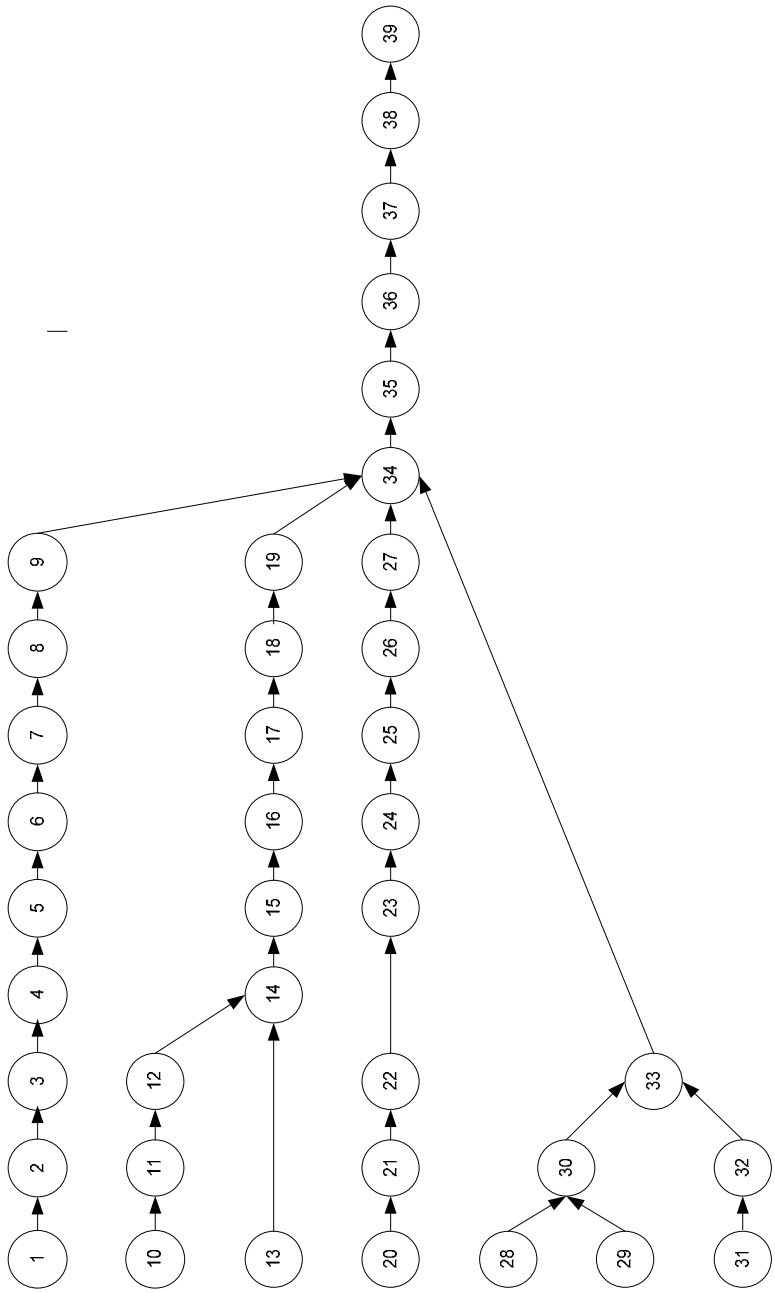
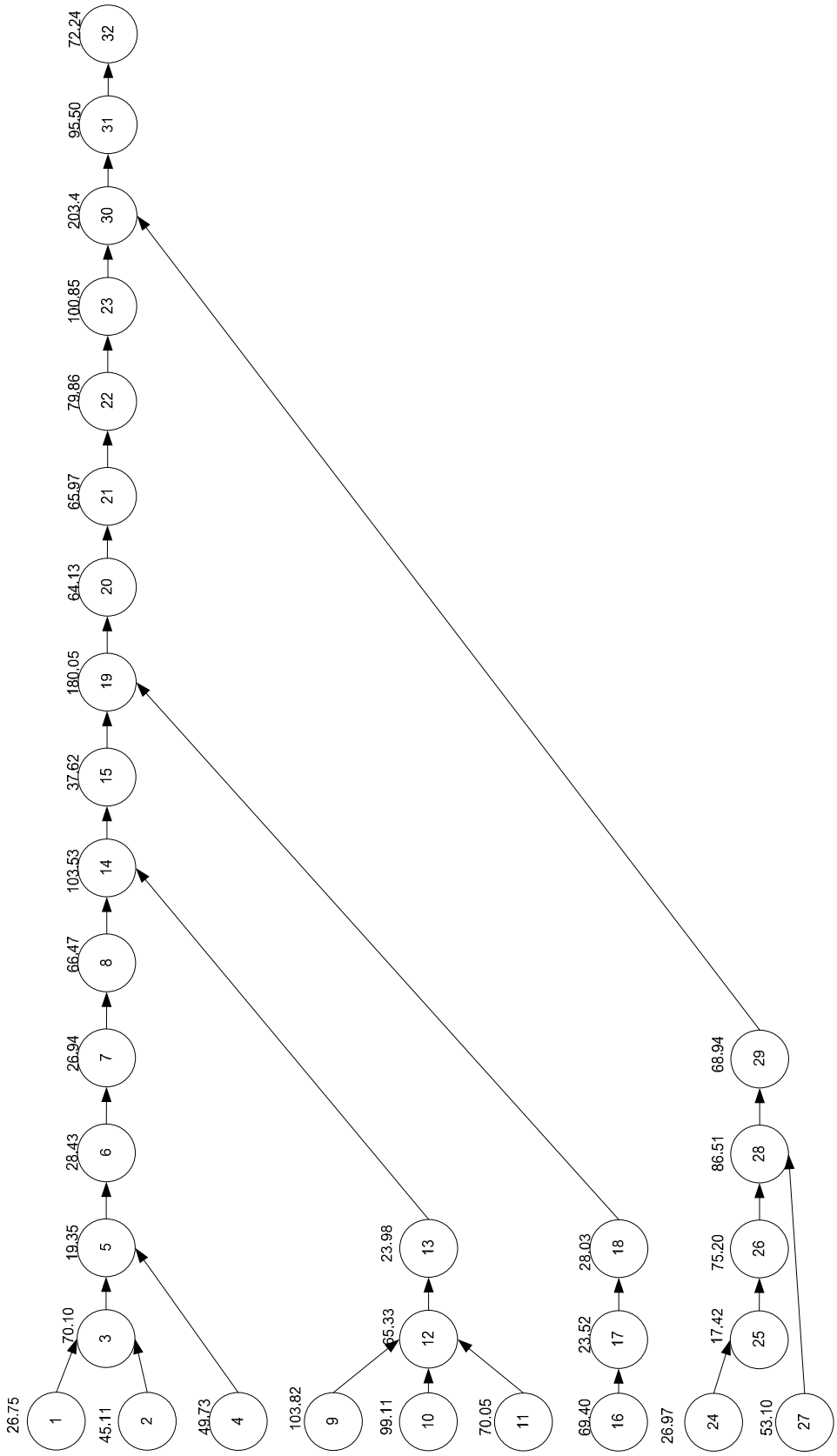
**Lampiran 1:** ***Precedence Diagram*** **Meja Setrika**



**Lampiran 2: *Precedence Diagram* Kemeja**



**Lampiran 3: Prioritas Operasi Kerja Meja Setrika Setelan**

| No. Proses | Proses | Waktu Proses (detik) | Proses Pendahulu |
|---|---|---|---|
| 1 | Potong PB | 20.477837 | - |
| 2 | Rol PB | 26.224876 | 1 |
| 3 | Bor PB | 20.454928 | 2 |
| 4 | Las 1 | 68.67561 | 3 |
| 5 | Amplas 1 | 262.08458 | 4 |
| 6 | Cat 1 KM | 1139.5437 | 5 |
| 7 | Gantung KM | 9.768067 | 6 |
| 8 | Cat 2 KM | 931.40229 | 7 |
| 9 | Oven KM | 36.83112 | 8 |
| 10 | Potong PK | 19.641936 | - |
| 11 | Rol PK | 25.484439 | 10 |
| 12 | Bor PK | 20.45298 | 1 |
| 13 | Potong Kw | 24.364461 | - |
| 14 | Las 2 | 68.610477 | 12,13 |
| 15 | Amplas 2 | 186.254292 | 14 |
| 16 | Cat 1 TS | 782.788052 | 15 |
| 17 | Gantung TS | 9.728206 | 16 |
| 18 | Cat 2 TS | 644.611753 | 17 |
| 19 | Oven TS | 36.91556 | 18 |
| 20 | Potong P1 | 10.758021 | - |
| 21 | Rol P1 | 13.612424 | 20 |
| 22 | Bor P1 | 11.361697 | 21 |
| 23 | Amplas 3 | 122.520069 | 22 |
| 24 | Cat 1 So | 457.280122 | 23 |
| 25 | Gantung So | 9.79529 | 24 |
| 26 | Cat 2 So | 298.831695 | 25 |
| 27 | Oven So | 36.882353 | 26 |
| 28 | Potong Ky | 7.459627 | - |
| 29 | Potong Bs | 3.402001 | - |
| 30 | Gabung KBs | 6.680035 | 28,29 |
| 31 | Potong Kn | 5.822749 | - |
| 32 | Jahit Kn | 8.392313 | 31 |
| 33 | Pasang Kn | 17.168143 | 30,32 |
| 34 | Pasang TS | 11.850113 | 9,19,27,33 |
| 35 | Pasang So | 5.645169 | 34 |
| 36 | Pasang Kel | 13.880612 | 35 |
| 37 | Pasang KK | 13.138706 | 36 |
| 38 | Pasang KM | 16.581614 | 37 |
| 39 | *Packing* | 17.978611 | 38 |

