IE 469 Manufacturing Systems

Chapter 3 Tutorial

3.1 **(A)** A batch of parts is produced on a semi-automated production machine. Batch size is 200 units. Setup requires 55 min. A worker loads and unloads the machine each cycle, which takes 0.44 min. Machine processing time is 2.86 min/cycle, and tool handling time is negligible. One part is produced each cycle. Determine (a) average cycle time, (b) time to complete the batch, and (c) average production rate.

(a) $T_c = T_h + T_o + T_{th}$
$= 0.44 + 2.86 + 0 = 3.3$ min

(b) $T_b = T_{su} + Q T_c$
$= 55 + 200(3.3) = \underline{715}$ min $= 11.92$ hrs

(c) avg. production time $= T_p = \frac{715}{200} = 3.575$ min/pc

Prod. rate $= R_p = \frac{1}{T_p} \times 60 = \frac{60}{3.575} = 16.78$ pc/hr

3.2 In a batch machining operation, setup time (T_{su}) is 1.5 hours and batch size (Q) is 80 units. The cycle time consists of part handling time (T_h) of 30 sec and processing time (T_o) of 1.37 min. One part is produced each cycle. Tool changes (T_{th}) must be performed every 10 parts and this takes 2.0 min. Determine (a) average cycle time, (b) time to complete the batch, and (c) average production rate.

(a) $T_c = T_h + T_o + T_{th} \rightarrow T_{th} = \frac{2}{10} = 0.2$ min

$= 0.5 + 1.37 + 0.2 = 2.07$ min

(b) $T_b = T_{su} + Q\,T_c = 1.5(60) + 80(2.07)$

$= 255.6$ min $= 4.26$ hr

(c) avg. prod. time $= T_p = \frac{255.6}{80} = 3.195$ min/pc

avg. prod. rate $= R_p = \frac{1}{T_p} \times 60 = \frac{60}{3.195} = 18.78$ pc/hr

3.4 A flow line mass production operation consists of eight manual workstations. Work units are moved synchronously and automatically between stations, with a transfer time (T_r) of 15 sec. The manual processing operations performed at the eight stations take (40 sec, 52 sec, 43 sec, 48 sec, 30 sec, 57 sec, 53 sec, and 49 sec, respectively). Determine (a) cycle time for the line, (b) time to process one work unit through the eight workstations, (c) average production rate, and (d) time to produce 10,000 units.

(a) $T_c = T_r + \text{Max } T_o$; Max $T_o = 57$ sec at workstation 6

$T_c = 15 + 57 = 72$ sec $= 1.2$ min

(b) Time to process 1 unit $= 8(1.2) = 9.6$ min

(c) avg. prod. time $= T_p = T_c = 1.2$ min

avg. prod. rate $= R_p = \frac{60}{T_p} = \frac{60}{1.2} = 50$ pc/hr

(d) time to produce 10,000 units $= \frac{1}{50} \times 10{,}000 = 200$ hr

3.6 **(A)** A mass-production plant has six machines and currently operates one 8-hour shift per day, 5 days per week, 50 weeks per year. The six machines produce the same part each at a rate of 12 parts per hour. (a) Determine the annual production capacity of this plant. (b) If the plant were to operate three 8-hour shifts per day, 7 days per week, 52 weeks per year, determine the annual percentage increase in plant capacity?

n = 6

R_p

(a) $PC = n \times \underbrace{S_w \times H_{sh}}_{\text{per year}} \times R_p = 6\,(8 \times 5 \times 50)(12)$

$= 6\,(2000)(12)$

$= 144{,}000$ pc/yr

(b) $H_{pc} = \underbrace{\underbrace{\underbrace{8 \times 3}_{\text{day}} \times 7}_{\text{week}} \times 52}_{\text{year}} = 8{,}736$ hrs

% ?

$PC = 6\,(8{,}736)(12) = 628{,}992$ pc/yr

% of increase $= \dfrac{628{,}992 - 144{,}000}{144{,}000} \times 100 = 336.8\%$

3.8 A job shop has four machines and operates 40 hours per week. During the most recent week, machine 1 processed part A for 25 hours at a production rate of 10 parts per hour, and part B for 12 hours at a rate of 7 parts per hour. Machine 2 processed part C for 37 hours at a rate of 14 parts per hour, and was idle 3 hours. Machine 3 processed part D for 15 hours at a rate of 20 parts per hour, and part E for 25 hours at a rate of 15 parts per hour. Machine 4 processed part F for 13 hours at a rate of 9 parts per hour, part G for 12 hours at a rate of 18 parts per hour, and was idle the rest of the week. Determine (a) weekly production output of the shop and (b) average utilization of equipment.

