HOCHSCHULE RHEIN-WAAL

Rhine-Waal University of Applied Sciences

"Il Bombo"

2707

Quality and production management

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Task 1

1. Takt time

Data:

Units in a year:	$U_{tot,\,year} = 120\,000$
Working days in a year:	$D_{year} = 250\ days$
Number of shifts a day:	$S = 3$
Working time in a shift:	$t_{shift} = 7.5\ h$
Total components:	$N_{tot} = 150$

Working time:

$$t_w = D_{year} \cdot S \cdot t_{shift} = 20\,250\,000\ s = 5\,625\ h$$

Takt time:

$$T = \frac{t_w}{U_{tot,\,year}} = 168.75\ s/unit$$

one scooter is produced every 2.8 min to meet the yearly plan.

2. Set ups and batch sizes

2.1 Metal Stamping

One coil cutting line is needed for the process, in order to make 625 units (that means 625 parts from (1-8).

Details given:

-Coil length is 750000mm

-Sheet lengths: {1200, 900, 850, 600, 580, 520, 250, 150} mm going in order from parts 1-8

-Cutting/Material Transfer and Cycle Model: Stay on one coil till 625 parts are made, then switch to the next coil type for the next part. On the second wave all coils going from 2-8 must need to use the coil that was not fully used in the first wave and also most likely a new coil.

- cutting time = 0.6 $\frac{s}{cut}$

-material conveying speed= 1000 $\frac{mm}{s}$

-Total cycle time per piece= 0.6s + ($\frac{length\ of\ part\ n}{1000\frac{mm}{s}}$)s

- Coil not used completely (relevant for cycles after the first round)= 1200s (only the first part consumes the whole coil, hence 625 pieces are chosen).

-It is a single continuous that way the change of product is minimized.

Setup Times

Feeding a new coil of same product= 600s

Switching from a product to another= 2400s

Calculation:

Relevant Formulas:

$$n_{sheets} = \frac{750000mm}{raw\ sheet\ length}$$

$$T_{part} = [\frac{length\ sheet\ type}{v_{Feed}} + 0.6\frac{s}{cut}] * 625 \quad \text{(this is without considering if the coil has not been}$$

used up completely, that will be shown in the calculation when it is needed).

Part 1:

$$T_{part1} = [\frac{1200mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s = 1725s$$

Addition of 600s accounts for the 10min needed to place the coil on to the clamp or rolling device. There is no need to add a new coil, coil length is exact.

Part 2:

$$T_{part2} = [\frac{900mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s + 1200s = 2737.5s$$

In this case 20 minutes are added because the amount of coil needed to produce 625 parts is less than 750m needed, so it must be dismounted.

Part 3:

$$T_{part3} = [\frac{850mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s + 1200s = 2706.25s$$

Part 4:

$$T_{part4} = [\frac{600mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s + 1200s = 2550s$$

Part 5:

$$T_{part5} = [\frac{580mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s + 1200s = 2537.5s$$

Part 6:

$$T_{part6} = [\frac{520mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s + 1200s = 2500s$$

Part 7:

$$T_{part7} = [\frac{250mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s + 1200s = 2331.25s$$

Part 8:

$$T_{part8} = [\frac{150mm}{1000mm/s} + 0.6\frac{s}{cut}] * 625 + 600s + 1200s = 2268.75s$$

$$T_{processing} = T_{part1} + T_{part2} + T_{part3} + T_{part4} + T_{part5} + T_{part6} + T_{part7} + T_{part8} = 28056.25s$$

This number is only considered (processing+coil feeds+removing coils). Now the switches between parts are included which are 7 switches if the consideration is one continuous line.

$$T_{Total} = T_{processing} + (7x2400s) = 28056.25s + 16800s = 36856.25s$$

Comparing to the batch time to the takt time:

$$T_{unit} = \frac{36856.25s}{625units} = 58.97\frac{s}{unit}$$

So it is well below the takt time, even if in the next rounds the coils that were not used up had to be welded to the same type of coil it would not go over the takt time.

2.2 Metal forming

For metal forming the set up that will be used consists of 2 large presses and 1 small press, the batch size consists of 625 pieces for all 8 metal sheets.
-Large Press 1 handles 3 parts (1-3)
-Large Press 2 handles 3 parts (4-6)
-Small Press 1 handles 2 parts (7-8)

The benefit of less pieces and less dyes to change but also more expensive of course.
Forming step {1:2,2:5,3:4,4:4,5:3,6:3,7:5,8:6}.

Automated Stroke Times: large press=7.5 $\frac{s}{stroke}$, small press=5.5$\frac{s}{stroke}$

Automated setup Times: large press= 32+5=37min*(60$\frac{s}{1min}$)=2220$\frac{s}{setup}$,

small=25+5=30min=1800$\frac{s}{setup}$.