**Lampiran 4: Prioritas Operasi Kerja Kemeja**

| No. Proses | Proses | Waktu Proses (detik) | Proses Pendahulu |
|---|---|---|---|
| 1 | Blexer | 26.75 | - |
| 2 | Corong | 45.11 | - |
| 3 | Patrun Depan | 70.1 | 1,2 |
| 4 | Gosok Kantong | 49.73 | - |
| 5 | Jahit Label Size | 19.35 | 3,4 |
| 6 | Jahit Label MC | 28.43 | 5 |
| 7 | Kelim Kantong | 26.94 | 6 |
| 8 | Jahit Kantong | 66.47 | 7 |
| 9 | Patrun Pundak Luar | 103.82 | - |
| 10 | Patrun Pundak Dalam | 99.11 | - |
| 11 | Patrun Belakang | 70.05 | - |
| 12 | Jahit Pundak dan Belakang | 65.33 | 9,10,11 |
| 13 | Stik Pundak dan Belakang | 23.98 | 12 |
| 14 | Jahit Depan-Belakang | 103.53 | 8,13 |
| 15 | Stik Depan dan Belakang | 37.62 | 14 |
| 16 | Patrun Tangan | 69.4 | - |
| 17 | Corong Tangan | 23.52 | 16 |
| 18 | Kelim Tangan | 28.03 | 17 |
| 19 | Jahit Tangan | 180.05 | 15,18 |
| 20 | Stik Pasang Tangan | 64.13 | 19 |
| 21 | Kelim Bawah | 65.97 | 20 |
| 22 | Slip Pinggir | 79.86 | 21 |
| 23 | Mike Up | 100.85 | 22 |
| 24 | Setrika Kaki Kerah | 26.97 | - |
| 25 | Stik Kaki Kerah | 17.42 | 24 |
| 26 | Pasang Bis | 75.2 | 25 |
| 27 | Stik Daun Kerah | 53.1 | 26,28 |
| 28 | Bikin Kerah | 86.51 | - |
| 29 | Setrika kerah Jadi | 68.94 | 27 |
| 30 | Pasang Kerah | 203.4 | 23,29 |
| 31 | *Side slide* | 95.5 | 30 |
| 32 | QC | 72.24 | 31 |

**Lampiran 5: Perintah Lingo *Straight Line Balancing* untuk Knalpot Suzuki Carry Extra**

```
SETS:
  TASK/ 1..28 /: T;
  PRED( TASK, TASK)/ 1,2 2,3 4,5 5,6 6,7 3,7 8,9 9,10 7,10 10,12 11,12 12,21
13,14 14,22 15,16 16,17 17,23 18,19 19,20 20,23 21,24 22,24 23,24 24,25 25,26
26,27 27,28/;
  STATION/1..10/:Z;
  TXS( TASK, STATION): X,Y;
ENDSETS

 DATA:
  T = 8.91 7.06 6.10 18.41 22.53 21.74 12.64 8.10 5.27 12.34 7.86 16.81 5.92
24.62 4.21 3.78 4.61 4.81 2.64 5.66 51.18 26.70 21.88 14.25 49.59 18.35 62.27
7.72;
 ENDDATA

 The model;
  @FOR(TASK (I): @SUM(STATION(K):X(I,K)) = 1);

@FOR(PRED(R,S):
  @SUM(STATION(K):
   (10-K+1)*(X(R,K)-X(S,K))) >= 0);

  @FOR(STATION(K):
  @SUM(TASK(I) :T(I) * (X(I,K))) <= 62.27);

@FOR(STATION(K):
  @SUM(TASK(I) :(X(I,K))) <= 28*Z(K));
```

**Lampiran 5: Perintah Lingo *Straight Line Balancing* untuk Knalpot Suzuki Carry Extra (sambungan)**

```
@SUM(STATION(K):Z(K))=ZTOTAL;

 MIN = ZTOTAL;

 @FOR( TXS: @BIN( X));
 @FOR( STATION: @BIN( Z));

END
```

**Lampiran 6: *Mixed Integer Programming Straight Line Balancing* untuk Meja Setrika Setelan**

1. Fungsi tujuan:

$$Min \sum_{j=1}^{39} z_j$$

2. Kendala:

a. $\sum_{j=1}^{m_{max}} x_{ij} = 1$, untuk $i = 1, \ldots, n$

$$\sum_{j=1}^{39} x_{ij} = 1$$

Untuk $i = 1$

$[x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + \ldots + x_{1.39}] = 1$

Untuk $i = 2$

$[x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + \ldots + x_{2.39}] = 1$

|

|

|

Untuk $i = 39$

$[x_{39.1} + x_{39.2} + x_{39.3} + x_{39.4} + x_{39.5} + \ldots + x_{39.39}] = 1$

b. $\sum_{i=1}^{n} t_i * x_{ij} \leq C$, untuk $j = 1, \ldots, m_{max}$

$$\sum_{i=1}^{39} t_i * x_{ij} \leq C$$

Untuk $j = 1$

$\{[t_1.x_{11}] + [t_2.x_{21}] + [t_3.x_{31}] + [t_4.x_{41}] + [t_5.x_{51}] + \ldots + [t_{39}.x_{39.1}]\} \leq 1139.54370$

Untuk $j = 2$

$\{[t_1.x_{12}] + [t_2.x_{22}] + [t_3.x_{32}] + [t_4.x_{42}] + [t_5.x_{52}] + \ldots + [t_{39}.x_{39.2}]\} \leq 1139.54370$

|

|

|

**Lampiran 6: *Mixed Integer Programming Straight Line Balancing* untuk Meja Setrika Setelan (sambungan)**

Untuk $j = 39$

$\{[t_1.x_{1.39}] + [t_2.x_{2.39}] + [t_3.x_{3.39}] + [t_4.x_{4.39}] + [t_5.x_{5.39}] + \ldots + [t_{39}.x_{39.39}\} \leq 1139.54370$

c. $\sum_{i=\|W_j\|} x_{ij} \leq \|W_j\| Z_j$, untuk $j = 1, \ldots, m_{max}$

Untuk $j = 1$

$\{[x_{11} + x_{21} + x_{31} + x_{41} + x_{51} + \ldots + x_{39.1}\} \leq 39z_1$

Untuk $j = 2$

$\{x_{12} + x_{22} + x_{32} + x_{42} + x_{52} + \ldots + x_{39.2}\} \leq 39z_2$

Untuk $j = 3$

$\{x_{13} + x_{28} + x_{33} + x_{43} + x_{53} + \ldots + x_{39.3}\} \leq 39z_3$

|

|

Untuk $j = 39$

$\{x_{1.39} + x_{2.39} + x_{3.39} + x_{4.39} + x_{5.39} + \ldots + x_{39.39}\} \leq 39z_{39}$

d. $\sum_{j=1}^{m_{\max}} (m_{\max} - k + 1)(x_{rj} - x_{sj}) \geq 0$ untuk $(r, s) \in P$

$$\sum_{j=1}^{39} (m_{\max} - k + 1)(x_{rj} - x_{sj}) \geq 0$$

Untuk (1,2)

$\{[(39-1+1)(x_{11} - x_{21})] + [(39-2+1)(x_{12} - x_{22})] + [(39-3+1)(x_{13} - x_{23})] + [(39-4+1)(x_{14} - x_{24})] + [(39-5+1)(x_{15} - x_{25})] + \ldots + [(39-39+1)(x_{1.39} - x_{2.39})]\} \geq 0$

Untuk (2,3)

$\{[(39-1+1)(x_{21} - x_{31})] + [(39-2+1)(x_{22} - x_{32})] + [(39-3+1)(x_{23} - x_{33})] + [(39-4+1)(x_{24} - x_{34})] + [(39-5+1)(x_{25} - x_{35})] + \ldots + [(39-39+1)(x_{2.39} - x_{3.39})]\} \geq 0$

**Lampiran 6: *Mixed Integer Programming Straight Line Balancing* untuk Meja Setrika Setelan (sambungan)**

Untuk (3,4)

$\{[(39\text{-}1+1)(x_{31} - x_{41})] + [(39\text{-}2+1)(x_{32} - x_{42})] + [(39\text{-}3+1)(x_{33} - x_{43})] +[(39\text{-}4+1)(x_{34} - x_{44})] + [(39\text{-}5+1)(x_{35} - x_{45})] + \ldots + [(39\text{-}39+1)(x_{3.39} - x_{4.39})]\} \geq 0$

|

|

Untuk (38,39)

