

DAFTAR ISI

| | |
|---|--------|
| LEMBAR PENGESAHAN | ii |
| PERNYATAAN BEBAS PLAGIASI..... | iii |
| KATA PENGANTAR..... | v |
| DAFTAR ISI..... | vii |
| DAFTAR TABEL | xvii |
| DAFTAR GAMBAR | xxiv |
| DAFTAR <i>CODE & STANDARD</i> YANG DIGUNAKAN..... | xxvi |
| ABSTRAK..... | xxvii |
| <i>ABSTRACT</i> | xxviii |
| BAB I PENDAHULUAN..... | 1 |
| 1.1. Latar Belakang | 1 |
| 1.2. Tinjauan Pustaka | 4 |
| 1.2.1. Urea..... | 4 |
| 1.2.2. <i>Diammonium Phosphate</i> (DAP)..... | 5 |
| 1.2.3. Kalium Klorida (KCl) | 5 |
| 1.2.4. Batuan Fosfat (<i>Phosphate Rock</i>)..... | 5 |
| 1.2.5. <i>Clay</i> | 6 |
| 1.2.6. Dolomit | 6 |
| 1.2.7. Pupuk NPK | 6 |
| 1.2.8. <i>Slow Release Fertilizer</i> (SRF) | 7 |
| 1.2.9. Poliuretan | 8 |
| 1.3. Pemilihan Proses | 9 |
| 1.4. Analisis Pasar | 13 |
| 1.4.1. Performa Produksi..... | 13 |
| 1.4.2. Performa Pasar | 15 |
| 1.4.3. <i>Forecasting</i> | 19 |
| 1.5. Penentuan Kapasitas Produksi | 21 |
| 1.6. Pemilihan Lokasi | 21 |
| BAB II URAIAN PROSES | 25 |
| 2.1. Persiapan dan Umpan Bahan Baku | 25 |
| 2.2. Proses Granulasi | 25 |
| 2.3. Proses Pengeringan | 26 |



| | | |
|---|---|----|
| 2.4. | Proses Pendinginan | 26 |
| 2.5. | Proses <i>Screening</i> | 26 |
| 2.6. | Proses <i>Coating</i> | 27 |
| 2.7. | Pengantongan Produk | 27 |
| 2.8. | Proses Pengolahan Debu | 28 |
| BAB III SPESIFIKASI BAHAN | | 29 |
| 3.1. | Bahan Baku | 29 |
| 3.1.1. | Urea | 29 |
| 3.1.2. | <i>Diammonium Phosphate</i> (DAP) | 30 |
| 3.1.3. | Kalium Klorida (KCl) | 31 |
| 3.1.4. | <i>Phosphate Rock</i> | 32 |
| 3.1.5. | <i>Clay</i> | 33 |
| 3.1.6. | Dolomit | 34 |
| 3.1.7. | Isosianat | 34 |
| 3.1.8. | Poliol | 35 |
| 3.2. | Bahan Penunjang | 36 |
| 3.2.1. | <i>Coloring Agent</i> | 36 |
| 3.3. | Produk Utama | 37 |
| 3.3.1. | Pupuk SRF NPK | 37 |
| BAB IV DIAGRAM ALIR KUALITATIF, KUANTITATIF, DAN PEFD | | 39 |
| 4.1. | Diagram Alir Kualitatif | 40 |
| 4.2. | Diagram Alir Kuantitatif | 41 |
| 4.3. | <i>Process Engineering Flow Diagram</i> | 42 |
| BAB V NERACA MASSA | | 43 |
| 5.1. | Neraca Massa Total | 43 |
| 5.2. | Neraca Massa Masing-Masing Alat | 46 |
| 5.2.1. | <i>Raw Material Feed System</i> | 46 |
| 5.2.2. | <i>Belt Conveyor 5</i> (BC-05) | 47 |
| 5.2.3. | <i>Bucket Elevator 1</i> (BE-01) | 48 |
| 5.2.4. | Granulator NPK (G-01) | 49 |
| 5.2.5. | <i>Rotary Dryer</i> (RD-01) | 50 |
| 5.2.6. | <i>Rotary Cooler</i> (RD-02) | 51 |
| 5.2.7. | <i>Vibrating Scrrener</i> (GS-01) | 52 |
| 5.2.8. | <i>Hammer Mill 4</i> (HM-04) | 52 |
| 5.2.9. | <i>Recycle Bin</i> (RB-01) | 53 |

