Available online at www.sciencedirect.com

ScienceDirect

IFAC Papers Online
CONFERENCE PAPER ARCHIVE

IFAC-PapersOnLine 48-6 (2015) 045–049

Results of Real-Time Production Optimization of a maturing North Sea Gas Asset with Production Constraints

R.J.P. van der Linden*, J.W. Marck*, J.P. de Boer*

**TNO Heat Transfer and Fluid Dynamics, Delft, P.O. box 155, 2600 AD The Netherlands (Tel: +31 888665647, ruud.vanderlinden@tno.nl).*

Abstract: Operating maturing assets poses increasingly complex challenges to operators. Meeting hourly or daily production targets becomes more difficult when wells are more often shut in for e.g. water washes (against salt deposition) or solvent jobs (at asphaltenes deposition). Declining reservoir pressure in turn results in less margin to compensate lost production while topside facilities can put constraints when production GOR and watercut increase at late production life. In a joint industry project of Wintershall, GdF, EBN, Siemens and TNO the applicability of real-time optimization is explored. The problem description, system architecture and initial optimizer results were presented in Linden (2013). This paper presents results of the optimization project and looks ahead to further field realization. The goal of this paper is to demonstrate that production of a mature North Sea gas asset can be optimized taking into account realistic constraints. All wells at this gas asset are intermittently shut in for water washes while daily nominations must be met. It will be shown that the optimization algorithm obeys the constraints and is fast enough for real-time application and thereby ready for field implementation.

© 2015, IFAC (International Federation of Automatic Control) Hosting by Elsevier Ltd. All rights reserved.

Keywords: Real-time, Optimization problems, Model reduction, Prediction methods, Gas turbines.

1. INTRODUCTION AND PROBLEM DESCRIPTION

The asset considered in this study consists of a satellite platform (3 wells) connected to a main platform (5 wells). The satellite platform is connected to the main platform at which two separator trains in operation, and two compressor trains. Individual wells can be switched between separator trains through manifolds and compressor selection is possible downstream of the joint separator gas outlet. For a schematic layout of the 8-well system, see Figure 1.

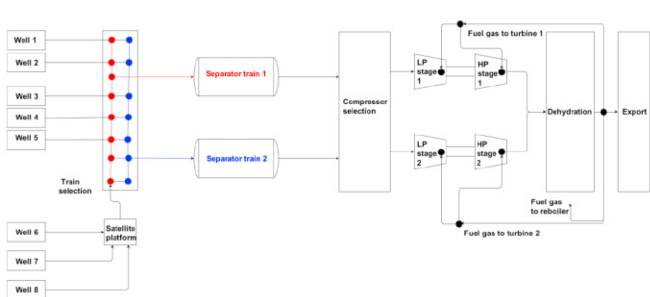

Fig. 1. Schematic asset layout with wells (left), separator trains (middle) and compressor trains (right).

Production of this asset is characterized by:

- Fast decline of well pressure due to salt precipitation in the well/near-wellbore. This results in frequent shut-in of wells and fresh water washing operations. For the least performing wells the production/wash cycle spans a few days;
- Dynamic behavior of the wellhead pressure after a well starts producing, due to pressure buildup in the near-wellbore;
- Topside compression constraints (depending on number of wells producing);
- Rerouting of wells to maximize production and cope with well start-up of wells prone to liquid loading;
- (Slow) degradation of compressor performance due to salt;
- Slow decline of reservoir pressure.

The optimizer qualifies for field application if the optimization algorithm proves able to cope with all of the above dynamics and constraints. The optimization algorithm is applied to optimization objectives, representing operational considerations. The two objectives are:

1. Minimize compressor fuel gas consumption while delivering a required hourly production target (Q_{SP}) in a steady production state:
2. Minimize overall operational cost while delivering a daily production target. Operational cost consist of fuel cost and penalties for under/overproduction (if inevitable):

The corresponding objective functions are respectively:

$$\min J = Q_{fuel}(k) + W\left(Q(k) - Q_{sp}(k)\right)^2 \qquad (1)$$

and

2405-8963 © 2015, IFAC (International Federation of Automatic Control) Hosting by Elsevier Ltd. All rights reserved.
Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2015.08.008

min $J =$

$$\sum_{k_0}^{24/\Delta t} Q_{fuel}(k) + W\left[\left(IQ_{sp} - IQ(k_o)\right) - \sum_{k_0}^{24/\Delta t} Q(k)\right]^2 \quad (2)$$

Note that any term can be added to such objective function, as long as the required output (e.g. instantaneous compressor rpm, or cumulative water production) is calculated by the network model. The network model properties will be discussed in the section 'Method'.

