Basic Factory Dynamics (2)

<Experiment result & analysis>

Experiment 1. Record TH, WIP, and CT for the entire production system, and verify the Little's Law for the best case and case with changes.

- Changes for M/C 5 and M/C 6 are considered **simultaneously**

(Case 1: Type A → 6 min/job, Type B → 4 min/job)

(Case 2: Type A → 9 min/job, Type B → 3 min/job)

		TH	WIP	CT	Little's Law verified?
Case 1	Best case	0.250	18.5	74	O
	Fluctuated	0.383	46.401	104.274	X
Case 2	Best case	0.250	18.5	74	O
	Fluctuated	0.445	29.333	65.982	O

In both best cases of 1 and 2, the input rate of Type A and Type B is 8 min/job.

Experiment 2. For Case 1 of experiment 1, Record TH, WIP, and CT for each product, and verify the Little's Law for the best case and case with changes.

- Changes for M/C 5 and M/C 6 are considered **simultaneously**

		TH	WIP	CT	Little's Law verified?
Best case	A Type	0.125	11.25	90	O
	B Type	0.125	7.25	58	O
Fluctuated	A Type	0.133	31.901	191.256	X
	B Type	0.250	14.5	58	O

In the best case, the input rate of Type A and Type B is 8 min/job.

Experiment 3. For Case 1 of experiment 1, Record TH, WIP, and CT for each station, and verify the Little's Law for the best case and case with changes.

- Changes for M/C 5 and M/C 6 are considered **respectively**

		TH	WIP	CT	Little's Law verified?
Station 5	Best case	0.250	18.5	74	O
	Fluctuated	0.384	46.75	105.667	X
Station 6	Best case	0.250	18.5	74	O
	Fluctuated	0.384	46.576	105.214	X

In the fluctuated cases, the capacity of stations are calculated by the average of the best cases. When station 6 is fixed, station 5 has a capacity of 13.5 min/job. When station 5 is fixed, station 6 has a capacity of 5 min/job.

<Discussion & conclusion>

(1) Explain why sum of cycle time for each type cannot replace the cycle time for the entire production system.

The cycle time for each type represents the time it takes for a single unit of product type A or B to complete its designated sequence through the production system, which is specific to each item. The simulation in Experiment 2 shows that the individual cycle times for A and B during the best case scenario, Type A has a cycle time of 90 minutes/job, and Type B has 58 minutes/job. These cycle times are specific to their own production paths.

In contrast, the cycle time for the entire production system is a measure of the time it takes for any product to move from the start to the end of the production line, taking into account of all routes and interactions between them. In the simulation above, the cycle time for the entire system is 74 minutes/job for the best case in Experiment 1.

Summing up the cycle times for each type cannot realistically replace the cycle time for the entire production system. First, the stations in the production system are shared between product types A and B. Delays or efficiencies in one product type's route can affect the other product type's progression through the system. Second, if there are bottlenecks in the system, these will affect the throughput of the entire system, but may not be apparent at individual cycle times. Third, the production system has variability in processing times at each station. Considering the system as a whole, this variability can compound, leading to a different cycle time in the entire system level. Lastly, products may experience queuing time before processing can begin if another product is being processed, which would contribute to the overall cycle time of the system but may not be noticed when only considering the individual cycle times.

(2) Discuss the conditions under which the TH of the current production system to become TH of the Practical Worst Case (PWC).

The Practical Worst Case is when there is “maximum randomness”. Under the maximum randomness scenario, there are three conditions which needs to be satisfied: 1) The line must be balanced with same average process times, 2) All stations consist of single machines, 3) Process times should be random and follow an exponential distribution with memoryless property. These three conditions assure that all states are equally likely to happen.

Under these conditions, the Practical Worst Case throughput for a given WIP level, w, is given by,

$$TH_{PWC} = \frac{w}{W_0 + w - 1} r_b$$

$$(W_0: critical\ WIP\ level, r_b: bottleneck\ rate)$$

The throughput of the PWC are always between those of the best case and the worst case.

(3) Discuss the circumstances in which the actual production system performs worse than the TH of the PWC.

General circumstances of performing worse than the PWC could be when there is increased process variability. If the actual process times have higher variability than assumed in the PWC scenario, this can lead to unexpected bottlenecks. Also, unplanned machine downtime due to maintenance issues or failures can significantly reduce throughput. Furthermore, delays in the supply chain can lead to material shortages, slowing down production and decreasing throughput.

Applying the conditions of the PWC in the context of this experiment, there can be several reasons for why the actual system could perform worse than the PWC. Firstly, having multiple machines at stations does not align with the PWC condition of a single machine per station, which can affect actual throughput due to synchronization issues and capacity variance. Secondly, the production system having different capacities and number of machines for different types of jobs suggest that the line is not balanced as required by the PWC model, leading to potential bottlenecks and reduced throughput. Next, this experiment uses fixed inter-arrival times, while PWC assumes a random, memoryless exponential distribution of process times. This means that the actual system may not experience all states as equally likely which could affect throughput negatively. Lastly, variability and fluctuation in capacity can lead to a throughput that is lower than the PWC throughput because it introduces more complexity and potential for inefficiency.