$\{[(39\text{-}1+1)(x_{38.1} - x_{39.1})] + [(39\text{-}2+1)(x_{38.2} - x_{39.2})] + [(39\text{-}3+1)(x_{38.3} - x_{39.3})] +[(39\text{-}4+1)(x_{38.4} - x_{39.4})] + [(39\text{-}5+1)(x_{38.5} - x_{39.5})] + \ldots + [(39\text{-}39+1)(x_{38.39} - x_{39.39})]\}\geq 0$

**Lampiran 7: Perintah Lingo *Straight Line Balancing* untuk Meja Setrika Setelan**

```
SETS:
  TASK/ 1..39 /: T;
  PRED( TASK, TASK)/ 1,2  2,3  3,4 4,5 5,6 6,7 7,8 8,9 10,11 11,12 13,14 12,14
14,15 15,16 16,17 17,18 18,19 20,21 21,22 22,23 23,24 24,25 25,26 26,27 28,30
29,30 31,32 32,33 30,33 33,34 9,34 19,34 27,34 34,35 35,36 36,37 37,38 38,39/;
  STATION/1..5/:Z;
  TXS( TASK, STATION): X,Y;
ENDSETS

 DATA:
  T = 20.477837 26.224876 20.454928 68.675610 262.084580 1139.543700
9.768067 931.402290 36.831120 19.641936 25.484439 20.452980 24.364461
68.610477 186.254292 782.788052 9.728206 644.611753 36.915560 10.758021
13.612424 11.361697 122.520069 457.280112 9.795290 298.831695 36.882353
7.459627 3.402001 6.680035 5.822749 8.392313 17.168143 11.850113 5.645169
13.880612 13.138706 16.581614 17.978611;
 ENDDATA

 The model;
  @FOR(TASK (I): @SUM(STATION(K):X(I,K)) = 1);

 @FOR(PRED(R,S):
  @SUM(STATION(K):
   (5-K+1)*(X(R,K)-X(S,K))) >= 0);

  @FOR(STATION(K):
  @SUM(TASK(I) :T(I) * (X(I,K))) <= 1139.54370);
```

**Lampiran 7: Perintah Lingo *Straight Line Balancing* untuk Meja Setrika Setelan (sambungan)**

```
@FOR(STATION(K):
   @SUM(TASK(I) : (X(I,K))) <= 39*Z(K));
@SUM(STATION(K):Z(K))=ZTOTAL;

  MIN = ZTOTAL;

  @FOR( TXS: @BIN( X));
  @FOR( STATION: @BIN( Z));

END
```

**Lampiran 8: Hasil *Software* Lingo *Straight Line Balancing* untuk Meja Setrika Setelan**

| *Variable* | *Value* |
|---|---|
| ZTOTAL | 5 |
| Z(1) | 1 |
| Z(2) | 1 |
| Z(3) | 1 |
| Z(4) | 1 |
| Z(5) | 1 |
| X(1,1) | 1 |
| X(2,1) | 1 |
| X(3,1) | 1 |
| X(4,1) | 1 |
| X(5,1) | 1 |
| X(6,3) | 1 |
| X( 7, 4) | 1 |
| Y( 8, 4) | 1 |
| Y( 9, 4) | 1 |
| X(10,1) | 1 |
| X(11,1) | 1 |
| X(12,1) | 1 |
| X(13,2) | 1 |
| X(14,2) | 1 |
| X(15,2) | 1 |
| X(16,2) | 1 |
| X(17,5) | 1 |

| | |
|---|---|
| X( 18,5) | 1 |
| X( 19,5) | 1 |
| X(20,1) | 1 |
| X(21,1) | 1 |
| X(22,1) | 1 |
| X(23,1) | 1 |
| X(24,1) | 1 |
| X(25,1) | 1 |
| X(26,5) | 1 |
| X( 27,5) | 1 |
| X( 28,1) | 1 |
| X(29,1) | 1 |
| X( 30,1) | 1 |
| X(31,1) | 1 |
| X( 32,1) | 1 |
| X(33,1) | 1 |
| X(34,5) | 1 |
| X(35,5) | 1 |
| X(36,5) | 1 |
| X(37,5) | 1 |
| X(38,5) | 1 |
| X(39,5) | 1 |

**Lampiran 9: Pembagian Elemen Kerja pada Stasiun Kerja *Straight Line Balancing* untuk Meja Setrika Setelan**

| Stasiun Kerja | No. Proses | Proses | Waktu Proses | Total Waktu Proses |
|---|---|---|---|---|
| 1 | 1 | Potong PB | 20.4778 | 1137.749677 |
| | 2 | Rol PB | 26.2249 | |
| | 3 | Bor PB | 20.4549 | |
| | 4 | Las 1 | 68.6756 | |
| | 5 | Amplas 1 | 262.085 | |
| | 10 | Potong PK | 19.6419 | |
| | 11 | Rol PK | 25.4844 | |
| | 12 | Bor PK | 20.453 | |
| | 20 | Potong P1 | 10.758 | |
| | 21 | Rol P1 | 13.6124 | |
| | 22 | Bor P1 | 11.3617 | |
| | 23 | Amplas 3 | 122.52 | |
| | 24 | Cat 1 So | 457.28 | |
| | 25 | Gantung So | 9.79529 | |
| | 28 | Potong Ky | 7.45963 | |
| | 29 | Potong Bs | 3.402 | |
| | 30 | Gabung KBs | 6.68004 | |
| | 31 | Potong Kn | 5.82275 | |
| | 32 | Jahit Kn | 8.39231 | |
| | 33 | Pasang Kn | 17.1681 | |
| 2 | 13 | Potong Kw | 24.3645 | 1062.017282 |
| | 14 | Las 2 | 68.6105 | |
| | 15 | Amplas 2 | 186.254 | |
| | 16 | Cat 1 TS | 782.788 | |
| 3 | 6 | Cat 1 KM | 1139.54 | 1139.5437 |
| 4 | 7 | Gantung KM | 9.76807 | 978.001477 |
| | 8 | Cat 2 KM | 931.402 | |
| | 9 | Oven KM | 36.8311 | |
| 5 | 17 | Gantung TS | 9.72821 | 1106.044392 |
| | 18 | Cat 2 TS | 644.612 | |
| | 19 | Oven TS | 36.9156 | |
| | 26 | Cat 2 So | 298.832 | |
| | 27 | Oven So | 36.8824 | |
| | 34 | Pasang TS | 11.8501 | |

**Lampiran 9: Pembagian Elemen Kerja pada Stasiun Kerja *Straight Line Balancing* untuk Meja Setrika Setelan (sambungan)**

| Stasiun Kerja | No. Proses | Proses | Waktu Proses | Total Waktu Proses |
|---|---|---|---|---|
| 5 | 35 | Pasang So | 5.64517 | |
| | 36 | Pasang Kel | 13.8806 | |
| | 37 | Pasang KK | 13.1387 | |
| | 38 | Pasang KM | 16.5816 | |
| | 39 | *Packing* | 17.9786 | |

**Lampiran 10: *Mixed Integer Programming Straight Line Balancing* untuk Kemeja**

1. Fungsi tujuan:

$$Min \sum_{j=1}^{32} z_j$$

2. Kendala:

a. $\sum_{j=1}^{m_{max}} x_{ij} = 1$, untuk $i = 1, \ldots, n$

$$\sum_{j=1}^{32} x_{ij} = 1$$

Untuk $i = 1$

$[x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + \ldots + x_{1.32}] = 1$

Untuk $i = 2$

$[x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} \ldots + x_{2.32}] = 1$

|

|

|

Untuk $i = 32$

$[x_{32.1} + x_{32.2} + x_{32.3} + x_{32.4} + x_{32.5} + \ldots + x_{32.32}] = 1$

b. $\sum_{i=1}^{n} t_i * x_{ij} \leq C$, untuk $j = 1, \ldots, m_{max}$

$$\sum_{i=1}^{32} t_i * x_{ij} \leq C$$

Untuk $j = 1$

$\{[t_1.x_{11}] + [t_2.x_{21}] + [t_3.x_{31}] + [t_4.x_{41}] + [t_5.x_{51}] + \ldots + [t_{32}.x_{32.1}]\} \leq 203.4$

Untuk $j = 2$

$\{[t_1.x_{12}] + [t_2.x_{22}] + [t_3.x_{32}] + [t_4.x_{42}] + [t_5.x_{52}] + \ldots + [t_{32}.x_{32.2}]\} \leq 203.4$

