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FRAMEWORK OF PRODUCTION HOUSE AND PROCESS FOR ANIL´S FURNITURE COMPANY

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ABSTRACT

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The aim of this thesis was to establish a new production house and to create a framework for the production to run smoothly and effectively. Since the company is a new establishment, it needs innovative ways of production and a good plant layout to perform the production process.

The thesis also discusses the ways of managing the human resource, products, and resources. In addition, the thesis acknowledges the use of simulation work to design the plant layout and to develop the necessary production processes. This thesis provides the company an ideal and simplistic way of production process which will be both profitable and sustainable.

Key words
Furniture, Plant, Production, Simulation.

CONCEPT DEFINITIONS

DFMA	Design for manufacture and assembly
CNC	Computer Numerical Control
2D	Two Dimensional
3D	Three Dimension
MTBF	Mean Time Between Failures
MTTF	Mean Time To Fail
MTTR	Mean Time To Repair.
Negexp	Negative exponential
KPC	Key Process Characteristic
KCC	Key Control Characteristic

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1 INTRODUCTION

We are in the modern era of business and technology where most of the work is done by the machines and limited effort of the human being. The markets are very competitive and risky specially for new entrants. For a new company, there are always dilemmas of what to do, what not to do, what to keep, what not to keep, how to do, how not to do and so on. In the market where there are numerous professionals and well-established organizations, there is a tremendous possibility that the obstacles may exist on a new company's journey to success. Therefore, before running a new company it is always wise to have a feasible design or framework in mind as to how the company will sustain in the future.

For a company, the production is the backbone or the major aspect of its business. For a smooth run, the production process should be planned step by step or one process to another consecutively. If the machines are placed at a large distance from each other, there can be waste of time, effort, and resources. All wastage of time, effort and resource is the waste of company's finances. While building the production plant we must keep such things in mind. For the company, the machines are usually a one-time investment and it is essential to use them with care and efficiency.

The idea of this thesis is to progress further from the business plan. Thus, I thought why not to try different one´s own business plan. We have learned some simulation subject which is handy, and it might help someone who is searching for the layout of production plant. There will be always spaced to improve and make correction but if we do not start today. That is why not on this and use what I learn.

This thesis mainly focused on designing the production plants and processes. The production plant design and the process design are not entirely different in their approach because the plant layout is created according to the production process. After working out the designs of plant and processes, it is also necessary to calculate the time of production. Such an approach will help the company to estimate the time needed for one complete supply chain of a product, from order of the product to its delivery. The time estimations also help the production manager to plan and complete necessary tasks on time.

In this thesis, the layout of production house for the company and the process for the products will be built. The aim was to build the production house in proper process through simulation which will be effective in saving time, energy, and other resources. Through the design of processes and plant layouts, through this we can find the best way to put the machines, storage, and other necessary tools in most appropriate places. We were to find out the role and responsibilities of human resource for effective and efficient use of the production tools and resources.

2 BACKGROUND OF THE COMPANY

Anil's furniture company is not an established company, but it is just business plan. The Aim of this company is to produce dining tables which would be affordable to everyone and craft design as per need of the customer. The Company will be built manufacturing plant in Ylivieska, Finland. The head office would be in Helsinki, Finland. As a resource the company will be using Finnish wood, it is much popular in the world. Thus, company will use Finnish wood for the production. The main priority of the company is to satisfy the customer and employee.

The mission of this company is to manufacture excellent dining tables. Not only sell them in Finland but also to export products to Europe. Company´s aim should be higher to achieve that is how the company will growth otherwise limited company will not be success in future. For the company quality will be most important priority and improvement will be in progress. If customers want than the company will specialize the product. The company plans to have their own retail house where 75% product are their own and 25% of other companies too.

The company is willing to provide services to customers for the first-year free charge and after that some charge will be cost on labor and repair part. Moreover, there will be a warranty for 2 years for the products. The company will spend a large amount of money for the advertising in main cities of the country and in small cities with a small amount.

