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Optimization Processes and Analysis of Impact on Productivity

B.Sc. Engineering (Mechanical) Thesis

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Candidate's Declaration

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or professional qualification.

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Abstract

Optimization in industrial systems is crucial for the competitiveness of any industry in a competitive economy. A well optimized process can ensure most effective utilization of the limited resources, prove to be cost-effective and thereby increase profitability. This paper carries out literal review on several categories of optimization, such as, line optimization, production process optimization, layout optimization and inventory optimization; and tools and processes like discrete event simulation (DES), time study, root cause analysis, ANOVA, EOQ, EPQ etc. that are used to evaluate different models and scenarios for optimizing current systems. It also investigates the most effective solutions as mentioned by different researchers in their specific situations. The paper also documents the applications of such optimization porecesses in a local chemical factory and analyzes productivity improvement through these optimization processes. Finally, it is concluded that with widespread use of such optimization techniques across different industries, organizations can better enable themselves to grow and thrive.

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Chapter 1. Introduction

Industrial systems are concerned with the organization and effective utilization of available resources of modern manufacturing and process industries so as to minimize wastes of time, money, materials, and energy. It is thus clear that optimization in industrial systems is crucial for the competitiveness of any industry in a highly competitive economic environment. Consequently, how to utilize advanced modelling and optimization technologies as well as to develop new modelling and optimizations methods to design and manage these systems has attracted the interest of many mathematicians, engineers, and practitioners. A major concern in many goods-producing industries (process industry) is to improve the quality of final products. Of course, every type of products involves a different and specific process and producing rolls of paper is obviously different from producing pneumatics. However, improving the quality of products can be seen as a very similar problem for all of process industries (Kano and Nakagawa 2008). In such a type of industries, each production line follows the following schema: some raw materials define the inputs; the process is characterized by some settings such as the machines speed; and the output is characterized by some criteria on the final products (Vincent et al. 2015). So, optimization is an important topic for industries so have good quality product and better profit.

Chapter 2. Literature Review

2.1 Line Optimization

Assembly line is component of a manufacturing plant where succession of identical products is progressively assembled. A product is any item designed, manufactured and delivered with the intention of making a profit for the producer by enhancing the quality of life of the customer. Parts can be described as a unit of production that make up the final product. There are four major process types that engineers take into consideration before selecting the right assembly layout. These are job process, batch process, line process and continuous process. Each of these production type has a unique characteristic. The job-shop process method has low production volume, but workers will be able to perform vast variety of processes. Process method is flexible and can have many different configured sequences of process. The batch process has a moderate production volume. This method allow manufacturer to produce several varieties of products either in small batches or large batches. This process type is flexible as workers only need to set-up workstations and production equipment for a specific batch. The line process has a high production volume and usually consist of a few major products. It is a repetitive process as all product undergo the same standardized process. The continuous process has the highest production volume and is only dedicated to producing one product. In the process layout, as the name would suggest is specialized in process task. Workstations and machineries with similar processing capability are grouped together. These group will form a department specialize in one general task such as drilling, inspection, welding and others. The group will be placed in different but methodical section of the assembly line. The intention of assembly line balancing is to ensure that an assembly line has a satisfied precedence relations and optimized measurements of effectiveness such as balance delay minimization, line efficiency enhancement, productivity increment and reduction of idle time. A basic assembly line consists of workstations connected by material handling devices. Workstation is a point on an assembly line where a certain amount of the total assembly work is performed. Each workstation in an assembly line is assigned with different tasks or operations and is set up with all necessary materials, machines, operators or even robotic arms. The basic process of an assembly line begins with a part being fed into the first workstation. After the parts have been received, the first workstation will perform the assigned operation. Once the operation is completed, the part will be sent to the next station by material handling device and the next station will perform assigned operation. These processes are repeated until the end product is achieved. The time needed to complete an operation at a workstation is called as operation time while the time required to complete all operations at the workstation is known as cycle time. The idea of line balancing was first introduced by Bryton in 1954 (Bryton 1954).

2.1.1 Classification of Assembly Line Balancing Problem

There are two types of simple line balancing problem (SALBP): Type-I and type-II (Baybars 1986). But based on objectives, SALBP can be classified into following categories:

- SALBP-1: Minimize the number of workstations, K, to achieve a desired cycle time, CT.

- SALBP-2: Minimize the cycle time, CT, to achieve a desired number of workstations, K.

- SALBP-E: To minimize the number of workstations, K and cycle time, CT and maximize the line efficiency simultaneously.

- SALBP-F: To determine feasibility of assembly line balance for a given number of combination of workstations, K and cycle time, CT. (Boysen, Fliedner, and Scholl 2007) (Scholl and Becker 2006)

2.1.2 Lean Production

Lean Production is a method to eliminate production waste and any expenditure with no value added with the basis of lean fundamentals (Elbert 2012) (Nguyen and Do 2016) (Indrawati and Ridwansyah 2015). There are seven wastes that exist in a manufacturing system as known as "Muda" which in Japanese means uselessness and wastefulness (Baudin 2002) (Womak, Jones, and Roos 1990). The seven wastes are as follows:

- Motion: Unnecessary effort which is not related to the work and non-value added such as walking, stretching, lifting and reaching.

- Inappropriate processing: Using facilities, equipment, systems or processes which are costly or time consuming while a simpler method would suffice.

- Rework: These are action of correcting faulty such as quality defects which consumes extra time and cost.

- Waiting: Wasteful time which is non-value added and should be eliminated.

- Inventory: Excess inventory causes adverse effects such as space occupying, additional storage, extra handling cost and inhibits communication.
- Transportation: Excessive material handling of product or movement of employees which is nonvalue added.
- Overproduction: Overproduction incurred when an item is manufactured before it is needed. It creates other wastes like motion, transportation and inventory.

2.1.3 Karakuri

In this era, material handling is a major section in all the manufacturing industries especially for delicate and huge components. The typical material handing devices usually consume fuel or electricity. This adds extra cost to the manufacturing of the products as the demand and cost of energy resources are increasing day by day. For the purpose of solving this problem in one step of solution, Karakuri is often used to replace energy consuming material handling devices. The term "Karakuri" is a Japanese word which means "mechanisms" or "trick" (Law 2015). Karakuri is an automation mechanism that was first invented by the Japanese around 18th century with the intention to create movement in puppets.

