Optimising Production through Sand Management: A Case Study from the United Kingdom Continental Shelf (UKCS)

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1 ABSTRACT

Sand Management Strategies are evolving; Maximum Sand Free Rate (MSFR) objectives are being superseded by Maximum Acceptable Sand Rates (MASR). This shift in philosophy is driven by various factors; technological advances in process systems for handling, disposal and detection of sand, advances in erosion and prediction modelling and greater sand management awareness within operators. However the primary driver in this systematic change is the ever increasing demand for oil and gas production.

Produced sand can be effectively detected by acoustic or intrusive sand monitors; although, in isolation, the sand monitoring system data is not sufficient to implement a strategic production optimisation process based within a Sand Management Strategy. Correlation of the sand monitoring data with production, inspection, integrity and modelling data adds value through system integration. When this data has been analysed, informed decisions can be made to implement the production optimisation process.

The case study concentrates within two areas of Sand Management practice; Prevention and Production [4]; however within this genre the study proves that with effective usage of Sand Management principles there are significant gains to be made in terms of production output. The paper postulates that effective Sand Management within the operator environment is best facilitated by a dedicated “Sand Champion” who acts as a focal point to gather and assimilate the data necessary for the optimisation process within the control envelope of the Sand Management Strategy. Thus the end benefits are not achieved through a unique or unrepeatable process but rather a formulaic approach that could be implemented in any ongoing Sand Management philosophy.

This paper describes a field example in the UK Southern North Sea sector, where expertise in Well Optimisation, Production, Inspection and Sand Monitoring has combined to develop processes and procedures to safely increase production.

2 INTRODUCTION

ConocoPhillips (UK) Ltd SNS (Southern North Sea) Sand Management Strategy has been the subject of topical discussion in the recent past. This discussion has focused on the integrity aspects of the strategy [3]; however it is clear that with the inclusion in October 2003 of a section specifically relating to production optimisation, major successes have been achieved with safely increased production on an individual well and overall field basis. Therefore a re-appraisal of the strategy with reference to an increased emphasis in optimisation is required to address the significance of this new development.

2.1 CoP (UK) Ltd Southern North Sea Field

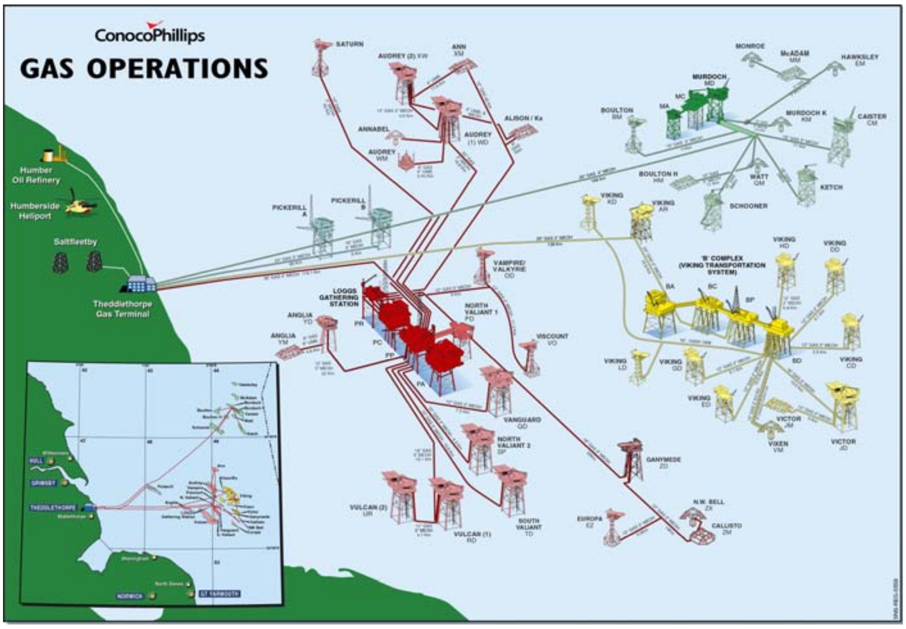

Fig. 1 – CoP (UK) Ltd SNS assets

The ConocoPhillips (UK) Ltd Southern North Sea (SNS) fields consist of three main platforms, twenty five satellite platforms and fourteen subsea installations.

