Investigation of Debutaniser Reconfiguration on the Northern Endeavour FPSO

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Abstract

The project is a conceptual cost reduction study of different processing configurations involving the Debutaniser and the Fuel Gas System on the Northern Endeavour Floating, Production, Storage and Offloading (FPSO) Facility. The Northern Endeavour is located in the Timor Sea and services the Laminaria and Corallina fields which are now in decline. The study specifically investigates options for cost minimisation for low production rates extending to end of field life. Upon implementation, the modifications identified in the study are expected to lead to a significant reduction in operational expenditure.

1.0 Introduction

The Laminaria and Corallina Fields are located in the Timor Sea about 550 kilometers northwest of Darwin in a water depth of 350m. The Laminaria and Corallina fields produce 59° and 60° API gravity oil respectively, which indicates the fields are primarily condensate with a high portion or LPG's.

First production was in 1999 and at peak production the two fields produced 180,000 barrels of oil per day (bopd). The fields have been in steady decline since that time.

Woodside Energy Limited (WEL) has recognised that as both fields continue to decline the configuration of the processing facilities needs to be adjusted to reduce operating expenditure (OPEX) associated with energy usage and facility maintenance. The unit operations that are expected to have the highest impact on reducing OPEX are the debutaniser and the fuel gas system.

2.0 Topsides Processing Configuration

The Topsides processing facility (simplified in Figure 1) has been designed for an oil capacity of 180,000 bpd and a total liquid handling capacity of 240,000 bpd. The primary purpose of the processing plant is to produce a stabilised export crude product with a maximum Reid Vapour Pressure (RVP) specification of 8 psia.

Reservoir fluids enter the primary oil stabilisation train via the turret. Approximately 30% of the C_5+ fraction are carried over to the gas compression systems from the oil stabilisation train as a result of the high fraction of LPG components (C_3,C_4) that are present in the oil.

Condensed liquids from the gas compression, dehydration and fuel gas systems are routed to the debutaniser to separate the C_5+ fraction from gas and LPG. Both the gas and LPG components are uneconomic to market separately. The surcharge produced LPG fraction is currently disposed of by subsurface re-injection, rather than flared, to minimise environmetal impacts.

Gas Lift is employed for enhanced oil recovery and, currently, approximately 90% of the gas entering the turret is recycled lift gas. At present the facility is bordering on fuel gas deficiency due to the low Gas Oil Ratio (GOR) of the reservoir fluids entering the facility. It is very likely that fuel gas deficiency will continue to worsen in line with declining production.

