ENGR 1181  |  Lab 2: Quality and Productivity Lab

- Preparation Material
- Lab Procedure
- Report Guidelines
Preparation Material
1. Overview of Quality and Productivity Lab

The Quality and Productivity lab introduces various aspects of the manufacturing process. At the end of this laboratory experience, it is expected that the students understand the core, fundamental principles of Lean and Sigma manufacturing as well as understand the difference between a push and pull system.

Learning Objectives – students will be able to:

1. Gain an appreciation for the importance of engineering in manufacturing processes. Industrial Systems Engineering encompasses the design, analysis, and evaluation of the whole manufacturing process.
2. Enhance productivity, speed, quality, cost and sustainability in the manufacturing process via the core, fundamental principles of Lean production (eliminating waste) and Six Sigma (reducing variation in the product).
3. Understand the fundamental difference between PUSH and PULL systems on the assembly line.

2. Manufacturing Processes

Products are manufactured in a variety of different ways following many unique and different processes.

Fixed Manufacturing Process

Here the product does not move and remains in a fixed position throughout the manufacturing process, as portrayed in Figure 1. This type of manufacturing process is typical of large cumbersome items such as a home or office building.

![Figure 1: Fixed Manufacturing Process](image)
Lab Procedure

Custom Product Manufacturing Process

This process is typical of products where inputs from the customer (and outcomes from other processes) are used to modify the product during the manufacturing process. Products manufactured through this process are usually of low volume, such as custom software, as portrayed in Figure 2.

![Figure 2: Custom Product Manufacturing Process](image)

Batch Manufacturing Process

In this manufacturing process, the final product is made in a series of independent and disconnected stages. It has the advantage of being capable of producing several products in a single production line. A simple example of the Batch manufacturing process is listed below.

1. Collect your dirty washing as two loads.
2. Put the first load into the washing machine.
3. When washed, dry the first load in the drier and place the second load into the washer.
4. When the first load is dry, place the second load into the drier and begin ironing and folding the first load.
5. Iron and fold the second load when it has been dried.

Sequential Manufacturing Process

In this process the product is moved sequentially along an assembly line. There are two typical sub-types of this manufacturing process, the push system and the pull system:

Push System

In a push system, assumptions regarding demand are made to simplify the overall process. This “made for stock” approach is sometimes used to build inventory to manage over-demand cycles for products without having to add additional staff. This results in high inventory and work-in-process which can be useful to quickly satisfy the expected demand. Here, material and information flow sequentially in the same direction. Information about the design, requirements, etc. follows the material; therefore, each worker knows what to produce. Figure 4, below, shows how the push system is used to make hamburgers in a restaurant chain like McDonalds.
Pull System

In a pull system, no assumptions are made regarding demand. Products or services are created only when there is a specific demand from the customer. This usually results in a lower inventory and work-in-progress but the production time is typically increased. This may occur because of less expertise in production or down time in changeover for the system to create a different product. The pull system requires good communication and coordination to ensure that the workers along the sequential line are aware of the order. Here, material and information flow in opposite directions. Figure 4, below, shows the sequential pull system similar to the one utilized in a restaurant for producing a hamburger (or other specialized meal).

3. A Simple View of the Manufacturing Process

The manufacturing process as a whole consists of many interdependent functions. Good communication and coordination between functions is a crucial part of the process. This ensures that the optimization of one function does not come at the expense of the overall goals and objectives. Figure 5, below, overviews the manufacturing process with the associated functions.
4. **Quality and Productivity**

A company must be profitable to have a sustainable business. Profitability is dependent upon several factors, including quality and productivity.

**Quality** – The American Society for Quality defines quality in two ways: as 'the characteristics of a product or service that bear on its ability to satisfy stated or implied needs', and additionally as 'a product or service free of deficiencies'.

**Productivity** – Author Joseph Juran defines productivity in his book “Juran’s Quality Handbook” as ‘the measurement of how much output is produced for given resources (people & equipment) per amount of time’.