2.1.4 Selected Heuristic Procedure

Assembly line balancing problem is depending on a set of complex assumptions and considerations. The solution is flexible as there is no absolute solution. Heuristic method is a technique with no optimal or perfect assurance but has been used by researchers for various case studies.

- Ranked Position Weight (RPW) technique:

The RPW technique is a heuristic procedure to select tasks to assign to workstations on basis of their positional weight (PW) (Helgeson and Birnie 1961). RPW is the total of the task processing time and the processing times of all its successors (longest path time for the corresponding task in the precedence diagram).

- Largest Candidate Rule (LCR)

The fundamental of LCR is to assign tasks to workstations based on their processing times. Preparation of a task list must be done before tasks assigning begins. The list should be arranged in a such manner that the task with largest processing time at the top of the list while the task with smallest processing time at the bottom of the list (descending order). Tasks assigning then begins in accordance to the sequence of tasks on the list.

- Kilbridge and Wester Heuristic (KWM)

The KWM is a heuristic method which has the objective to select tasks and assign them to workstations based on their position in the precedence diagram (Kilbridge and Wester 1961). The prepared precedence diagram is needed to be rearranged in a manner that tasks with identical precedence are arranged in columns.

- Number of Predecessor (NOP) method

The NOP method has been widely used in assembly line balancing. In this method, the number of predecessors of all tasks are identified and listed in ascending order in a Table.

The tasks are assigned to workstations in accordance to the number of predecessors staring from the top of the Table.

2.1.5 Approach to Line Balancing

Process study: In this stage, a comprehensive study on the current assembly line including the full process, line construction, number of workstations, number of operators and task of operators was conducted. Long processes were divided into several segments (tasks) which were feasible and convenient for conducting time study.

Time Study: In this stage, time needed by qualified and well-trained operators to complete a specific task in an assembly line was determined. First 30-minute performance was not counted as it was considered to be a warm up section where performance could be inconsistent. A well calibrated professional stopwatch was used to measure the task time of each task. Ten sets of data were collected for accuracy. Standard cycle time and standard workstation time was calculated using the following formulas:

$$CT = \sum_{i=0}^{K} TT_i$$

$$Range = TT_{max} - TT_{min}$$

$$Allowance = \frac{CT_{min} - \sum TT_{min}}{\sum Range} \times Range_i$$

$$Standard\ Task\ Time = TT_{min} + Allowance$$

$$Standard\ Workstation\ Time = \sum_{i=0}^{K} TT_i$$

Here, CT = Cycle Time

K = Total number of tasks (For CT)

K= Total number of tasks in the workstation (For SWT)

TT_i = Task time of Task i

TT_{max} = Maximum task time

TT_{min} = Minimum task time

CT_{min} = Minimum cycle time

$Range_i$ = Range of Task i

- Performance evaluation: Different solutions are evaluated through various measures. Some of these measures are:

  Rate of production is defined as the rate at which the product is produced.

$$Rate\ of\ production = \frac{Total\ productivity\ per\ day}{Total\ running\ hour\ per\ day}$$

Line efficiency is the degree to which the resources of the assembly line including human and capital resources are wisely and effectively used.

$$Line\ efficiency = \frac{SCT}{SWT_{max} \times K}$$

Where, SCT = Standard cycle time

SWT_{max} = Maximum standard workstation time

SWT_i = Standard workstation time of Workstation i

In case of the balancing the lamp production assembly line, at first the process and time study of the current assembly line was done. Then root cause analysis of the current assembly line found out that the assembly line has imbalance in workstation time and the operators are having uneven work load which eventually led to low line efficiency and poor smoothness index. Four alternate proposals for assembly line were then prepared based on four heuristic procedure: RPW, LCR, KWM, NOP. Same time study and performance evaluation was done four those four proposals. The summary of the findings and comparison between these proposals are given in the following tables:

Table 3-1: Comparison between current and proposed lines (Kit, Olugu, and Zulkoffli 2018)

	Current	LCR	NOP	KWM	RPW
Number of operator	7	6	6	6	6
Number of workstation	7	6	6	6	6
Line efficiency	66.56%	85.67%	85.67%	85.67%	85.67%
Smoothness index	108.25	38.94	46.60	38.82	38.82
Overall tasks idle percentage	4.40%	16.79%	11.83%	12.26%	12.27%
Overall tasks processing percentage	32.45%	31.58%	32.94%	31.57%	31.57%
Overall tasks blockage percentage	36.44%	3.94%	19.44%	4.92%	4.93%
Overall operators idle percentage	35.90%	25.54%	22.17%	25.56%	24.58%
Overall operator utilize percentage	58.67%	73.10%	76.25%	73.08%	74.06%
Total productivity (1 day)	258	279	291	279	279
Production rate (unit per hr)	32.25	34.88	36.38	34.88	34.88

Table 3-2: Choosing proposals based on different parameters (Kit, Olugu, and Zulkoffli 2018)

	Current	LCR	NOP	KWM	RPW
Number of operator		√	√	√	√
Number of workstation		√	√	√	√
Line efficiency		√	√	√	√
Smoothness index				√	√
Overall tasks idle percentage	√				
Overall processing percentage			√		
Overall blockage percentage		√			
Overall operators idle percentage			√		
Overall operator utilize percentage			√		
Total productivity (1 day)			√		
Production rate (unit per hr)			√		

From these calculations, it was determined that the NOP version of the assembly line proposal gained the highest ticks and hence was chosen as the assembly line to be implemented. This assembly line consists of three Karakuri Flow Racks which eliminate non-value-added motion, transportation and waiting, which makes it better suitable from the perspective of lean production.

2.1.6 Alternate Approach to Line Balancing

In this approach, the methodology mentioned in the table was used:

Table 3-3: Phases in line balancing (Choon, Olugu, and binti Zulkoffli 2018)

Phase	Objective	Description
1	Identify problems in the Assembly Line	- Detailed study of assembly line and manufacturing process flow to identify the root cause of problems.
2	Develop an improved model of the assembly line process flow	- Data collection and analysis - Productivity evaluation of current process flow - Remodel process flow for comparison with current process flow - Development of proposed assembly line
3	Evaluate proposed model of the assembly line using DES	- Test proposed assembly line through model simulation using DES software.