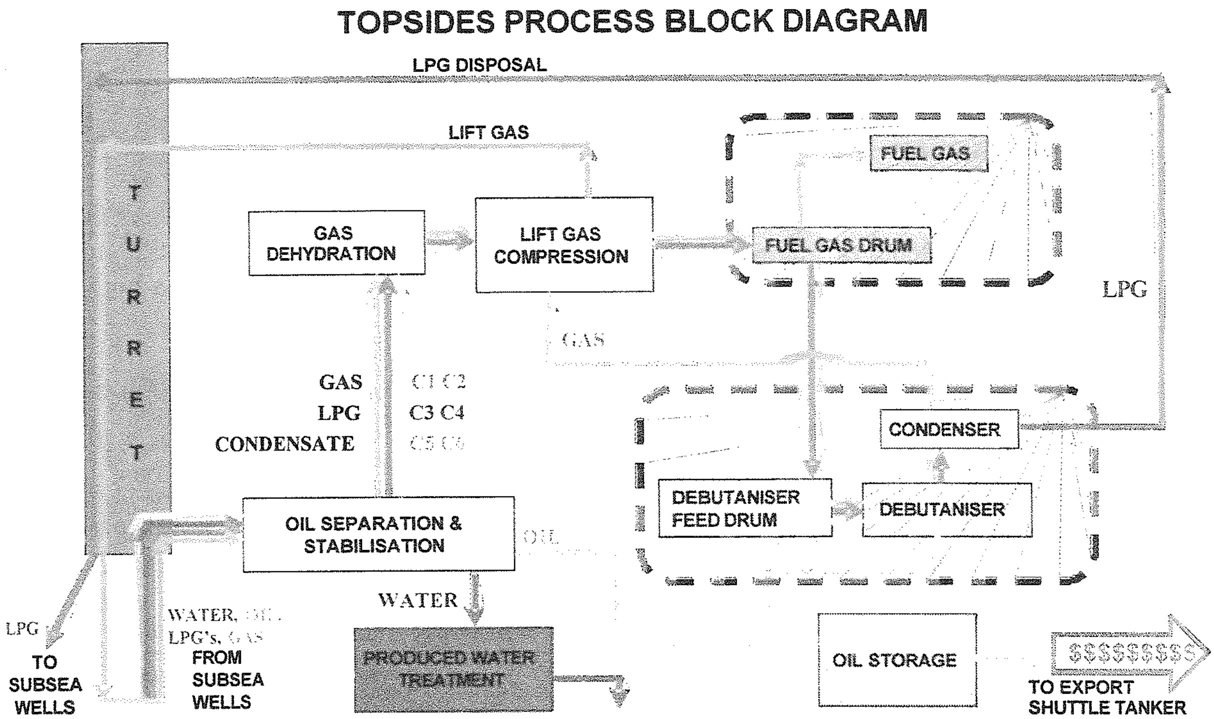
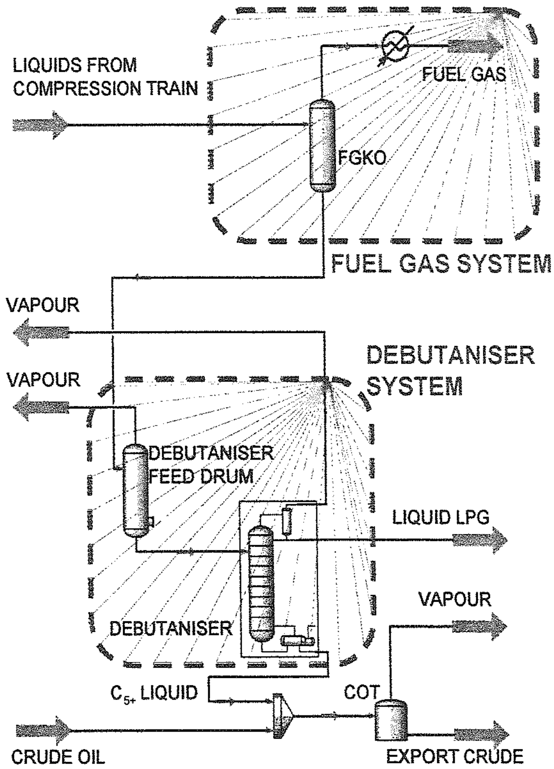


Figure 1 - The Northern Endeavour Topsides Process Block Diagram

2.1 Fuel Gas System



Before entering the debutaniser, the liquids formed in the gas compression systems first enter the Fuel Gas Knock Out (FGKO) drum. The FGKO drum is used to flash and separate the liquid from the gas. The fuel gas is then superheated in an electric heater and routed through filters and scrubbers to remove residual liquid droplets. The clean, superheated fuel gas is then used to power the generators and the compressor turbines. The liquids are passed to the Debutaniser Feed Drum.

At times of reduced production there is insufficient fuel gas to run the power generation turbines. Although far more expensive, diesel and crude are the present alternative source of fuel when this occurs.

2.2 Debutaniser

The Debutaniser is a distillation column designed to recover C_5+ components from the liquids formed in the gas compression systems. LPG and non-condensed gas are formed as by-products from the Debutaniser system. The LPG is currently injected downhole and the gas is returned to the compression system.