Profitable companies usually provide goods or services which are valued by customers. Therefore, it is important for companies to listen to their customers and identify what aspects they consider valuable. Typically, the customer wants and is willing to pay for:

- The correct product
- On-time delivery
- Zero defects

Engineers play an important role in ensuring quality and productivity in any manufacturing process. Engineers are usually involved in the following processes:

1. Design
2. Development
3. Build, manufacture, and assembly
4. Deliver, service, and support
5. Recycle/disposal
5. Lean and Six Sigma Manufacturing

Quality and productivity can be improved using the concepts of lean manufacturing and six sigma. Briefly, lean manufacturing increases productivity and reduces waste while six sigma reduces variation to improve quality.

**Lean Manufacturing**

Lean manufacturing increases productivity by eliminating waste. The principles of lean manufacturing include zero inventory, just-in-time supplier delivery, shifting to a pull system, zero waiting time, and several others. The different types of waste that lean manufacturing aims to eliminate are:

1. **Transportation** – Any unnecessary movement of materials or Work in Process (WIP). WIP is a deliverable that is partly assembled by an Operator.
2. **Intelect** - Any failure to fully utilize the time and talents of people
3. **Inventory** – Any more than the minimum to get the job done
4. **Waiting** – Waiting on parts, waiting for information
5. **Overproduction** – Producing too much or too soon
6. **Rework/Defects** – Any repair, defect or rework; does not conform
7. **Processing** – Over-processing, process variability, over handling due to defects
8. **Motion** – Any motion of the worker that does not add value
9. **Wrong Order** – Miscommunication delivers the wrong product to the customer

**Six Sigma Manufacturing**

A six sigma manufacturing process improves quality by reducing variation. A decrease in manufacturing process variation can lead to defect reduction, an increase in profits, increased employee morale, and the overall quality of the products or services. Some sources of increased variation are:

1. **No Visible Measurement/Management System** – Workers have no visibility for process performance
2. **Lack of Training** – Workers have not been trained to do the job
3. **Worker Training Worker** – Bad habits get passed on
4. **Voice of Customer** – Weak specification of customer requirements/demands
5. **Supplier Variation** – Too much, too little, poor quality, change in quality
6. **Unforeseen Events** – Equipment failure, accidents, absences, environmental conditions
7. **Lack of Standardization** – No standard operation procedures (SOPs), no method consistency, no work standards
8. **Paradigms/Habits** – People locked into a way of doing something because it's always been done that way
Lab Procedure
Introduction and Background
The Mr. Potato Head market has sky rocketed in Columbus. Because of this increase in demand, four new firms have risen up to make a profit (Teams Brutus, Scarlet, Gray, and Buckeye). It has been projected that the Mr. Potato Head market will continue to rise over the next 5 to 10 years. The process that all new firms go through is determining the most efficient and profitable way to produce Mr. Potato Head. As employees in a consulting company, it is your job to help make the assembly line as profitable as possible by choosing the right method of manufacturing and optimization.

Task 1. Understand Your Role and What Team You Are On
Before the lab begins, your GTA will have assigned you and your team members a specific role as well as a production team. It is important that you read through and understand the responsibilities of your specific role prior to coming to the lab. In our lab the class will be divided into four teams and each team will run an assembly line. Teams will have three production runs to attempt to make a profit.

Figure 6, below, shows the different stages of the assembly for the three different types of Mr. Potato Heads that each team will be manufacturing. The top row is Type A, and the following two, Type B and C, respectively.

Figure 6: Different stages of manufacture of the Mr. Potato Heads
Figure 7, below, displays what individual team member will be working based on their role. “CA” and “CB” represent customers A and B, “o1” through “o9” are where the operators will be located. “OM” represents the Operations Manager, “ISE” are where the Industrial Engineers will be working, and “Tran” is the location of the transporter.
Roles and Responsibilities

Read over the descriptions of each role, and **be absolutely sure you come to class with a solid understanding of your role and responsibilities.** Each team will have 1 operations manager (OM), 9 operators (o1-o9), 1 final tester (FT), 2 industrial systems engineers (ISE), 1 transporter (Trans), and 2 customers (CA/CB).