Formulas used in this approach for time study and weight distance analysis to develop the new layout plan:

$$R - X_{max} - X_{min}$$

$$\overline{t_c} = \frac{R(t_{cmin} - \sum X_{min}}{\sum R} + X_{min}$$

$$D_{i,j} = \sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2}$$

$$WD_{i,j} = \sum D_{i,j} \times W_{i,j}$$

$$TS = \frac{D}{\bar{t}_{ctp}}$$

$$\bar{t}_{ptp} = \frac{D}{TS}$$

Here, R = Range

X_{min} = Time minimum

X_{max} = Time maximum

t_c = Time element

t_{cmin} = Minimum total cycle time

$\sum X_{min}$ = Summation of Minimum Time Sample

$\sum R$ = Summation of Range

$D_{i,j}$ = Distance between block i and j

X_i = x co-ordinate of block i

X_j = x co-ordinate of block j

Y_i = y co-ordinate of block i

Y_j = y co-ordinate of block j

$WD_{i,j}$ = Weight-distance between block I and j

$W_{i,j}$ = Weightage

TS = Transport speed

D = Distance

T_{ctp} = Current transport time

This approach was utilized in remodeling the process flow of a metal division assembly. First Pareto chart analysis was used to determine the product with highest production efficiency. Then time element was used to standardize the time cycle for each process to produce that product. Then the weight-distance method was utilized to develop a new layout plan using the following steps:

- Gather information of space and set current closeness factors by plotting a block plan.
- Determine the closeness matrix of each pair relative to each other.
- Rank each block closeness factor starting from highest to lowest.
- Design a block plan and relocate workstations or departments accordingly.
- Conduct Euclidean distance analysis.
- Calculate the weight-distance.
- Choose the layout with lowest weight-distance.

Then time analysis was calculated based on distance between workstations or departments' changes after relocation. Thus, the transport time between the pair would differ. Then the theoretical transport time between the workstations or departments pair was determined. The current assembly line was modelled using DES software such as FlexSim by plotting blocks and inputting all necessary parameter. The model was simulated, and the result showed which workstations with high idle time and lead time of operation. Then, a comparison between the current assembly line and redesigned assembly line was evaluated to observe improvements in idle, processing and total run time. The improvement achieved is shown in the table below:

Table 3-4: Improvement in layout (Choon, Olugu, and binti Zulkoffli 2018)

Current Layout Weight-Distance	10548.422
Proposed Layout Weight-Distance	7708.842
Improvement	26.92%

From the results, it is clear that the model of the shop floor layout configuration yielded higher productivity.

2.2 Layout Optimization

Facility layout is an important component of a manufacturer's operations especially in terms of maximizing the effectiveness of the production process. The key of good facility layout is the integration of the needs of people, materials and machinery in such a way that it does create a single well-functioning system. An effective layout can help an organization achieve a strategy that supports differentiation, low cost or response while wrong layout planning will lead to lack of space in key areas, poor placement of key activities, excessive material handling, and increased operating costs. (Nazif A, Kamar N, Dahan SM 2016)

This study aims to identify the line balancing efficiency of current layout focusing on process cycle time and to compare the productivity effectiveness between traditional layout and cellular layout. The methods used to archive this objective are observation and time study. Observation method allows the documentation process of the methodology in the production layout and workflow process in order to determine the time and observe the line balancing of the current layout. In the layout time study analysis is very important. It is a factor that we can optimize and then we can use it for better productivity. Waste time is undesirable. So, by time study process we can find out where the time is wasting more.

Layout is very important for production efficiency. We can use discrete event simulation by using arena to find different layout. Different layout will obviously result in different efficiency. The efficiency of the production line is closely linked with the worker and line balancing. The worker satisfaction and capability to their task at each workstation will affect the efficiency and the fairness of work distribution to the worker will make the production line more balance.

Simulation helps us to understand more about the optimization. As we see in the paper, we have achieved 3 different layouts. By considering cycle time, waste time we saw that layout three is very suitable for better production.

2.3 Inventory Optimization

Inventory management is a must have thing in any production plant. It manages products that comes from the plant to store and distribute to the market. Inventories are the materials stored either waiting for processing or experiencing processing and in some cases for future delivery. Inventories are treated both as blessings and evil. As they are like money placed in a drawer, assets tied up in investments, incurring costs for the care of the stored material and also subject to spoilage and obsolescence there have been a spate of programs developed by industries, all aimed at reducing inventory levels and increasing efficiency on the shop floor. Nevertheless, they do have positive purposes such as stable source of input required for production, less replenishment and may reduce ordering costs because of economies of scale. Finished goods inventories provide for better customer service. So, formulating a suitable inventory model is one of the major concerns for an industry. Again, considering reliability of any process is an important trend in the current research activities. Inventory models could be both deterministic and probabilistic and both of which must account for the reliability of the associated production process. inventories are used to serve a variety of the functions chief among which are:

(i) Coordinating operations

(ii) Smoothing production

(iii) Achieving economies of scale

(iv) Improving customer service

Two things are very important for any inventory models: when to order and how much to order and the latter is termed as economic order quantity. Traditional approaches to the problem of determining economic ordering quantities for different models of inventory have always assumed implicitly that items produced are of perfect.

Economic order quantity (EOQ) is the ideal order quantity a company should purchase to minimize inventory costs such as holding costs, shortage costs, and order costs. The goal of the EOQ formula is to identify the optimal number of product units to order. If achieved, a company can minimize its costs for buying, delivery, and storing units. The EOQ formula can be modified to determine different production levels or order intervals, and corporations with large supply chains and high variable costs use an algorithm in their computer software to determine EOQ.

The economic production quantity model (also known as the EPQ model) determines the quantity a company or retailer should order to minimize the total inventory costs by balancing the inventory holding cost and average fixed ordering cost. The difference between these two methods is that the EPQ model assumes the company will produce its own quantity or the parts are going to be shipped to the company while they are being produced, therefore the orders are available or received in an incremental manner while the products are being produced. While the EOQ model assumes the order, quantity arrives complete and immediately after ordering, meaning that the parts are produced by another company and are ready to be shipped when the order is placed.

In fact, there is nothing like a perfect production method, and it is necessary to integrate reliability into it. Any product simulation, whatever the sort. (Ahmed I, Sultana I. 2014)

Chapter 3. Methodology & Results

3.1 Factory Setup

Our main goal is to optimize a production facility by doing various of optimization in different sectors. We went to a factory called Color Zone situated near Mirpur 12, Dhaka. The main product of this factory is to produce color that are used for various use. We saw the factory layout, the production line and inventory of the facility.