Untuk $j = 3$

$\{[t_1.x_{13}] + [t_2.x_{23}] + [t_3.x_{33}] + [t_4.x_{43}] + [t_5.x_{53}] + \ldots + [t_{32}.x_{32.3}]\} \leq 203.4$

|

|

**Lampiran 10: *Mixed Integer Programming Straight Line Balancing* untuk Kemeja (sambungan)**

Untuk $j = 32$

$\{[t_1.x_{1.32}] + [t_2.x_{2.32}] + [t_3x_{3.32})] + [t_4.x_{4.32}] + [t_5.x_{5.32}] + \ldots + [t_{32}.x_{32.32}\} \leq 203.4$

c. $\sum_{i=\|W_j\|} X_{ij} \leq \|W_j\| Z_j$, untuk $j = 1, \ldots, m_{max}$

Untuk $j = 1$

$\{x_{11} + x_{21} + x_{31} + x_{41} + x_{51} + \ldots + x_{32.1}\} \leq 32z_1$

Untuk $j = 2$

$\{x_{12} + x_{22} + x_{32} + x_{42} + x_{52} + \ldots + x_{32.2}\} \leq 32z_2$

Untuk $j = 3$

$\{x_{13} + x_{23} + x_{33} + x_{43} + x_{53} + \ldots + x_{32.3}\} \leq 32z_3$

|

|

|

Untuk $j = 32$

$\{x_{1.32} + x_{2.32} + x_{3.32} + x_{4.32} + x_{5.32} + \ldots + x_{32.32}\} \leq 32z_{32}$

d. $\sum_{j=1}^{m_{\max}} (m_{\max} - k + 1)(x_{rj} - x_{sj}) \geq 0$ untuk $(r, s) \in P$

$\sum_{j=1}^{32} (m_{\max} - k + 1)(x_{rj} - x_{sj}) \geq 0$

Untuk (1,3)

$\{[(32-1+1)x_{11} - x_{31})] + [(32-2+1)x_{12} - x_{32})] + [(32-3+1)x_{13} - x_{33})] + [(32-4+1)x_{14} - x_{34})] + [(32-5+1)x_{15} - x_{35})] + [(32-6+1)x_{16} - x_{36})] + [(32-7+1)x_{17} - x_{37})] + \ldots + [(32-32+1)x_{1.32} - x_{3.32})]\} \geq 0$

Untuk (2,3)

$\{[(32-1+1)x_{21} - x_{31})] + [(32-2+1)x_{22} - x_{32})] + [(32-3+1)x_{23} - x_{33})] + [(32-4+1)x_{24} - x_{34})] + [(32-5+1)x_{25} - x_{35})] + [(32-6+1)x_{26} - x_{36})] + [(32-7+1)x_{27} - x_{37})] + \ldots + [(32-32+1)x_{2.32} - x_{3.32})]\} \geq 0$

**Lampiran 10: *Mixed Integer Programming Straight Line Balancing* untuk Kemeja (sambungan)**

Untuk (3,5)

$\{[(32\text{-}1+1)x_{31} - x_{51})] + [(32\text{-}2+1)x_{32} - x_{52})] + [(32\text{-}3+1)x_{33} - x_{53})] + [(32\text{-}4+1)x_{34} - x_{54})] + [(32\text{-}5+1)x_{35} - x_{55})] + [(32\text{-}6+1)x_{36} - x_{56})] + [(32\text{-}7+1)x_{37} - x_{57})] + \ldots + [(32\text{-}32+1)x_{3.32} - x_{5.32})]\} \geq 0$

|

|

Untuk (31,32)

$\{[(32\text{-}1+1)(x_{31.1} - x_{32.1})] + [(32\text{-}2+1)(x_{31.2} - x_{32.2})] + [(32\text{-}3+1)(x_{31.3} - x_{32.3})] + [(32\text{-}4+1)(x_{31.4} - x_{32.4})] + [(32\text{-}5+1)(x_{31.5} - x_{32.5})] + [(32\text{-}6+1)(x_{31.6} - x_{32.6})] + [(32\text{-}7+1)(x_{31.7} - x_{32.7})] + \ldots + [(32\text{-}32+1)(x_{31.32} - x_{32.32})]\} \geq 0$

**Lampiran 11: Perintah Lingo *Straight Line Balancing* untuk Kemeja**

```
SETS:
  TASK/ 1..32 /: T;
  PRED( TASK, TASK)/ 1,3 2,3 3,5 4,5 5,6 6,7 7,8 8,14 9,12 10,12 11,12 12,13
13,14 14,15 15,19 16,17 17,18 18,19 19,20 20,21 21,22 22,23 23,30 24,25 25,26
26,27 28,27 27,29 29,30 30,31 31,32/;
  STATION/1..12/:Z;
  TXS( TASK, STATION): X,Y;
 ENDSETS

 DATA:
  T = 26.75 45.11 70.10 103.82 49.73 99.11 70.05 19.35 28.43 26.94 65.33 66.47
23.98 103.53 69.40 23.52 37.62 28.03 180.05 64.13 26.97 17.42 65.97 75.20
53.10 79.86 86.51 100.85 68.94 203.40 95.50 72.24;
 ENDDATA

The model;
 @FOR(TASK (I): @SUM(STATION(K):X(I,K)) = 1);

@FOR(PRED(R,S):
  @SUM(STATION(K):
   (12-K+1)*(X(R,K)-X(S,K))) >= 0);

 @FOR(STATION(K):
  @SUM(TASK(I) :T(I) * (X(I,K))) <= 203.40);

@FOR(STATION(K):
  @SUM(TASK(I) :(X(I,K))) <= 32*Z(K));

@SUM(STATION(K):Z(K))=ZTOTAL;
MIN = ZTOTAL;
```

**Lampiran 11: Perintah Lingo *Straight Line Balancing* untuk Kemeja (sambungan)**

```
 @FOR( TXS: @BIN( X));
 @FOR( STATION: @BIN( Z));

END
```

**Lampiran 12: Hasil *Software* Lingo *Straight Line Balancing* untuk Kemeja**

| *Variable* | *Value* |
|---|---|
| ZTOTAL | 12 |
| Z(1) | 1 |
| Z(2) | 1 |
| Z(3) | 1 |
| Z(4) | 1 |
| Z(5) | 1 |
| Z(6) | 1 |
| Z(7) | 1 |
| Z(8) | 1 |
| Z(9) | 1 |
| Z(10) | 1 |
| Z(11) | 1 |
| Z(12) | 1 |
| X(1,2) | 1 |
| X(2,1) | 1 |
| X(3,2) | 1 |
| X(4,1) | 1 |
| X(5,3) | 1 |
| X(6,4) | 1 |
| X(7,4) | 1 |
| X(8,4) | 1 |
| X(9,2) | 1 |
| X(10,1) | 1 |
| X(11,3) | 1 |
| X(12,4) | 1 |
| X(13,5) | 1 |
| X(14,5) | 1 |
| Y(15,5) | 1 |
| X(16,3) | 1 |
| X(17,3) | 1 |
| X(18,5) | 1 |
| X(19,6) | 1 |
| X(20,7) | 1 |
| X(21,7) | 1 |
| X(22,8) | 1 |
| X(23,9) | 1 |
| X(24,8) | 1 |
| X(25,8) | 1 |
| X(26,8) | 1 |
| X(27,7) | 1 |
| X(28,9) | 1 |
| X(29,10) | 1 |
| X(30,11) | 1 |
| X(31,12) | 1 |
| X(32,12) | 1 |

**Lampiran 13: Pembagian Elemen Kerja pada Stasiun Kerja *Straight Line Balancing* untuk Kemeja**

| Stasiun Kerja | No. Proses | Proses | Waktu Proses | Total Waktu Proses |
|---|---|---|---|---|
| 1 | 2 | Corong | 45.11 | 193.95 |
| | 4 | Gosok Kantong | 49.73 | |
| | 10 | Patrun Pundak Dalam | 99.11 | |
| 2 | 1 | Blexer | 26.75 | 200.67 |
| | 3 | Patrun Depan | 70.1 | |
| | 9 | Patrun Pundak Luar | 103.82 | |
| 3 | 5 | Jahit Label Size | 19.35 | 182.32 |
| | 11 | Patrun Belakang | 70.05 | |
| | 16 | Patrun Tangan | 69.4 | |
| | 17 | Corong Tangan | 23.52 | |
| 4 | 6 | Jahit Label MC | 28.43 | 187.17 |
| | 7 | Kelim Kantong | 26.94 | |
| | 8 | Jahit Kantong | 66.47 | |
| | 12 | Jahit Pundak dan Belakang | 65.33 | |
| 5 | 13 | Stik Pundak dan Belakang | 23.98 | 193.16 |
| | 14 | Jahit Depan-Belakang | 103.53 | |
| | 15 | Stik Depan dan Belakang | 37.62 | |
| | 18 | Kelim Tangan | 28.03 | |
| 6 | 19 | Jahit Tangan | 180.05 | 180.05 |
| 7 | 20 | Stik Pasang Tangan | 64.13 | 183.2 |
| | 21 | Kelim Bawah | 65.97 | |
| | 27 | Stik Daun Kerah | 53.1 | |
| 8 | 22 | Slip Pinggir | 79.86 | 199.45 |
| | 24 | Setrika Kaki Kerah | 26.97 | |
| | 25 | Stik Kaki Kerah | 17.42 | |
| | 26 | Pasang Bis | 75.2 | |
| 9 | 23 | Mike Up | 100.85 | 187.36 |
| | 28 | Bikin Kerah | 86.51 | |
| 10 | 29 | Setrika kerah Jadi | 68.94 | 68.94 |
| 11 | 30 | Pasang Kerah | 203.4 | 203.4 |
| 12 | 31 | *Side slide* | 95.5 | 167.74 |
| | 32 | QC | 72.24 | |