A comprehensive network of sand monitoring equipment has been installed; these consist of acoustic and intrusive monitors supplied from the major system vendors. Regardless of the differences in the sand monitoring methodology and equipment manufacturer, the common feature throughout the systems is two fold:

- All locations are “online” real time, monitoring systems.
- All locations can be accessed through remote link from the CoP (UK) Ltd office at Rubislaw House, Aberdeen for analysis and interpretation.

These sand monitoring systems are a critical element not only from a safety view, but also, as can be demonstrated, from a production optimisation aspect.

3 SAND MANAGEMENT STRATEGY

3.1 Historical Review

The development of the ConocoPhillips (UK) Ltd SNS Sand Management Strategy is well documented, and as such the background information is given on a “refresher basis” as follows:

During a period in 1996/97 sand production led to hydrocarbon releases through the process of erosion. These erosion related events prompted ConocoPhillips (UK) Ltd in conjunction with DNV [3] to develop and implement the “Conoco SNS Sand Management Strategy”. The Sand Management Strategy was based on the “Maximum Acceptable Sand Rate (MASR)” theory. The strategy implemented the installation of a real time “online” sand monitoring system, erosion modelling of choke valves and ranking of wells for sand production potential. This ranking system subsequently led to wells evaluated as high risk being flow restricted by means of Tubing Head Pressure (THP) limitations. The actual THP limitations for each well is stated in a controlled document, the CoP (UK) Ltd Well Operating Guidelines (WOGL).

The "online" sand monitoring network installed as part of this initial drive from the Sand Management Strategy [3] was utilised as an early warning system of the onset of sand production and erosion of process system components. It may be noted that the sand monitoring system and instrument data was not intended as an aid to production optimisation, but rather as a safety critical system, hence the trending capabilities of the Data Control System (DCS) at this time.

3.1.1 Data Control System (DCS) / Sand Monitoring System

The Data Control System (DCS) and Sand Monitoring System were integrated using an industry standard Modbus serial communication protocol. This integration enabled the Control Room Operators (CRO) to trend real time sand probe data and therefore respond quickly to alarm signals. The sand monitoring data transferred to the DCS had to be filtered and or averaged to ensure that any spurious data; from liquid slugs or increased noise, did not result in unfounded alarms, whilst genuine increases in sand production did produce an alarm output. This resulted in the filtered data being deemed unsuitable for short time frame, safety critical operations such as THP reductions, increased flow rates or any other conditions that could induce sand production. Thus as a consequence, guidelines for well start up, well testing and THP reduction procedures required the mobilisation of personnel and portable equipment to installations to monitor these activities.

3.1.2 Pressure Integrity Management System (PIMS)

The Sand Management Strategy identified that no individual department could solve the problem of sand production. Therefore the (Pressure Integrity Management System) PIMS was developed as a result of these findings. The basis of the PIMS framework was the collection and analysis of relevant data from a wide range of operational sources. This system was intended solely for integrity management but the processes involved in PIMS have been adapted to suit production optimisation.

Fig. 2 – Pressure Integrity Management System (PIMS)

3.2 Sand Management Revisions: Production Optimisation

The inclusion in October 2003 of production optimisation processes into the Sand Management Strategy was a significant revision to the strategy. This inclusion signalled a change in implementation from being a safety only procedure towards a method for increasing gas production through controlled decision processes whilst still maintaining asset integrity.