| | | |
|---------------------------------------|--|----|
| 5.2.10. | <i>Cyclone Separator 1 (CY-01)</i> | 54 |
| 5.2.11. | <i>Cyclone Separator 2 (CY-02)</i> | 55 |
| 5.2.12. | <i>Scrubber (SC-01)</i> | 56 |
| 5.2.13. | <i>Slurry Pond (SP-01)</i> | 57 |
| 5.2.14. | <i>Belt Conveyor 6 (BC-06)</i> | 58 |
| 5.2.15. | <i>Pre-Heater Poliol (HE-01)</i> | 58 |
| 5.2.16. | <i>Coater SRF NPK (G-02)</i> | 59 |
| 5.2.17. | <i>Belt Conveyor 7 (BC-07)</i> | 60 |
| BAB VI NERACA PANAS | | 61 |
| 6.1. | Neraca Panas Masing-Masing Alat | 61 |
| 6.1.1. | <i>Granulator NPK (G-01)</i> | 61 |
| 6.1.2. | <i>Rotary Dryer (RD-01)</i> | 62 |
| 6.1.3. | <i>Rotary Cooler (RD-02)</i> | 63 |
| 6.1.4. | <i>Cyclone Separator 1 (CY-01)</i> | 64 |
| 6.1.5. | <i>Cyclone Separator 2 (CY-02)</i> | 65 |
| 6.1.6. | <i>Scrubber (SC-01)</i> | 66 |
| 6.1.7. | <i>Pre-Heater Poliol (HE-01)</i> | 66 |
| 6.1.8. | <i>Coater SRF NPK (G-02)</i> | 67 |
| BAB VII SPESIFIKASI ALAT | | 68 |
| 7.1. | Gudang Penyimpanan S-01 | 68 |
| 7.2. | Gudang Penyimpanan S-02 | 68 |
| 7.3. | Gudang Penyimpanan S-03 | 69 |
| 7.4. | Gudang Penyimpanan S-04 | 69 |
| 7.5. | Gudang Penyimpanan S-05 | 70 |
| 7.6. | Gudang Penyimpanan S-06 | 70 |
| 7.7. | Gudang Penyimpanan S-07 | 71 |
| 7.8. | Tangki Penyimpanan T-01 | 71 |
| 7.9. | Tangki Penyimpanan T-02 | 72 |
| 7.10. | Tangki Penyimpanan T-03 | 73 |
| 7.11. | Pompa P-01 | 74 |
| 7.12. | Pompa P-02 | 75 |
| 7.13. | Pompa P-03 | 76 |
| 7.14. | Pompa P-04 | 77 |
| 7.15. | Pompa P-05 | 79 |
| 7.16. | Pompa P-06 | 80 |