**Lampiran 14: Perintah Lingo U-*Line Balancing* untuk Knalpot Suzuki Carry Extra**

```
SETS:
  TASK/ 1..28 /: T;
  PRED( TASK, TASK)/ 1,2 2,3 4,5 5,6 6,7 3,7 8,9 9,10 7,10 10,12 11,12 12,21
13,14 14,22 15,16 16,17 17,23 18,19 19,20 20,23 21,24 22,24 23,24 24,25 25,26
26,27 27,28/;
  STATION/1..9/:Z;
  TXS( TASK, STATION): X,Y;
ENDSETS

 DATA:
  T = 8.91 7.06 6.10 18.41 22.53 21.74 12.64 8.10 5.27 12.34 7.86 16.81 5.92
24.62 4.21 3.78 4.61 4.81 2.64 5.66 51.18 26.70 21.88 14.25 49.59 18.35 62.27
7.72;
 ENDDATA

 The model;
  @FOR(TASK (I): @SUM(STATION(K):X(I,K)+Y(I,K)) = 1);

@FOR(PRED(R,S):
  @SUM(STATION(K):
   (9-K+1)*(X(R,K)-X(S,K))) >= 0);
  @FOR(PRED(R,S):
  @SUM(STATION(K):
   (9-K+1)*(Y(S,K)-Y(R,K))) >= 0);

  @FOR(STATION(K):
  @SUM(TASK(I) :T(I) * (X(I,K) + Y(I,K))) <= 62.27);

@FOR(STATION(K):
  @SUM(TASK(I) :(X(I,K) + Y(I,K))) <= 62.27*Z(K));
```

**Lampiran 14: Perintah Lingo U-*Line Balancing* untuk Knalpot Suzuki Carry Extra (sambungan)**

```
@SUM(STATION(K):Z(K))=ZTOTAL;

  MIN = ZTOTAL;

  @FOR( TXS: @BIN( X));
  @FOR( TXS: @BIN( Y));
  @FOR( STATION: @BIN( Z));

END
```

**Lampiran 15: *Mixed Integer Programming* U-*Line Balancing* pada Meja Setrika Setelan**

1. Fungsi tujuan:

$$Min \sum_{j=6}^{39} z_j$$

2. Kendala:

a. $\sum_{j=1}^{m_{max}} (x_{ij} + y_{ij}) = 1$, untuk $i = 1, \ldots, n$

$$\sum_{j=1}^{39} (x_{ij} + y_{ij}) = 1$$

Untuk $i = 1$

$[(x_{11} + y_{11}) + (x_{12} + y_{12}) + (x_{13} + y_{13}) + (x_{14} + y_{14}) + (x_{15} + y_{15}) + \ldots + (x_{1.39} + y_{1.39})] = 1$

Untuk $i = 2$

$[(x_{21} + y_{21}) + (x_{22} + y_{22}) + (x_{23} + y_{23}) + (x_{24} + y_{24}) + (x_{25} + y_{25}) + \ldots + (x_{2.39} + y_{2.39})] = 1$

|

|

|

Untuk $i = 39$

$[(x_{39.1} + y_{39.1}) + (x_{39.2} + y_{39.2}) + (x_{39.3} + y_{39.3}) + (x_{39.4} + y_{39.4}) + (x_{39.5} + y_{39.5}) + \ldots + (x_{39.39} + y_{39.39})] = 1$

b. $\sum_{i=1}^{n} t_i (x_{ij} + y_{ij}) \leq C$, untuk $j = 1, \ldots, \lceil m_{min} \rceil$

$$\sum_{i=1}^{39} t_i (x_{ij} + y_{ij}) \leq C$$

Untuk $j = 1$

$\{[t_1(x_{11} + y_{11})] + [t_2(x_{21} + y_{21})] + [t_3(x_{31} + y_{31})] + [t_4(x_{41} + y_{41})] + [t_5(x_{51} + y_{51})] + \ldots + [t_{39}(x_{39.1} + y_{39.1})]\} \leq 1139.54370$

**Lampiran 15: *Mixed Integer Programming* U-*Line Balancing* pada Meja Setrika Setelan (sambungan)**

Untuk $j = 2$

$\{[t_1(x_{12} + y_{12})] + [t_2(x_{22} + y_{22})] + [t_3(x_{32} + y_{32})] + [t_4(x_{42} + y_{42})] + [t_5(x_{52} + y_{52})] + \ldots + [t_{39}(x_{39.2} + y_{39.2})]\} \leq 1139.54370$

Untuk $j = 3$

$\{[t_1(x_{13} + y_{13})] + [t_2(x_{23} + y_{23})] + [t_3(x_{33} + y_{33})] + [t_4(x_{43} + y_{43})] + [t_5(x_{53} + y_{53})] + \ldots + [t_{39}(x_{39.3} + y_{39.3})]\} \leq 1139.54370$

|

Untuk $j = 5$

$\{[t_1(x_{15} + y_{15})] + [t_2(x_{25} + y_{25})] + [t_3(x_{35} + y_{35})] + [t_4(x_{45} + y_{45})] + [t_5(x_{55} + y_{55})] + \ldots + [t_{39}(x_{39.5} + y_{39.5})]\} \leq 1139.54370$

c. $\sum_{i=1}^{n}(x_{ij} + y_{ij}) \leq Cz_j$, untuk $j = \lceil m_{\min} \rceil + 1, \ldots, m_{max}$

$\sum_{i=1}^{39}(x_{ij} + y_{ij}) \leq Cz_j$

Untuk $j = 6$

$\{[t_1(x_{16} + y_{16})] + [t_2(x_{26} + y_{26})] + [t_3(x_{36} + y_{36})] + [t_4(x_{46} + y_{46})] + [t_5(x_{56} + y_{56})] + \ldots + [t_{39}(x_{39.6} + y_{39.6})]\} \leq 1139.54370z_6$

Untuk $j = 7$

$\{[t_1(x_{17} + y_{17})] + [t_2(x_{27} + y_{27})] + [t_3(x_{37} + y_{37})] + [t_4(x_{47} + y_{47})] + [t_5(x_{57} + y_{57})] + \ldots + [t_{39}(x_{39.7} + y_{39.7})]\} \leq 1139.54370z_7$

Untuk $j = 8$

$\{[t_1(x_{18} + y_{18})] + [t_2(x_{28} + y_{28})] + [t_3(x_{38} + y_{38})] + [t_4(x_{48} + y_{48})] + [t_5(x_{58} + y_{58})] + \ldots + [t_{39}(x_{39.8} + y_{39.8})]\} \leq 1139.54370z_8$

|

|

Untuk $j = 39$

$\{[t_1(x_{1.39} + y_{1.39})] + [t_2(x_{2.39} + y_{2.39})] + [t_3(x_{3.39} + y_{3.39})] + [t_4(x_{4.39} + y_{4.39})] + [t_5(x_{5.39} + y_{5.39})] + \ldots + [t_{39}(x_{39.39} + y_{39.39})]\} \leq 1139.54370z_{39}$

**Lampiran 15: *Mixed Integer Programming* U-*Line Balancing* pada Meja Setrika Setelan (sambungan)**

d. $\sum_{j=1}^{m_{\max}}(m_{\max} - j + 1)(x_{rj} - x_{sj}) \geq 0$ for (r, s) ∈ P

$\sum_{j=1}^{39}(m_{\max} - j + 1)(x_{rj} - x_{sj}) \geq 0$

Untuk (1,2)

{[(39-1+1)($x_{11}$ – $x_{21}$)] + [(39-2+1)($x_{12}$ – $x_{22}$)] + [(39-3+1)($x_{13}$ – $x_{23}$)] +[(39-4+1)($x_{14}$ – $x_{24}$)] + [(39-5+1)($x_{15}$ – $x_{25}$)] + … + [(39-39+1)($x_{1.39}$ – $x_{2.39}$)]} ≥ 0

Untuk (2,3)

{[(39-1+1)($x_{21}$ – $x_{31}$)] + [(39-2+1)($x_{22}$ – $x_{32}$)] + [(39-3+1)($x_{23}$ – $x_{33}$)] +[(39-4+1)($x_{24}$ – $x_{34}$)] + [(39-5+1)($x_{25}$ – $x_{35}$)] + … + [(39-39+1)($x_{2.39}$ – $x_{3.39}$)]}≥ 0

Untuk (3,4)

{[(39-1+1)($x_{31}$ – $x_{41}$)] + [(39-2+1)($x_{32}$ – $x_{42}$)] + [(39-3+1)($x_{33}$ – $x_{43}$)] +[(39-4+1)($x_{34}$ – $x_{44}$)] + [(39-5+1)($x_{35}$ – $x_{45}$)] + … + [(39-39+1)($x_{3.39}$ – $x_{4.39}$)]} ≥ 0

|

|

Untuk (38,39)