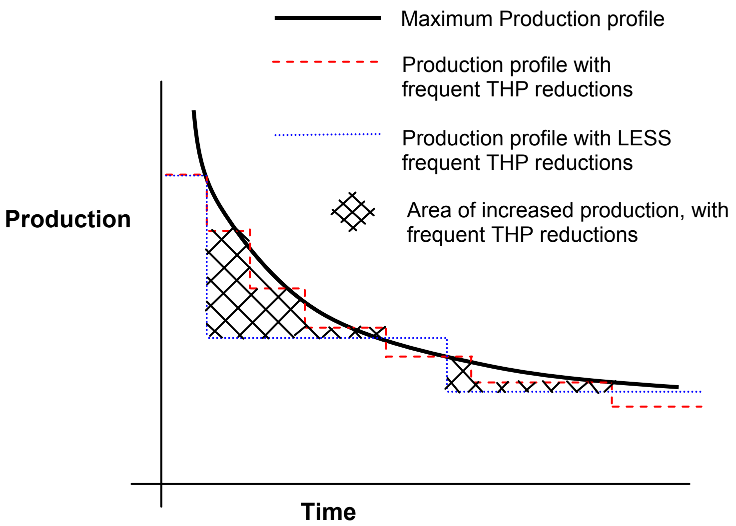

Fig.3 – Production Profile over Time

The CoP (UK) Ltd SNS assets, are situated in a mature gas province, and therefore are prone to sand production due to a combination of physical characteristics; weakly consolidated formations, reservoir depletion inducing water breakthrough and also from initial completion strategies not requiring sand screens. This characteristic reservoir depletion requires THP reductions in order to maintain production rates.

Fig. 3 demonstrates the benefits of the production optimisation processes in a typical reservoir depletion curve. The stippled area represents the production gain possible by implementing a frequent optimisation programme.

Therefore the goal of the optimisation process is to maximise production uplift as close as possible to the theoretical optimal production profile within a controlled procedural framework.

Prior to the production optimisation processes being implemented into the Sand Management Strategy, modifications were necessary to the existing DCS and document control; i.e. the update and introduction of Sand Risk Assessments into the strategy. These changes provided the steps necessary to append the production optimisation process into the existing Sand Management Strategy.

3.2.1 Sand Risk Assessments (SRA)

Sand Risk Assessments (SRA's) are a pre-requisite prior to Tubing Head Pressure (THP) reductions or indeed from any planned workscope that may induce reservoir sand production as a consequence. The SRA comprises of data inputs from a variety of sources e.g. current production conditions, UT wall thickness integrity data, sand probe data and erosion models. The net result of these data inputs is the prediction of sand production and erosion rates at the proposed THP. Evidently the SRA's represent a safety critical feature and provide a Go/No Go stop point for the operational process.

The SRA can not be issued without each criteria being met and satisfied through due process control. The key to the SRA production is the integration of data into a single process to systematically control operations. The sand monitoring specialist is responsible for the SRA production with designated area managers being responsible for issuing of the SRA. It may be noted that on completion of any testing activity the resultant data is analysed and correlated with production, probe and sampling data. From these inputs the level of risk posed from sand production levels at the tested THP is assessed and evaluated. If the substantiated risk level is within accepted values, then the Well Operating Guidelines (WOGL) is amended to reflect the revised production conditions.