| | | |
|-------|---|-----|
| 7.17. | Pompa P-07..... | 81 |
| 7.18. | <i>Hopper</i> H-01..... | 82 |
| 7.19. | <i>Hopper</i> H-02..... | 83 |
| 7.20. | <i>Hopper</i> H-03..... | 83 |
| 7.21. | <i>Hopper</i> H-04..... | 84 |
| 7.22. | <i>Hopper</i> H-05..... | 85 |
| 7.23. | <i>Hopper</i> H-06..... | 85 |
| 7.24. | <i>Weigher</i> W-01..... | 86 |
| 7.25. | <i>Weigher</i> W-02..... | 86 |
| 7.26. | <i>Weigher</i> W-03..... | 87 |
| 7.27. | <i>Weigher</i> W-04..... | 88 |
| 7.28. | <i>Weigher</i> W-05..... | 88 |
| 7.29. | <i>Weigher</i> W-06..... | 89 |
| 7.30. | <i>Belt Conveyor</i> BC-01a (1)..... | 90 |
| 7.31. | <i>Belt Conveyor</i> BC-01a (2)..... | 90 |
| 7.32. | <i>Belt Conveyor</i> BC-01b (1)..... | 91 |
| 7.33. | <i>Belt Conveyor</i> BC-01b (2)..... | 92 |
| 7.34. | <i>Belt Conveyor</i> BC-01c..... | 92 |
| 7.35. | <i>Belt Conveyor</i> BC-01d (<i>Climb</i>)..... | 93 |
| 7.36. | <i>Belt Conveyor</i> BC-01d (<i>Horizon</i>)..... | 94 |
| 7.37. | <i>Belt Conveyor</i> BC-01e..... | 94 |
| 7.38. | <i>Belt Conveyor</i> BC-02..... | 95 |
| 7.39. | <i>Belt Conveyor</i> BC-03..... | 96 |
| 7.40. | <i>Belt Conveyor</i> BC-04..... | 96 |
| 7.41. | <i>Belt Conveyor</i> BC-05a..... | 97 |
| 7.42. | <i>Belt Conveyor</i> BC-05b..... | 98 |
| 7.43. | <i>Belt Conveyor</i> BC-05c..... | 99 |
| 7.44. | <i>Belt Conveyor</i> BC-06..... | 99 |
| 7.45. | <i>Belt Conveyor</i> BC-07..... | 100 |
| 7.46. | <i>Bucket Elevator</i> BE-01..... | 101 |
| 7.47. | <i>Bucket Elevator</i> BE-02..... | 101 |
| 7.48. | <i>Bucket Elevator</i> BE-03..... | 102 |
| 7.49. | <i>Bucket Elevator</i> BE-04..... | 102 |
| 7.50. | <i>Hammer Mill</i> HM-01..... | 103 |
| 7.51. | <i>Hammer Mill</i> HM-02..... | 104 |



| | | |
|-------------------------|---|-----|
| 7.52. | <i>Hammer Mill</i> HM-03 | 104 |
| 7.53. | <i>Hammer Mill</i> HM-04 | 105 |
| 7.54. | <i>Blower</i> BW-01 | 105 |
| 7.55. | <i>Blower</i> BW-02 | 106 |
| 7.56. | <i>Blower</i> BW-03 | 107 |
| 7.57. | <i>Blower</i> BW-04 | 107 |
| 7.58. | <i>Cyclone</i> CY-01 | 108 |
| 7.59. | <i>Cyclone</i> CY-02 | 109 |
| 7.60. | <i>Scrubber</i> SC-01 | 110 |
| 7.61. | <i>Slurry Pond</i> SP-01 | 111 |
| 7.62. | <i>Rotary Granulator</i> G-01 | 112 |
| 7.63. | <i>Rotary Coater</i> G-02 | 113 |
| 7.64. | <i>Rotary Dryer</i> RD-01 | 115 |
| 7.65. | <i>Rotary Cooler</i> RD-02 | 116 |
| 7.66. | <i>Mixer</i> M-01 | 117 |
| 7.67. | <i>Mixer</i> M-02 | 117 |
| 7.68. | <i>Vibrating Screener</i> GS-01 | 118 |
| 7.69. | <i>Recycle Bin</i> RB-01 | 119 |
| 7.70. | <i>Pre-Heater</i> Poliol HE-01 | 119 |
| BAB VIII UTILITAS | | 122 |
| 8.1. | Unit Penyedia dan Pengolahan Air | 122 |
| 8.1.1. | Kebutuhan Air | 122 |
| 8.1.2. | Sumber Air | 126 |
| 8.1.3. | Tahapan Pengolahan Air | 127 |
| 8.1.4. | Deskripsi Proses Pengolahan Air | 136 |
| 8.1.5. | Spesifikasi Alat Utilitas | 140 |
| 8.2. | Unit Pembangkitan <i>Steam</i> | 159 |
| 8.2.1. | Neraca Massa pada <i>Boiler</i> | 161 |
| 8.2.2. | Neraca Panas pada <i>Boiler</i> | 162 |
| 8.2.3. | Kebutuhan Bahan Bakar | 164 |
| 8.2.4. | Kebutuhan Udara Pembakaran | 164 |
| 8.2.5. | Perhitungan <i>Superheater</i> | 167 |
| 8.3. | Unit Penyedia Udara | 170 |
| 8.3.1. | Udara Tekan untuk Instrumentasi | 171 |
| 8.3.2. | Udara Panas untuk <i>Rotary Dryer</i> dan <i>Coater</i> | 175 |

