

2.008 Design and Manufacturing II

Lab IX – Manufacturing Systems (the Lego lab)

Introduction

This lab involves a substantial set of in-lab exercises that will explain the functional differences between two distinctively different manufacturing systems. We will call one “System I”, and the other “System II”. You will build a figure from Lego blocks under a variety of conditions. You will participate in these simulations and complete the lab write-up before lab session is over to enforce the lessons learned.

Manufacturing Systems Simulation

This simulation will set up a hypothetical manufactured item and investigate the differences between two different systems for making this item. In this lab, you will produce “Orthogonal Pete,” a modular children’s toy.



Figure 1: Orthogonal Pete

This simulation needs around eight people: four assemblers, one quality controller, and three data collectors. If there are more or fewer people, the lab instructors will recommend alternatives. You will do the System I simulation first, then switch to System II. After finishing those simulations, you will have a chance to discuss and design a new system to improve the system performance.

System I Organization

This system requires around 8 people:

- Blueblox assembly
- Yellowblox assembly
- Redblox assembly
- Final Assembly
- Quality Control
- Three Roving Data Collector (RDC)

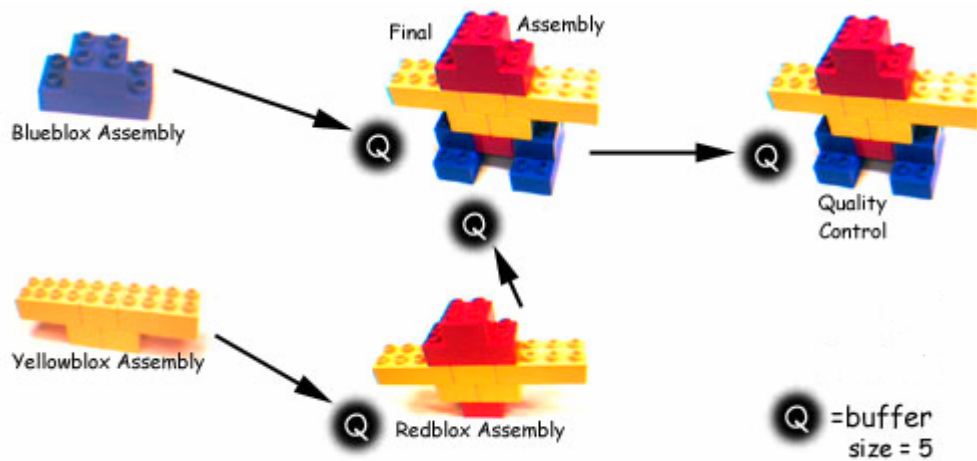


Figure 2: System I overview

Job Descriptions

Person #1 is responsible for **Blueblox assembly**. You will use one small blue block and one large blue block (Type A) or three small blocks (Type B) to produce Orthogonal Pete's leg. You should produce roughly 3 type "A" blocks for each type "B" block. Each Orthogonal Pete doll will have two legs. It does not matter which type of leg each Pete has. Block orientation for the leg assemblies is not critical.

You will run one machine, the Leg Creator.

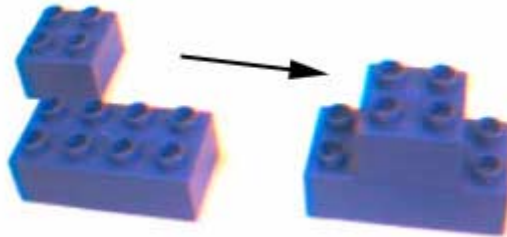


Figure 3: A type A leg

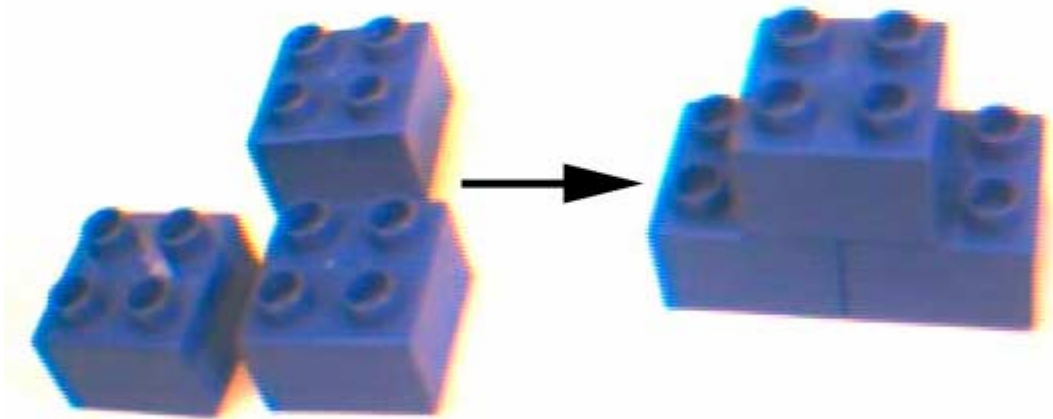


Figure 4: A type B leg

Person #2 is responsible for **Yellowblox assembly**. You will use two large yellow blocks and three small yellow blocks to construct Orthogonal Pete's torso and arms. Block orientation is not critical.