3 SIMULATION

Simulation is the most important tools in helping to avert a total failure in a real-life situation. A simulation model is made to examine the real-life system without any interruption. There is always small improvement which can be implemented but doing in a real life without plan will cause major problems. A fully developed model and smoothly running process can give a solution to every question. (Sharma 2015)

3.1.1 Steps of simulation

a) Set objectives and plan**:** After formulating the problem, the objective also should be clear as crystal. Objective is the one which answers the whole questions of the problem. Thus, the objective is important for every plan. After objective and plan is clear then further process is to make the plan to solve the problem, process to success.

b) Problem formulation: Before simulation, we should make a list of problems so that we can focus on the main objective and make a correct model. Without a clear problem we will be stuck in middle of the process which creates another problem.

c) Conceptualize model**:** Conceptual mode is the assumption model for the real system. It is the clear version of a real-life system which describes the objectives, outputs, inputs, content, and assumptions also. A Good conceptual model should map same to the real-life.

d) Data collection**:** collecting data takes much of time but correct data only helps to run he model. Data should be a real which used in present world not the assumption one. Otherwise, the model would not be made as the objective and planned.

e) Create simulation model**:** After collecting data and creating a conceptual model, now we can create an actual model in the application. After that we will be ready for the result. After gathering the parameters from the day-to-day process. Simulation software reduce the effort of the real life but not the solution of the problem yet.

f) Verification and validation: After everything we need to check first the design whether it is possible in real life or not. In additional, all the requirements and data should match to the real-life. After the verification of the model than we need to check if the process corresponds to the real-life event or not. If not, we need to make it again and whole plan as well as objective are failed. The process will be repeat until a correct model has been created.

g) Experimental design**:** After all, everything is ready the model, coding, and parameter, we should start the experiment. After experiment, we should find out the most impact user and rear use in the process.

h) Documentation and report**:** After experiment, we will get result after that the result should be present in written also. In documentation, it should be present both program and process which is act as reference guide for the future problem and the solution to the current problem. (Sharma 2015)

Advantage of simulation

- Simulation helps to study and experiment real life problems on productions,
- It helps to solve a problem practically without changing any system in real life,
- While developing the model it helps to find the faults which helps to make better process than before,
- In simulation, we can examine any situation with any tools and machine. than we can get better result than we expect,
- It saves money and time, not buying wrong machine and wait for it,
- It helps to put the right thing in the right place to run process smoothly. (Sharma 2015)

Disadvantage of simulation

- To run the software, we need special training and application to buys,
- Need exact data for the simulation which is hard to find and model to draw which fit in real system.
- Modeling and analysis take time and are also expensive. (Sharma 2015)

4 LAYOUT PLANNING

Layout planning is the decision of arrangement of resources for the use to process for the work to be done. Layout planning is the most important part for the new design or rearrangement for the company. It is not performed only when new facility or plant to build, can be done for new arrangement of old department to create some space for add new member at work or decreasing some space on facility (Kassir 2014)

Layout always affect in the productivity in the process of work. Due to poor layout, waste of energy, time and confusion might occur between works also. Face to face interaction is also important between workers, so to maintain the working environment and setting office layout plays vital role. Appropriate planned layout can be critical in facility somehow increase the flow of information, good working relationships and communication improvement. (Kassir 2014)

Layout can be applied in various levels of planning such as:

- Plant location planning: to build the new plant, the best location should be selected according the available resource and to supply to the customer.
- Department location planning: every department of the company plays a vital role in every process. planning should be done according to the deals of the paperwork or the production process. The fixed material entry and exit points will help the continuous process of the work.
- Machine location planning: Every machine should be in correct place without wasting the time. so, it helps the production run smoothly.
- Detailed planning: The final stage includes the facility planning by using CAD tools or detailed engineering drawings of the entire floor plan. Facility planning includes the power supplies, cables for networks, etc. should kept in mind. (Kassir 2014)

4.1 Plant layout

Plant layout is the physical arrangement of the existing things in the proper manner, so the act of production goes smoothly. While planning the plant layout, things to keep in mind are, position of machines, equipment for production and service department to have good co-ordination between workers and efficiency of 4M´s (Men, Materials, Machine and Methods) in the plant. (Kassir 2014)

Plant layout would be responsible for flow of materials, productivity, and morale of the workers also. Then it must be very systematic. layout should be like easy to change without any problem on expansion, change in product design, diversification or change in technology. By this layout, we can minimize the effect of changing old layout to new layout though it can minimize the production loss. (Kassir 2014)

