

## DAFTAR ISI

|  |             |
|--|-------------|
| <b>HALAMAN JUDUL .....</b>                                     | <b>i</b>    |
| <b>HALAMAN PERSETUJUAN .....</b>                               | <b>iii</b>  |
| <b>PERNYATAAN KEASLIAN KARYA ILMIAH.....</b>                   | <b>iv</b>   |
| <b>KATA PENGANTAR .....</b>                                    | <b>v</b>    |
| <b>HALAMAN PERSEMBAHAN .....</b>                               | <b>vi</b>   |
| <b>ABSTRAK .....</b>   | <b>vii</b>  |
| <b>ABSTRACT .....</b>  | <b>viii</b> |
| <b>DAFTAR ISI .....</b>  | <b>ix</b>   |
| <b>DAFTAR GAMBAR.....</b>                                      | <b>xi</b>   |
| <b>DAFTAR TABEL .....</b>                                      | <b>xii</b>  |
| <b>DAFTAR LAMPIRAN.....</b>                                    | <b>xiii</b> |
| <br>   |             |
| <b>BAB I PENDAHULUAN.....</b>                                  | <b>1</b>    |
| 1.1 Latar Belakang.....  | 1           |
| 1.2 Perumusan Masalah.....                                     | 4           |
| 1.3 Maksud dan Tujuan .....                                    | 4           |
| 1.4 Ruang Lingkup dan Batasan Penelitian.....                  | 5           |
| 1.5 Hipotesis .....  | 6           |
| 1.6 Sistematika Penulisan .....                                | 6           |
| <b>BAB II TINJAUAN LAPANGAN.....</b>                           | <b>8</b>    |
| 2.1 Lokasi Lapangan.....                                       | 8           |
| 2.2 Geologi Lapangan.....                                      | 9           |
| 2.2.1. Geologi Regional .....                                  | 9           |
| 2.2.2. Stratigrafi Regional.....                               | 12          |
| 2.2.3. <i>Petroleum System</i> .....                           | 14          |
| 2.2.4. Model Pengendapan.....                                  | 18          |
| 2.3 Geofisika Lapangan .....                                   | 18          |
| 2.3.1. Data Seismik .....                                      | 18          |
| 2.3.2. Interpretasi Seismik .....                              | 20          |
| 2.3.3. Pemetaan Struktur Waktu dan Kedalaman .....             | 22          |
| <b>BAB III TINJAUAN PUSTAKA .....</b>                          | <b>24</b>   |
| <b>BAB IV TEORI DASAR DAN METODOLOGI PENELITIAN .....</b>      | <b>27</b>   |
| 4.1. Teori Dasar <i>Uncertainty Assessment</i> .....           | 27          |
| 4.1.1. Metode Deterministik dan Probabilistik .....            | 27          |
| 4.1.2. Estimasi Faktor Risiko <i>Subsurface</i> .....          | 29          |
| 4.1.3. <i>Uncertainty Assessment Volume Gas In Place</i> ..... | 31          |
| 4.1.4. <i>Uncertainty Assessment</i> Deliverabilitas Gas ..... | 33          |
| 4.2. Teori Dasar Simulasi Monte Carlo .....                    | 37          |
| 4.2.1. Model Perhitungan dan Variabel Input.....               | 37          |
| 4.2.2. Konsep Distribusi Probabilitas .....                    | 38          |
| 4.2.3. Konsep <i>Random Numbers</i> .....                      | 42          |
| 4.2.4. Perhitungan Jumlah Iterasi .....                        | 43          |