**Operations Manager (OM)**

1. The OM is accountable to the order fulfillment process performance. He/she is the owner of the entire manufacturing system and leads, coordinates, and supervises improvements to the individual processes and system.
2. The OM makes the final decision on which improvement recommendations are implemented in the second run of the assembly line.
3. The OM works with the customer, final tester, and industrial systems engineers to ensure that the orders are fulfilled and the manufacturing system is meeting quality requirements (i.e., that the product is being delivered free of defects).
4. The OM should incorporate aspects of **lean manufacturing** and **six sigma** to ensure a profit is made (e.g. combining operator roles, rearranging the assembly line, better training for different roles, etc.). These improvements may be implemented for either run.
5. The OM is to record all customer orders during manufacturing.
6. The OM is to ensure that all orders are sent by the transporter to the customer complete and on time. **Partial orders can NOT be delivered.**
7. The OM cannot do any other work or physically assist team members in their tasks.
8. The OM takes WIP Inventory. WIP is a deliverable which is partly assembled by an Operator.

**Operators**

1. Each operator will have a different task in the assembly line. The task will be outlined on a laminated sheet at the work desk.
2. Perform your assembly instruction as directed.
3. Follow any instructions presented to you by your team’s operations manager.
4. Notify an ISE on your team if a defective assembly reaches your station.
5. The final operator is required to hold onto the finished products until it is requested by the final tester.

**Final Tester**

1. The final tester is responsible for ensuring defect-free products are delivered to the customer. The final tester is finding defects before the products leave the ‘factory’ to be delivered. This type of defect is known as an **internal defect.** (If a customer finds a defect it is known as an **external defect,** which is more costly than an internal defect found by the final tester).
2. The final tester gives complete orders to the transporter for delivery to the customer. Only fully complete orders may be given to the transporter.
3. The final tester will randomly sample one product from each order to inspect it for defects, as described on the defect guide sheet (provided in lab). If a defect is found, the tester should place the defective product to the side, record the event on the final test data log, and request a replacement product. The order may not be delivered until a replacement product is received and the order is complete.

4. To request a replacement product, the final tester calls for a transporter to collect a completed product from the final operator. Once replaced, the total order may be handed off to the transporter to be taken to the customer.

5. The final tester is encouraged to work with the operations manager and ISEs to conduct problem solving and help train the operators.

6. The final tester must fill out the data sheet to record the total number of internal defects found for each production run.

7. The role of the final tester may change from production run 1 to production run 2, as improvements are implemented by the operations manager.

8. Final testers cannot create deliverables and cannot correct any defects themselves.

### Industrial Systems Engineers

1. The ISE Reports directly to the operations manager and assists in making observations to improve the quality and productivity of the manufacturing process.

2. Each ISE will take notes during the process on production line issues such as the weak points, operator performances, etc (this will require either paper & pencil or a tablet).

3. Each ISE will observe 1-2 tables where the operators are assembling the products. The following should be noted and recorded:
   - Which operators are having any difficulty assembling the product?
   - Which operators have idle time waiting for product to reach their station?
   - Were road blocks or bottlenecks happening in the process? (You will know this is happening when excess product piles up at one station, awaiting further steps).

4. After the run is completed, the ISE will summarize his or her observations and make suggestions to improve quality and productivity to the operations.

5. ISEs may not perform any other tasks (assist operator, transporter, final tester, etc.)

### Transporters

1. Transporters physically move complete orders from the last operator to final tester.

2. If there are 2 transporters, one of them can move partially assembled product from one table in the assembly line to the next.

3. Transporters will be provided with plastic bins in which to move product around. Product may ONLY be moved when it is in the plastic bin.

4. When the final tester requests a replacement product, the transporters move products from the last operator to the final tester.