{[(39-1+1)($x_{38.1}$ – $x_{39.1}$)] + [(39-2+1)($x_{38.2}$ – $x_{39.2}$)] + [(39-3+1)($x_{38.3}$ – $x_{39.3}$)] +[(39-4+1)($x_{38.4}$ – $x_{39.4}$)] + [(39-5+1)($x_{38.5}$ – $x_{39.5}$)] + … + [(39-39+1)($x_{38.39}$ – $x_{39.39}$)]}≥ 0

e. $\sum_{j=1}^{m_{\max}}(m_{\max} - j + 1)(y_{sj} - y_{rj}) \geq 0$ for (r, s) ∈ P

$\sum_{j=1}^{5}(m_{\max} - j + 1)(y_{sj} - y_{rj}) \geq 0$

Untuk (1,2)

{[(39-1+1)($y_{21}$ – $y_{11}$)] + [(39-2+1)($y_{22}$ – $y_{12}$)] + [(39-3+1)($y_{23}$ – $y_{13}$)] +[(39-4+1)($y_{24}$ – $y_{14}$)] + [(39-5+1)($y_{25}$ – $y_{15}$)] + … + [(39-39+1)($x_{2.39}$ – $x_{1.39}$)]}≥ 0

**Lampiran 15: *Mixed Integer Programming* U-*Line Balancing* pada Meja Setrika Setelan (sambungan)**

Untuk (2,3)

$\{[(39\text{-}1+1)(y_{31} - y_{21})] + [(39\text{-}2+1)(y_{32} - y_{22})] + [(39\text{-}3+1)(y_{33} - y_{23})] +[(39\text{-}4+1)(y_{34} - y_{24})] + [(39\text{-}5+1)(y_{35} - y_{25})] + \ldots + [(39\text{-}39+1)(x_{3.39} - x_{2.39})]\} \geq 0$

Untuk (3,4)

$\{[(39\text{-}1+1)(y_{41} - y_{31})] + [(39\text{-}2+1)(y_{42} - y_{32})] + [(39\text{-}3+1)(y_{43} - y_{33})] +[(39\text{-}4+1)(y_{44} - y_{34})] + [(39\text{-}5+1)(y_{45} - y_{35})] + \ldots + [(39\text{-}39+1)(x_{4.39} - x_{3.39})]\} \geq 0$

Untuk (4,5)

$\{[(39\text{-}1+1)(y_{51} - y_{41})] + [(39\text{-}2+1)(y_{52} - y_{42})] + [(39\text{-}3+1)(y_{53} - y_{43})] +[(39\text{-}4+1)(y_{54} - y_{44})] + [(39\text{-}5+1)(y_{55} - y_{45})] + \ldots + [(39\text{-}39+1)(x_{5.39} - x_{4.39})]\} \geq 0$

|

|

|

Untuk (38,39)

$\{[(39\text{-}1+1)(y_{39.1} - y_{38.1})] + [(39\text{-}2+1)(y_{39.2} - y_{38.2})] + [(39\text{-}3+1)(y_{39.3} - y_{38.3})] +[(39\text{-}4+1)(y_{39.4} - y_{38.4})] + [(39\text{-}5+1)(y_{39.5} - y_{38.5})] + \ldots + [(39\text{-}39+1)(x_{39.39} - x_{38.39})]\} \geq 0$

**Lampiran 16: Perintah Lingo U-*Line Balancing* untuk Meja Setrika Setelan**

```
SETS:
  TASK/ 1..39 /: T;
  PRED( TASK, TASK)/ 1,2  2,3  3,4 4,5 5,6 6,7 7,8 8,9 10,11 11,12 13,14 12,14
14,15 15,16 16,17 17,18 18,19 20,21 21,22 22,23 23,24 24,25 25,26 26,27 28,30
29,30 31,32 32,33 30,33 33,34 9,34 19,34 27,34 34,35 35,36 36,37 37,38 38,39/;
  STATION/1..5/:Z;
  TXS( TASK, STATION): X,Y;
ENDSETS

 DATA:
  T = 20.477837 26.224876 20.454928 68.675610 262.084580 1139.543700
9.768067 931.402290 36.831120 19.641936 25.484439 20.452980 24.364461
68.610477 186.254292 782.788052 9.728206 644.611753 36.915560 10.758021
13.612424 11.361697 122.520069 457.280112 9.795290 298.831695 36.882353
7.459627 3.402001 6.680035 5.822749 8.392313 17.168143 11.850113 5.645169
13.880612 13.138706 16.581614 17.978611;
 ENDDATA

 The model;
  @FOR(TASK (I): @SUM(STATION(K):X(I,K)+Y(I,K)) = 1);

 @FOR(PRED(R,S):
   @SUM(STATION(K):
    (5-K+1)*(X(R,K)-X(S,K))) >= 0);
  @FOR(PRED(R,S):
   @SUM(STATION(K):
    (5-K+1)*(Y(S,K)-Y(R,K))) >= 0);
  @FOR(STATION(K):
   @SUM(TASK(I) :T(I) * (X(I,K) + Y(I,K))) <= 1139.54370);
```

**Lampiran 16: Perintah Lingo U-*Line Balancing* untuk Meja Setrika Setelan (sambungan)**

```
@FOR(STATION(K):
   @SUM(TASK(I) :(X(I,K) + Y(I,K))) <= 1139.54370*Z(K));
@SUM(STATION(K):Z(K))=ZTOTAL;

  MIN = ZTOTAL;

  @FOR( TXS: @BIN( X));
  @FOR( TXS: @BIN( Y));
  @FOR( STATION: @BIN( Z));

END
```

**Lampiran 17: Hasil *Software* Lingo U-*Line Balancing* untuk Meja Setrika Setelan**

| *Variable* | *Value* |
|---|---|
| ZTOTAL | 5 |
| Z(1) | 1 |
| Z(2) | 1 |
| Z(3) | 1 |
| Z(4) | 1 |
| Z(5) | 1 |
| X(1,3) | 1 |
| X(2,3) | 1 |
| X(3,3) | 1 |
| X(4,3) | 1 |
| X(5,3) | 1 |
| X(6,4) | 1 |
| X( 7, 5) | 1 |
| Y( 8, 5) | 1 |
| Y( 9, 5) | 1 |
| X(10,1) | 1 |
| X(11,1) | 1 |
| X(12,1) | 1 |
| X(13,2) | 1 |
| X(14,2) | 1 |
| X(15,2) | 1 |
| X(16,2) | 1 |
| X(17,2) | 1 |

| | |
|---|---|
| Y( 18, 3) | 1 |
| Y( 19, 2) | 1 |
| X(20,1) | 1 |
| X(21,1) | 1 |
| X(22,1) | 1 |
| X(23,1) | 1 |
| X(24,1) | 1 |
| X(25,1) | 1 |
| X(26,1) | 1 |
| Y( 27, 1) | 1 |
| X( 28, 5) | 1 |
| X(29,1) | 1 |
| Y( 30, 2) | 1 |
| X(31,1) | 1 |
| X( 32, 2) | 1 |
| Y(33,1) | 1 |
| Y(34,1) | 1 |
| Y(35,1) | 1 |
| Y(36,1) | 1 |
| Y(37,1) | 1 |
| Y(38,1) | 1 |
| Y(39,1) | 1 |

**Lampiran 18: Pembagian Elemen Kerja pada Stasiun Kerja U-*Line Balancing* untuk Meja Setrika Setelan**

| Stasiun kerja | No. Proses | Proses | Waktu proses | Jumlah waktu proses |
|---|---|---|---|---|
| 1 | 10 | Potong PK | 19.6419 | 1132.09 |
| | 11 | Rol PK | 25.4844 | |
| | 12 | Bor PK | 20.453 | |
| | 20 | Potong P1 | 10.758 | |
| | 21 | Rol P1 | 13.6124 | |
| | 22 | Bor P1 | 11.3617 | |
| | 23 | Amplas 3 | 122.52 | |
| | 24 | Cat 1 So | 457.28 | |
| | 25 | Gantung So | 9.79529 | |
| | 26 | Cat 2 So | 298.832 | |
| | 27 | Oven So | 36.8824 | |
| | 29 | Potong Bs | 3.402 | |
| | 31 | Potong Kn | 5.82275 | |
| | 33 | Pasang Kn | 17.1681 | |
| | 34 | Pasang TS | 11.8501 | |
| | 35 | Pasang So | 5.64517 | |
| | 36 | Pasang Kel | 13.8806 | |
| | 37 | Pasang KK | 13.1387 | |
| | 38 | Pasang KM | 16.5816 | |
| | 39 | *Packing* | 17.9786 | |
| 2 | 13 | Potong Kw | 24.3645 | 1123.73 |
| | 14 | Las 2 | 68.6105 | |
| | 15 | Amplas 2 | 186.254 | |
| | 16 | Cat 1 TS | 782.788 | |
| | 17 | Gantung TS | 9.72821 | |
| | 19 | Oven TS | 36.9156 | |
| | 30 | Gabung KBs | 6.68004 | |
| | 32 | Jahit Kn | 8.39231 | |
| 3 | 1 | Potong PB | 20.4778 | 1042.53 |
| | 2 | Rol PB | 26.2249 | |
| | 3 | Bor PB | 20.4549 | |