A good layout saves time and effort of handling paper works, spaces for new things in future, minimize travel time and increases production. A good layout makes it easy to utilize the labors efficiently and less waiting time for machine. If the layout is poor, the products will not be economical, and the cost will be high for the production and customers also. (Kassir 2014)

According to the Sansonneti and Malilick from Factory management Vol. 103 “It is planning the right equipment, coupled with right place, to permit the processing of a product unit in the most effective manner, through the shortest possible distance and in the shortest possible time.” (Chand 2020)

4.1.1 Principal of plant layout

- Principle of integration: a good layout is the one which combines all the resources like men, machine, methods, and material in the place where it can be use in production.
- Principle of minimum distance: the principle main concern is to minimize the travel distance between worker and material and straight-line movement as possible.

- Principle of cubic space utilization: while layout drawing, this principle has concern to use of the space both vertical and horizontal. Not only the floor space is used but also the height of the plant is utilized.
- Principle of flow: continuously process without any obstacles while a product is in process is the main concern of this principle. Due to that, there is no waste of time and resources.
- Principle of maximum flexibility: this principle wants to concerns about the future requirement; adding of a new worker or machine, change in production line, such things should be kept in mind while drawing the layout.
- Principle of safety, security, and satisfaction: this one is the most important principles; every place should be safe from the hazardous tools for workers, satisfaction, and protection tools in production line.
- Principle of minimum handling: it is like less human work and more machine work in the office section also. Which will reduce the material handling in minimum level. (Kassir 2014)

4.1.2 Types of plant layout

4.1.2.1 Process layout/functional layout

The process layout is used mostly in low volume production places where product is not systemized. This type of a layout can be seen in companies with a random processing system. The process layout can only use when the same product is produced in large numbers.
In this system, machine which are performed in same room, but processed in separate room, like; a milling machine is in one room, a grinding machine in one room and painting in one room. This process might cause more time in process by travelling one room to another one which cause delay in material handling also might be possible of backtracking. (Kassir 2014)
The process layout presented in FIGURE1 and the advantages and disadvantages of the process layout are presented in the following lists.

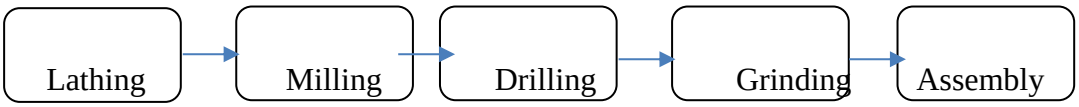


FIGURE 1. Process Layout

Advantages of the process layout

- Lower investment
- Flexibility of equipment
- Better supervision
- Full utilization of equipment
- No stoppage of production
- Place to expansion (Kassir, 2014)

Disadvantages of the process layout

- Skilled labor needed
- Big space requirement
- Inefficient material handling
- High investment in inventory
- Costly supervision
- Longer production time. (Kassir 2014)

4.1.2.2 Product layout/assembly lines layout

The product layout is known as an assembly line layout. This layout arranged sequentially according the process of the product. This layout is designed to produce only one product or one version. The flow of production should be divided between worker and machine for the operate smoothly. This facility would be used to achieve lower cost per unit and an efficient utilization of machine. The is only special purposed layout of the process of the machine which perform quickly and would be reliable. This kind of a layout would be use in continuous production. This layout is used to produce only one kind of product which has long run production with high degree of automation. (Kassir 2014) Product layout is presented in FIGURE 2.