|   |           |
|---|-----------|
| 4.2.5. Analisa Hasil Simulasi Monte Carlo .....   | 44        |
| 4.3. Teori Dasar Reservoir <i>Multilayer</i> .....                                      | 45        |
| 4.4. Teori Dasar Simulasi Reservoir .....   | 47        |
| 4.4.1. Simulator Petroleum Expert (PETEX) .....   | 49        |
| 4.5. Metodologi Penelitian .....  | 50        |
| <b>BAB V PERHITUNGAN DAN ANALISA STUDI PENGEMBANGAN</b>                                 |           |
| <b>LAPANGAN SALAP BERDASARKAN <i>UNCERTAINTY ASSESSMENT</i></b>                         |           |
| <b>MENGGUNAKAN SIMULASI MONTE CARLO .....</b>   | <b>53</b> |
| 5.1 Pengumpulan Data .....  | 53        |
| 5.1.1. Data Lapangan Salap .....  | 53        |
| 5.1.2. Data Analog Lapangan Salap .....   | 54        |
| 5.2 Penentuan Variabel <i>Uncertainty</i> .....   | 57        |
| 5.3 Preparasi Data Variabel Input .....   | 57        |
| 5.3.1. Estimasi Tekanan dan Temperatur Reservoir .....                                  | 57        |
| 5.3.2. Model PVT Fluida Reservoir .....   | 58        |
| 5.3.3. Analisa Pemusatan Skala Data .....   | 59        |
| 5.4 <i>Uncertainty Assessment</i> Probabilistik Simulasi Monte Carlo .....              | 61        |
| 5.4.1. Pembuatan Nilai Random Number .....  | 61        |
| 5.4.2. <i>Uncertainty Assessment</i> Data <i>Volume Bulk &amp; Net to Gross</i> . ..... | 61        |
| 5.4.3. <i>Uncertainty Assessment</i> Data Porositas & Saturasi Air .....                | 62        |
| 5.4.4. <i>Uncertainty Assessment</i> Data <i>Net Pay &amp; Permeabilitas</i> .....      | 63        |
| 5.4.5. Input Persentase Faktor Risiko <i>Subsurface</i> .....                           | 64        |
| 5.4.6. Perhitungan Jumlah Iterasi Simulasi Monte Carlo .....                            | 64        |
| 5.4.7. Permodelan Simulasi Monte Carlo .....  | 64        |
| 5.4.8. Penentuan Input Simulasi Reservoir Case Probabilistik .....                      | 66        |
| 5.5 Model Simulasi Reservoir .....  | 68        |
| 5.5.1. Model Reservoir .....  | 68        |
| 5.5.2. Model Produktivitas Formasi .....  | 68        |
| 5.5.3. Model Sumur Produksi .....   | 68        |
| 5.5.4. Asumsi <i>Surface Facility</i> .....   | 69        |
| 5.5.5. Asumsi Prediksi Simulasi .....   | 69        |
| 5.5.6. Sistem Buka dan Tutup Sumur/Zona .....   | 69        |
| 5.5.7. Asumsi <i>Timeline</i> Pengembangan Lapangan .....                               | 69        |
| 5.6 Simulasi Reservoir Case Probabilistik .....   | 70        |
| 5.7 Simulasi Reservoir Case Deterministik .....   | 72        |
| <b>BAB VI PEMBAHASAN .....</b>  | <b>77</b> |
| <b>BAB VII KESIMPULAN DAN SARAN .....</b>   | <b>80</b> |
| 7.1. Kesimpulan .....   | 80        |
| 7.2. Saran .....  | 81        |
| <b>DAFTAR PUSTAKA .....</b>   | <b>82</b> |
| <b>DAFTAR SIMBOL .....</b>  | <b>84</b> |
| <b>LAMPIRAN .....</b>   | <b>86</b> |

