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Lab 8: Line Balancing

IE 2400

3/31/2017

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Introduction

This lab's purpose was for students to practice calculating line balancing and machine-worker assignment problems. In this lab, students worked collaboratively to solve the three problems assigned to be turned in for completion. This was done was to give students an understanding of how to calculate and deliver numeric values in order to solve real life line balancing and worker assignment predicaments.

Procedure

Within their lab group, students reviewed the data collected from lab 3 and 4 to solve problem #1, and collaboratively worked to calculate numbers for problems #2 and #3. The team then showed their finished calculations for the first problem to receive attendance credit for this week's lab.

Results

Below are the result of the problems that the students were instructed to solve.

Problem # 1

Using the time study results from lab 3 & 4 (table 1), determine the number of workstations, number of workers, and assignment of elements to workstations and workers based on a required production rate of 50,000 units per year. Use the following assumptions:

- Do not include the sorting/inventory element (element 1 on your previous reports) or the inspection element. Assume that everything is sorted beforehand.

- The assembly facility is open 50 weeks per year, 5 days per week, 8 hours per day.

- It takes 2 seconds on average to transfer pieces between workstations

Elements	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average	Standard Deviation
1	56	68	64	65	66	63.8	4.60
2	77	47	48	51	37	52	14.93
3	9	6	12	6	6	7.8	2.68
4	84	82	81	76	89	82.4	4.72
5	17	56	16	14	15	23.6	18.15
6	74	44	57	55	52	56.4	11.01
7	53	33	31	35	36	37.6	8.82
8	8	9	6	5	4	6.4	2.07
9	6	5	3	3	3	4	1.41
Total:	**384 seconds**	**350 seconds**	**318 seconds**	**310 seconds**	**308 Seconds**	**334 seconds**	**68.41**

Table 1: Lab 3 Time Study Data

1. Calculate the Work Content Time

$$T_{wc} = \sum_i T_i$$

$$T_{wc} = 52 + 7.8 + 82.4 + 23.6 + 56.4 + 37.6 + 6.4 = 334\ seconds = 4.43\ minutes$$

2. Calculate Required Production rate in Units Per Hour

$$50\ Weeks\ \times 5\ Days\ a\ Week\ \times 8\ Hours\ a\ Day = 2{,}000\ Hours\ a\ Year$$

$$\frac{50{,}000\ Units\ a\ Year}{2{,}000\ Hours\ a\ Year} = 25\ Units\ per\ Hour$$

3. Required cycle time to meet production levels

$$T_c = \frac{E * 60\ Minutes}{R_p}$$

$$T_c = \frac{0.98 * 60\ Minutes}{25\ Units\ per\ Hour} = 2.352\ minutes\ per\ unit = 141.12\ Seconds\ per\ Unit$$

4. Theoretical minimum number of workers

$$\frac{T_{wc}}{T_c} = Theoretical\ Minimum\ Number\ of\ Workers$$

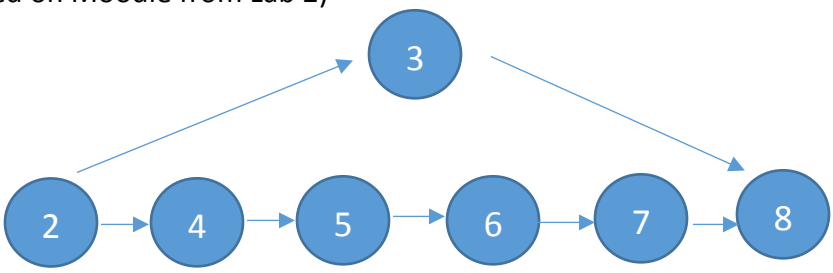
$$\frac{4.43}{2.352} = 1.8835 \cong 2\ Workers$$

5. Service time

$$T_s = T_c - T_r$$

$$T_s = 141.12\ Seconds\ per\ Unit - 2\ Seconds\ transfer\ time = 139.12\ Seconds\ per\ unit$$

6. Precedence diagram (PERT chart) for the elements (use the Operation Process chart posted on Moodle from Lab 2)



7. Assigned elements to workstations/workers

Workstation 1	Workstation 2
2 - 52 seconds	3 - 7.8 seconds
4 - 82. 4 seconds	5 - 23.6 seconds
	6 - 56.4 seconds
	7 - 37.6 seconds
	8 - 6.9 seconds
∑ 134.4 Seconds	∑ 131.8 Seconds

Table 2: Assigned Elements to Workstation Table

8. Actual production rate for the year

$$Actual\ Production\ = \frac{2.7units}{hour} \times \frac{8\ hours}{day} \times \frac{5\ days}{week} \times \frac{50\ weeks}{year} = 5{,}400\ units\ per\ year$$

9. Actual efficiency of the line

$$Line\ Efficiency = \frac{T_{wc}}{workers\ \times\ T_s}$$

$$Line\ Efficiency = \frac{4.43}{2\ workers\ \times 2.3187} = 95.7\ \%\ Efficiency$$

Problem #2

The production requirements for your plant are 2000 units/day. The plant runs 8 hours/day currently, and you are looking at the number of workstations, staffing levels, and line balancing. You have the following standard times for the seven major steps required to produce one unit:

Operation #	Operation Description	Standard time (min)
1	Assembly 1	0.401
2	Assembly 2	0.633
3	Cement	0.198
4	Rivet	0.325
5	Form carton	0.122
6	Label	0.103
7	Packout	0.360