The factory has 3 sets of same production line. We worked with one as they are the same. The production line has one mixing machine, one filtering machine. The raw materials come in barrels. Different barrels contain different products.

At first, we tried to see in which way we could optimize in that factory. So, we had to set our goal. We marked out which type of optimization we would implement in our factory.

After finding out we came to a conclusion that we could implement optimization in line balancing, layout optimization and inventory optimization.

Figure 3.1: Factory Setup

Figure 3.2: Factory setup from another angle

In these pictures we see there are a lot of drums. These drums contain raw materials. These drums are used to collect different materials. Then they go to the mixture machine. The raw materials are titanium powder, pigment binder, softner, emulsion. These 4 materials have different loading time. After that these materials goes to the mixer machine. In that machine these raw materials stay for 1 hour almost. Then the unloading and filtering work is done. After that it goes for the packaging. All these steps are not automated. There are operators that are responsible for different types of processes that are mentioned.

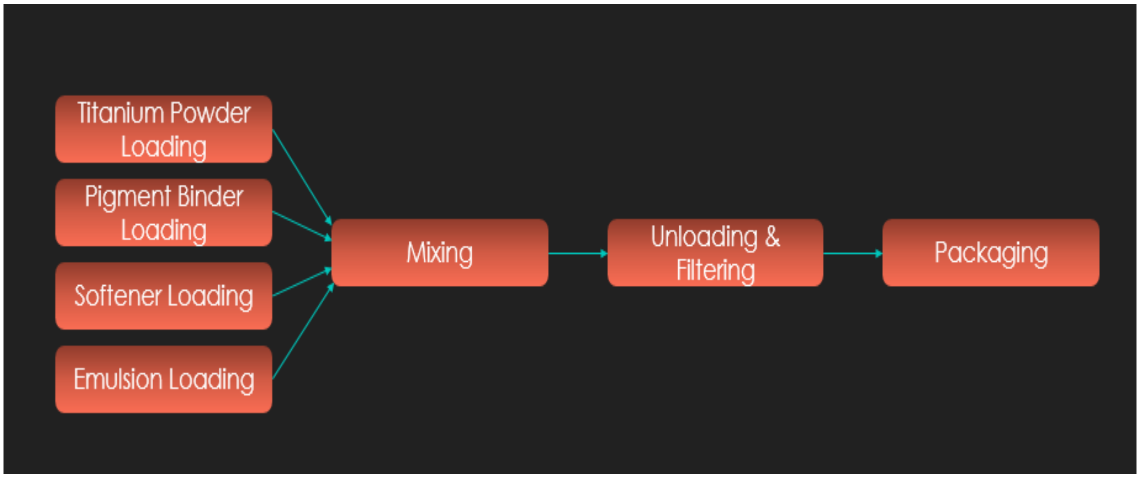

Figure 3.3: Precedence Diagram

Figure 3.4: Mixing Machines

3.2 Line Optimization

For line optimization we can create a calculated sequence in the activities of an operation. Enables optimization of time, machinery and labor. Ensures maximization of output. So, for obtaining this process we should follow some steps. We differentiated these steps into two segments.

Step 01:

Study the current assembly line, which includes the full process, line construction, number of workstations, number of operators and task of operators.

Step 02:

Conduct a time study analysis. Each task will be performed by well-trained operator, and the task time will be measured 10 times by calibrated stopwatch. Calculate standard cycle time and standard workstation time.

Step 03:

Evaluate the performance of the current assembly line with parameters like rate of production and line efficiency.

Step 04:

Perform root cause analysis to find out the exact reasons for lack of efficiency e.g. imbalanced workstation time, uneven distribution of work-load, points of high waiting time etc.

Step 05:

Create four alternate proposals based on four heuristic methods - Ranked Position Weight (RPW), Largest Candidate Rule (LCR), Kilbridge and Wester Heuristic (KWM) and Number of Predecessor (NOP) - and do similar time study analysis and performance evaluation.

Step 06:

Perform comparison among the current line assembly and the four proposed assembly. Factors to be compared are given as:

Table 3-5: Factors to compare in line balancing proposals

Number Of Operator	Overall Blockage Percentage	Overall Operators Utilization Percentage
Number Of Workstation	Overall Tasks Idle Percentage	Total Productivity (Per Day)
Line Efficiency	Overall Tasks Processing Percentage	Production Rate (Units Per Hour)
Smoothness Index	Overall Operators Idle Percentage	

Step 07:

Considering these factors, select the best alternative. Test the proposed assembly line through model simulation using Discrete Event Simulation (DES) software e.g. FlexSim, Arena etc.

By following these steps, we have gathered some data. Then we applied them. From the above equations we have managed to calculate the values that we want.

There are 2 operators that works for sourcing the raw materials. After that these materials goes to the mixing machine. There is one operator that operates this machine. He also helps so unlpoad the final product. After that it goes to the filtering section. In this section the materials go for filtering. In here the materials stay for around 20 minutes. Then the materials go for packaging.

3.2.1 Data Collection & Calculation

For data collection we have managed to take the best operator. He will do the same job for 10 times. So, we collected data for 10 times in each process.

Table 3-6: 10 Sets of Task Time

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
T Powder Loading	5.23	5.11	4.57	5.03	5.06	5.21	5.36	5.45	5.16	5.17
P Binder Loading	5.55	5.25	5.43	5.28	5.12	5.32	5.2	5.13	5.22	5.1
Softener Loading	3.29	3.45	3.12	3.33	3.27	3.33	3.14	3.06	3.13	3.16
Emulsion Loading	3.45	3.24	3.11	3.22	3.47	3.18	3.47	3.14	3.5	3.21
Mixing	60	60	60	60	60	60	60	60	60	60
Unloading & Filtering	20.25	20.11	20.12	20.16	20.14	20.47	20.11	19.55	20.13	20.05
Packaging	10.29	10.34	10.14	10.15	10.29	10.45	10.28	10.54	10.17	10.14
Total Cycle Time	**108.06**	**107.5**	**106.49**	**107.17**	**107.35**	**107.96**	**107.56**	**106.87**	**107.31**	**106.83**

For the calculation part we used the aove mathematical formula.

