The *Single Piece Flow*© Simulation

Why A Cell Layout Reduces WIP

One of the immediate benefits of producing one or more parts (or even a complete product assembly) in a cell is the prevention of batch production. That is due to the proximity between consecutive machines used to make a part (or product). Now, there is no need to be dogmatic and insist on one-piece flow in every cell. But at the same time, you should always be on the lookout to split an order batch into <u>at least two</u> (smaller) transfer batches! The reason why a Transfer Batch differs from a Process Batch is as follows:

- Process Batch (= Order Size i.e. this is the quantity ordered by the customer)
- Transfer Batch (= a fraction of the Process Batch ex. 1/2, 1/3, 1/4, etc.)
- Single Piece Flow (aka Make One Move One because the Transfer Batch Size = 1)

Purpose of this Simulation

The purpose of this simulation is to show how the compactness of the cell layout facilitates the use of different batching policies to process the same order inside a flowline-type FLean (Flexible and Lean) manufacturing cell. The table below lists the generic manufacturing sequence of steps for any part produced in the cell:

Step #	Description of Machining Operation
1	Turn on HAAS Lathe (or Mori Seiki)
2	Grind on Melchiorre
3	Mill on HAAS Mill
4	Slit on Cincinnati Mill
5	Hand Deburr + Install Spring
6	Drill Hole + Insert Pin
7	Rebore on LeBlonde + Light Tight

If Step #s 1 and 2 could both be done inside the cell, then the only steps that prevent batch-splitting between any two consecutively used machines inside a linear or U-shaped cell layout for the MPC would be Steps #2, #4 and #7.

Structure of this Simulation

The simulation is a highly simplified version of the real cell! For the sake of simplicity, it is structured as follows:

- A single part will be made.
- The manufacturing sequence of operations for producing this part contains five steps: 1, 2, 3, 4, 5.
- The cell layout will be linear i.e. M1→M2→M3→M4→M5. You can seat the individuals who will be the five different "machines" in the appropriate sequence of steps. Use two tables for a line layout and one table for a U layout.
- Each machine must X out their Machine # five times for each part in the batch that arrives at their machine. So M1 will X out the number "1", M2 will X out the number 2, and so on.

- Good vs. Bad Quality: At each machine, the machine operator should take pains to ensure good workmanship. Please see the handout that shows examples of what is acceptable vs. what is unacceptable when Xing out each number square.
- The simulation must be run three times as follows:
  - **RUN #1:** This is the case of Transfer Batch = Process Batch = 6. *All 6 pages are stapled together to represent the Process Batch. Each page represents an individual part. Place the Process Batch in front of Machine #1. The entire batch of 6 parts must be processed at each machine before the batch can be transferred to the next machine.*
  - **RUN #2:** This is the case of Transfer Batch = 3. *The 6 pages are split up into two sets of 3 pages apiece. Each page represents an individual part. Each set of 3 pages is stapled together to create a Transfer Batch. Place the two Transfer Batches on top of each other in front of Machine #1. Each Transfer Batch of 3 pages can (and must) be processed at each machine before that batch can be transferred to the next machine.*
  - **RUN #3:** This is the case of Transfer Batch = 1 (Single Piece Flow). *Place the 6 pages together in a loose pile in front of Machine #1. No staples! No paper clip! Each page represents an individual part. As soon as a single page is processed at each machine, it can be transferred to the next machine.*

Tracking Cell Performance

For every run, the following data must be collected on the *Cell Performance Tracker* sheet that has been developed for this game:

Run #	TRANSFER BATCH SIZE	START TIME (hh:mm:ss)	END TIME (hh:mm:ss)	FLOW TIME (sec)
1	6 (= Order Batch)			
2	3 (= ½ Order Batch)			
3	1 (= 1/6 Order Batch) Single-Piece Flow			

Discussion Items

- Did the Flow Time for the order reduce as the Transfer Batch Size was reduced? Why?
- How does the change of Transfer Batch Size impact other metrics such as :
  - WIP?
  - Cash Flow Velocity ($ shipped per second)?
  - Floorspace requirements?
  - Quality feedback between operators at the different machines?
  - Other KPI's (Key Performance Indicators) of interest to your management?
- If more than one part were being made in the cell, how could you still use the same ideas taught in Run #2 and Run #3 if these parts had (i) the same routing (M1→M2→M3→M4→M5), (ii) different values for Process Batch, (iii) different processing times on the five machines?
- If more than one part were being made in the cell, how could you still use the same ideas taught in Run #2 and Run #3 if these parts had (i) different routings (Examples:

M1→M2→M5, M1→M2→M3→M4, M2→M3→M4, etc.), (ii) different values for Process Batch, (iii) different processing times on the five machines?
- How does a FTT (First Time Through) Quality Cost get impacted with the reductions in Transfer Batch Size from 6 to 3 to 1?

Optional Discussion Items

If any of the members of the team playing this simulation can think of a manufacturing cell in their facility that is a good candidate for Single Piece Flow (ideally) or Transfer Batch Flow (realistically), it may be worthwhile to discuss the following questions pertaining to that cell:

- What are the constraints that currently prevent the use of Transfer Batches in that cell? Could these constraints be eliminated? How?
- What are the constraints that currently prevent the use of Single Piece Flow in that cell? Could these constraints be eliminated? How?