The column is of a conventional arrangement with the feed location in the middle of the tower, a reboiler arrangement at the bottom and a condenser/reflux arrangement at the top.

The debutaniser is modeled by a distillation column in HYSYS. The model uses the reflux rate, reboiler temperature and condenser temperature as convergence parameters.

3.0 Methodology and Processes

The project aims to identify the optimal cost reduction configuration of the debutaniser and fuel gas systems and was split into two phases. The two phases were the simulation phase and the fiscal evaluation phase.

3.1 Simulation Phase

A software simulation of the FPSO processing plant had already been developed by WEL using the software package HYSYS. This simulation was used as the template of the investigations.

Sensitivity studies were performed with respect to gas lift flow rates and water cut production rates. This was done to confirm the validity and accuracy of the results produced by the software model for the very low production rates.

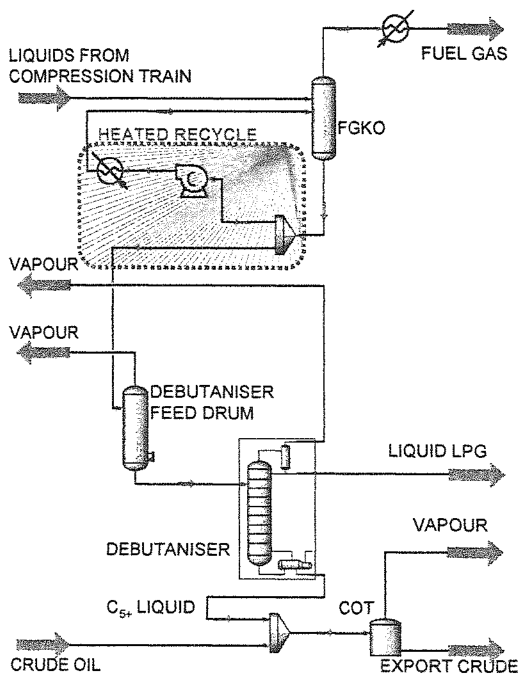
During the simulation phase numerous physical contraints had to be represented in the software model. These included:

- Dew point specification of the fuel gas.
- Maximum RVP specification of the combined crude product.
- Correct RVP specification of the liquid C_5+ stream from the debutaniser.
- Minimum reflux rate specification of the debutaniser.
- Gas lift total input must equal gas lift total output of the plant.
- Operation of Two turbines will be required for reliability of production.

The simulation phase allowed the termination of many options and resulted in three final options for fiscal evaluation. These options are:

3.1.1 Option 1

- No modification to the debutaniser.
- Add a heated recycle loop to the FGKO Drum.



The implementation of the heated recycle on the FGKO drum will increase the amount of fuel gas available for the power generation turbines (Figure 2). It does this by producing a fuel gas rich in the currently unused LPG components. This will reduce the facility's future dependence on crude and diesel for fuel sources. The modification also offers the facility the same benefits at current production levels when individual or multiple well shutdowns occur due to the frequent subsea infrastucture failures.

The cost benefit of implementing this modification is anticipated to be many magnitudes larger than the modification cost itself. The usage of the LPG component as a fuel source will also allow a higher portion of the methane fraction to be deviated to the lift gas compression train. Thus further assuring the supply of lift gas for enhanced oil recovery.