Table 3-7: Calculating Range, Allowance and Standard Time Calculation

TASK	TT MIN	RANGE	ALLOWANCE	STANDARD TIME
T Powder Loading	4.57	0.88	0.246297376	4.816297376
P Binder Loading	5.1	0.45	0.125947522	5.225947522
Softener Loading	3.06	0.39	0.109154519	3.169154519
Emulsion Loading	3.11	0.39	0.109154519	3.219154519
Mixing	60	0	0	60
Unloading & Filtering	19.55	0.92	0.257492711	19.80749271
Packaging	10.14	0.4	0.111953353	10.25195335
TOTAL	**105.53**	**3.43**		**106.49**

These are the basic calculation we had to do for the next step.

3.2.2 Simulation

For simulation purpose we used FlexSim 2021. This softwer is very easy to use. We had the student version of this softwer.

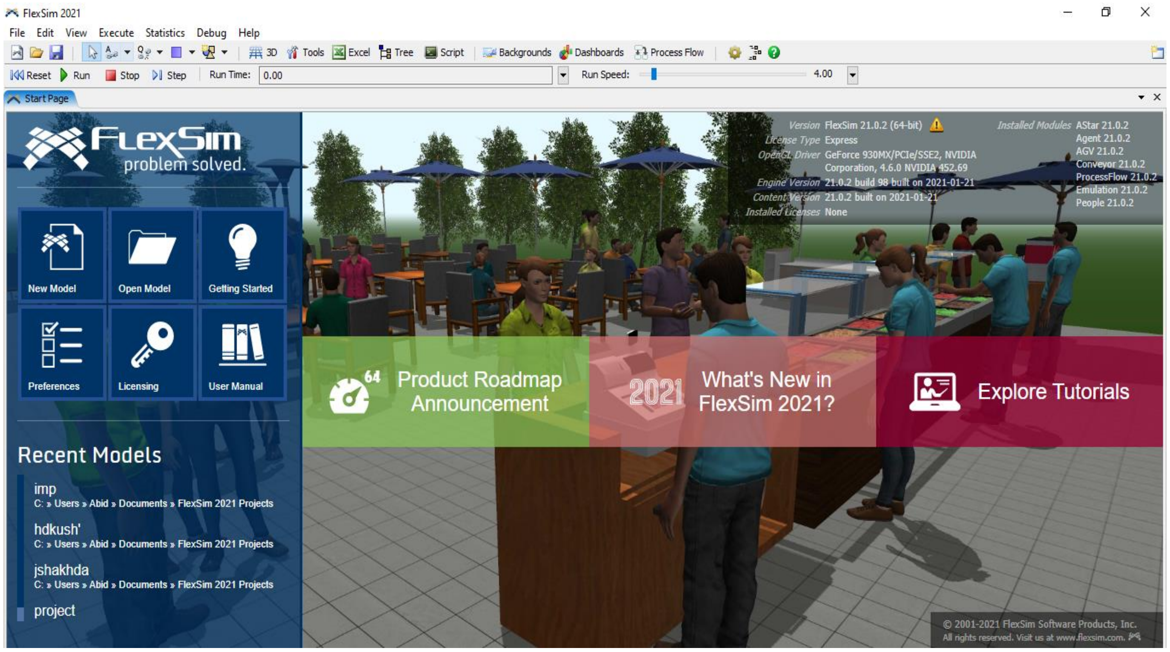

Figure 3.5: FlexSim Software

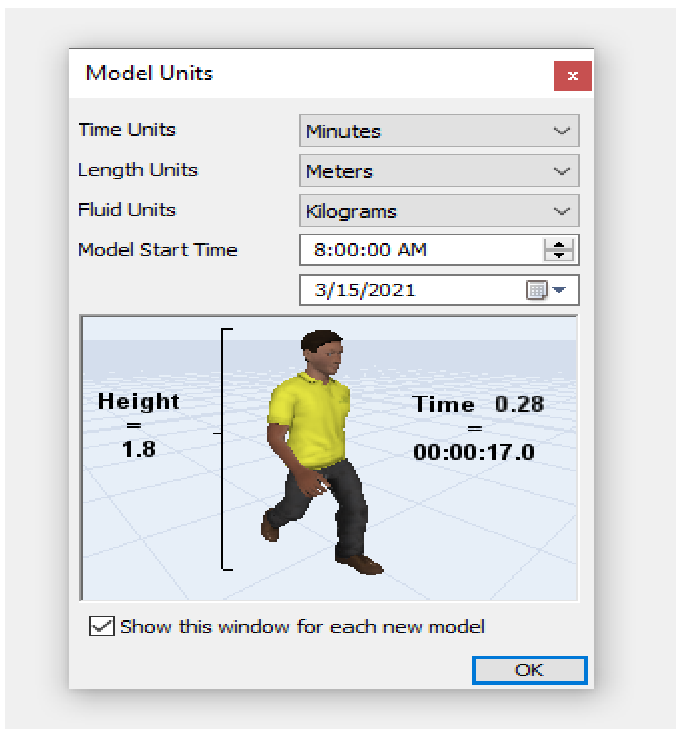

Figure 3.6: Units used in FlexSim

The units that we used to do the simulation is shown here.