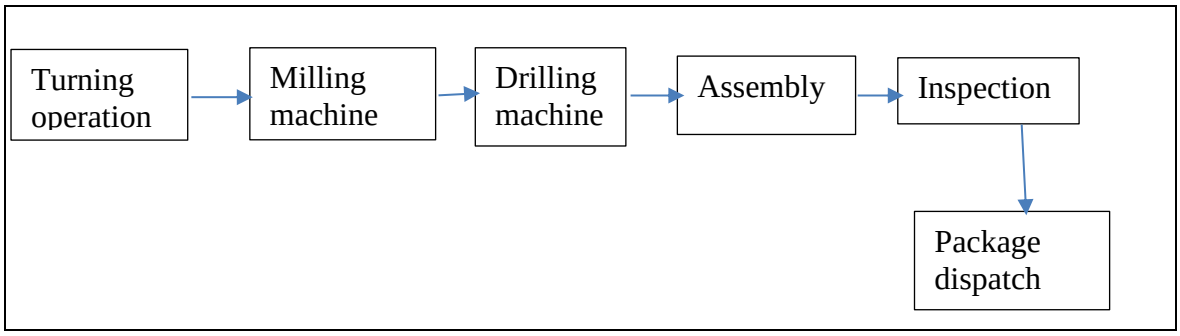


FIGURE 2. Product layout

The advantages and disadvantages of the product layout are presented in the following lists and characteristics of process and product layout are collected in TABLE 1.

Advantages of the product layout

- Continues flow of production,
- Minimum movement of workers,
- Smooth flow,
- Less work in progress,
- Lower material handling cost,
- Production control,
- Saves time,
- Effective supervision. (Kassir 2014)

Disadvantages of the product layout

- Expansion is almost impossible,
- Lack of flexibility,
- Complete stoppage during breakdown,
- Monotones for worker,
- High labor cost. (Kassir 2014)

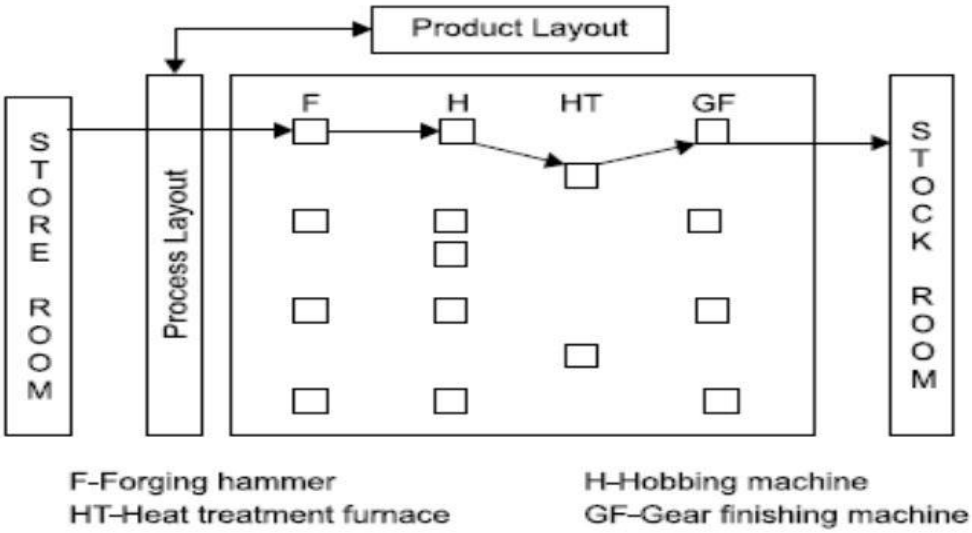
TABLE 1. Characteristics of process and product layout (Kassir 2014)

Process layout	Product layout
Can be produce in large number of different products.	Can produce small amount of product efficiently.
Facilities are more labor intensive.	Facilities are more capital intensive.
Resources are used on general propose.	Resources used on specialized.
High material handling costs.	Lower material handling costs.
Slower processing rates.	Faster processing rate.
Higher space requirement.	Lower space requirement.
Greater flexibility to the market.	Lower flexibility to the market.

4.1.2.3 Combination layout

The combine layout is the combination of the process and product layout. In this layout, machinery is arranged according to the process layout, but the grouping is arranged according to the sequence of the manufacturing process with various types and sizes of the product. In this layout, the sequence of the process remains the same with products and sizes. The point is that production sequence will be according to the need of the production. (Kassir 2014)

The combination layout is useful where the product is produced in the same sequence, but it is not use in mass production. Some example where combination layout can be used included, saws, wood, files etc. (Kassir 2014)



PICTURE 1. Combination layout (Kassir 2014)

4.1.2.4 Fixed position layout/project layout

Fixed position layout is performed when the large product is produced. All the machinery and manpower are collected in the place where is the product is going to build like, ship or airplane or bridge. Where small products are produced in the production house but this kind of product will be built in the project site where all machine and manpower are arranged in the site.