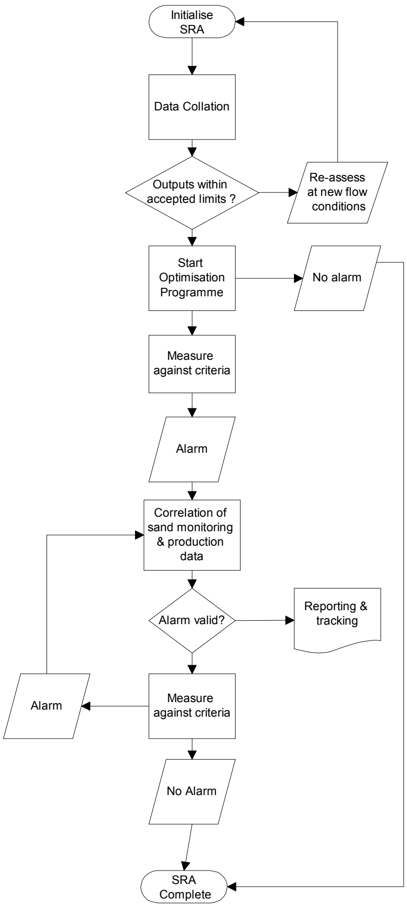

Fig. 4 - Sand Risk Assessment Process

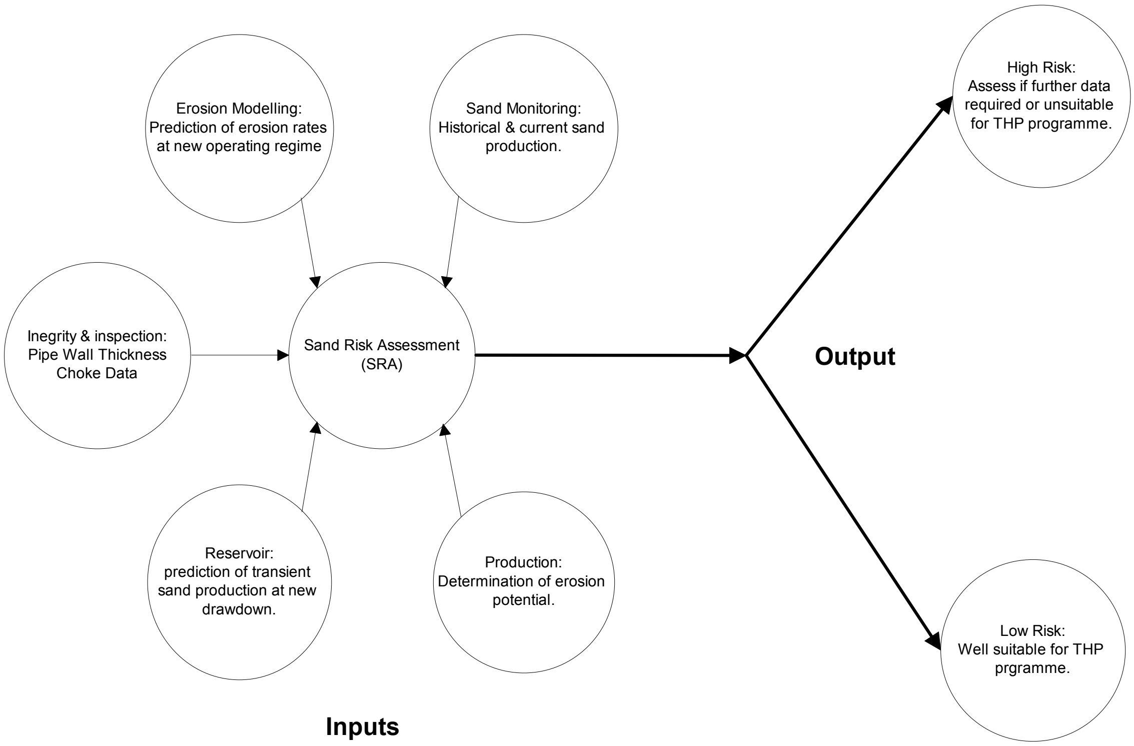

Fig. 5 – SRA Inputs and Outputs

The sand risk assessments are based on the information gathered as part of the PIMS framework; however the primary data sources and outputs of the assessment are as displayed in Fig.5. In essence the outcome is either a high or low risk of sand production and erosion rates. The levels of acceptable sand production and erosion rate per year are stated in the Sand Management Strategy. If the outcome posses a low risk then the optimisation process can continue. If the outcome is high risk, then the results are analysed and an informed decision can be made on the suitability of the proposed optimisation programme.

3.2.2 Data Control System (DCS) Modifications

The Data Control System (DCS) was adapted to allow additional functionality of the system, providing not only filtered sand monitoring data but also the raw data output from the sand monitoring database. This raw data input to the DCS therefore allowed the sand monitoring system to be used for THP reductions as real time instantaneous changes could be viewed. The data gathered from the sand monitoring system can be manipulated and correlated with production and process data allowing test data to be interpreted and analysed in a very short timeframe, without any additional operational costs such as mobilising specialist personnel and equipment.

3.3 Sand Monitoring Specialist

A major factor in the success of the production optimisation process is the contribution of the dedicated sand system engineer. The specialist facilitates all aspects of the SRA process, therefore enabling the operator to perform more THP optimisation programmes per annum. In conjunction with the SRA workscope, the increased sand monitoring system knowledge greatly adds to the in-house competency available within the operator. This further reduces requirements for unnecessary operational expenditure as the engineer can remotely interrogate and run diagnostic system checks to verify the sand monitoring system functionality. Historically these system health checks would require site visits to ascertain the sand monitoring system error.