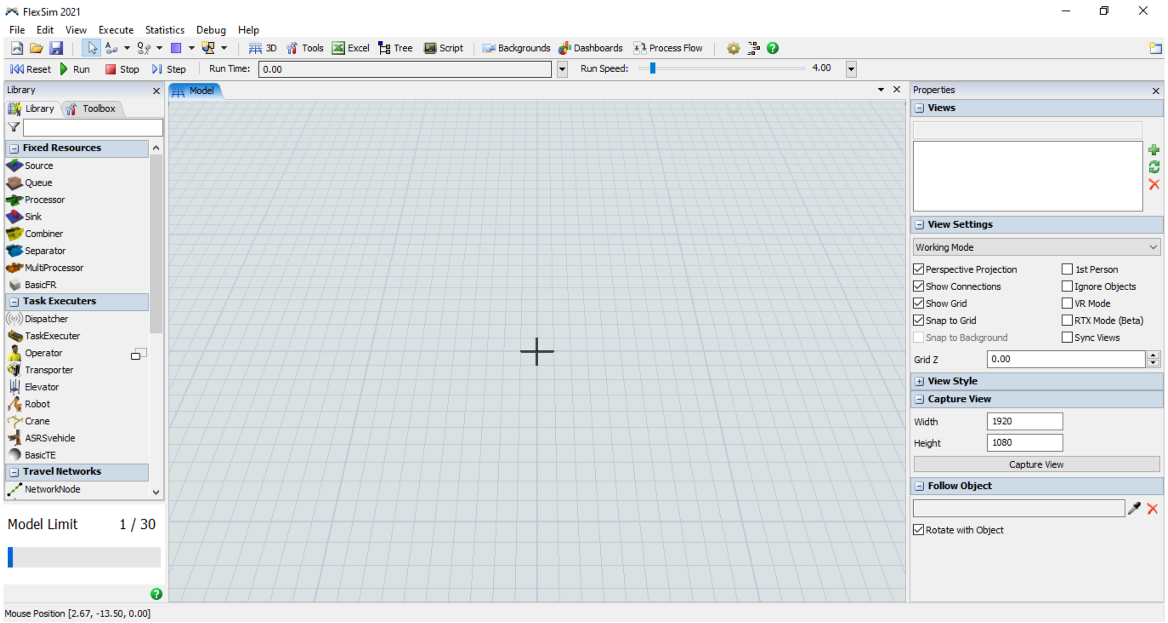

Figure 3.7: Common grid view of the software

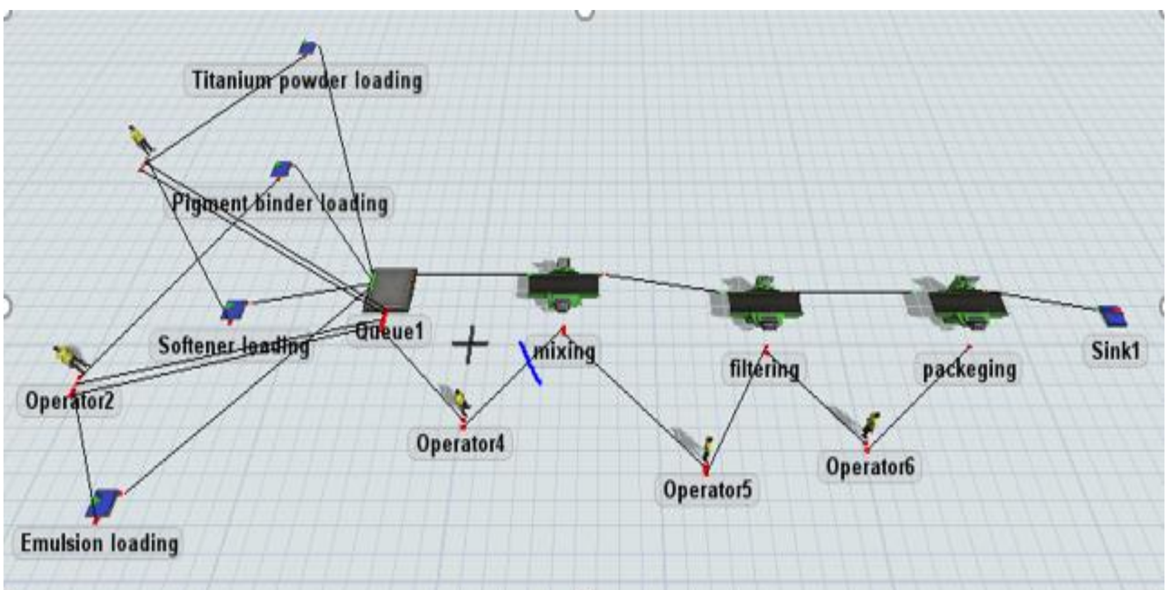

Figure 3.8: Current layout of production facility

So, here is the current layout of the production facility. We see there are 5 operators that are used to run the production line.

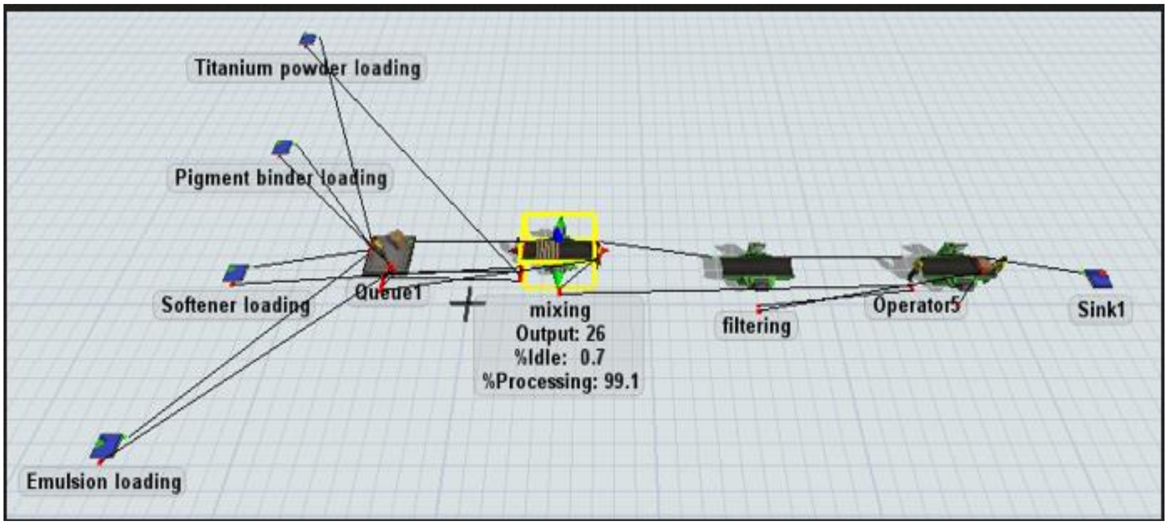

Figure 3.9: Simulating current layout

After simulation we got the value of idle and processing for the current layout for the mixer machine.

