DESTINY: A Software for Flow Diagnostics and History Matching Using Streamlines

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Outline

- Software Introduction
  - Flow diagnostics & History matching

- Flow diagnostics
  - Streamline
  - Time of Flight
  - Drainage (Swept) Volume
  - Rate Allocation
  - Injection Efficiency

- History matching
  - Well Responses Before and After Calibration
  - Permeability Calibration
  - BHP, WCT Sensitivity
Software Introduction

**ECLIPSE**

Finite difference simulation

**DESTINY**

Not streamline simulator but Post-simulation processing

**Visualization**

Flow diagnostics:
- Streamlines
- Well partitioning
- Drainage/swept volume
- Rate allocation
- Injection efficiency

History matching:
- Permeability calibration
- Sensitivity calculation

Flow Diagnostics

- **Streamline**: show flow path according to the velocity field.
- **Time of flight (TOF)**: particle travel time along streamline.
- **Drainage volume of producer at time t**: the reservoir volume covered by streamlines within time t.
Flow Diagnostics

A tight gas reservoir case with producers only

Time of flight to producer
Partition by producers
Drainage volume of producers at 10000 day

Time of flight to injectors
Partition by injectors
Swept volume of injectors at 10000 day

Brugge Case

MCERI

MCERI
Flow Diagnostics

- Phase tracing captures the movement of every phase

Field oil saturation
Total velocity tracing

Water streamlines
Oil streamlines

Rate Allocation Map

- Connector thickness stands for liquid rate allocation (streamline number)
Flow Diagnostics

Production Allocation Map

- Bubble size stands for liquid production rate
- Portion size stands for rate allocation from different injectors

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Flow Diagnostics

Injection Allocation Map

- Bubble size stands for injection rate
- Portion size stands for injection allocation to different producers

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Flow Diagnostics

\[ \text{Injection Efficiency} = \frac{\text{offset oil rate (STB / Day)}}{\text{injection rate (STB / Day)}} \]

For rate optimization:
Increase injection rate of high efficiency
Decrease injection rate of low efficiency

History Matching

Trace streamline

BHP sensitivity
WCT sensitivity

Calculate sensitivity
Calibrate perm
Shift well response

Calculate sensitivity Calibrate perm Shift well response
History Matching: Basic Workflow

Initial Model → Finite difference simulation → streamline tracing

misfit? NO YES

model update sensitivity

Calibrated Model

Training
Software interface

Setting
1. Name of simulation deck file
2. Run simulation or not
3. All: trace streamlines for all steps; Single: need to specify which step to trace streamline in Schedule time box.
4. Total number of streamlines for the whole reservoir.
5. Trace streamline from producers or injectors
6. Can trace phase streamlines or streamlines of total flux.
7. History matching water cut and flowing bottom hole pressure for each producer.
8. Output inversion sensitivity

Generated Files

Under working directory
- ECLIPSE.SLN10000
- ECLIPSE.SLN10001
- ECLIPSE.SLN10002
- ECLIPSE.SLN10003
- ECLIPSE.SLN10004
- ECLIPSE.SLN10005
- ECLIPSE.SLN10006

Streamline

rate allocation
Injection efficiency

WCT WCTH
BHP BPH

Inside Destiny folder
- D_ALLOC_INJ.10.txt
- D_ALLOC_PRO.10.txt
- D_INJ_Efficiency.10.txt
- D_sensitivity_bhp_8R-P-10.10.10.txt
- D_sensitivity_wct_8R-P-10.30.10.txt
- D_Well_Response.0.txt
- D_Well_Response.10.txt
- PERMX:DIFFERENCE:GRDECL
- PERMX:GRDECL
- PERMX:GRDECL

sensitivity

Permeability calibration

The following slides shows how to visualize these files in Petrel and Excel.
Flow Diagnostics

Streamline

full streamline

Streamline only for BR-P-15
1. Open petrel and go to cases tab.
2. Right click to import file.
3. Choose ECLIPSE.DATA to import the Brugge case simulation result.