4 OPERATIONAL BENEFITS

The production optimisation inclusion to the Sand Management Strategy has led to several areas of significant benefit to CoP (UK) Ltd. These benefits can be divided into four main areas of interest:

- Gas Production.
- Costs.
- Risk.
- Environment.

4.1 Gas Production

As a result of the ongoing THP optimisation programmes the net daily increase in gas production to CoP (UK) Ltd in 2005 is in the region of tens of millions of cubic feet per day (MMSCFD). This is equivalent to a yearly increase in produced gas in the scale of billions of cubic feet per year (BCFY). The financial implications of the production optimisation programme are very apparent, especially when taking into account the market value of gas to be $9.84/MMBTU in August 2005. This obviously has a substantial impact with world demand increasing rapidly. Special reference can be made to emerging nations with high growth rate economies such as China and India that have vast energy consumption rates. Currently China and India rank second and sixth respectively in the current largest energy consumer tables.

4.2 Cost

Prior to placement of the sand system specialist, it was deemed necessary to provide manpower and equipment to test each well with a portable sand monitoring system. On average this related to a six figure sum per annum. However with the engineer office based, the vast majority of wells can now be tested and monitored by remote access from the CoP (UK) Ltd office in Aberdeen. Therefore the associated costs incorporated with mobilising specialist field staff and equipment have been largely eliminated – helicopter flights, shipping, scaffolding, equipment rental and manpower resources.

4.3 Risk

As a consequence of lessened field activity, there is a subsequent reduction in risk from everyday operational occurrences. This is especially relevant to operations on the NUI's (Normally Unmanned Installations), where resources are required for operational specials such as planned portable sand monitoring visits for the THP programmes. In addition, due to the increased number of THP programmes throughout the year, there is less risk of formation damage as the drawdown is graduated in smaller step changes. This therefore minimises the potential to initiate sand grain detachment and transportation; the first steps in the 'Sand Life Cycle' [1]

4.4 Environment

The Sand Management Strategy has aided the operator to provide a basis for minimising erosion related unplanned emissions. This highlights the benefits of a holistic approach to the Sand Management process, incorporating the specialist skills of a wide range of departments to achieve targets in a controlled framework.

5 CONCLUSIONS

Historically within the CoP (UK) Ltd Southern North Sea assets, sand and erosion monitoring technology has been used as a method by inspection teams to ensure process and system integrity. However with the integration in October 2003 of production optimisation processes in the Sand Management Strategy, it can be proved that the sand monitoring systems can be implemented not only as a reactive, but also as a proactive system. Thus these monitoring systems, in combination with cross disciplinary data sources provide invaluable data as a tool to safely increase production uplift.

The integration of the production optimisation processes has required fundamental method change and stresses the involvement of inter-departmental groups. However, unquestionably the sand monitoring specialist has a key role to play as focal point in two main areas;

- Sand Risk Assessment compilation and analysis.
- Production Optimisation sand monitoring and reporting.

This specialist knowledge of the sand monitoring system has provided the operator with confidence to safely implement production optimisation programmes. Furthermore the sand monitoring specialist acts as a front line, focal point in the document control required by the Sand Management Strategy.

The integration of the production optimisation processes into the control framework of the Sand Management Strategy has been a significant event in the evolution of the strategy. This strategy can no longer be viewed purely as a safety critical process but now reflects processes to increase production. Indeed it can be argued that the Sand Management Strategy provides the ideal backdrop for production optimisation as it constrains and controls processes whilst providing the tools to verify safely increased production rates through online, real time sand monitoring technology.

NOTATION

DCS	Data Control System
CRO	Control Room Operator
SRA	Sand Risk Assessment
CoP	ConocoPhillips (UK) Ltd
SNS	Southern North Sea
NUI	Normally Unmanned Installation
THP	Tubing Head Pressure
WOGL	Well Operating Guidelines
MSFR	Maximum Sand Free Rate
MASR	Maximum Allowable Sand Rate
PIMS	Pressure Integrity Management System
MMSCFD	Million Standard Cubic Feet per Day
BSCFY	Billion Standard Cubic Feet per Year – US Billion = 1000 Million
MMBTU	Million British Thermal Units

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