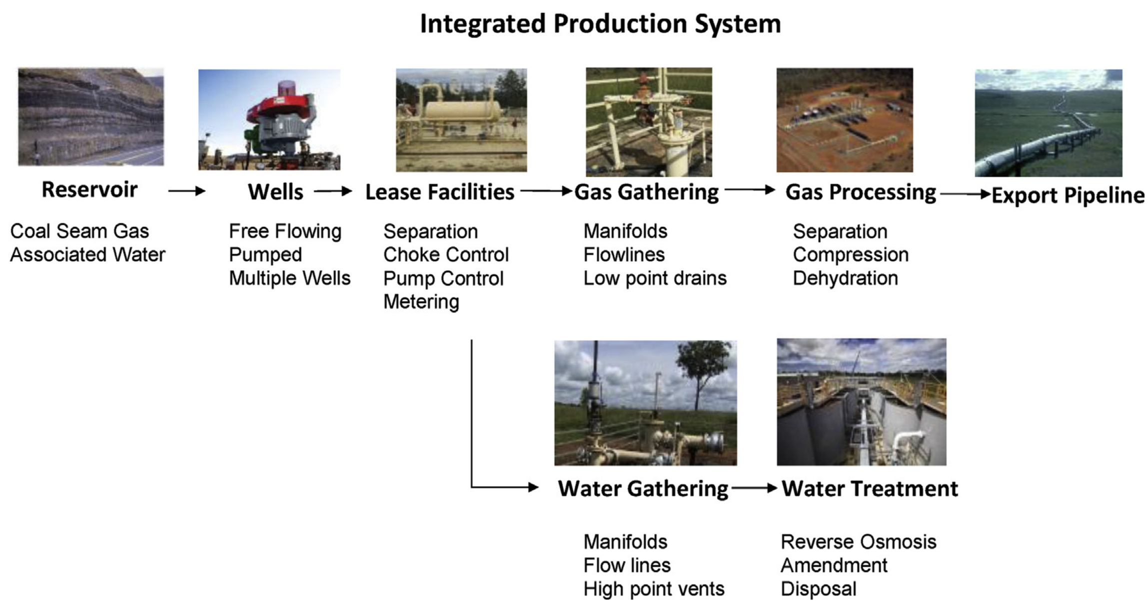

Fig. 1. The CSG Integrated Production System (IPS). External boundary conditions of the IPS begin at the reservoir and end at the export pipeline inlet.

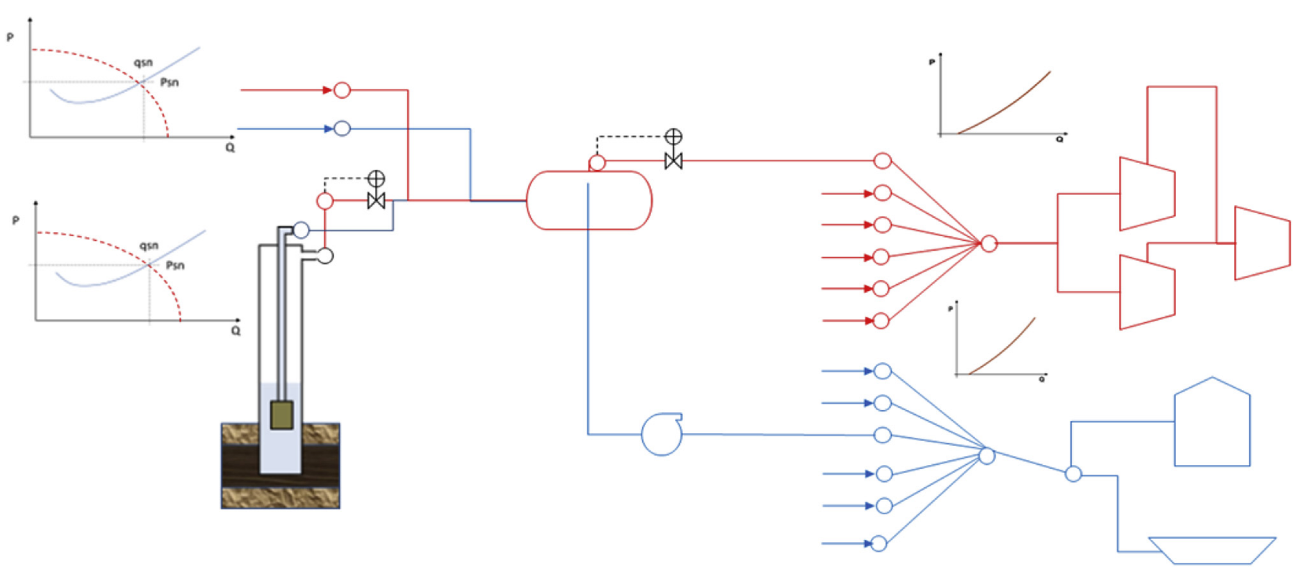

Fig. 2. Schematic representation of an Integrated Production Model (IPM) showing the interconnected elements from coal seam reservoir to export pipeline including a drainage area of the reservoir (IPR curve), producer wells (VLP curve), surface pipe network, valves, fluids separator, manifolds, compressor station, and tanks.