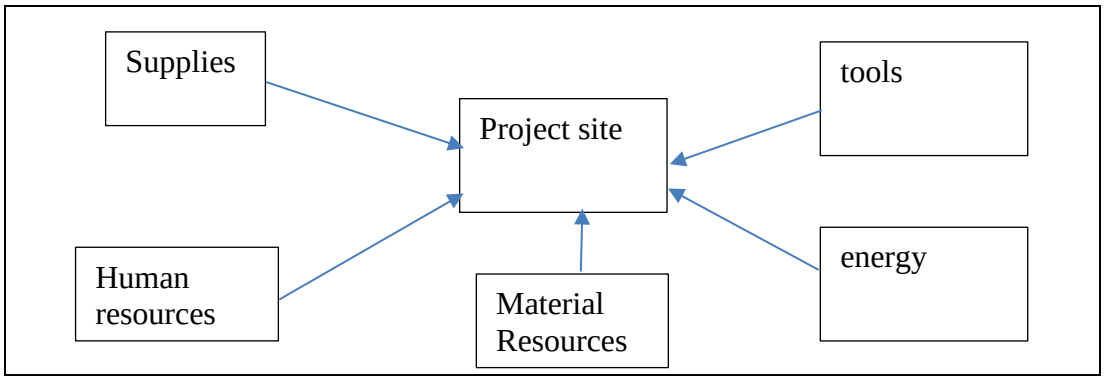


FIGURE 3. Fixed position layout. (Kassi 2014)

Advantages of the fixed position layout

- Capital investment is lower in this layout.
- Flexibility with the layout.
- Job enlargement and upgrades in the skill of operators.
- Little movement of materials. (Kassir 2014)

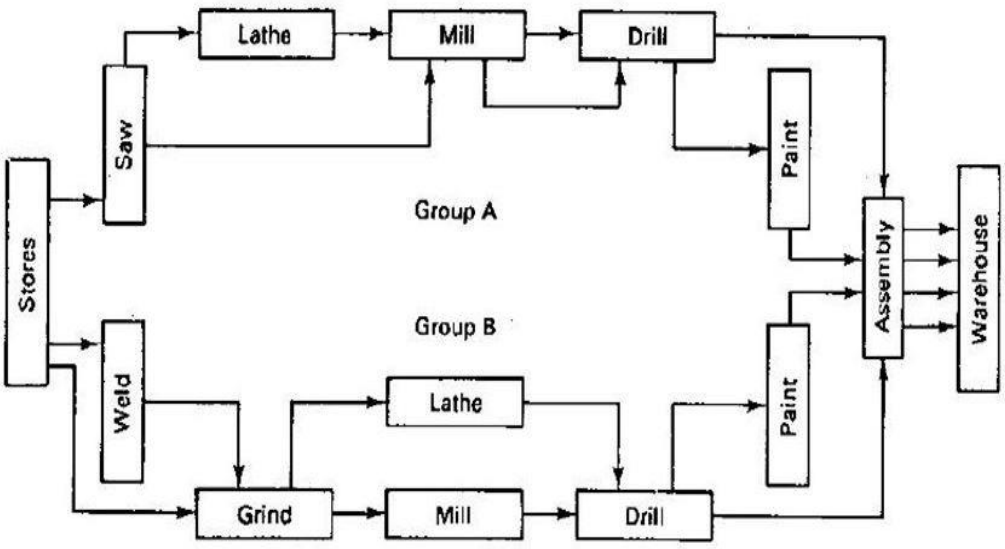
Disadvantages of the fixed position layout

- Low content of work-in-progress.
- High equipment handling cost.
- Low utilization of labor and equipment. (Kassir 2014)

4.1.2.5 Group layout/cellular layout

Group layout is also a combination of product layout and process layout, but this layout is arranged by the grouped as sequences of productions of same components which is important in the process. It tries to bring flexibility in the manufacturing system by to batch sizes and the sequence of operation. Group layout analysis and compare and placed them to the familiar group with same character. This layout is useful for those who try to produce various parts in small numbers. This layout is also considered as an economic layout. (Kassir 2014)

