(ASSEMBLY) LINE BALANCING

(Read pp. 56-64)

(Assembly) Line Balancing - an application of worker-machine relationships to determine the ideal number of workers (#workstations, #workers/station) to be assigned to a production line

1) Simple straight line

1-Operator	**2**-Standard time/op	**3**-Delay time (min)	**4**- Col #2/ Req ST	**5** #Oper	**6**- New ST/op	**7**-New Delay time
1	.52	.13	.52/.15=3.46	4	.52/4=.13	.0075
2	.48	.17	3.2	4	.1200	.0175
3	.65	.00	4.33	5	.1300	.0075
4	.41	.24	2.73	3	.1367	.0008
5	.55	.10	3.67	4	.1375	.0000

$$\%\text{Efficiency (E)} = \frac{\sum \text{S M (standard minutes)}}{\sum \text{AM (allowed minutes)}} * 100 = \frac{2.61}{5*.65} * 100 = 80.3\%$$

$$\%\text{Idle (old)} = \frac{\sum \text{Delay time}}{\sum \text{Allowed time}} *100 = \frac{.64}{5*.65} * 100 = 19.7\%$$

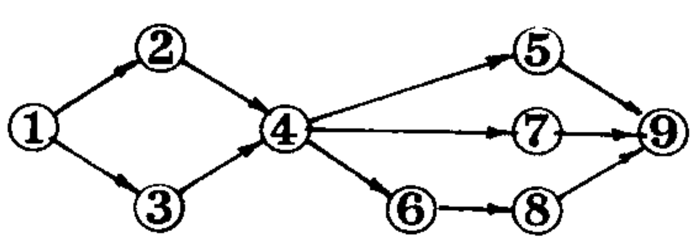
Required production is 3200 units/day, need to produce one unit in $\frac{480 \text{ min/day}}{3200 \text{ units/day}} = .15$ min/unit

$$\text{Number of operators} = \frac{R \times \sum SM}{E} = \frac{3200 \text{ units/day}}{480 \text{ min/day}} * \frac{2.61 \text{ op-min/unit}}{E} = 17.4 \text{ op (at least 18, maybe more)}$$

$$\%\text{Idle (new)} = \frac{\sum \text{Delay time}}{\sum \text{Allowed time}} \times 100 = \frac{0.0333}{20 \times 0.1375} \times 100 = 1.2\%$$

To further balance:
1) have #3 operator work overtime, accumulate a small inventory
2) part time help at station #3
3) have some of #1 operators help out at station #3

2) Complex assembly line -



Create **Positional Weight Matrix**

Oper	ST (hrs)	Delay (hrs)	1	2	3	4	5	6	7	8	9	PW	Immediate Predecessors
1	.05	.01	(1)	1	1	1	1	1	1	1	1	.37	-
2	.03	.03	0	(1)	0	1	1	1	1	1	1	.28	1
3	.04	.02	0	0	(1)	1	1	1	1	1	1	.29	1
4	.05	.01	0	0	0	(1)	1	1	1	1	1	.25	2,3
5	.01	.05	0	0	0	0	(1)	0	0	0	1	.07	4
6	.04	.02	0	0	0	0	0	(1)	0	1	1	.14	4
7	.05	.01	0	0	0	0	0	0	(1)	0	1	.11	4
8	.04	.02	0	0	0	0	0	0	0	(1)	1	.10	6
9	.06	.00	0	0	0	0	0	0	0	0	(1)	.06	5,7,8

Worst (unbalanced) case - time set by slowest station
$\sum$Delays = .01 + .03 + .02 + .01 + .05 + .02 + .01 + .02 + 0 = .17   %idle = .17/(9*.06) * 100 = 31.5%

Basic logic - Assign operators to a work station until cycle time of that station is about to be exceeded, in order of decreasing positional weight, as allowed by precedence (i.e. immediate predecessors have been assigned)

Positional weight (for an operator) = $\sum$ST for all operator with a '1' relationship
PW_1 = (.05) + .03 + .04 + .05 + .01 + .04 + .05 + .04 + .06 = .37

Estimate cycle time and number of workstations based on desired production rate (57 units/8 hrs):

$$\# \text{ stations} = R \times \frac{\sum SM}{E} = 57 / 8 \times 0.37 = 2.64$$

Operation	Immediate Predecessors	PW	ST	Station time	Station delay time
1	-	.37	.05		
3	1	.29	.04		
2	1	.28	.03	.12	.02
4	2,3	.25	.05		
6	4	.14	.04		
7	4	.11	.05	.14	0
8	6	.10	.04		
5	4	.07	.01		
9	5,7,8	.06	.06	.11	.03

%idle time = .05/(3*.14) * 100 = 12%