IE 469 Manufacturing Systems

Chapter 17 Tutorial

Parts Feeding

17.1 **(A)** The feeder-selector device at one of the workstations of an assembly machine has a feed rate of 56 components/min and provides a throughput of one part in five. The ideal cycle time of the assembly machine is 6 sec. The low-level sensor on the feed track is set at 10 components, and the high-level sensor is set at 25 components. (a) How long will it take for the supply of components to be depleted from the high-level sensor to the low-level sensor once the feeder-selector device is turned off? (b) How long will it take for the components to be resupplied from the low-level sensor to the high-level sensor, on average, after the feeder-selector device is turned on? (c) What are the time proportions that the feeder-selector device is turned on and turned off?

Solution: (a) Time to deplete from n_{f2} to n_{f1}
Rate of depletion = cycle rate $R_c = 60/T_c = 60/6 = 10$ parts/min
Time to deplete $T_{de} = (25 - 10)/10 = 15/10 =$ **1.5 min**

(b) Time to resupply from n_{f1} to n_{f2}
Rate of resupply = $f\theta - R_c = 56(1/5) - 10 = 11.2 - 10 = 1.2$ parts/min
Time to resupply = $T_{re} = (25 - 10)/1.2 = 15/1.2 =$ **12.5 min**

(c) Total cycle of depletion and resupply = 1.5 + 12.5 = 14.0 min
Proportion of time feeder-selector is on = 12.5/14 = **0.893**
Proportion of time feeder-selector is off = 1.5/14 = **0.107**

17.4 An assembly machine has eight stations and must produce at an average rate of 500 completed assemblies/hr. Average downtime per breakdown is 2.5 min. When a breakdown occurs, all subsystems (including the feeder) stop. The frequency of breakdowns of the assembly machine is once every 55 parts. Average downtime per breakdown is 2.0 min. One of the stations is an automatic assembly operation that uses a feeder-selector. Components fed into the selector have a 20% probability of passing through. Parts rejected by the selector are fed back into the hopper. What minimum rate must the feeder deliver components to the selector during system uptime in order to keep up with the assembly machine?

Solution: $T_p = 60/500 = 0.12$ min/asby
$T_p = T_c + FT_d = T_c + (1/55)(2.0) = T_c + 0.03636$
$T_c = 0.12 - 0.03636 = 0.08364$ min/asby
$R_c = 1/\mathrm{T_c} = 1/0.08364 = 11.95$ asby/min
Min $f\theta = 0.20 f = 11.95$ asby/min
Feeder rate $f = 11.95/0.20 =$ **59.8 parts/min**

Multi-Station Assembly Systems

17.5 **(A)** A ten-station assembly machine has an ideal cycle time of 6 sec. The fraction defect rate at each station is 0.005 and a defect always jams the affected station. When a breakdown occurs, it takes 1.2 min, on average, for the system to be put back into operation. Determine (a) the hourly production rate for the assembly machine, (b) yield of good product (final assemblies containing no defective components), and (c) proportion uptime of the system.

Solution: (a) If defects always jam the affected station, then $m = 1.0$.

$T_p = 6/60 + 10(1.0)(0.005)(1.2) = 0.16$ min/asby

Production rate $R_p = 60/0.16 =$ **375 asby/hr**

(b) Yield $P_{ap} = (1 - 0.005 + 1 \times 0.005)^8 =$ **1.0**

(c) Proportion uptime $E = 0.1/0.16 = 0.625 =$ **62.5%**

17.8 A six-station dial-indexing machine assembles components to a base part. The operations, element times, q and m values for components added are given in the table below (NA means q and m are not applicable to the operation). The indexing time is 2 sec. When a jam occurs, it requires 1.5 min to release the jam and put the machine back in operation. Determine (a) hourly production rate for the assembly machine, (b) yield of good product (final assemblies containing no defective components), and (c) proportion uptime of the system.

Station	Operation	Element time	q	m
1	Add part A	4 sec	0.015	0.6
2	Fasten part A	3 sec	NA	NA
3	Assemble part B	5 sec	0.01	0.8
4	Add part C	4 sec	0.02	1.0
5	Fasten part C	3 sec	NA	NA
6	Assemble part D	6 sec	0.01	0.5

Solution: (a) $\Sigma(mq) = 0.6(0.015) + 0.8(0.01) + 1(0.02) + .5(0.01) = .042$
$T_p = 0.1333 + 0.042(1.5) = 0.19633$ min/asby
$R_p = 60/0.19633 =$ **305.6 asby/hr**

(b) $P_{ap} = (1\text{-}0.015+0.6\times0.015)(1\text{-}0.01+0.8\times0.01)(1\text{-}0.02+1\times0.02)(1\text{-}0.01+0.5\times0.01)$
$= (0.994)(0.998)(1.0)(0.995) =$ **0.98705**

(c) $E = 0.1333/0.19633 = 0.679 =$ **67.9%**

17.10 **(A)** An eight-station automatic assembly machine has an ideal cycle time of 6 sec. Downtime is caused by defective parts jamming at the individual assembly stations. The average downtime per occurrence is 2.5 min. Fraction defect rate is 0.2% and the probability that a defective part will jam at a given station is 0.6 for all stations. The cost to operate the assembly machine is \$95.00/hr and the cost of components being assembled is \$0.73 per unit assembly. Ignore other costs. Determine (a) yield of good assemblies, (b) average hourly production rate of good assemblies, (c) proportion of assemblies with at least one defective component, and (d) unit cost of the assembled product.