3.2.3 RPW Method

Table 3-8: RPW Calculation

TASKS (ORDER AS PER RPW)	TASK TIME	RPW Descending
P Binder Loading	5.225947522	95.28539359
T Powder Loading	4.816297376	94.87574344
Emulsion Loading	3.219154519	93.27860058
Softener Loading	3.169154519	93.22860058
Mixing	60	90.05944606
Unloading & Filtering	19.80749271	30.05944606
Packaging	10.25195335	10.25195335

Table 3-9: RPW Calculation Continued

Station	Task	Task Time	T<=TMAX
1	P Binder Loading	5.225947522	16.43055394
	T Powder Loading	4.816297376	
	Emulsion Loading	3.219154519	
	Softener Loading	3.169154519	
2	Mixing	60	60
3	Unloading & Filtering	19.80749271	30.05944606
	Packaging	10.25195335	

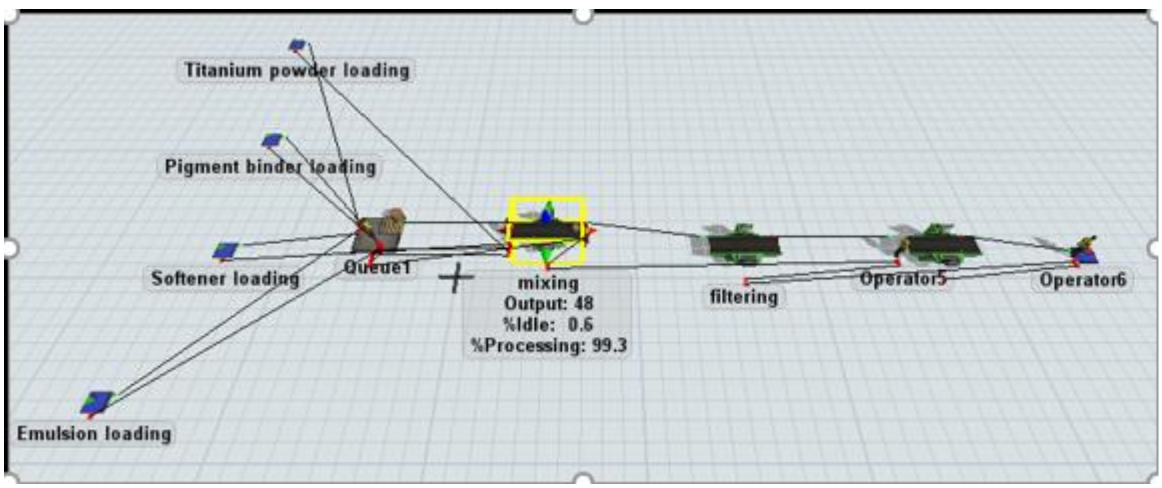

Figure 3.10: Layout Simuation of RPW Proposal

Here is the simulation using RPW method. We see the idle has decreased and processing percentage has increased.

3.2.4 KWM Method

Table 3-10: KWM Calculation

TASKS (ORDER AS PER RPW)	TASK TIME
P Binder Loading	5.225947522
T Powder Loading	4.816297376
Emulsion Loading	3.219154519
Softener Loading	3.169154519
Mixing	60
Unloading & Filtering	19.80749271
Packaging	10.25195335

Table 3-11: KWM Calculation Continued

Station	Task	Task Time	T<=TMAX
1	P Binder Loading	5.225947522	16.43055394
	T Powder Loading	4.816297376	
	Emulsion Loading	3.219154519	
	Softener Loading	3.169154519	
2	Mixing	60	60
3	Unloading & Filtering	19.80749271	30.05944606
	Packaging	10.25195335	

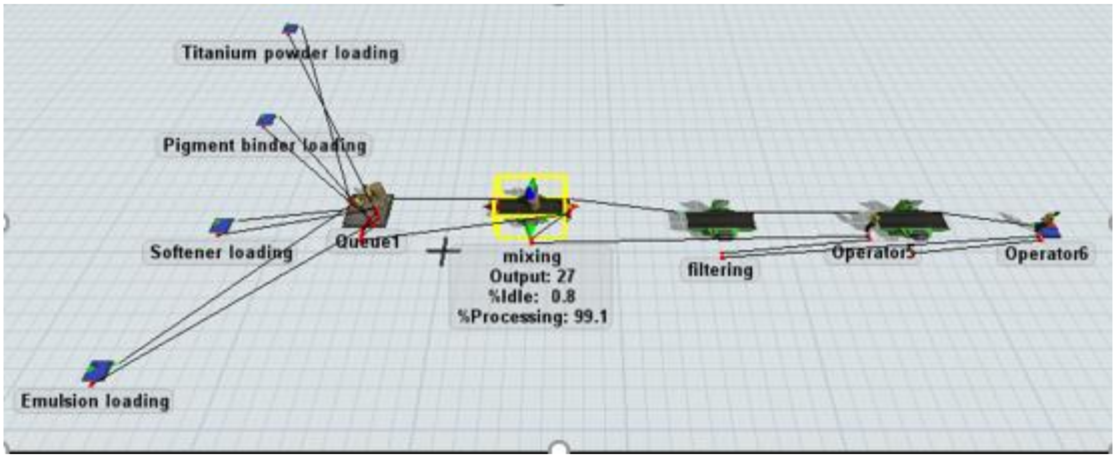

Figure 3.11: Layout Simuation of KWM Proposal

So, the idle is higher and the processing is lower in this method. That is not desirable.

3.3 Layout Optimization

For optimizing the layout, we have used the weight distance method. To calculate this, it's a simple formula. As, all the materials are not in the same place and all the quantities of the material are not the same same, we tried to optimize this by using the most weighted material to cover the least distance.