| | | |
|--|---|-----|
| 8.3.3. | Udara Lingkungan untuk <i>Rotary Cooler</i> | 178 |
| 8.3.4. | Udara Kering untuk Pembakaran di <i>Boiler</i> dan <i>Furnace</i> | 178 |
| 8.4. | Unit Pengolahan Limbah | 179 |
| 8.4.1. | Limbah Cair | 179 |
| 8.4.2. | Limbah Gas | 180 |
| 8.4.3. | Limbah Padat | 182 |
| 8.5. | Unit Penyedia dan Pendistribusian Listrik | 182 |
| 8.5.1. | Kebutuhan Listrik untuk Alat-Alat Proses | 182 |
| 8.5.2. | Kebutuhan Listrik untuk Alat-Alat Utilitas | 184 |
| 8.5.3. | Kebutuhan Listrik untuk Instrumentasi | 186 |
| 8.5.4. | Kebutuhan Listrik untuk Kebutuhan Lainnya | 186 |
| 8.5.5. | <i>Emergency Diesel Generator</i> | 186 |
| BAB IX TATA LETAK PABRIK DAN ALAT PROSES | | 188 |
| BAB X PERTIMBANGAN ASPEK KESELAMATAN, KESEHATAN KERJA, DAN LINGKUNGAN..... | | 196 |
| 10.1. | Sistem Manajemen <i>Safety, Health, and Environment</i> (SHE) | 196 |
| 10.2. | Identifikasi <i>Hazard</i> Bahan Proses dan Produk | 214 |
| 10.2.1. | Identifikasi <i>Hazard</i> Bahan Kimia | 214 |
| 10.2.2. | Identifikasi Potensi Paparan Bahan Kimia | 223 |
| 10.3. | Identifikasi <i>Hazard</i> Limbah Pabrik | 239 |
| 10.3.1. | Identifikasi <i>Hazard</i> Limbah Padat pada Proses dan Utilitas | 239 |
| 10.3.2. | Identifikasi <i>Hazard</i> Limbah Cair pada Proses dan Utilitas | 242 |
| 10.3.3. | Identifikasi <i>Hazard</i> Limbah Gas pada Proses dan Utilitas | 246 |
| 10.4. | Identifikasi <i>Hazard</i> Alat Proses dan Utilitas | 248 |
| 10.4.1. | Identifikasi <i>Hazard</i> Kondisi Peralatan Proses | 248 |
| 10.4.2. | Identifikasi <i>Hazard</i> Kondisi Peralatan Utilitas | 291 |
| 10.4.3. | Identifikasi <i>Hazard</i> Lokasi Proses | 318 |
| 10.4.4. | Identifikasi Potensi Paparan Fisis | 320 |
| 10.4.5. | Identifikasi <i>Hazard Plant Layout</i> | 323 |
| 10.5. | <i>Process Hazard Analysis</i> dengan Metode HAZOP | 327 |
| 10.5.1. | Pertimbangan Pemilihan Alat | 327 |
| 10.5.2. | HAZOP pada <i>Coater</i> (G-02) | 330 |
| 10.5.3. | HAZOP pada <i>Boiler</i> (BL-01) | 342 |
| BAB XI ORGANISASI PERUSAHAAN | | 356 |
| 11.1. | Bentuk Perusahaan | 356 |