Solution: (a) $P_{ap} = (1 - 0.002 + 0.6\times0.002)^8 = (0.9992)^8 = \mathbf{0.9936}$

(b) $T_p = 6/60 + 8(0.6)(0.002)(2.5) = 0.124$ min/asby
$R_p = 60/0.124 = 483.9$ asby/hr
$R_{ap} = (0.9936)(483.9) =$ **480.8 good asby/hr**

(c) $P_{qp} = 1 - 0.9936 = \mathbf{0.0064}$

(d) $C_{pc} = [0.73+(95/60)(0.124)]/0.9936 = 0.99263/0.9936 =$ **\$0.9323/asby**

Single-station Assembly Systems

17.15 **(A)** A single-station assembly machine is to be considered as an alternative to the dial-indexing machine in Problem 17.8. Use the data given in that problem to determine (a) hourly production rate, (b) yield of good product (final assemblies containing no defective components), and (c) proportion uptime of the system. Handling time to load the base part and unload the finished assembly is 7 sec and the downtime averages 1.5 min every time a component jams. Why is the proportion uptime so much higher than in the case of the dial-indexing machine in Problem 17.8?

Solution: (a) $T_c = 7 + (4 + 3 + 5 + 4 + 3 + 6) = 7 + 25 = 32$ sec = 0.5333 min
$\Sigma(mq) = 0.6(0.015) + 0.8(0.01) + 1(0.02) + 0.5(0.01) = 0.042$ (same as for Problem 17.4)
$T_p = 0.5333 + 0.042(1.5) = 0.59633$ min
$R_p = 60/0.59633 =$ **100.6 asby/hr**

(b) $P_{ap} = (1\text{-}0.015\text{+}0.6\text{x}0.015)(1\text{-}0.01\text{+}0.8\text{x}0.01)(1\text{-}0.02\text{+}1\text{x}0.02)(1\text{-}0.01\text{+}0.5\text{x}0.01) =$ **0.98705** (same as for Problem 17.4)

(c) $E = .5333/.59633 = 0.8943 =$ **89.43%**

Partial Automation

17.19 A manual assembly line has six stations. The service time at each manual station is 60 sec. Parts are transferred by hand from one station to the next, and the lack of discipline in this method adds 12 sec to the cycle time. Hence, the current cycle time is 72 sec. The following two proposals have been made: (1) Install a mechanized transfer system to pace the line; and (2) automate one or more of the manual stations using robots that would perform the same tasks as humans only faster. The second proposal requires the mechanized transfer system of the first proposal and would result in a partially- or fully-automated assembly line. The transfer system would have a transfer time of 6 sec, thus reducing the cycle time on the manual line to 66 sec. Regarding the second proposal, all six stations are candidates for automation. Each automated station would have an assembly time of 30 sec. Thus if all six stations were automated the cycle time for the line would be 36 sec. There are differences in the quality of parts added at the stations; these data are given in the table below for each station (q = fraction defect rate, m = probability that a defect will jam the station). Average downtime per station jam at the automated stations is 3.0 min. Assume that the manual stations do not experience line stops due to defective components. Cost data: C_{at} = \$0.10/min; C_w = \$0.20/min; and C_{as} = \$0.15/min. Determine if either or both of the proposals should be accepted. If the second proposal is accepted, how many stations should be automated and which ones? Use cost per piece as the criterion for your decision. Assume for all cases considered that when an automated station stops, the whole line stops, including the manual stations.

Station	q_i	m_i	Station	q_i	m_i
1	0.005	1.0	4	0.020	1.0
2	0.010	1.0	5	0.025	1.0
3	0.015	1.0	6	0.030	1.0

Solution: Proposal 1: Current operation: $T_c = 1.2$ min $C_o = 6(0.20) = \$1.20$/min
$C_{pc} = 1.20(1.2) =$ **\$1.44/asby**
Proposal: $T_c = 1.1$ min $C_o = 0.10 + 6(0.20) = 1.30$/min
$C_{pc} = 1.30(1.1) =$ **\$1.43/asby**

Conclusion: Accept Proposal 1.

Proposal 2: $T_c = 36$ sec $= 0.6$ min if all six stations are automated. If fewer stations than six were automated, then the cycle time would still be determined by the one minute manual assembly time.
$F = 0.005(1.0) + 0.01(1.0) + 0.015(1.0) + 0.02(1.0) + 0.025(1.0) + 0.03(1.0) = 0.105$
$T_p = 0.6 + 0.105(3.0) = 0.6 + 0.315 = 0.915$ min/unit
$C_o = 0.10 + 6(0.15) = 1.00$/min
$C_{pc} = 1.00(0.915) =$ **\$0.915/asby**

Conclusion: Accept Proposal 2.