(a) weekly prod. output $= 10 \times 25 + 7 \times 12 + 14 \times 37 + 20 \times 15$

$+ 15 \times 25 + 9 \times 13 + 18 \times 12 = 1860$ pc/wk

(b) $U = \dfrac{[25 + 12 + 37 + 15 + 25 + 13 + 12]}{4 \times 40}$

hrs each machine was working

machines the job shop has

hrs per week

$= 86.9\%$

3.11 **(A)** A certain batch of parts is routed through six machines in a batch production plant. The setup and operation times for each machine are given in the table below. Batch size is 100 and the average nonoperation time per machine is 12 hours. Determine (a) manufacturing lead time and (b) hourly production rate for operation 3.

n_o Q T_{no}

Machine	1	2	3	4	5	6
Setup time (hours)	4	2	8	3	3	4
Operation time (min)	5.0	3.5	6.2	1.9	4.1	2.5

(a) $MLT = n_o(T_{su} + QT_c + T_{no})$

$T_{su} = (4+2+8+3+3+4)/6 = \frac{24}{6} = 4$ hrs

$T_c = (5+3.5+6.2+1.9+4.1+2.5)/6 = \frac{23.2}{6} = 3.867$ min

$MLT = 6\left(4 + 100\left(\frac{3.867}{60}\right) + 12\right) = 134.67$ hr

(b) $T_p = \frac{(T_{su} + QT_c)}{Q} = \frac{8 + 100\left(\frac{6.2}{60}\right)}{100} = 0.1833$ hr/pc

$R_p = \frac{1}{T_p} = \frac{1}{0.1833} = 5.455$ pc/hr

3.16 The average part produced in a certain batch manufacturing plant must be processed sequentially through an average of eight operations. Twenty (20) new batches of parts are launched each week. Average operation time is 6 min, average setup time is 5 hours, average batch size is 25 parts, and average nonoperation time per batch is 10 hours per machine. There are 18 machines in the plant. Any machine can be set up for any type of batch processed in the plant. The plant operates 75 production hours per week. Determine (a) manufacturing lead time for an average part, (b) plant capacity if all machines could be operated at 100% utilization, (c) plant utilization, and (d) work-in-process (number of parts-in-process). (e) How would you expect the nonoperation time to be affected by plant utilization?

(a) $MLT = n_o(T_{su} + QT_c + T_{no}) = 8\left(5 + 25\left(\frac{6}{60}\right) + 10\right) = 140$ hr

(b) $PC = n H R_p / n_o$

$R_p = \frac{1}{T_p}$

$T_p = \frac{T_{su} + QT_c}{Q} = \frac{5 + 25\left(\frac{6}{60}\right)}{25} = 0.3$ hr/pc

$R_p = \frac{1}{T_p} = \frac{1}{0.3} = 3.33$ pc/hr

$PC = \frac{18(75)(3.33)}{8} = 562$ pc/wk

(c) $U = \frac{\text{required units}}{PC} = \frac{20 \times 25}{562} = \frac{500}{562} = 0.89 = \underline{89\%}$

(d) $WIP = \frac{U \times PC \times MLT}{H} = \frac{0.89 \times 562 \times 140}{75}$

$= 933\ pc$

(e) as $U \uparrow$ non-operation time $\uparrow$

3.18 A certain job shop specializes in one-of-a-kind orders dealing with parts of medium-to-high complexity. A typical part is processed sequentially through ten machines in batch sizes of one. The shop contains a total of eight conventional machine tools and operates 40 hours per week of production time. Average time values on each part per machine are: machining time = 0.5 hour, work handling time = 0.3 hour, tool change time = 0.2 hour, setup time = 3 hours, and nonoperation time = 12 hours. A new programmable machine is being considered that can perform all ten operations in a single setup. The programming of the machine for this part will require 20 hours; however, the programming can be done off-line, without tying up the machine. Setup time will be just 2 hours because simpler fixtures will be used. Total machining time will be reduced to 80% of its previous value due to advanced tool control algorithms; work handling time will be the same as for one machine; and total tool change time will be reduced by 50% because tools will be changed automatically under program control. For the one machine, nonoperation time is expected to be 12 hours, same as for each conventional machine. (a) Determine the manufacturing lead time for the conventional machines and for the new programmable machine. (b) Compute the plant capacity for the following alternatives: (i) a job shop containing the eight traditional machines, and (ii) a job shop containing two of the new programmable machines. Assume the typical jobs are represented by the data given above. (c) Determine the average level of work-in-process for the two alternatives in part (b), if the alternative shops operate at full capacity.