Streamline

1. Go to Models tab and check streamline box to show streamline.
2. Choose the property which is to be shown on streamline.
3. Choose the time step to show streamline.
4. Turn on all wells for visualizing the well positions.
5. Pick streamlines only for specific well.
Time of Flight

1. Choose Time of flight(end) to view TOF to producers

2. Choose Time of flight(start) to view TOF to injectors
1. Import diagnostic results from D_grid_diagnose_10.grdecl.
2. Double click Properties and go to filter tab.
Drainage(Swept) Volume

The use of filter
1. Choose filter tab.
2. Check use value filter box.
3. Highlight PARTITION_FLUID_SINK term.
4. Check use filter box.
5. Set Max as 23.

(the partition numbers of corresponding wells are listed in D_terminator.log file, which is in Destiny folder under current case directory).

Drainage(Swept) Volume

The use of filter
1. Choose filter tab.
2. Check use value filter box.
3. Highlight PARTITION_FLUID_SOURCE term.
4. Check use filter box.
5. Set Max as 33.

(the partition numbers of corresponding wells are listed in D_terminator.log file, which is in Destiny folder under current case directory).
Drainage(Swept) Volume

1. Choose PAERIRION_FLUID_SINK term to view reservoir partition according to producers.

2. Use TOF_FLUID_PRO as filter to cut out drainage volume at time 2000 day.

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Drainage(Swept) Volume

1. Choose PARTITION_FLUID_SOURCE term to view reservoir partition according to injectors.

2. Use TOF_FLUID_INJ as filter to cut out swept volume at time 2000 day.
Rate Allocation

1. Open D_RateAlloc_Plot.xlsm
2. Import data to data sheet from D_PRO_ALLOC_10.txt and D_INJ_ALLOC_10.txt.
3. Click PLOT in data sheet.
4. Check result in PLOT sheet.
History Matching

Well Responses Before and After Calibration

![Graphs showing well responses before and after calibration.](image-url)
Well Responses Before and After Calibration

1. Open D_Well_plot.xlsm in the package
2. Import initial simulation result D_Well_Response_0.txt to initial sheet
3. Import final simulation result D_Well_Response_10.txt to final sheet
4. Go to chart_template sheet and click PLOT
5. Check the plots in PLOT sheet

Permeability Calibration

Initial permx histogram  updated permx histogram
Permeability Calibration

1. Import PERMX_DIFFERENCE10
2. In Filter tab, uncheck all value filters but only use PARTITION_FLUID_SOURCE, set the Min as 1 to filter out all the inactive cells

Permeability Calibration

1. Choose PERMX_DIFFERENCE10 to view and double click it to set colors
2. Choose Colors tab
3. Check Override global property templates
4. Choose RGB
5. Insert new color tab in the middle of color scale
6. Set max as 500
7. Set min as -500 and make the color blue
8. Set middle value as 0 and make the color gray
Use DESTINY to import sensitivity

1. Choose D_sensitivity_wct_BR-P-10 to import sensitivity of cells towards BR-P-10’s WCT curve.
2. Choose D_sensitivity_bhp_BR-P-10 to import sensitivity of cells towards BR-P-10’s BHP curve.
BHP, WCT Sensitivity

1. highlight D_sensitivity_wct_BR-P-10 in filter tab
2. Check use filter
3. Set Max as -10 to filter out insensitive cells
4. In Models section, Choose D_sensitivity_wct_BR-P-10 to view the cells that are sensitive for well BR-P-10’s water cut.

BHP, WCT Sensitivity

1. highlight D_sensitivity_bhp_BR-P-10 in filter tab
2. Check use filter
3. Set Min as 1 to filter out insensitive cells
4. In Models section, Choose D_sensitivity_bhp_BR-P-10 to view the cells that are sensitive for well BR-P-10’s bottom hole pressure.