**Tabel 1.** Prosedur Perawatan Menggunakan *Markov Chain*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **J**  **I** | **1** | **2** | **3** | **4** | **5** |
| **1** | Q11 | Q12 | Q13 | Q14 | Q15 |
| **2** | 0 | Q22 | Q23 | Q24 | Q25 |
| **3** | 0 | 0 | Q33 | Q34 | Q35 |
| **4** | 0 | 0 | 1 | Q44 | Q45 |
| **5** | Q51 | 0 | 0 | 0 | Q55 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tabel 2.**Data jumlah kerusakan komponen beserta jumlah kenaikan persentase *downtime*. | | | | |
| **No** | **Komponen Kerusakan *Spiral Pipe Machine*** | ***Downtime* Jam /Bulan (2021)** | ***Downtime* Jam /Bulan (2022)** | ***Persentase***  ***%*** |
| 1 | Hidrolis | 72.85 | 78,9 | 7.66% |
| 2 | Sistem Kontrol | 12.61 | 25.80 | 51.12% |
| 3 | *Trafo Welding* | 17.84 | 19.71 | 9.49% |
| 4 | Bongkar *Roll Hold Down* | 72.61 | 83.72 | 13.27% |
| 5 | *WireFeeder* | 38.84 | 40.44 | 3.96% |
| 6 | *Cutting* Plasma | 17.34 | 34.62 | 49,91% |
| 7 | *Elektrode* Macet | 69.19 | 78.90 | 12.30% |
| 8 | Motor/*Gearbox* *Milling* | 88.16 | 91.23 | 3.36% |
| 9 | *Conveyor Milling* | 27.34 | 33.18 | 17.60% |
| 10 | Sikat *Gram Milling* | 61.17 | 82.5 | 25.85% |
|  | Total *Downtime* | 477.95 | 569 | - |

|  |  |  |
| --- | --- | --- |
| **Tabel 3**. Data jumlah komponen kerusakan mesin | | |
| **No** | **Type Komponen** | **Jumlah** |
| 1 | Hidrolis | 3 |
| 2 | Sistem Kontrol | 4 |
| 3 | *Trafo Welding* | 4 |
| 4 | Bongkar *Roll Hold Down* | 1 |
| 5 | *Wire Feeder* | 2 |
| 6 | *Cutting Plasma* | 2 |
| 7 | Elektro Macet | 6 |
| 8 | Motor / *Gearbox Milling* | 5 |
| 9 | *Conveyor Milling* | 8 |
| 10 | Sikat *Gram Milling* | 3 |

**Tabel 4.** Data Waktu Pemeliharaan *Preventive*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No**  **(1)** | **Mesin**  **(2)** | **Jumlah**  **(3)** | **Waktu Mesin**  **(4)** | **Total Waktu Mesin / Bulan (5)** | **Total waktu**  **(Jam/bulan)** | **Total Waktu**  **(Jam/tahun)** |
| 1 | Hidrolis | 3 | 24.28 | 72.85 | 1.21 | 14.52 |
| 2 | Sistem Kontrol | 4 | 3.15 | 12.61 | 0.21 | 2.52 |
| 3 | *Trafo Welding* | 4 | 4.46 | 17.84 | 0.29 | 3.48 |
| 4 | Bongkar *Roll Hold Down* | 1 | 72.61 | 72.61 | 1.21 | 14.52 |
| 5 | *Wirefeeder* | 2 | 19.42 | 38.84 | 0.64 | 7.68 |
| 6 | *Cutting Plasma* | 2 | 8.67 | 17.34 | 0.28 | 3.36 |
| 7 | *Elektrode* Macet | 6 | 11.53 | 69.19 | 1.15 | 13.80 |
| 8 | Motor / *Gearbox Milling* | 5 | 17.63 | 88.16 | 1.46 | 17.52 |
| 9 | *Conveyor Milling* | 8 | 3.41 | 27.34 | 0.45 | 5.40 |
| 10 | Sikat *Gram Milling* | 3 | 20.39 | 61.17 | 1.01 | 12.12 |