The group layout includes two basic steps; the first one is to determine the component families and group and the second is to arrange the equipment and set for the process which are grouped in the first step. This layout has a small plant in the plant which produces small parts of products. Applying this layout, reduces the production planning time and setup time. The main reason of this layout is to identify the families of components which have similar role from the machines are grouped into cells. Each cell can reach a satisfying result which is required from the assigned task. The main objective of the group layout is to reduce the cost of transportation and the cost of equipment. (Kassir 2014)



PICTURE 2. Group layout. (Kassir 2014)

Advantages of the group layout

- Effective machine operation and productivity.
- Component standardization and rationalization.
- Customer service. (Kassir 2014)

Disadvantages of the group layout

- Paper-work and overall production time
- Work in progress and work movement
- Overall cost. (Kassir 2014)

5 PRODUCTION PROCESS

Production process is the event where the resources are used to create more value and useful for the customers. Process is always a chain from customer to customer. In a process there is use of resources like, money time, material and manpower are used which add the values. (Makkonen 2020)

5.1 Process planning

Process planning is the selection and operation to transform a raw material into a finished product. It is the act of the detailed work to produce a goods. This plan includes the selection of operation of manufacturing, equipment, tools, and jigs and it also includes the determining manufacturing parameters and specific criteria of the selection of quality assurance (QA) methods to check product quality. Sometimes products are complex in shape and forms which is hard to produce in one sequence. Thus, there is a possibility to produce different way and assembly at the end of the production line. (Scallan 2003)

Process planning is planned according to the namely jobs, discrete part manufacturing or mass/flow manufacturing (scallan 2003). According to Rembold. (1993), “The level of detail incorporated into the process plans depends on the types of environment employed” (Scallan 2003)

5.1.1 Process selection

Process selection is the most important part of the production process. It affects the future of the company. Process selection includes the whole decision of the process which include the quality and cost of components. Selecting the process must be done according the design of the plan which should be considered. This decision of selection might affect the future of the product which is going to be in the market. (Booker 2002)

Process selection strategy:

- Estimate the annual production quantity,
- Choose a material type
- Understand the process variations
- Consider the material compatibility
- Assess conformance of component concept with design rules
- Compare tolerance and surface finish requirements with process capability data
- Consider the economic position,
- Review the selected process. (Booker 2002)

5.1.2 Design for manufacture and assembly (DFMA)

DFMA is the combination of the manufacturing and assembly. It is performed to design expertly manufactured and easily assemble in low labor cost. Through this method, the company can determine, prevent, quantify, and eliminate waste and manufacturing faults within product design. By this method, the design and manufacturing engineers will work together to develop the product manufacturing an assembly simultaneously with the design. (Quality- one international 2020)

DFMA is used for three main activities:

- To provide the guidance to the design team about the product to reduce manufacturing and assembly costs and the quantify the improvement,
- To study competitors' products and quantify manufacturing and assembly difficulties,
- To help to negotiate suppliers' contract and help to control cost on should-cost tool. (Quality- one international 2020)

DFMA method allows new or improved version of products to be manufactured and available in shorter time. It helps to eliminate the multiple revised process and design changes which might cause program delays and increase cost. With DFMA the design generally meets customer satisfaction and is efficient to produce. The shorter time to the market is the result of lower development cost the result of applying. This method is shorter

assembly time, lower assembly cost, increased product reliability and elimination of process waste. (Quality- one international 2020).

5.1.2.1 How to perform design for manufacturing/assembly DFMA.

Nowadays many companies use DFM/DFA to work together as design and manufacturing engineers. This DFM/DFA techniques are two different methods. DFM techniques concentrate on individual parts and components with the goal of minimizing the expenses, as well as the complex or useless features which create obstacles while manufacturing. The objective of the DFA technique is to reduce and standardize parts, sub-assembling and assembling. Using both might create a problem to each other on the process. but the result is difficult and expensive if the process did not met goal. To achieve the goal, both methods should work together. (Quality- one international 2020)

5.1.2.1.1 Reduce quantity of component parts and simplify part design

While designing the assembling design, the designer should review the part by parts and check whether there is any possibility to reduce the part or collaborate with another part. It should be kept in mind that the theoretical minimum quantify parts are required for the assembly. For that, first the designer should list all the needed machine or process in the assembly. (Quality- one international 2020) than one should ask the following questions.