-Setup is per forming setup and amortized over the batch (setup_seconds x number of steps)/625

Per press per unit-times (Automated Handling)

Large Press 1 (Parts 1,2,3)
stroke work per unit= (2+5+4)x7.5s=**82.5s** (only considering time taken for strokes)
setups=(2+5+4)=11 steps — 11x[(5min+32min)*60s]/625 =**39.072s**
Total Time per unit [1-3]=82.5s+39.072s=**121.57s < Takt Time**

Large Press 2 (Parts 4,5,6)
stroke work per unit= (4+3+3)x7.5s=**75s** (only considering time taken for strokes)
setups=(4+3+3)=10 steps — 10x[(5min+32min)*60s]/625 =**35.52s**
Total Time per unit [4-6]=75s+35.52s=**110.52s < Takt Time**

Small Press 1 (Parts 7,8)
stroke work per unit= (5+6)x5.5s=**60.5s** (only considering time taken for strokes)
setups=(5+6)=11 steps — 11x[(5min+25min)*60s]/625 =**31.68s**
Total Time per unit [7-8]=60.5s+31.68s=**92.18s < Takt Time**

2.3 Robot spot welding
Number of spot weld $N_s = 250$, after 10 points, the robot needs $t_r = 3s$ repositioning time.

Consider also the time for the table to go in and out of the cell which is $t_t = 20s$

Set up options:

1 robot cell:
Welding time per spot $t_{ws} = 2s$

Total time welding $t_w = Ns * t_{ws} = 250 * 2s = 500s$

Total repositioning time $t_{rt} = \frac{N_s}{10} * t_r = \frac{250}{10} * 3s = 75s$

Total time per piece $t_{tot} = t_w + t_{rt} + t_t = 500s + 75s + 20s = 595\frac{s}{u}$

2 robot cell:

Robot 1 welds 60% of the spots, while robot 2 only 40%. The two robots work simultaneously, but robot one will work more, therefore the total time per piece it's considered equal to the time of robot 1.

Number of spot weld for robot 1 $N_s = 150$, after 10 points, the robot needs $t_r = 3s$ repositioning time.

 Welding time per spot $t_{ws} = 2.5s$

Total time welding $t_w = Ns * t_{ws} = 150 * 2.5s = 375s$

Total repositioning time $t_{rt} = \frac{N_s}{10} * t_r = \frac{150}{10} * 3s = 45s$

Total time per piece $t_{tot} = t_w + t_{rt} + t_t = 375s + 45s + 20s = 440\frac{s}{u}$ ->T (takt time)

To reach the required takt time more than one 2 robot-cell is needed.

<u>number of lines:</u>

$$n_{lines} = \frac{t_{tot}}{T} = \frac{440s}{168.75s} = 2.6$$

3 lines are needed

<u>Batch size: 1</u>

2.3 Robot MAG welding

<u>Total length:</u> $l = 750mm$
Welding speed $v_\omega = 480 \, mm/min = 8 \, mm/s$

16 MAG weld seams
<u>Robot positioning time after each seam : $t_{positioning} = 4 \, s$</u>

Consider also the time for the table to go in and out of the cell which is $t_t = 20s$

1-robot cell: $t_w = \frac{l}{v_\omega} = 93.75\ s$

Repositioning: $t_r = 16 \cdot 4\ s = 64\ s$

Total time per piece: $t_{tot} = t_w + t_r = 93.75s + 64s = 157.75\ s$ <T (takt time)

Batch size: 1

number of lines: $n_{lines} = 1$

2.4 Injection molding

Data:
L (large size)

M (mid size)

S (small size)

Number of parts:
$N_{L, parts} = 5$

$N_{M, parts} = 10$

$N_{S, parts} = 10$

Process time:
$t_{L, run} = 32\ s$

$t_{L, set\ up} = 30\ min$

$t_{M, run} = 23\ s$

$t_{M, set\ up} = 25\ min$

Number of cavities:
$N_{L, cavities} = 1$

$N_{M, cavities} = 4$

$N_{S, cavities} = 8$

For the small pieces it can be assumed that they are produced with the same machine as mid size pieces in a die with 8 cavities.

Total number of pieces:
$N_{L, pieces\ tot} = U_{tot, year} \cdot N_{L, parts} = 600\ 000$

$N_{M, pieces\ tot} = U_{tot, year} \cdot N_{M, parts} = 1\ 200\ 000$

$$N_{S, pieces\ tot} = U_{tot, year} \cdot N_{S, parts} = 1\ 200\ 000$$

<u>Batch size for large parts:</u> $B_L = 1100$

<u>Total time to produce the pieces and to set up the different molds:</u> it includes the time to produce every piece and the time to change mold after the production of 1100 pieces

$$t_{L, run+set\ up} = N_{L, pieces\ tot} \cdot t_{L, run} + \frac{N_{L, pieces\ tot}}{B_L \cdot N_{L, cavities}} \cdot t_{L, set\ up} = 20\ 181\ 818.18\ s = 5\ 606.06\ h$$