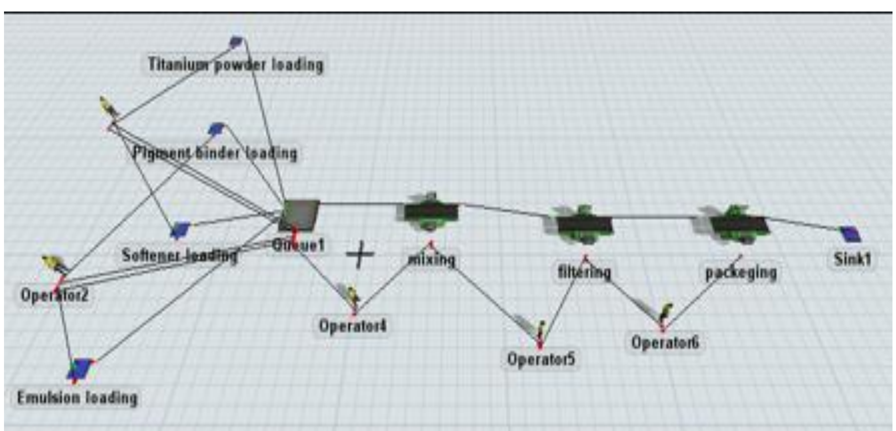

Figure 3.12: Current Layout

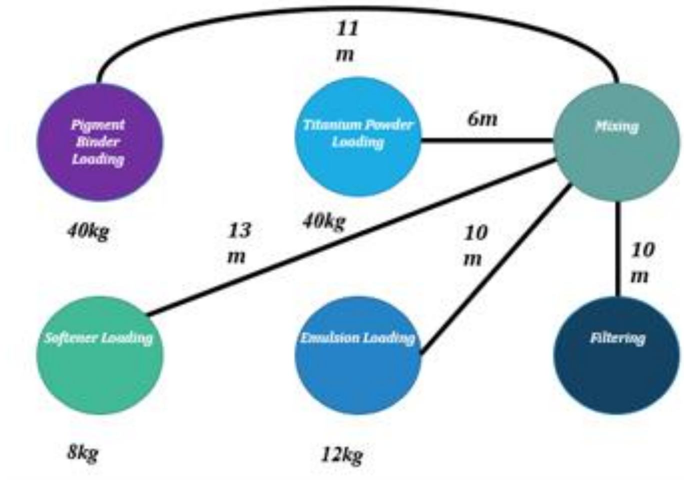

Figure 3.13: Flow diagram for current layout

So this is the flow diagram for the current layout to calculate the weight distance.

$$\text{Current weight-distance} = \sum_{i=1}^{n} \sum_{j=1}^{n} X_{ij} M_{ij}$$

$$= 40 \times 11 + 40 \times 6 + 8 \times 13 + 12 \times 10$$

$$= 904$$

We got the value of 904 for the current layout.

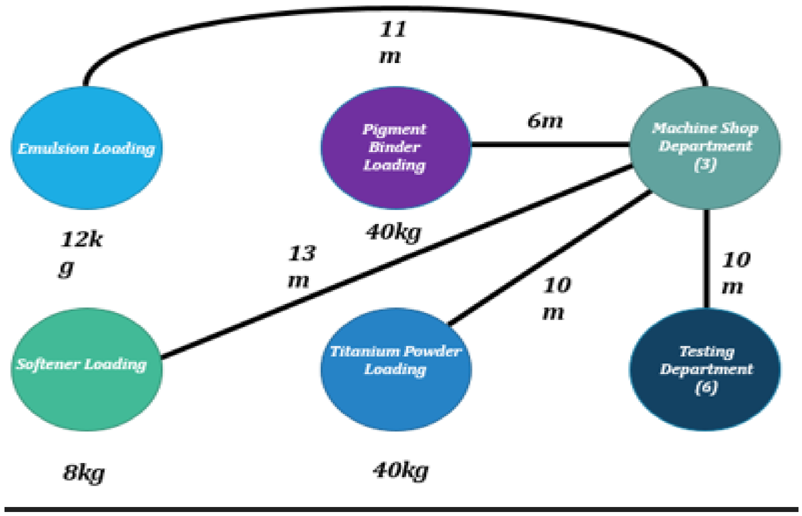

Figure 3.14: Flow diagram for proposed layout

This is the proposed layout weight distance.

$$\text{Cost} = \sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}M_{ij}$$

$$= 40 \times 6 + 40 \times 10 + 12 \times 11 + 8 \times 13$$

$$= 876$$

Improvement= 3.09%

For the proposed layout we have got the value of 876. Which is a improvement of 3.09%.

3.4 Inventory Optimization

Inventory optimization is a very important aspect of optimization. It determines a huge amout of money that is needed to run a company. If inventory is too high, it will be a loss.

Also if the inventory is less then there will be a shortage of supply. By optimizing the inventory, it creates an optimum inventory planning. Helps to decide when to order and how much to buy. Helps to decide when to ship and how much to produce. Prevents unnecessary blockage of funds and excess storage.

For optimizing the inventory, we used EOQ or Economic Order Quantity model.

Economic Order Quantity:

- Optimum order size that should be placed to a vendor to minimize blockage of funds, holding cost and ordering cost.
- At the same time, it will be an adequate quantity to ensure unstopped production or sales activity.
- Total Inventory Cost = Cost of Material + Holding Cost + Ordering or Set-up Cost
- EOQ is achieved when:

Holding Cost = Ordering or Set-up Cost

$(Q/2)H = (D/Q)S$ Where,

Q = Number of pieces per order,

D = Annual demand in units for the inventory item

S = Setup or ordering cost for each order,

H = Holding or carrying cost per unit per year

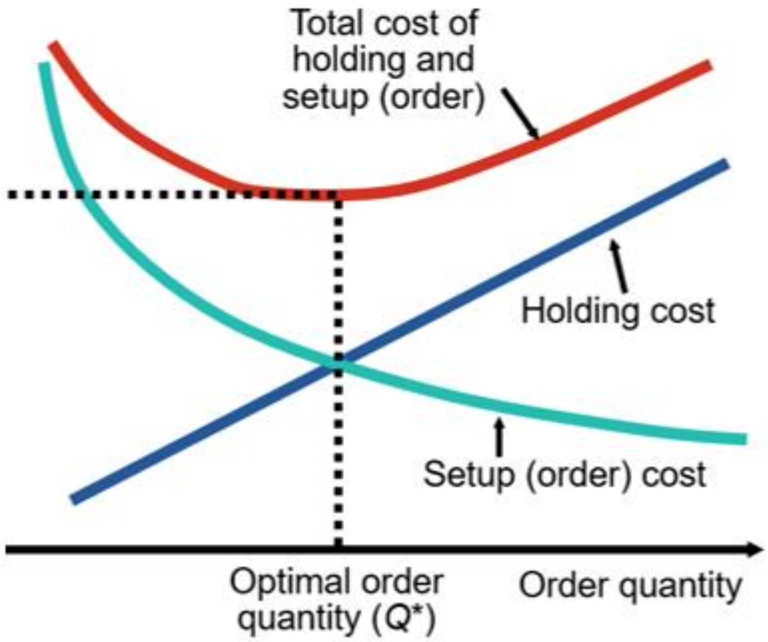

Figure 3.15: EOQ Model

In this picture we see holding cost and setup cost is minimum when they are balanced.

In this way we should determine how we will measure our inventory

Chapter 4. Conclusion

In real life there is nothing called perfect system for any production system. So, there will always be flaws. To eliminate most of them is our desired goal. For betterment of the productivity, we can use different methods of optimization techniques. We can also focus on different factors to enhance their ability for better productivity. Time consideration, line balancing, common process, common component, EOQ, EPQ these are the factor we should focus on. Optimizing the process, inventory, line, layout and schedule at different aspects on the manufacturing factory can greatly increase productivity and efficiency, reduce lead time, increase profit and ensure safe and sound working environment.

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