**Tabel 5.** Data Biaya *Downtime*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No** | **Komponen mesin** | **Jumlah** | **Biaya *down* *time*/jam** | **Total Biaya *Downtime*** |
| 1 | Hidrolis | 3 | Rp.2.432.000 | Rp.7.296.600 |
| 2 | Sistem Kontrol | 4 | Rp.12.712.000 | Rp.50.848.000 |
| 3 | *Trafo Welding* | 4 | Rp.1.268.730 | Rp.5.074.920 |
| 4 | Bongkar *Roll Hold Down* | 1 | Rp.4.711.600 | Rp. 4.711.600 |
| 5 | *Wirefeeder* | 2 | Rp.1.430.000 | Rp.2.860.000 |
| 6 | *Cutting Plasma* | 2 | Rp.3.424.300 | Rp.6.848.600 |
| 7 | *Elektrode* Macet | 6 | Rp.3.568.200 | Rp.21.409.200 |
| 8 | Motor / *Gearbox Milling* | 5 | Rp.8.331.000 | Rp.41.655.000 |
| 9 | *Conveyor Milling* | 8 | Rp.2.480.152 | Rp.19.841216 |
| 10 | Sikat *Gram Milling* | 3 | Rp.936.000 | Rp.2.808.000 |

**Tabel 6.** Data Transisi Status Mesin Spiral.

|  |  |
| --- | --- |
| A | Kondisi iBaik ike iBaik |
| B | Kondisi iBaik ike iRingan |
| C | Kondisi iBaik ike iSedang |
| D | Kondisi iBaik ike iBerat |
| E | Kondisi iRingan ike iRingan |
| F | Kondisi iRingan ike iSedang |
| G | Kondisi iRingan ike iBerat |
| H | Kondisi iSedang ike iSedang |
| I | Kondisi iSedang ike iBerat |
| J | Kondisi iBerat ike iBaik |

**Tabel 7.** Transisi Status

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bulan/ Tahun** | **Transisi Status** | | | | | | | | | |
| **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** |
| Januari | 1 | 0 | 0 | 0 | 0 | 3 | \* | \* | 2 | 1 |
| Februari | 0 | 0 | 0 | \* | \* | \* | \* | \* | \* | 1 |
| Maret | 0 | 0 | 0 | 0 | \* | 0 | \* | 4 | \* | \* |
| April | 0 | 0 | 0 | \* | 2 | \* | 1 | \* | 0 | \* |
| Mei | 1 | 0 | 0 | 1 | \* | \* | 0 | \* | 0 | \* |
| Juni | 0 | 0 | 0 | 0 | \* | \* | 1 | 0 | 0 | \* |
| Juli | 0 | 0 | 2 | 0 | \* | \* | 2 | 0 | 5 | \* |
| Agustus | 0 | 2 | 1 | 0 | \* | \* | \* | 1 | 0 | 0 |
| September | 1 | 1 | 1 | 0 | \* | 2 | \* | 0 | 0 | 0 |
| Oktober | 0 | 0 | \* | 0 | \* | \* | 1 | 0 | 1 | 0 |
| November | 0 | 1 | \* | 0 | \* | \* | 0 | \* | 0 | 0 |
| Desember | 0 | 1 | \* | 0 | \* | 1 | 1 | 1 | 0 | 0 |

**Tabel 8.** *Output* Matrik Komponen Mesin *Spiral*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **J**  **I** | **1 (j)** | **2(j)** | **3(j)** | **4(j)** |
| **Baik** | **Ringan** | **Sedang** | **Berat** |
| Baik | 0 | 0 | 1 | 0 |
| Ringan | 0,63 | 0,25 | 0 | 0,12 |
| Sedang | 0 | 1 | 0 | 0 |
| Berat | 1 | 0 | 0 | 0 |

**Tabel 9.** Status Tindakan dan Kategori *Policy*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Keputusan** | **Tindakan**  **yang dilakukan** | ***Policy*** | **Keterangan** | **d1 (P)** | **d2 (P)** | **d3 (P)** | **d4 (P)** |
| 1 | Tidak dilakukan tindakan | P0 | Pemeliharaan korektif pada status 4 | 1 | 1 | 1 | 3 |
| 2 | Dilakukan pemeliharaan pencegahan (sistem kembali ke status sebelumnya) | P1 | Pemeliharaan korektif pada status 4 dan pemeliharaan pencegahan pada status 3 | 1 | 1 | 2 | 3 |
| 3 | Pemeliharaan korektif (sistem kembali ke status 1) | P2 | Pemeliharaan korektif pada status 3 dan 4, serta pemeliharaan pencegahan pada status 2 | 1 | 2 | 3 | 3 |
|  | | P3 | Pemeliharaan korektif pada status 4, serta pemeliharaan pencegahan pada status 2 dan 3 | 1 | 2 | 2 | 3 |
| P4 | Pemeliharaan korektif pada status 3 dan 4 | 1 | 1 | 3 | 3 |