The actual asset dynamics as they appear in the field were discussed above. The available actions ("manipulated variables") in this optimization problem are:

- Compressor turbine rpm
- Choke setting of a limited number of wells
- Compressor train recycle valve

Optimal routing of wells (e.g. matching total rates to compressor trains, or matching high/low pressure wells) and wash-cycle time optimization are not included in the current optimization problem. Practical constraints arise from gas well liquid loading minimum production rates, see Belfroid et al (2008) and Veeken (2010). Constraints in terms of maximal flow rates can be set to limit erosion.

2. METHOD

A full physics-based network model is setup to predict asset behavior with maximum accuracy against minimal calculation time and minimal fitting effort. Each well consists of a reservoir, well- and choke model. At the topside manifold well streams meet, depending on separator and compressor routing). The asset model ends downstream of the compressor train, at export facilities. The asset network model is broken down into the components:

- Reservoir model, calculating the reservoir pressure P_{RES} as function of production flow Q;
- Dynamic wellbore, adds a dynamic term to P_{RES} to capture well dynamics around shut-in;
- Well model, calculates the tubing head pressure *THP* from the reservoir pressure and production flow Q;
- Salt model, additional pressure drop for the well model based on the cumulative gas production since last water wash;
- Choke model, calculates the choke pressure drop corresponding to a gas flow rate using classic single-phase orifice relations;
- Compressor model, calculates the required compressor rpm (and through efficiency, the fuel) to achieve a certain suction pressure using Odom (2009) and *Data collection and analysis of the combined heat and power system at Eastern Maine Medical Center,* (2008)

The pressure drop in the topside piping between the chokes and compressor inlet is set to the constant value of 1.0 bar, based on field measurements.
For the individual components literature models are available to relate the observed pressure drop to estimated gas flow rate. This is required for the optimizer to determine which change in manipulated variable (choke, compressor rpm, …) is necessary to find the optimal operational strategy.

Since no bottom hole pressure measurements are available, the reservoir-wellbore are combined into a single, total pressure drop. This also includes a data-driven pressure drop representing the salt deposition in the near-wellbore. For each well, the decline due to salt precipitation is a function of cumulative gas production since the last water wash. Parameters for this are fitted to well test intervals when flow measurements are available. Figure 2 shows the relations between the models and indicates which quantities are available from field measurements.

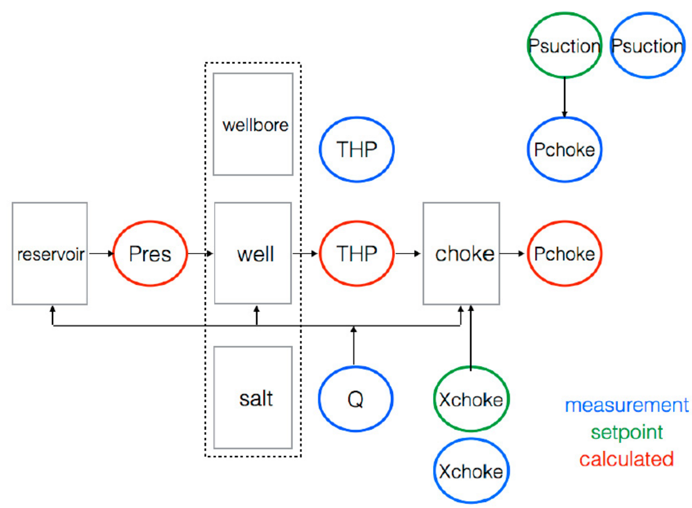

Fig. 2. Reservoir-well-choke models and key variables.

The reservoir consists of a two-tank model, to account for pressure build-up in the near-wellbore. A Cullender-Smith model is used to relate flow and pressure drop over the wellbore (Chaudhry, 2003). The models are validated according to Figure 4 and the overall flow estimation (using the combined reservoir-well-choke models) is compared against intervals during which flow measurements are available. The available measurements are:

- Q: wet gas flow sensor (hourly, during well test intervals only)
- *THP*: tubing head pressure (continuously)
- X_{CHOKE}: choke position/opening (continuously)
- $P_{SUCTION}$: compressor suction pressure

With flow rate measurements being available hourly, the calculations for the asset optimization are performed hourly as well, as will be presented below.

Download English Version:

https://daneshyari.com/en/article/712302

Download Persian Version:

https://daneshyari.com/article/712302

Daneshyari.com