<u>Number of machines:</u>

$$N_{L, machines} = \frac{t_{L, run+set\ up}}{t_w} = 0.99$$

1 machine needed to produce big pieces

<u>Batch size for mid and small parts:</u> $B_{M/S} = 70$

<u>Total time to produce the pieces and to set up the different molds:</u>

$$t_{M, run+set\ up} = \frac{N_{M, pieces\ tot}}{N_{M, cavities}} \cdot t_{M, run} + \frac{N_{M, pieces\ tot} / N_{M, cavities}}{B_M} \cdot t_{M, set\ up} = 13\ 328\ 571.43\ s = 3\ 702.38\ h$$

$$t_{S, run+set\ up} = \frac{N_{S, pieces\ tot}}{N_{S, cavities}} \cdot t_{S, run} + \frac{N_{S, pieces\ tot} / N_{S, cavities}}{B_S} \cdot t_{S, set\ up} = 6\ 664\ 285.72\ s = 1\ 851.19\ h$$

<u>Number of machines:</u>

$$N_{L, machines} = \frac{t_{M, run+set\ up} + t_{S, run+set\ up}}{t_w} = 0.98$$

1 machine needed to produce mid and small pieces

2.5 Painting
Data:
C: chassis
IM: injection molding

<u>Number of stations:</u>
$$N_{C, stations} = 3$$
$$N_{IM, stations} = 2$$

<u>Process time:</u>
$$t_{run} = 20\ s$$
$$t_{set\ up} = 20\ min$$

Chassis parts:

Number of parts per product: $N_{C,parts} = 1$

Batch size: 1

Total time:
$$t_{C,tot} = t_{set\,up} + t_{run} \cdot N_{C,stations} = 20min + 20s * 3 = 21\,min > \text{T (takt time)}$$

number of lines:

$$n_{lines} = \frac{t_{tot}}{T} = \frac{(21*60)s}{168.75s} = 7.46$$

8 lines needed

Injection molded parts:

Number of parts per product: $N_{IM,parts} = 5$

Batch size: $n_{lot} = 40$

Time per part:
$$t_{IM,part} = t_{set\,up} \cdot N_{IM,parts} + t_{run} \cdot N_{IM,stations} \cdot n_{lot} = (20 * 60)s + 20s * 2 * 40 = 2800s$$
Total time:

$$t_{total} = t_{IM,part} * N_{IM,parts} = 2800s * 5 = 14000s$$

Time per product:

$$t_u = \frac{t_{total}}{n_{lot}} = \frac{14000s}{40} = 350\,\frac{s}{u} > \text{T (takt time)}$$

Number of lines:

$$n_{lines} = \frac{t_u}{T} = \frac{350\frac{s}{u}}{168.75s} = 2.074$$

3 lines needed

2.6 Assembly line
Number of components: $N_{tot} = 150$

Component A:

Installation time: $t_A = 32\ s$

Number of components $n_A = 30$

Component B:

Installation time $t_B = 19\ s$

Number of components $n_B = 50$

Component C:

Installation time $t_C = 16\ s$

Number of components $n_C = N_{tot} - n_A - n_B = 70$

Batch size: 1

$T_A = t_A \cdot n_A = 960\ s$

$T_B = t_B \cdot n_B = 950\ s$

$T_C = t_C \cdot n_C = 1120\ s$

$T_{tot} = T_A + T_B + T_C = 3030\ s$

Number of lines:

$n_{lines} = \frac{T_{tot}}{T} = 17.95$

18 assembly line needed

3. **Work force**

Injection molding

Operator per two injection molding machines: $n_w = 1$

Time of employment work force:

$T_{wf} = D_{year} * S * t_{shift} = 5625\ \frac{h}{year}$

Assembly:

2 operators: $n_w = 2$

$T_{wf} = n_w * D_{year} * S * t_{shift} * n_{lines} = 2 * 250 * 3 * 7.5h * 18 = 202500\ \frac{h}{year}$

Spot welding:

Operator per line $n_w = 1$

Time of employment work force:

$T_{wf} = n_w * n_{lines} * D_{year} * S * t_{shift} = 1 * 3 * 250 * 3 * 7.5h = 16\,875\ \frac{h}{year}$

MAG welding:

operator per line $n_w = 1$

Time of employment work force:

$$T_{wf} = n_w * n_{lines} * D_{year} * S * t_{shift} = 1 * 1 * 250 * 3 * 7.5h = 5625 \frac{h}{year}$$

Painting
5 operators: $n_w = 5$

$$T_{wf} = n_w * D_{year} * S * t_{shift} * n_{lines} = 5 * 250 * 3 * 7.5h * 11 = 772750 \frac{h}{year}$$

Metal Forming
2 operators needed to supervise the automotive process for the machines: $n_w = 2$

$$T_{wf} = n_w * D_{year} * S * t_{shift} = 11\,250 \frac{h}{year}$$

Metal Stamping
3 operators needed, 2 operators to handle the coil replacement/movement/welding of one coil of the same type to an existing coil. And the last operator takes care of the machine (starting/stopping). $n_w = 3$

$$T_{wf} = n_w * D_{year} * S * t_{shift} * n_{lines} = 3 * 250\,days * 7.5hr/shift * 1\,line = 16875 \frac{h}{year}$$