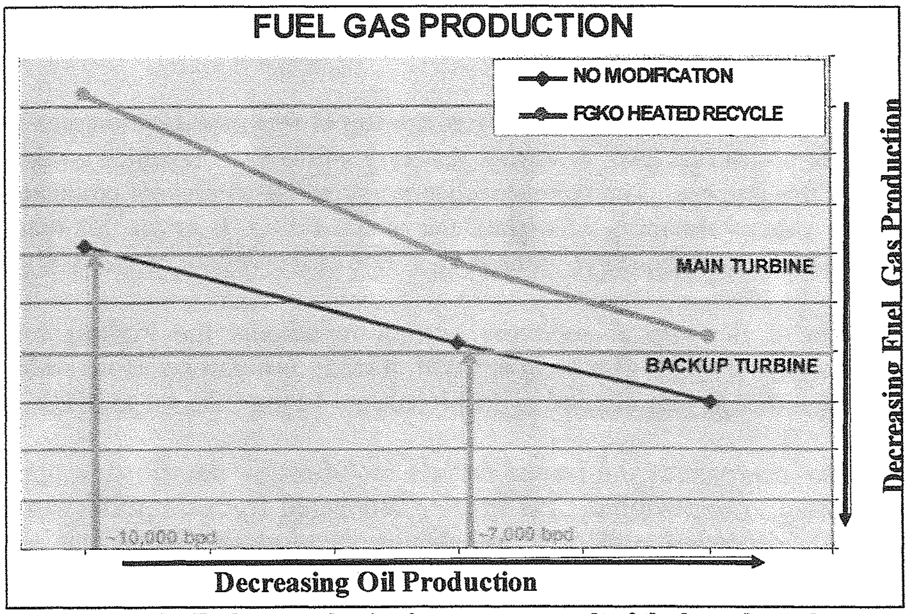
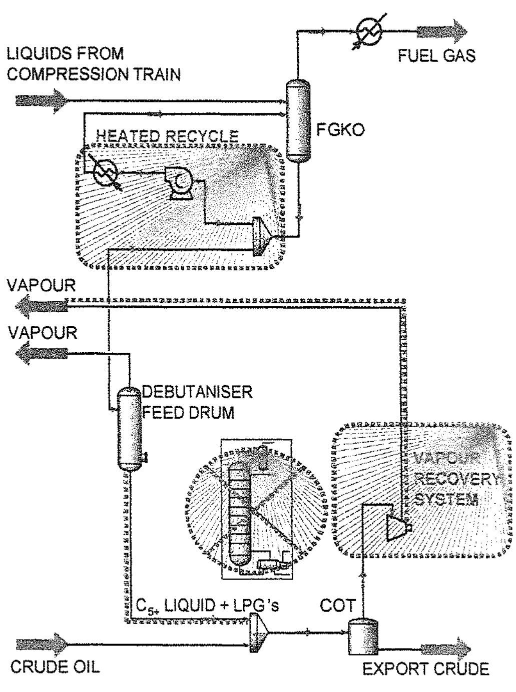


Figure 2 – Fuel gas production increase as a result of the heated recycle modification on the Fuel Gas Knock Out Drum.

3.1.2 Option 2

- Decommission the debutaniser.
- Reduce the pressure in the debutaniser feed drum and run the liquids from the debutaniser feed drum directly to the crude oil tanks (COT).
- Re-route the debutaniser feed drum vapour stream to the re-compressor inlet cooler.
- Install a vapour recovery system on the COT.
- Add a heated recycle loop to the FGKO Drum.



In addition to reducing the OPEX associated with the debutaniser, this modification has the advantage of also decommissioning many other process operations associated with the debutaniser. These include the waste heat recovery unit (WHRU), the heating medium (HM) system, the debutaniser reboilers and pumps, the debutaniser inlet and outlet heat exchangers, and the LPG injection pumps.

The simulation models show that the debutaniser must be left in its current configuration down to a production level of 7,000 bopd. Otherwise the RVP of the crude product is unacceptably high. Below 7,000 bopd it is anticipated that the residence time of the crude product in the COT will be of sufficient length to meet RVP specification at take off intervals. Further analysis will be required to increase the confidence in this decision as failure to meet this specification results in supply penalties being incurred by WEL.

The LPG rich vapour coming from the COT as a result of this modification requires recycling back into the plant for use as fuel gas. A vapour recovery unit will be installed on the cold vapour vent on the COT for this purpose. The vapour recovery unit will also prevent production shutdowns as a result of dense vapour slumping onto the deck of the FPSO. It is for this reason alone that the decomissioning of the debutaniser requires the addition of the vapour recovery system.