**Lampiran 18: Pembagian Elemen Kerja pada Stasiun Kerja U-*Line Balancing* untuk Meja Setrika Setelan (sambungan)**

| | | | | |
|---|---|---|---|---|
| 3 | 4 | Las 1 | 68.6756 | |
| | 5 | Amplas 1 | 262.085 | |
| | 18 | Cat 2 TS | 644.612 | |
| 4 | 6 | Cat 1 KM | 1139.54 | 1139.54 |
| 5 | 7 | Gantung KM | 9.76807 | 985.461 |
| | 8 | Cat 2 KM | 931.402 | |
| | 9 | Oven KM | 36.8311 | |
| | 28 | Potong Ky | 7.45963 | |

**Lampiran 19: *Mixed Integer Programming* U-*Line Balancing* pada Kemeja**

1. Fungsi tujuan:

$$Min \sum_{j=12}^{32} z_j$$

2. Kendala:

a. $\sum_{j=1}^{m_{max}} (x_{ij} + y_{ij}) = 1$, untuk $i = 1, \ldots, n$

$$\sum_{j=1}^{32} (x_{ij} + y_{ij}) = 1$$

Untuk $i = 1$

$[(x_{11} + y_{11}) + (x_{12} + y_{12}) + (x_{13} + y_{13}) + (x_{14} + y_{14}) + (x_{15} + y_{15}) + (x_{16} + y_{16}) + (x_{17} + y_{17}) + (x_{18} + y_{18}) + (x_{19} + y_{19}) + (x_{1.10} + y_{1.10}) + (x_{1.11} + y_{1.11}) + \ldots + (x_{1.32} + y_{1.32})] = 1$

Untuk $i = 2$

$[(x_{21} + y_{21}) + (x_{22} + y_{22}) + (x_{23} + y_{23}) + (x_{24} + y_{24}) + (x_{25} + y_{25}) + (x_{26} + y_{26}) + (x_{27} + y_{27}) + (x_{28} + y_{28}) + (x_{29} + y_{29}) + (x_{2.10} + y_{2.10}) + (x_{2.11} + y_{2.11}) + \ldots + (x_{2.32} + y_{2.32})] = 1$

|

|

|

Untuk $i = 32$

$[(x_{32.1} + y_{32.1}) + (x_{32.2} + y_{32.2}) + (x_{32.3} + y_{32.3}) + (x_{32.4} + y_{32.4}) + (x_{32.5} + y_{32.5}) + (x_{32.6} + y_{32.6}) + (x_{32.7} + y_{32.7}) + (x_{32.8} + y_{32.8}) + (x_{32.9} + y_{32.9}) + (x_{32.10} + y_{32.10}) + (x_{32.11} + y_{32.11}) + \ldots + (x_{32.32} + y_{32.32})] = 1$

b. $\sum_{i=1}^{n} t_i (x_{ij} + y_{ij}) \le C$, untuk $j = 1, \ldots, \lceil m_{min} \rceil$

$$\sum_{i=1}^{32} t_i (x_{ij} + y_{ij}) \le C$$

Untuk $j = 1$

$\{[t_1(x_{11} + y_{11})] + [t_2(x_{21} + y_{21})] + [t_3(x_{31} + y_{31})] + [t_4(x_{41} + y_{41})] + [t_5(x_{51} + y_{51})] + \ldots + [t_{32}(x_{32.1} + y_{32.1})]\} \le 203.4$

**Lampiran 19: *Mixed Integer Programming* U-*Line Balancing* pada Kemeja (sambungan)**

Untuk $j = 2$

$\{[t_1(x_{12} + y_{12})] + [t_2(x_{22} + y_{22})] + [t_3(x_{32} + y_{32})] + [t_4(x_{42} + y_{42})] + [t_5(x_{52} + y_{52})] + \ldots + [t_{32}(x_{32.2} + y_{32.2})]\} \leq 203.4$

Untuk $j = 3$

$\{[t_1(x_{13} + y_{13})] + [t_2(x_{23} + y_{23})] + [t_3(x_{33} + y_{33})] + [t_4(x_{43} + y_{43})] + [t_5(x_{53} + y_{53})] + \ldots + [t_{32}(x_{32.3} + y_{32.3})]\} \leq 203.4$

|

|

Untuk $j = 11$

$\{[t_1(x_{1.11} + y_{1.11})] + [t_2(x_{2.11} + y_{2.11})] + [t_3(x_{3.11} + y_{3.11})] + [t_4(x_{4.11} + y_{4.11})] + [t_5(x_{5.11} + y_{5.11})] + \ldots + [t_{32}(x_{32.11} + y_{32.11})]\} \leq 203.4$

c. $\sum_{i=1}^{n}(x_{ij} + y_{ij}) \leq Cz_j$, untuk $j = \lceil m_{\min} \rceil + 1, \ldots, m_{max}$

$\sum_{i=1}^{32}(x_{ij} + y_{ij}) \leq Cz_j$

Untuk $j = 12$

$\{[t_1(x_{1.12} + y_{1.12})] + [t_2(x_{2.12} + y_{2.12})] + [t_3(x_{3.12} + y_{3.12})] + [t_4(x_{4.12} + y_{4.12})] + [t_5(x_{5.12} + y_{5.12})] + \ldots + [t_{32}(x_{32.12} + y_{32.12})]\} \leq 203.4z_{12}$

Untuk $j = 13$

$\{[t_1(x_{1.13} + y_{1.13})] + [t_2(x_{2.13} + y_{2.13})] + [t_3(x_{3.13} + y_{3.13})] + [t_4(x_{4.13} + y_{4.13})] + [t_5(x_{5.13} + y_{5.13})] + \ldots + [t_{32}(x_{32.13} + y_{32.13})]\} \leq 203.4z_{13}$

Untuk $j = 14$

$\{[t_1(x_{1.14} + y_{1.14})] + [t_2(x_{2.14} + y_{2.14})] + [t_3(x_{3.14} + y_{3.14})] + [t_4(x_{4.14} + y_{4.14})] + [t_5(x_{5.14} + y_{5.14})] + \ldots + [t_{32}(x_{32.14} + y_{32.14})]\} \leq 203.4z_{14}$

|

|

Untuk $j = 32$

$\{[t_1(x_{1.32} + y_{1.32})] + [t_2(x_{2.32} + y_{2.32})] + [t_3(x_{3.32} + y_{3.32})] + [t_4(x_{4.32} + y_{4.32})] + [t_5(x_{5.32} + y_{5.32})] + \ldots + [t_{32}(x_{32.32} + y_{32.32})]\} \leq 203.4z_{32}$

**Lampiran 19: *Mixed Integer Programming* U-*Line Balancing* pada Kemeja (sambungan)**

d. $\sum_{j=1}^{m_{\max}}(m_{\max} - j + 1)(x_{rj} - x_{sj}) \geq 0$ for (r, s) ∈ P

$\sum_{j=1}^{32}(m_{\max} - j + 1)(x_{rj} - x_{sj}) \geq 0$

Untuk (1,3)

$\{[(32-1+1)(x_{11} - x_{31})] + [(32-2+1)(x_{12} - x_{32})] + [(32-3+1)(x_{13} - x_{33})] + [(32-4+1)(x_{14} - x_{34})] + [(32-5+1)(x_{15} - x_{35})] + [(32-6+1)(x_{16} - x_{36})] + [(32-7+1)(x_{17} - x_{37})] + \ldots + [(32-32+1)(x_{1.32} - x_{3.32})]\} \geq 0$

Untuk (2,3)

$\{[(32-1+1)(x_{21} - x_{31})] + [(32-2+1)(x_{22} - x_{32})] + [(32-3+1)(x_{23} - x_{33})] + [(32-4+1)(x_{24} - x_{34})] + [(32-5+1)(x_{25} - x_{35})] + [(32-6+1)(x_{26} - x_{36})] + [(32-7+1)(x_{27} - x_{37})] + \ldots + [(32-32+1)(x_{2.32} - x_{3.32})]\} \geq 0$

Untuk (3,5)

$\{[(32-1+1)(x_{31} - x_{51})] + [(32-2+1)(x_{32} - x_{52})] + [(32-3+1)(x_{33} - x_{53})] + [(32-4+1)(x_{34} - x_{54})] + [(32-5+1)(x_{35} - x_{55})] + [(32-6+1)(x_{36} - x_{56})] + [(32-7+1)(x_{37} - x_{57})] + \ldots + [(32-32+1)(x_{3.32} - x_{5.32})]\} \geq 0$

|

|

Untuk (31,32)