You will run two machines, the Arm Joiner and the Center Block Joiner.



Figure 5: Parts of the Yellowblox assembly



Figure 6: Complete Yellowblox assembly

Person #3 is responsible for **Redblox assembly**. You must place a large red block (neck block) onto the Yellowblox Assembly. Following that, you must align a small red block (head block) so that its DUPLO lettering is facing in the same direction as the lettering on the large red block. Attach this block to the center of the large red block. Finally, attach a small red block (bottom block) to the center bottom of the torso.

You will run three machines, the Neck Block Joiner, the Head Block Joiner, and the Bottom Block Joiner.

Note: The large block must be attached to the yellow block before the small block can be fixed on. You cannot prepare a bunch of head assemblies and just attach them to the body.

Note: Some large DUPLO blocks will have individual top-holes with different DUPLO lettering alignments. In order to decide which way to align your lettering, you can ignore the center holes. Align your part such that it's lettering faces the same way as the majority of outer holes.



Figure 7: Yellowblox with neck block



Figure 8: Yellowblox with neck and head block

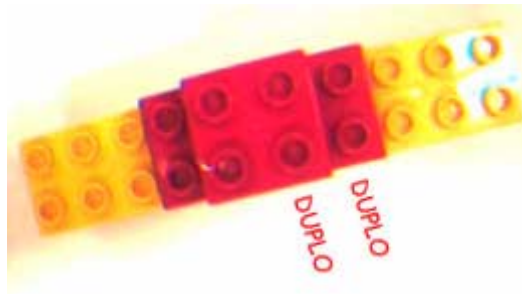


Figure 9: Correct alignment of the neck and head blocks



Figure 10: Complete Redblox assembly

Person #4 is responsible for **Final assembly**. They must join two Blueblox Assemblies to each Redblox Assembly as shown. It is permissible to use any combination of Type A and B leg assemblies. Lettering orientation is not critical at this step.

You will run one machine, the Leg Block Assembler.



Figure 11: Completed Orthogonal Pete

Person #5 is responsible for **Quality Control**. They must inspect all parts to insure that they are properly assembled and record the number of parts produced per minute. The Quality Control person should be especially conscious of the orientation of the red blocks to make sure that they are properly aligned.

If a bad part comes through the QC station, the QC manager should inform the failing station that it is producing bad parts. This can be accomplished verbally or in written form. “Hey, body assembler - your parts are bad” is a perfectly acceptable way to inform a station that it is producing bad parts. If you prefer nonverbal methods, you can tear out the “quality correction notice” in Appendix C and hand it to the failing station. The QC manager should be aware of each team member’s responsibilities so that he knows who to contact in the event of catching badly produced parts.

You will run one machine, the Inspection Station.

Person #6~#8 are **Roving Data Collectors**. In order to understand the functioning of the system from a more detached viewpoint, these people should move from station to station and collect data about the system performance.

- Data Collector #1 (Person #6) will collect the number of seconds required to complete an operation at that station. This action should be repeated at least three times for each station in order to collect a statistically meaningful average time.
- Data Collector #2 (Person #7) will collect the number of work-in-process (WIP), which includes numbers of parts in the queues and those under process. This action should also be done at least three times. This person should also note the stations where starvations and buffer buildups take place.
- Data Collector #3 (Person #8) will measure the overall cycle. He will be given a limited number of “Indicator Blocks.” These are small green blocks that are given to the Yellowblox Assembler, who will substitute it for the center yellow piece. (See Figure 12) This roving data collector will then follow that block through the assembly process. Using the stopwatch, the RDC should track the total cycle time from the block entering the Yellowblox Assembler’s hands to the time the completed part leaves the Quality Control station. The total cycle time should be recorded for at least three parts in each 5-minute period.



Figure 12: Yellowblox with an “indicator block”



Figure 13: Orthogonal Pete with an “indicator block”

System I Operation

In System I, information flows from downstream operations to upstream operations. You should feel free to alter your production rate to accommodate the needs of the downstream process.

One way to have information flow from downstream operations is to set a buffer limit. For this simulation, we will set a buffer size of five assemblies. (Count a pair of legs as one assembly.) If the buffer downstream of you overflows, you should stop working until the buffer depletes below five assemblies.