1. Required production rate per minute

$$R_p = \frac{2{,}000\ units}{day} \times \frac{day}{8\ hours} \times \frac{1\ hour}{60\ minutes} = 4.17\ units\ per\ minutes$$

2. Balance the line. Define the number of workstations, the operations at each workstation, and the number of workers at each workstation. You may assume that all transfers between operations are taken care of in the standard time.

$$T_{wc} = 0.401 + 0.633 + 0.198 + 0.325 + 0.122 + 0.103 + 0.36 = 2.142\ minutes\ per\ unit$$

$$T_c = \frac{1.00\ efficiency}{4.17\ Units\ per\ Hour} = 0.2398\ minutes\ per\ unit$$

$$Minimum\ \#\ of\ \ Workers = \frac{2.142\ minutes\ per\ units}{0.2398\ minutes\ per\ unit} = 8.93 \cong 9\ Workers\ or\ Stations$$

$$T_s = 0.2398\ Minutes\ per\ Unit - \ T_r = 0.2398\ minutes\ per\ unit$$

Operation	ST (Min/Unit)	Workers	Actual Time (min/unit)
1	0.401	2	0.201
2	0.633	3	0.211
3	0.198	1	0.198
4	0.325	2	0.1625
5	0.122	1	0.122
6	0.103	1	0.103
7	0.36	2	0.18

3. Show that your line will meet production goals. (What is the daily production rate of your line?) Show all calculations.

$$\frac{1\ unit}{0.633\ minutes} \times \frac{480\ minutes}{people \times day} \times 3\ people = 2275\ units\ per\ day$$

4. What is the final efficiency of your line?

$$Line\ Efficiency = \frac{T_{wc}}{workers\ \times\ T_s}$$

$$Line\ Efficiency = \frac{2.142\ minutes\ per\ unit}{4\ workers\ \times 0.2398} = 81.2\ \%\ Efficiency$$

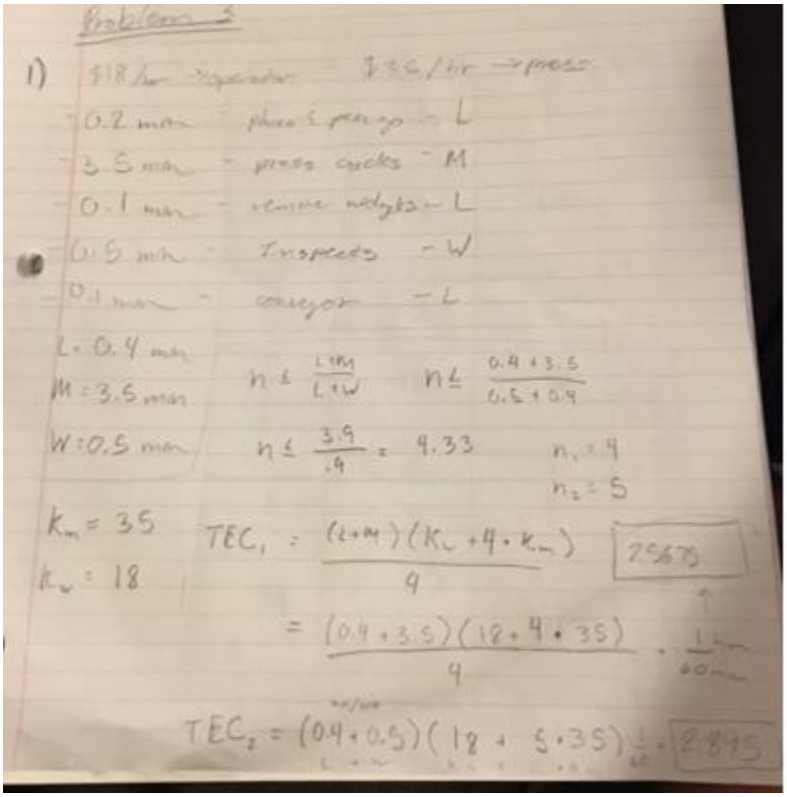
Problem #3

The following activities with times (minutes) are available for a press operator:

- Place raw blank into press and press "GO" 0.2 min
- Press cycles automatically 3.5 min
- Remove widget from press 0.1 min
- Inspect widget 0.5 min
- Place widget on conveyor to next station 0.1 min

The operator is paid $18/hour and the press costs $35/hour to run

1. Determine the optimal number of machines per operator to minimize unit cost.



2. Create a worker-machine chart.

3. What is the % idle time?

4. What is the unit cost?

$$Unit\ Cost = TEC_1 = \frac{(0.4+3.5)(\frac{\$18}{hour} + 0.4 \times \frac{\$35}{hour})}{4} \times \frac{1\ hour}{60\ min} = \frac{(3.9) \times (15)}{4} = \$14.625$$

5. How many units can be produced per hour with this system?

$$\frac{6.5\ unit}{4\ minute} = 1.625 \rightarrow \frac{1}{1.625} = 0.615\ unit\ per\ minute\ \times 60\ minutes\ per\ hour = 36.9 \frac{units}{hour}$$

Conclusion

This lab allowed students to become more comfortable with calculating line balancing and machine-worker assignment problems. Ultimately, the students became more familiar with line balancing and machine-worker assignment equations and became more adept at applying these calculations in real world situations.