| | | |
|---|--|------------|
| 11.2. | Struktur Organisasi | 357 |
| 11.3. | Tugas dan Wewenang | 360 |
| 11.4. | Pembagian Jam Kerja Karyawan..... | 372 |
| 11.5. | Pembagian Kebutuhan Jumlah Operator | 374 |
| 11.6. | Pembagian Gaji Karyawan | 376 |
| 11.7. | Kesejahteraan Sosial | 377 |
| 11.8. | Manajemen Produksi | 380 |
| BAB XII EVALUASI EKONOMI | | 382 |
| 12.1. | Tingkat Risiko Pabrik | 382 |
| 12.2. | Penentuan Indeks Harga | 383 |
| 12.3. | Penentuan <i>Fixed Capital Investment</i> | 385 |
| 12.3.1. | Perhitungan Harga Alat Proses dan Utilitas | 385 |
| 12.3.2. | Perhitungan Harga Bahan Baku, Bahan Pendukung, dan Produk..... | 395 |
| 12.3.3. | Perhitungan Harga Tanah | 399 |
| 12.3.4. | Perhitungan Biaya Pekerja | 399 |
| 12.3.5. | Perhitungan <i>Fixed Capital</i> | 400 |
| 12.3.6. | Perhitungan Faktor Lang | 401 |
| 12.4. | Perhitungan <i>Manufacturing Cost Investment</i> | 402 |
| 12.5. | Perhitungan <i>Working Capital</i> | 403 |
| 12.6. | Perhitungan <i>General Expense</i> | 404 |
| 12.7. | Perhitungan Keuntungan (<i>Profit</i>)..... | 405 |
| 12.8. | Analisis Keuntungan..... | 405 |
| 12.8.1. | <i>Return on Investment (ROI)</i> | 405 |
| 12.8.2. | <i>Pay Out Time (POT)</i> | 406 |
| 12.8.3. | <i>Discounted Cash Flow Rate of Return (DCFRR)</i> | 408 |
| 12.8.4. | <i>Break Even Point (BEP)</i> dan <i>Shut Down Point (SDP)</i> | 409 |
| 12.9. | <i>Sensitivity Analysis</i> | 411 |
| BAB XIII KESIMPULAN..... | | 415 |
| DAFTAR PUSTAKA..... | | 416 |
| ALAT YANG DIRANCANG DETAIL OLEH AHMAD YAZID | | 423 |
| | <i>Rotary Coater G-02</i> | 424 |
| ALAT YANG DIRANCANG DETAIL OLEH FATHIN BAGUSANTARA | | 454 |
| | <i>Rotary Granulator G-01</i> | 455 |
| LAMPIRAN PERHITUNGAN SEMUA ALAT PROSES..... | | 477 |
| | Gudang Penyimpanan S-01 | 478 |



| | |
|--|------------|
| Gudang Penyimpanan S-02..... | 480 |
| Gudang Penyimpanan S-03..... | 482 |
| Gudang Penyimpanan S-04..... | 484 |
| Gudang Penyimpanan S-05..... | 486 |
| Gudang Penyimpanan S-06..... | 488 |
| Gudang Penyimpanan S-07..... | 490 |
| Tangki Penyimpanan T-01..... | 492 |
| Tangki Penyimpanan T-02..... | 500 |
| Tangki Penyimpanan T-03..... | 508 |
| Pompa P-01..... | 516 |
| Pompa P-02..... | 527 |
| Pompa P-03..... | 539 |
| Pompa P-04..... | 552 |
| Pompa P-05..... | 564 |
| Pompa P-06..... | 576 |
| Pompa P-07..... | 588 |
| <i>Hopper H-01.....</i> | <i>599</i> |
| <i>Hopper H-02.....</i> | <i>604</i> |
| <i>Hopper H-03.....</i> | <i>609</i> |
| <i>Hopper H-04.....</i> | <i>614</i> |
| <i>Hopper H-05.....</i> | <i>619</i> |
| <i>Hopper H-06.....</i> | <i>624</i> |
| <i>Weigher W-01.....</i> | <i>629</i> |
| <i>Weigher W-02.....</i> | <i>633</i> |
| <i>Weigher W-03.....</i> | <i>637</i> |
| <i>Weigher W-04.....</i> | <i>641</i> |
| <i>Weigher W-05.....</i> | <i>645</i> |
| <i>Weigher W-06.....</i> | <i>649</i> |
| <i>Belt Conveyor BC-01a (1).....</i> | <i>653</i> |
| <i>Belt Conveyor BC-01a (2).....</i> | <i>657</i> |
| <i>Belt Conveyor BC-01b (1).....</i> | <i>661</i> |
| <i>Belt Conveyor BC-01b (2).....</i> | <i>665</i> |
| <i>Belt Conveyor BC-01c.....</i> | <i>669</i> |
| <i>Belt Conveyor BC-01d (Climb).....</i> | <i>673</i> |
| <i>Belt Conveyor BC-01d (Horizon).....</i> | <i>677</i> |