! part has to go through 10 machines $\therefore n_o = 10$

(a) current method : $MLT = 10(3 + \overbrace{(0.3 + 0.5 + 0.2)}^{T_c} + 12) = \underline{160}$ hrs

new M/c : $MLT = 1\,(2 + (\underbrace{0.8 \times 0.5 \times 10}_{\text{80\% of current machining time}} + 0.5 \times 0.2 \times \underbrace{10}_{\text{10 machines in current method}} + \underbrace{0.3}_{\text{same work handling time}}) + 12)$

$= \underline{\underline{19.3}}$ hrs

$T_c = 0.5 + 0.3 + 0.2$

(b) - current method : prod. rate for 1 machine: $T_p = \frac{(3+1)}{1} = 4\ hr$

$R_p = \frac{1}{T_p} = \frac{1}{4} = 0.25\ pc/hr$

but the shop has 8 machines, so $PC = \frac{8 \times 40 \times 0.25}{10} = 8$ order or part/week

10 → # operations

- new method : for 1 machine : $T_p = \frac{(2+5.3)}{1} = 7.3\ hr$

∴ $R_p = \frac{1}{T_p} = \frac{1}{7.3} = 0.137\ pc/hr$

for 2 machines : $PC = \frac{(2)(40)(0.137)}{1} = 10.96$ orders or parts/wk

machines

(c) - current method : $WIP = \frac{U \times PC \times MLT}{H_w} = \frac{1 \times 8 \times 160}{40} = 32$ parts

operating at full capacity

new method : $WIP = \frac{U \times PC \times MLT}{H_w} = \frac{1 \times 10.96 \times 19.3}{40} = 5.29$ parts

Q

3.20 **(A)** The break-even point is to be determined for two production methods, one manual and the other automated. The manual method requires two workers at $16.50 per hour each. Together, their production rate is 30 units per hour. The automated method has an initial cost of $125,000, a 4-year service life, no salvage value, and annual maintenance costs = $3000. No labor (except for maintenance) is required for the machine, but the power to operate it is 50 kW (when running). Cost of electric power is $0.05 (0.13) per kWh. The production rate for the automated machine is 55 units per hour. (a) Determine the break-even point for the two methods, using a rate of return = 25%. (b) How many hours of operation per year would be required for each method to reach the breakeven point?

$TC = FC + VC(Q)$

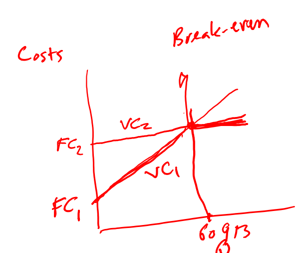
Break-even : $TC_1 = TC_2$

Manual : $VC = \frac{2(16.5)}{30} = \$1.1/pc$

$TC_1 = \cancel{FC}_0 + 1.1Q = 1.1Q$

Automated : $TC_2 = FC + VC(Q)$

$UAC = IC\,(A/p, i, n) + \text{maintenance}$



$(A/p, i, n) = \frac{i(1+i)^n}{(1+i)^n - 1}$

i : rate of return

n : # years

$$(A/P, 25\%, 4) = \frac{0.25(1+0.25)^4}{(1+0.25)^4 - 1} = 0.4234$$

$$UAC = 125,000(0.4234) + 3000 = \$\,55930/yr$$

$$\text{variable cost} = \frac{50\,kW \times 0.13}{55} = \$0.182/pc$$

$$TC_2 = 55\,930 + 0.182\,Q$$

break-even : $TC_1 = TC_2$

$$1.1\,Q = 55\,930 + 0.182\,Q$$

$$0.918\,Q = 55930 \implies Q = 60913\ pc/yr$$

(b) Hours of manual $= \frac{60\,913}{30} = 2030\ hr/yr$

" automated $= \frac{60\,913}{55} = 1108\ hr/yr$

3.22 Costs have been compiled for a certain manufacturing company for the most recent year. The summary is shown in the table below. The company operates two different manufacturing plants, plus a corporate headquarters. Determine (a) the factory overhead rate for each plant, and (b) the corporate overhead rate. The firm will use these rates in the following year.

Expense category	Plant 1	Plant 2	Corporate headquarters
Direct labor	$1,000,000	$1,750,000	
Materials	$3,500,000	$4,000,000	
Factory expense	$1,300,000	$2,300,000	
Corporate expense			$5,000,000

(a) $FOHR_1 = \frac{1,300,000}{1,000,000} = 1.3 = 130\%$ plant 1

$$FOHR_2 = \frac{2,300,000}{1,750,000} = 1.3143 = 131.43\%$$

(b) $COHR = \frac{5,000,000}{1,000,000 + 1,750,000} = 1.8182 = 181.82\%$