**Tabel 10.** Status Kerusakan Mesin Spiral

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Stationary Policy*** | ***Vis*** | | | **Berdasarkan kondisi kerusakan mesin spiral** | | | |
| **1** | **2** | **3** | **is** | **2s** | **3s** | **Es** |
| 1 | 0 | 0 | 3 | 0 | 0 | 1 | 3 |
| 2 | 0 | 1.25 | 0.12 |  |  |  | 0.071 |
| 3 | 0 | 0 | -1 | 0 | 0 | 1 | -1 |
| 4 | 0 | 1,25 | -1 | 0 | 0 | 1 | -1 |
| 5 | 0 | 0 | 0.12 |  |  |  | 0.06 |
| 6 | 1 | 1.25 | 0.3 |  | 0 | 1 | 3.10 |
| 7 | 0 | 0 | 0.12 |  |  |  | 0.061 |
| 8 | 0 | 1.25 | 0.12 |  |  |  | 0.69 |

**Tabel 11.** Biaya Perawatan dan Probabilitas Transisi Komponen Mesin Spiral

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Biaya perawatan** | | | |  | **Probabilitas Transisi** | | | |  |
| **No** | **Komponen mesin** |  | **P1** | **P2** | **P3** | **P4** | **Biaya** | **P1** | **P2** | **P3** | **P4** | **Biaya** |
| 1 | Hidrolis | P1 | 0.536 | 0.107 | 0.236 | 0.121 | 28133511 | 0.768 | 0.148 | 0.058 | 0.026 | 12878711 |
| P2 | 0.702 | 0.114 | 0.158 | 0.026 | 18273685 | 0.381 | 0.212 | 0.318 | 0.089 | 39489579 |
| P3 | 0.529 | 0.081 | 0.078 | 0.312 | 38396685 | 0.112 | 0.129 | 0.265 | 0.494 | 70552363 |
| P4 | 0.447 | 0.113 | 0.342 | 0.098 | 33.269071 | 0.114 | 0.054 | 0.321 | 0.511 | 72749422 |
| 2 | Sistem Kontrol | P1 | 0.452 | 0.117 | 0.356 | 0.232 | 51499825 | 0.118 | 0.431 | 0.120 | 0.331 | 58293569 |
| P2 | 0.322 | 0.104 | 0.417 | 0.l57 | 48032182 | 0.187 | 0.356 | 0.111 | 0.346 | 55834108 |
| P3 | 0.408 | 0.128 | 0.432 | 0.032 | 38281274 | 0.435 | 0.098 | 0.157 | 0.310 | 44375910 |
| P4 | 0.213 | 0.321 | 0.390 | 0.076 | 47945929 | 0.032 | 0.084 | 0.123 | 0.761 | 84095242 |
| 3 | Trafo *Welding* | P1 | 0.525 | 0.123 | 0.236 | 0.116 | 32539658 | 0.115 | 0.123 | 0.671 | 0.091 | 60071338 |
| P2 | 0.289 | 0.435 | 0.124 | 0.152 | 41808943 | 0.221 | 0.231 | 0.128 | 0.042 | 22810903 |
| P3 | 0.457 | 0.l57 | 0.030 | 0.356 | 40503737 | 0.081 | 0.078 | 0.312 | 0.529 | 74876841 |
| P4 | 0.435 | 0.032 | 0.435 | 0.098 | 40558374 | 0.113 | 0.342 | 0.098 | 0.447 | 63886728 |
| 4 | Bongkar *Roll Hold Down* | P1 | 0.089 | 0.381 | 0.212 | 0.318 | 61213472 | 0.081 | 0.078 | 0.312 | 0.471 | 69390041 |
| P2 | 0.494 | 0.112 | 0.129 | 0.265 | 38803042 | 0.113 | 0.342 | 0.098 | 0.533 | 72022328 |
| P3 | 0.300 | 0.l57 | 0.187 | 0.356 | 57507531 | 0.356 | 0.134 | 0.191 | 0.681 | 83374018 |
| P4 | 0.435 | 0.032 | 0.435 | 0.098 | 40558374 | 0.452 | 0.112 | 0.078 | 0.642 | 70962114 |