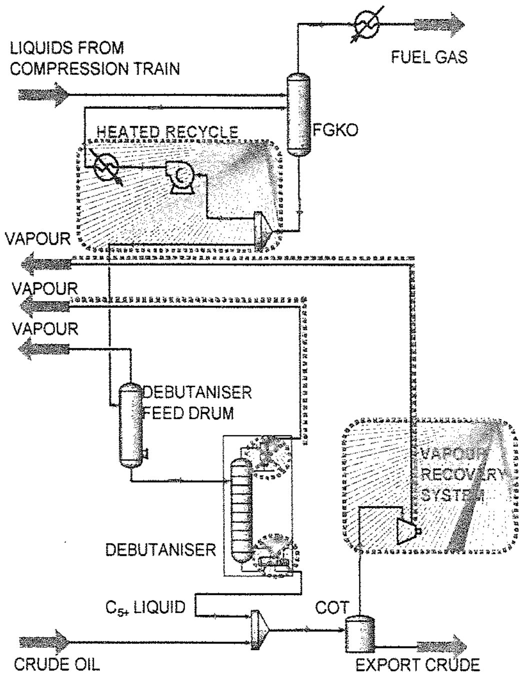
The installation of the vapour recovery system represents the highest capital expenditure recommended in this project. It also brings with it many installation issues which require detailed engineering and, although investigated in the project, are beyond the scope of this paper.

This option also incorporates the heated recycle modification described in option 1. The heated recycle is required to remove the LPG fraction recovered from the COT vapour by the vapour recovery unit. The decomissioning of the debutaniser therefore necessitates the addition of a vapour recovery system and the heated recycle on the FGKO drum.

3.1.3 Option 3

- Keep the debutaniser attached but decommission the reboiler, condenser, feed heat exchangers and the Waste Heat Recovery Unit (WHRU).
- Re-route the Debutaniser vapour stream to the re-compressor inlet cooler.
- Install a vapour recovery system on the COT.
- Add a heated recycle loop to the FGKO Drum.

This option is very similar to option 2, however, the debutaniser is used as a low pressure separator instead of the FGKO drum. This has the effect of reducing pipework modifications and hence reduces the cost of the modification. Using the debutaniser vessel as a low pressure separator will incur maintenance costs which are included in the fiscal comparison.



3.2.1 Fiscal Evaluation Phase

The fiscal evaluation of the final three models is currently being completed to ascertain which will offer the most financial benefit to WEL. The fiscal evaluation involves:

- Formulation of equipment data sheets.
- Reviewing facility layout diagrams.
- Sourcing quotes for new equipment and piping changes.
- Estimating decomissioning costs of redundant equipment.
- Extracting operational maintenance data compiled by WEL on each of the relevant pieces of processing equipment.

The Cost Benefit analysis of this project follows the Net Present Value (NPV) model and incorporates assumptions for the oil price, discount rate and time usefulness of the final configurations. The NPV analysis is of a cost benefit nature and as such does not include salvage costs for decommissioned equipment, depreciation or tax benefits.

4.0 Recommendations

The following two recommendations are subject to the findings of the final NPV analysis of each the final three cases.

4.1 Install the heated recycle on the FGKO drum (OPTION 1) at the next facility shutdown.

4.2 Decommission the debutaniser and install a vapour recovery system on the Crude Oil Tanks (OPTION 2 or OPTION 3) when production reaches 7000 bpd.

5.0 Conclusions

The outcomes of the project are expected to yield a sizeable reduction in operational expenditure of the facility. This may have the added benefit of extending the operating lifetime of the facility as revenue reduces in accordance with the declining production rates.

The project findings and eventual outcomes will also be shared with similar WEL operated facilities and are expected to net further benefits in the future when they approach end of field life production rates.

6.0 References

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