| | |
|--|-----|
| <i>Belt Conveyor</i> BC-01e | 681 |
| <i>Belt Conveyor</i> BC-02 | 685 |
| <i>Belt Conveyor</i> BC-03 | 689 |
| <i>Belt Conveyor</i> BC-04 | 693 |
| <i>Belt Conveyor</i> BC-05a | 697 |
| <i>Belt Conveyor</i> BC-05b | 701 |
| <i>Belt Conveyor</i> BC-05c | 705 |
| <i>Belt Conveyor</i> BC-06 | 709 |
| <i>Belt Conveyor</i> BC-07 | 713 |
| <i>Bucket Elevator</i> BE-01 | 717 |
| <i>Bucket Elevator</i> BE-02 | 720 |
| <i>Bucket Elevator</i> BE-03 | 723 |
| <i>Bucket Elevator</i> BE-04 | 726 |
| <i>Hammer Mill</i> HM-01 | 729 |
| <i>Hammer Mill</i> HM-02 | 731 |
| <i>Hammer Mill</i> HM-03 | 733 |
| <i>Hammer Mill</i> HM-04 | 735 |
| <i>Blower</i> BW-01 | 737 |
| <i>Blower</i> BW-02 | 741 |
| <i>Blower</i> BW-03 | 745 |
| <i>Blower</i> BW-04 | 749 |
| <i>Cyclone</i> CY-01 | 753 |
| <i>Cyclone</i> CY-02 | 763 |
| <i>Scrubber</i> SC-01 | 772 |
| <i>Slurry Pond</i> SP-01 | 781 |
| <i>Rotary Dryer</i> RD-01 | 787 |
| <i>Rotary Cooler</i> RD-02 | 794 |
| <i>Mixer</i> M-01 | 801 |
| <i>Mixer</i> M-02 | 807 |
| <i>Vibrating Screener</i> GS-01 | 812 |
| <i>Recycle Bin</i> RB-01 | 815 |
| <i>Pre-Heater</i> Poliol HE-01 | 818 |
| LAMPIRAN PERHITUNGAN SEMUA ALAT UTILITAS | 827 |
| <i>Screener</i> MS-01 | 828 |
| Bak Ekualisasi TE-01 | 830 |



| | |
|--|-----|
| Bak Sedimentasi TS-01 | 831 |
| <i>Mixer</i> Koagulan MU-01 | 834 |
| <i>Clarifier Tank</i> CL-01 | 846 |
| <i>Sand Filter</i> SF-01 | 853 |
| <i>Activated Carbon Filter</i> ACF-01 | 855 |
| <i>Mixer</i> Disinfeksi MU-02 | 859 |
| <i>Cation Exchanger</i> CE-01 | 871 |
| <i>Anion Exchanger</i> AE-01 | 876 |
| Deaerator DU-01 | 881 |
| Tangki Penyimpanan Alum TU-01 | 886 |
| Tangki Penyimpanan Natrium Hipoklorit TU-02 | 892 |
| Tangki Penyimpanan Air Kebutuhan Umum TU-03 | 898 |
| Tangki Penyimpanan Asam Klorida 5% TU-04..... | 903 |
| Tangki Penyimpanan Natrium Hidroksida 4% TU-05..... | 909 |
| Tangki Penyimpanan Air Demin TU-06 | 915 |
| Tangki Penyimpanan <i>Hydrazine</i> 35% TU-07 | 921 |
| Tangki Penyimpanan <i>Boiler Feed Water</i> TU-08..... | 927 |
| Tangki Penyimpanan Air Kondensat TU-09 | 932 |
| Pompa Utilitas..... | 937 |
| <i>Furnace</i> F-01..... | 949 |
| Lampiran Perhitungan Neraca Massa | 965 |
| Lampiran Perhitungan Neraca Panas | 986 |