## DAFTAR GAMBAR

|             |  |    |
|-------------|--|----|
| Gambar 2.1  | Peta Lokasi Lapangan Salap .....   | 8  |
| Gambar 2.2  | <i>Setting</i> Tektonik Cekungan Jawa Timur .....  | 10 |
| Gambar 2.3  | Struktur Lapangan Salap Zona F.....  | 11 |
| Gambar 2.4  | Stratigrafi Cekungan Jawa Timur .....  | 13 |
| Gambar 2.5  | Jalur Migrasi Hidrokarbon Blok Brantas Fasa <i>Late Eocene</i> .....   | 16 |
| Gambar 2.6  | Jalur Migrasi Hidrokarbon Blok Brantas Fasa <i>Late Oligocene</i> .....  | 17 |
| Gambar 2.7  | Lintasan Seismik Pada Area Lapangan Salap .....  | 19 |
| Gambar 2.8  | Interpretasi Seismik Regional .....  | 21 |
| Gambar 2.9  | Pemetaan Time & <i>Depth Structure</i> .....   | 22 |
| Gambar 4.1  | Contoh Perhitungan Metode Probabilistik.....   | 29 |
| Gambar 4.2  | Kategori Risiko .....  | 30 |
| Gambar 4.3  | <i>Probability Density Function</i> Distribusi Normal.....   | 39 |
| Gambar 4.4  | <i>Probability Density Function</i> Distribusi <i>Triangular</i> .....   | 40 |
| Gambar 4.5  | <i>Probability Density Function</i> Distribusi <i>Uniform</i> .....  | 41 |
| Gambar 4.6  | <i>Probability Density Function</i> Distribusi Diskrit Binomial .....  | 42 |
| Gambar 4.7  | Contoh Hasil Perhitungan <i>Gas In Place</i> Simulasi Monte Carlo .....  | 45 |
| Gambar 4.8  | Contoh Analisa PDF dan CDF Simulasi Monte Carlo .....  | 45 |
| Gambar 4.9  | Skema Reservoir <i>Multilayer</i> Dengan <i>Shale Barrier</i> Pada<br>Tiap Lapisan.....                                    | 46 |
| Gambar 4.10 | Skema Reservoir <i>Multilayer</i> Tanpa <i>Shale Barrier</i> Pada<br>Antar Lapisan .....                                   | 47 |
| Gambar 4.11 | Skema Fitur <i>Software</i> Simulator PETEX.....   | 50 |
| Gambar 4.12 | <i>Flow Chart</i> Penelitian .....   | 51 |
| Gambar 5.1  | Picket Plot Saturasi Air dan Porositas Lapangan AGT.....   | 54 |
| Gambar 5.2  | Plot <i>Flow Zone Indicator</i> (FZI) Lapangan AGT.....  | 55 |
| Gambar 5.3  | Plot PVT Gas Hasil Korelasi .....  | 58 |
| Gambar 5.4  | Hasil Simulasi Monte Carlo Nilai <i>Gas in Place</i> Total<br>Lapangan Salap .....   | 65 |
| Gambar 5.5  | Plot <i>Frequency</i> dan <i>Cumulative Distribution</i> Hasil<br>Simulasi Monte Carlo .....                               | 65 |
| Gambar 5.6  | Model Simulasi Reservoir GAP Lapangan Salap .....  | 68 |
| Gambar 5.7  | Profil Produksi Gas Total Lapangan Salap Hasil Prediksi<br>Simulasi Case Probabilistik P90, P50 & P10.....                 | 70 |
| Gambar 5.8  | Kumulatif Produksi Gas Total Lapangan Salap Hasil Prediksi<br>Simulasi Case Probabilistik P90, P50 & P10.....              | 71 |
| Gambar 5.9  | Profil Produksi Gas Total Lapangan Salap Hasil Prediksi<br>Simulasi Case Deterministik <i>Low, Mid &amp; High</i> .....    | 75 |
| Gambar 5.10 | Kumulatif Produksi Gas Total Lapangan Salap Hasil Prediksi<br>Simulasi Case Deterministik <i>Low, Mid &amp; High</i> ..... | 75 |