| 5 | *Wirefeeder* | P1 | 0.511 | 0.113 | 0.231 | 0.145 | 34504764 | 0.134 | 0.218 | 0.227 | 0.421 | 64903324 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | P2 | 0.090 | 0.432 | 0.157 | 0.321 | 59933970 | 0.321 | 0.234 | 0.400 | 0.045 | 41919115 |
| P3 | 0.032 | 0.321 | 0.061 | 0.586 | 73580417 | 0.044 | 0.435 | 0.120 | 0.401 | 65089431 |
| P4 | 0.043 | 0.071 | 0.576 | 0.310 | 71999375 | 0.096 | 0.543 | 0.099 | 0.262 | 55191011 |
| 6 | *Cutting Plasma* | P1 | 0.076 | 0.123 | 0.390 | 0.411 | 71030770 | 0.901 | 0.021 | 0.303 | 0.075 | 28832358 |
| P2 | 0.087 | 0.056 | 0.076 | 0.781 | 81539993 | 0.453 | 0.098 | 0.122 | 0.327 | 43578630 |
| P3 | 0.080 | 0.165 | 0.564 | 0.056 | 51231991 | 0.761 | 0.065 | 0.108 | 0.066 | 16491478 |
| P4 | 0.032 | 0.061 | 0.632 | 0.518 | 95090288 | 0.076 | 0.032 | 0.302 | 0.590 | 77960750 |
| 7 | *Elektrode* Macet | P1 | 0.450 | 0.231 | 0.145 | 0.134 | 32682479 | 0.543 | 0.l57 | 0.187 | 0.356 | 55353812 |
| P2 | 0.301 | 0.057 | 0.321 | 0.321 | 54905819 | 0.565 | 0.032 | 0.435 | 0.098 | 40558374 |
| P3 | 0.393 | 0.098 | 0.452 | 0.435 | 76475670 | 0.489 | 0.113 | 0.231 | 0.145 | 34504764 |
| P4 | 0.239 | 0.145 | 0.134 | 0.231 | 37364642 | 0.081 | 0.432 | 0.057 | 0.321 | 53061170 |
| 8 | Motor- *Gearbox* *Milling* | P1 | 0.435 | 0.098 | 0.452 | 0.356 | 69002270 | 0.356 | 0.134 | 0.851 | 0.361 | 98462498 |
| P2 | 0.623 | 0.145 | 0.134 | 0.098 | 24782842 | 0.452 | 0.112 | 0.637 | 0.073 | 55553666 |
| P3 | 0.213 | 0.321 | 0.321 | 0.145 | 49731097 | 0.134 | 0.218 | 0.430 | 0.078 | 46407308 |
| P4 | 0.761 | 0.082 | 0.044 | 0.113 | 17277999 | 0.231 | 0.145 | 0.134 | 0.510 | 63758042 |
| 9 | *Conveyor Milling* | P1 | 0.400 | 0.321 | 0.145 | 0.134 | 36594369 | 0.218 | 0.321 | 0.076 | 0.615 | 77354737 |
| P2 | 0.611 | 0.044 | 0.113 | 0.232 | 31625944 | 0.145 | 0.044 | 0.087 | 0.276 | 34001416 |
| P3 | 0.625 | 0.321 | 0.321 | 0.021 | 38000697 | 0.028 | 0.114 | 0.218 | 0.360 | 53993765 |
| P4 | 0.015 | 0.452 | 0.435 | 0.098 | 58813863 | 0.011 | 0.019 | 0.081 | 0.111 | 16893412 |
| 10 | Sikat Gram *Milling* | P1 | 0.114 | 0.753 | 0.016 | 0.117 | 44897332 | 0.232 | 0.022 | 0.021 | 0.275 | 28414528 |
| P2 | 0.696 | 0.056 | 0.032 | 0.216 | 25066961 | 0.115 | 0.033 | 0.157 | 0.695 | 77971656 |
| P3 | 0.132 | 0.549 | 0.054 | 0.265 | 52642844 | 0.021 | 0.019 | 0.453 | 0.493 | 78597428 |
| P4 | 0.043 | 0.462 | 0.064 | 0.431 | 65252230 | 0.011 | 0.065 | 0.021 | 0.097 | 13444742 |