Revitalization for Oil Nezzazat Reservoir Using Low-cost Water Dump Flood in an Offshore Environment
Case Study from Gulf of Suez

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GUPCO Oil Company - Background

- GUPCO is one of the largest E&P Companies in Egypt and Middle East.
- Established in **1965**.
- More than **3,000** employees.
- Joint Venture with BP.
- Offshore Oil Company in Gulf of Suez (GoS).
- Operates about **40** fields in GoS producing from **8** reservoirs.
- GUPCO produced more than **4.6** billion STBO which represent more than **43%** of Egypt's cum oil to date.
- Currently produces around **90** MBOEPD.
Introduction to the Asset

• The field is an offshore field located in the central part of the south Gulf of Suez.
• Tilted fault block accumulation.
• Oil Reservoir – Sandstone Heterogeneous Reservoir.
• Production History of 12 years.
• Production through Gas-Lift.
• Development through depletion and water injection.
The Case Study Outlines

- Reservoir Simulation Model was built by Nexus® Software for Nezzazat Reservoir.

- The Nezzazat Group is an 800 ft. thick interval overlying and conformable with the Nubia and comprises an inter-bedded sequence of limestone, sand and shale deposited in a marginal marine environment.

- It is classified as a heterogeneous reservoir It is subdivided into:
  - Raha,
  - Abu Qada,
  - Wata and
  - Matulla

- They represent three main regressive cycles in the Upper Cretaceous and can be mapped on a basin wide scale.
Depositional & Facies Model for Nezzazat Reservoir

- Fluvial Marsh
- Tidal Mud Flat
- Marine Shale
- Fluvial Channel
- Crevasse Splay
- Tidal Channel
- Inter-tidal Sand Bar
- Subtidal Shoals or Shelf Sands

Tidal Channel-Bars

- Shales & shallow subtidal carb / marls
- shelfal carbonate unit

- Fluvial Channels
- Crevasse
- Marine Subtidal sands
- Shelfal carbonate unit

- Shelfal Tidal
- Sheet Sands, Bar sands, good vertical and lateral connectivity
Reservoir Dynamic History

- The simulation Model has two wells (A1 & A6A).
- The only existing Nezzazat oil producer is A1 well.
- Originally, it was comingleld with the Nubia.
- The well was re-completed as a Nezzazat only producer in 2007 and flowed initially at 2,100 BOPD.
- The reservoir Pressure showed decline until reached below bubble point pressure.
Reservoir Connectivity

- All RFT data of the A6A Nezzazat sands showed some degree of depletion due to the production from A1 well.

- A6A was originally completed and successfully drained oil from in a high-pressured watered-out Nubia reservoir, making it an ideal dump-flood water source.

- 0.5 MMBO was recovered from A1 after starting the dump flood in A6 Nubia water.
A1 & A6A Production History & Performance

Start Prod: May-2007
Initial Rate: 2100 BOPD
Cum Oil: 1.51 MMSTB
Status: Online

Start Prod: Jun-2009
Initial Rate: 990 BOPD
Cum Oil: 0.49 MMSTB
Status: Converted to Injector

Production performance – DSS™
Field STOOIP & Reserves

- Material balance and static model suggested a connected volume of about 17 MMBO STOIIP.

- Expected recovery factor based on analogues fields for primary depletion of Nezzazat is in the range of 10 to 15%.

- The recovery factor using water flooding for the Nezzazat can reach up to 20% giving an incremental reserves of 1 to 1.5 MMBO if waterflooding successfully applied.
Dump Flooding Water Injection

- The dump-flood mechanism is to inject water from deeper reservoir with an active aquifer into an upper reservoir.
- The dump-flooding was initiated as it is an Offshore field with no water injection line connected to the platform.
- The dump-flood was initiated by commingling the target and water source reservoir through A6A well, allowing water to naturally cross-flow into the pressure depleted target reservoir.
- Production logging tools was run in well A6A and confirmed the cross-flow and the static pressure data was recorded in the producer and showed and increased pressure.
The production logging analysis for the well A6A has indicated good performance for reverse dump flood from Nubia to Nezzazat That was at initial condition directly after operating the well as dump flood.
NEXUS RESERVOIR SIMULATION MODEL
Build, HM & Forecast
Problem Identifying

- The pressure support was needed to support the reservoir pressure, so a dump-flood was done from Nubia to Nezzazat to support the depleted reservoir pressure as a low-cost solution.

- The Dump-flood well A6A was shut-in since 2015 due to mechanical problem.

- A numerical simulation solution is needed to estimate the value of restoring water injection and fix the mechanical problem in A6A either surface or dump-flood.
Key Challenges

- **Pressure depletion**
  - The field produces under depletion drive mechanism which need a pressure support.