## DAFTAR TABEL

|            |   |    |
|------------|---|----|
| Tabel IV-1 | Contoh Hasil Analisa Pemusatan Skala Data Porositas.....                        | 28 |
| Tabel IV-2 | Contoh Perhitungan Metode Deterministik .....                                   | 28 |
| Tabel IV-3 | Diagram Alir Perhitungan <i>Gas In Place</i> Metode Deterministik               | 32 |
| Tabel IV-4 | Diagram Alir Perhitungan <i>Gas In Place</i> Metode Probabilistik .             | 33 |
| Tabel IV-5 | Diagram Alir Perhitungan Deliverabilitas Gas<br>Metode Deterministik.....       | 36 |
| Tabel IV-6 | Diagram Alir Perhitungan Deliverabilitas Gas<br>Metode Probabilistik .....      | 37 |
| Tabel V-1  | Data Kedalaman Marker Reservoir Lapangan Salap .....                            | 53 |
| Tabel V-2  | Data Kisaran Nilai <i>Volume Bulk</i> Reservoir Lapangan Salap .....            | 53 |
| Tabel V-3  | Data <i>Net to Gross</i> Lapangan AGT .....                                     | 55 |
| Tabel V-4  | Data Porositas Lapangan AGT .....   | 55 |
| Tabel V-5  | Data Saturasi Air Lapangan AGT .....  | 56 |
| Tabel V-6  | Data <i>Net Pay</i> Lapangan AGT .....  | 56 |
| Tabel V-7  | Data Permeabilitas Lapangan AGT .....   | 56 |
| Tabel V-8  | Komposisi Gas Lapangan AGT .....  | 57 |
| Tabel V-9  | Estimasi Tekanan & Temperatur Reservoir Lapangan Salap ....                     | 58 |
| Tabel V-10 | Korelasi Faktor Volume Formasi Gas Lapangan Salap.....                          | 59 |
| Tabel V-11 | Analisa Pemusatan Skala Data <i>Net to Gross</i> .....                          | 59 |
| Tabel V-12 | Analisa Pemusatan Skala Data Porositas .....                                    | 60 |
| Tabel V-13 | Analisa Pemusatan Skala Data Saturasi Air.....                                  | 60 |
| Tabel V-14 | Analisa Pemusatan Skala Data <i>Net Pay</i> .....                               | 60 |
| Tabel V-15 | Analisa Pemusatan Skala Data Permeabilitas .....                                | 60 |
| Tabel V-16 | Model <i>Uncertainty Assessment</i> Variabel Input <i>Volume Bulk</i> ....      | 61 |
| Tabel V-17 | Model <i>Uncertainty Assessment</i> Variabel Input <i>Net to Gross</i> ....     | 62 |
| Tabel V-18 | Model <i>Uncertainty Assessment</i> Variabel Input Porositas .....              | 62 |
| Tabel V-19 | Model <i>Uncertainty Assessment</i> Variabel Input Saturasi Air.....            | 63 |
| Tabel V-20 | Model <i>Uncertainty Assessment</i> Variabel Input <i>Net Pay</i> .....         | 63 |
| Tabel V-21 | Model <i>Uncertainty Assessment</i> Variabel Input Permeabilitas ...            | 64 |
| Tabel V-22 | Hasil Analisa Nilai <i>in Place</i> dan Nomor Iterasi Plot CDF.....             | 66 |
| Tabel V-23 | Input Nilai <i>Gas in Place</i> Pada Simulasi Case Probabilistik.....           | 66 |
| Tabel V-24 | Input Variabel Transmibilitas Pada Simulasi Case Probabilistik                  | 67 |
| Tabel V-25 | Tabulasi Hasil Simulasi Case Probabilistik Lapangan Salap.....                  | 71 |
| Tabel V-26 | Input Model Perhitungan <i>Gas in Place</i> Simulasi Case<br>Deterministik..... | 73 |
| Tabel V-27 | Input Model Perhitungan Transmibilitas Simulasi<br>Case Deterministik .....     | 73 |
| Tabel V-28 | Input Nilai <i>Gas in Place</i> Simulasi Case Deterministik.....                | 74 |
| Tabel V-29 | Tabulasi Hasil Simulasi Case Deterministik Lapangan Salap ...                   | 76 |
| Tabel VI-1 | Tabulasi Perbandingan Case Deterministik Vs Case<br>Probabilistik .....         | 77 |

## DAFTAR LAMPIRAN

|  |    |
|--|----|
| LAMPIRAN 1 – Tabel <i>Risk Factor Calculation</i> .....                  | 87 |
| LAMPIRAN 2 – Tabel <i>Tranmibility Calculation</i> .....                 | 88 |
| LAMPIRAN 3 – Tabel <i>Uncertainty Calculation</i> .....                  | 89 |
| LAMPIRAN 4 – Tabel <i>Monte Carlo Iteration Number Calculation</i> ..... | 90 |