Remove parts from buffers in a **“first in-first out”** (FIFO) fashion. You should line up your buffers and always remove the part that has been in the buffer for the longest to work on. If you encounter a poorly or improperly assembled component, you should just keep working away at the part. Send it along as if nothing is wrong until it reaches the quality control person, who will mark it as a poorly produced part and tell the person who produced the bad part to correct their process. Do not try to reassemble the part by yourself so that it is correct.

System II Organization

This group will run on a traditional “push” system model. It requires the same primary assemblers as System I.

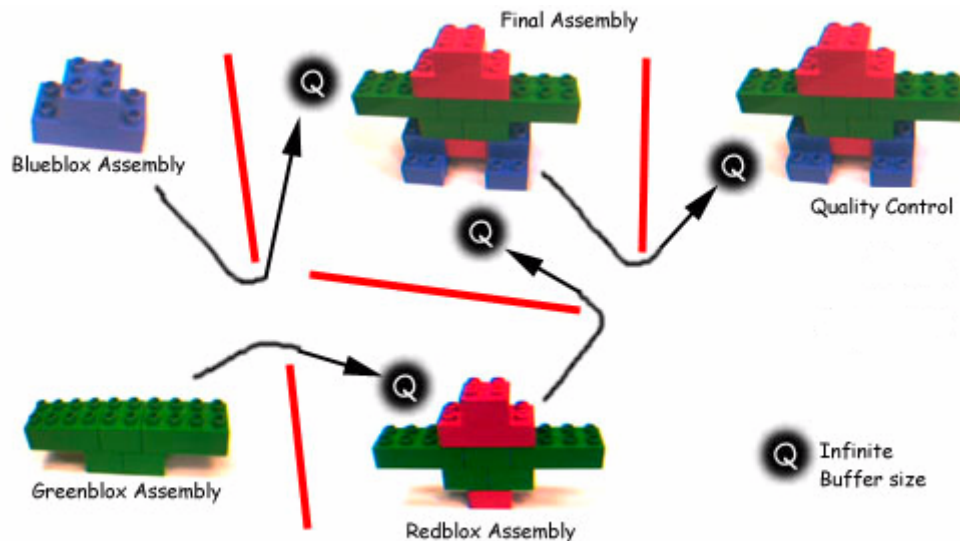


Figure 14: System II overview

Job Descriptions

Orthogonal Pete models produced on the push line will have a green center section, but the geometry is identical.



Figure 15: Greenblox assembly

In order to indicate a marked body section for cycle time computations, a roving data collector in this system will use a small yellow block, as shown in the following figure:

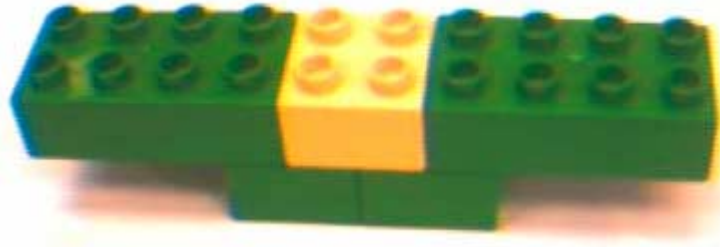


Figure 16: Greenblox assembly with an “indicator block”



Figure 17: Orthogonal Pete with an “indicator block”

System Operation

Note that “partitions” have been added to this system. Each station should work at its maximum production capacity and pay no attention to downstream processes.

System II has infinite buffer sizes. You should not be able to see each other's buffers and should not limit your production if buffers become large. Again, you will draw from the buffers in a FIFO fashion.

This system will react to quality problems in the same way as system I. If you encounter a poorly or improperly assembled component, you should just keep working away at the part. Send it along as if nothing is wrong until it reaches the quality control person, who will mark it as a poorly produced part and tell the person who produced the bad part to correct their process. Do not try to reassemble the part by yourself so that it is correct.

Activity Plan

Each simulation will run for five minutes, then you will take a short break to evaluate your system. We will then conduct two more five-minute runs with breaks in-between. After all three runs are complete; you will switch to the other kind of system and repeat the simulation. After you have done all of the simulations, you will have the opportunity to analyze your system's performance.

Now the group will have the opportunity to redesign the process. The product must be exactly as described earlier - all geometry and orientations must remain the same. You may set up the workflow, station responsibilities, buffer sizes, and assembly order any way you wish. Your only staffing restriction is that you must have a Roving Data Collector and you use all machines (including quality control). Your remaining five people can be assigned whichever machines you see fit. If you wish, you may “purchase” additional machines.

You will have 30 minutes to plan and test your new process. After this, your team will run the process for five minutes, keeping track of WIP, throughput, cycle time, and quality scrap. Keep in mind that your process should be robust with respect to quality and machine downtime.

Following this simulation of your own system, you will analyze your system's performance and discuss the results.

Deliverables

The lab write-up is a separate handout. Please complete the write-up in groups of no more than four people.