$\{[(32-1+1)(x_{31.1} - x_{32.1})] + [(32-2+1)(x_{31.2} - x_{32.2})] + [(32-3+1)(x_{31.3} - x_{32.3})] + [(32-4+1)(x_{31.4} - x_{32.4})] + [(32-5+1)(x_{31.5} - x_{32.5})] + [(32-6+1)(x_{31.6} - x_{32.6})] + [(32-7+1)(x_{31.7} - x_{32.7})] + \ldots + [(32-32+1)(x_{31.32} - x_{32.32})]\} \geq 0$

e. $\sum_{j=1}^{m_{\max}}(m_{\max} - j + 1)(y_{sj} - y_{rj}) \geq 0$ for (r, s) ∈ P

$\sum_{j=1}^{5}(m_{\max} - j + 1)(y_{sj} - y_{rj}) \geq 0$

Untuk (1,3)

$\{[(32-1+1)(y_{31} - y_{11})] + [(32-2+1)(y_{32} - y_{12})] + [(32-3+1)(y_{33} - y_{13})] + [(32-4+1)(y_{34} - y_{14})] + [(32-5+1)(y_{35} - y_{15})] + [(32-6+1)(y_{36} - y_{16})] + [(32-7+1)(y_{37} - y_{17})] + \ldots + [(32-32+1)(x_{3.32} - x_{1.32})]\} \geq 0$

**Lampiran 19: *Mixed Integer Programming* U-*Line Balancing* pada Kemeja (sambungan)**

Untuk (2,3)

$\{[(32\text{-}1+1)(y_{31} - y_{21})] + [(32\text{-}2+1)(y_{32} - y_{22})] + [(32\text{-}3+1)(y_{33} - y_{23})] + [(32\text{-}4+1)(y_{34} - x_{24})] + [(32\text{-}5+1)(y_{35} - y_{25})] + [(32\text{-}6+1)(y_{36} - y_{26})] + [(32\text{-}7+1)(y_{37} - x_{27})] + \ldots + [(32\text{-}32+1)(x_{3.32} - x_{2.32})]\} \geq 0$

Untuk (3,5)

$\{[(32\text{-}1+1)(y_{51} - y_{31})] + [(32\text{-}2+1)(y_{52} - y_{32})] + [(32\text{-}3+1)(y_{53} - y_{33})] + [(32\text{-}4+1)(y_{54} - y_{34})] + [(32\text{-}5+1)(y_{55} - y_{35})] + [(32\text{-}6+1)(y_{56} - y_{36})] + [(32\text{-}7+1)(y_{57} - y_{37})] + \ldots + [(32\text{-}32+1)(x_{5.32} - x_{3.32})]\} \geq 0$

|

|

Untuk (31,32)

$\{[(32\text{-}1+1)(y_{32.1} - y_{31.1})] + [(32\text{-}2+1)(y_{32.2} - y_{31.2})] + [(32\text{-}3+1)(y_{32.3} - y_{31.3})] + [(32\text{-}4+1)(y_{32.4} - y_{31.4})] + [(32\text{-}5+1)(y_{32.5} - y_{31.5})] + [(32\text{-}6+1)(y_{32.6} - y_{31.6})] + [(32\text{-}7+1)(y_{32.7} - y_{31.7})] + \ldots + [(32\text{-}32+1)(x_{32.32} - x_{31.32})]\} \geq 0$

**Lampiran 20: Perintah Lingo U-*Line Balancing* untuk Kemeja**

```
SETS:
  TASK/ 1..32 /: T;
  PRED( TASK, TASK)/ 1,3 2,3 3,5 4,5 5,6 6,7 7,8 8,14 9,12 10,12 11,12 12,13
13,14 14,15 15,19 16,17 17,18 18,19 19,20 20,21 21,22 22,23 23,30 24,25 25,26
26,27 28,27 27,29 29,30 30,31 31,32/;
  STATION/1..11/:Z;
  TXS( TASK, STATION): X,Y;
 ENDSETS

 DATA:
  T = 26.75 45.11 70.10 103.82 49.73 99.11 70.05 19.35 28.43 26.94 65.33 66.47
23.98 103.53 69.40 23.52 37.62 28.03 180.05 64.13 26.97 17.42 65.97 75.20
53.10 79.86 86.51 100.85 68.94 203.40 95.50 72.24;
 ENDDATA
```

The model;

```
 @FOR(TASK (I): @SUM(STATION(K):X(I,K)+Y(I,K)) = 1);

@FOR(PRED(R,S):
  @SUM(STATION(K):
   (11-K+1)*(X(R,K)-X(S,K))) >= 0);
 @FOR(PRED(R,J):
  @SUM(STATION(K):
   (11-K+1)*(Y(S,K)-Y(R,K))) >= 0);

 @FOR(STATION(K):
  @SUM(TASK(I) :T(I) * (X(I,K) + Y(I,K))) <= 203.40);

@FOR(STATION(K):
  @SUM(TASK(I) :(X(I,K) + Y(I,K))) <= 203.40*Z(K));
@SUM(STATION(K):Z(K))=ZTOTAL;
```

**Lampiran 20: Perintah Lingo U-*Line Balancing* untuk Kemeja (sambungan)**

```
MIN = ZTOTAL;

  @FOR( TXS: @BIN( X));
  @FOR( TXS: @BIN( Y));
  @FOR( STATION: @BIN( Z));

END
```

**Lampiran 21: Hasil *Software* Lingo U-*Line Balancing* untuk Kemeja**

| *Variable* | *Value* |
|---|---|
| ZTOTAL | 11 |
| Z(1) | 1 |
| Z(2) | 1 |
| Z(3) | 1 |
| Z(4) | 1 |
| Z(5) | 1 |
| Z(6) | 1 |
| Z(7) | 1 |
| Z(8) | 1 |
| Z(9) | 1 |
| Z(10) | 1 |
| Z(11) | 1 |
| X(1,1) | 1 |
| X(2,2) | 1 |
| X(3,5) | 1 |
| X(4,2) | 1 |
| X(5,7) | 1 |
| X(6,7) | 1 |
| X(7,10) | 1 |
| X(8,10) | 1 |
| X(9,2) | 1 |
| X(10,8) | 1 |
| X(11,10) | 1 |
| X(12,11) | 1 |
| X(13,11) | 1 |
| X(14,11) | 1 |
| Y(15,10) | 1 |
| X(16,4) | 1 |
| X(17,4) | 1 |
| X(18,8) | 1 |
| Y(19,9) | 1 |
| Y(20,8) | 1 |
| Y(21,7) | 1 |
| Y(22,5) | 1 |
| Y(23,4) | 1 |
| X(24,6) | 1 |
| X(25,6) | 1 |
| Y(26,7) | 1 |
| X(27,5) | 1 |
| Y(28,6) | 1 |
| Y(29,6) | 1 |
| Y(30,3) | 1 |
| Y(31,1) | 1 |
| Y(32,1) | 1 |

**Lampiran 22: Pembagian Elemen Kerja pada Stasiun Kerja U-*Line Balancing* untuk Kemeja**

| Stasiun kerja | No. Proses | Proses | Waktu proses | Jumlah waktu proses |
|---|---|---|---|---|
| 1 | 1 | Blexer | 26.75 | 194.49 |
| | 31 | *Side slide* | 95.5 | |
| | 32 | QC | 72.24 | |
| 2 | 2 | Corong | 45.11 | 198.66 |
| | 4 | Gosok Kantong | 49.73 | |
| | 9 | Patrun Pundak Luar | 103.82 | |
| 3 | 30 | Pasang Kerah | 203.4 | 203.4 |
| 4 | 16 | Patrun Tangan | 69.4 | 193.77 |
| | 17 | Corong Tangan | 23.52 | |
| | 23 | Mike Up | 100.85 | |
| 5 | 3 | Patrun Depan | 70.1 | 203.06 |
| | 22 | Slip Pinggir | 79.86 | |
| | 27 | Stik Daun Kerah | 53.1 | |
| 6 | 24 | Setrika Kaki Kerah | 26.97 | 199.84 |
| | 25 | Stik Kaki Kerah | 17.42 | |
| | 28 | Bikin Kerah | 86.51 | |
| | 29 | Setrika kerah Jadi | 68.94 | |
| 7 | 5 | Jahit Label Size | 19.35 | 188.95 |
| | 6 | Jahit Label MC | 28.43 | |
| | 21 | Kelim Bawah | 65.97 | |
| | 26 | Pasang Bis | 75.2 | |
| 8 | 10 | Patrun Pundak Dalam | 99.11 | 191.27 |
| | 18 | Kelim Tangan | 28.03 | |
| | 20 | Stik Pasang Tangan | 64.13 | |
| 9 | 19 | Jahit Tangan | 180.05 | 180.05 |
| 10 | 7 | Kelim Kantong | 26.94 | 201.08 |
| | 8 | Jahit Kantong | 66.47 | |
| | 11 | Patrun Belakang | 70.05 | |
| | 15 | Stik Depan dan Belakang | 37.62 | |
| 11 | 12 | Jahit Pundak dan Belakang | 65.33 | 192.84 |
| | 13 | Stik Pundak dan Belakang | 23.98 | |
| | 14 | Jahit Depan-Belakang | 103.53 | |