- **Water injection facilities**
  - The field has no water injection line connected to the platform, so surface injection wasn’t viable.

- **Scale accumulation**
  - This field specifically suffers from hard scale accumulation while producing, so the scale removing by acid pumping or CTU is a challenging process either technically or economically.
Key Challenges

- Dump flooding water injection rates
  - Only two production logs were run to identify the dump-flooding rate. The injection rates were estimated and adjusting based on the reservoir pressure performance.

- Gas rates allocation
  - One of main problems in the field is the gas rates reading and allocation which were adjusted to fit with the production data trends.

- Original OWC
  - No clear contact detected from the Nezzazat wells drilled in the field, so the OWC was estimated to be the same like the underlying reservoir Nubia.
Reservoir Simulation Nexus Model Workflow

**Step 1**
Model Building
- Static Model
- Rock Props
- Fluid Props
- Prod History

**Step 2**
HM
- Match Prod History
- Match Injection Period

**Step 3**
Forecast
- Production Forecast
- Restart
- Dump-flooding
Main Simulation Model Objectives

- Model constructed including the two wells (A1 & A6A) mainly to:
  - History match the historical data (from 2007 to 2019)
  - Forecast cases to model restarting the water flooding (from 2020 to 2025)
Static Inputs

- The Simulation Grids are 50 x 50 x 85 [212,500 Cells].
- Facies Model was built to mimic the different Facies within Nezzazat Reservoir
- Properties Modelling for Porosity, N/G & Permeability.
- The Faults & Layers were identified within the Static Model.
- OWC estimated to be like Nubia Reservoir
Dynamic Inputs

- Reservoir pressure data till Jun-19.
- Relative permeability data for Oil-Water from SCAL report of offset well
- Gas-Water relative permeability were estimated from an offset field
- Black Oil PVT data from an offset well.
- Well constraints was generated from the production data in SimDataStudio™.
Model Initialization – 3D Nexus View™

Facies Porosity Distribution

Pore Volume Distribution
Model Initialization – 3D Nexus View™

Initial Saturation Distribution

Initial Pressure Across The Nezzazat
Kh Multiplier & PV multiplier was used to history match the well rates and reservoir pressure.

The residual oil saturation slightly changed to match the recoverable oil and movement of water.

Adjusting water injection rates at the dump flooding period was essential to match the reservoir pressure trend in the injection period.
Average Reservoir Pressure Matching

![Graph showing reservoir pressure and water injection rate over time. The graph illustrates the pressure (in PSIA) and water injection rate (in STB/day) over a series of dates.]
Nexus® Model – Forecasting Cases

- Two Forecasting Cases:
  - 1- Do Nothing – Keep Producing with current well A1 till Jan-2025
  - 2- Restart Injection in 2020 with VRR = 1.5 till Jan-2025

- **Case_1** showed increasing gas saturation due to the decrease in reservoir pressure in some zones.

- **Case_2** showed improvement in reservoir pressure due to restoring injection with VRR=1.5 to prevent the water breakthrough in high perm zones
3D Nexus View™ – Forecast Cases

Case_1: Keep Producing without Injection

Case_2: After Restoring Injection
Nexus SimResults™ – Forecasting
Conclusions

- The successful natural dump-flood in the Gulf of Suez offshore environment provided numerous lessons learned to the operator.

- The implementing the dump-flood in the subject reservoir was beneficial without spending money, which enhance the offshore practice and maximize the gain from abandoned reservoir with nearly no capital cost.

- Reservoir simulation model construction assist in evaluating and forecasting the impact of restarting the water flooding in the reservoir after the well A6A was SI due to mechanical problem.

- 0.5 – 1 MMBO incremental reserves are expected to be recovered from the well A1 after re-starting water injection in A6A in Jan-2020.
Further Plan & Way Forward

- The model can be utilized in future for forecasting several depletion strategies to maximize the recovery in such heterogeneous reservoir.

- Dump-flooding can be applied in an offset Nezzazat field in GoS which don’t have a water injection facilities & pipelines.

- A recommendation will be issued to restart injection in the Nezzazat field based on Nexus simulation model.

- A SurfNet™ model can be constructed to manage & optimize the surface facilities rates and constraints on water injection & production.
Nexus® Experience

- The study took around two Months to build and model the dynamic model as the static was already constructed.
- Running in Parallel option using 8 cores make it faster to run the model by 30%.
- The SimDataStudio™ constraints generation facilitates easily allocation for the injection rates and forecast rates for both production and injection.
- The Macro option in SimResults™ easily utilized to retrieve different curves during history matching stage.
- The Nexus View™ easily used to optimize the perforation to be sure all are connected to the sand facies built in the static model.
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