5. Transporters cannot do any other work.
ENGR 1181 Lab2: Quality and Productivity Lab

Lab Procedure

Customers

Customers A and B decide on the number deliverables of each type before the beginning of each run. Each production run will have 4 orders, and each order will consist of 3 products. Orders will be announced at 1 minute, 2 minutes, 3 minutes, and 4 minutes. Orders are due within 75 seconds of being announced. Each production run will end at 5 minutes and 15 seconds, at which point no more orders may be considered “on time”.

Customer A

1. At the beginning of the run, you will start the stop watch and wait one minute. This allows a screenshot to be taken of the assembly line in action before the first order is placed. After 1 minute, announce to the operations manager the products for the first order (for example, “1 potato head model A and 2 potato head model Bs!”). At each subsequent minute, you will announce to the operations manager the products for that order.
2. Note the time each order arrives and enter this data in the customer data sheet.
3. To be on time, an order must be fulfilled within 75 seconds of being announced. Orders arriving after 75 seconds are considered late.
4. As time permits, assist Customer B in determining defective products and incorrect products.

Customer B

1. Responsible for ensuring the customer data sheet is completed during each production run.
2. Responsible for inspecting each order for defects or incorrect products. Each time a product is found to be defective or incorrect, mark it on the data sheet.
3. For each order, customer B will record:
   • the number of each product delivered,
   • the time each order arrives,
   • the number of defective products,
   • the number of incorrect products.
4. If an order is not delivered, record the ‘Time Arrived’ as 0 seconds.

Task 2. Perform Run 1 (Push)

Given your role, perform the first Push run. Be sure to do all the tasks you are responsible for as previously outlined. The production line should start making different products to satisfy the customer order which is not known. The OM should decide what types of product should be made before knowing the order which will be received later. Starting at minute 1, you will get 3 orders every minute and will have 60 seconds to complete each order for a total time of 5 minutes. Make sure that OMs, final testers, and customers complete their data sheet tables available in the lab’s Excel file, and ISEs also record production line notes.
Task 3. Perform Run 2 (Pull)
Starting at minute 0, you will get 3 orders every 75 seconds and will have 75 seconds to complete each order for a total time of 5 minutes. Make sure that OMs, final testers, and customers complete their data sheet tables available in the lab's Excel file, and ISEs also record production line notes.

Task 4. Improvement Cycle
Each group will be given 10 minutes between runs. During this time, your group shall brainstorm improvement strategies. These improvements are to be implemented during the second run. Note that this time may vary depending on how long the instructor wishes to hold the class discussion. Make sure to record all the changes for your lab report.

Task 5. Perform Run 3 (Pull)
Implement your improvement strategies and follow the same guidelines as Task 3. Pay attention to the improvement of performance caused by changes applied to the production line. Make sure that OMs, final testers, and customers complete their data sheet tables available in the lab's Excel file, and ISEs also record production line notes.

Task 5. Clean-Up Procedure
1. Disassemble all the potato heads
2. Put all the parts in the correct boxes

Task 6. Check-out Policy
After you have finished the lab and the clean-up procedure, have your instructor or GTA sign the “End-of-Lab Signoff” line at the end of the rubric. You will lose 5 points if this is not signed by your Instructor/TA.
Report Guidelines
ENGR 1181 | Executive Summary

General Guidelines

Write an Executive Summary
For details on content and formatting, see the Technical Communications Guide on Executive Summary specifications.

Lab Specific Directions

- In addition to requirements listed in the Technical Communications Guide, be sure to briefly address the following questions. Answer within your summary, not with numbers or bullets.
  - What were the issues identified after the first run?
  - What changes were made, if any, and why?
  - How did the second run compare to the first, in effectiveness and profitability and why?
  - Discuss the principles of Lean and Six Sigma manufacturing and how they applied to this lab experience.
  - Compare the two different production methods (Push and Pull) and provide the client with specific recommendations (improvements to their system), per their request based on the observations from third run.
- Lastly, attach in the appendix the lab worksheets, summary and respective team.