- Is it possible for the same part can be manufactured by using same materials as other part?
- How does the part in question move in relation to other moving parts?
- Can the parts be combined without any special process or tools?
- How do the combined parts affect the assembly process?
- If combined with another part does that impact ease of possible disassembly?

Reducing the component part quantities means reducing the amount of hardware and the number of steps of assembly. Through this, the error is also minimized in the assembly process (Quality- one international 2020)

5.1.2.1.2 Design parts for ease of fabrication

The designer should keep in mind that method of fabrication which might be use in production of parts. Also, the required material and volumes of production while designing the parts. Here are some guidelines to review:

- Specific materials which are used commonly and are compatible with production process will minimize the processing time and meet all functional requirements.
- All reviewing all the parts and removing unnecessary process might cause the additional process steps, extra effort, and expensive tools or complex.
- Exchanging the knowledge between the designer, engineering process, quality control and the fabrication team might be bringing some changes on the process and beneficial increasing the utilization of existing tools prevention of capital expenses to the special tools. (Quality- one international 2020)

5.1.2.1.3 Design within known process capabilities and avoid tight tolerances

The designer should know all the process uses of all equipment which are required in manufacturing. And check the process control to be assure that any special characteristic (KCCs or KPCs) can be observes. If there are any possibilities of improvement in early scheduled program, there should be place of allow improvement in the process and establish proper processes control. The designer should check every intersection between component parts to keep away the stack up issues. Parts measurement should be within tolerance range which might allow for the greatest variance and remain a functional conforming part. If there are possibilities than the chamfered and radius corner shape are allowed if there is no change in function of the part. (Quality- one international 2020)

5.1.2.1.4 Utilize common part and materials

The designer should include common parts and materials whenever it possible which are already in use in other products or assemblies. This would help to minimize the inventory levels and lower the cost and higher quality product. This is most of the most successful new products lunched. Through new content of the design reduced and the design risk also

reduced. In addition, the learning curve shape also reduced in assembly team members. (Quality- one international 2020)

5.1.2.1.5 Mistake proof product design and assembly

The designer should design the plant, which is mistake proof, proper assemble of produced parts which can be recognizable and easily to assemble. In the additional process, the designer should avoid special adjustments needs or alignments in the process. The designer should think about how to inspect the quality on the assembly process while some confirmed parts are also may require to verified with basic go/not go tools. While parts may need to measure while the designer should know any key or features, or problem might occur to the quality. (Quality- one international 2020)

5.1.2.1.6 Handling requirements and part orientation

The designer should mention the process of the handling the part during the manufacturing and assembly processes. If designer did not mention then, the process of handling might create the non-value-added motion and operator safety issues or needed special fixtures or lifting devices. While drawing, the designer should show the proper origination when the process starts. If possible, the design parts should be symmetric with both axis would allow easy fabrication and assemble correctly. The designer should keep in mind not to use the parts which are easily tangled or hard to pick up and handle. They might slow the production and increase the waste due to damage or lost parts for operator safety. An always avoid the sharp edges of the products. Designing workstation is always a good practice, if the plan is to minimize the workers travel time. (Quality- one international 2020)

5.1.2.1.7 Design for ease of assembly

The designer should know where the assembly will be performed, and the tools or equipment are available in the process. All know that the simpler the design, the easier the product is to assemble. During the assembling, the designer should avoid the multiple set-up or re-orientation which create waste of time. Creates the tools clearer and assure where operators can find what they are assembling with no hidden interfaces. Limited hardware sizes and

configurations will always help not to used wrong hardware in wrong place. Try to minimize the step in the assembly process and the movement. The designer should create simple patterns of movement, which does not confuse the workers. (Quality- one international 2020)

5.1.2.1.8 Design for automation

One fact is the automation production can be less flexible than manual production. For that the designer must designed which can be handled easily in automated equipment magnetic lifting, placement equipment or gripping. Using the simple parts-presentation devices, self-locating and avoid using the clamping or securing parts on the process. Some advantages of using automations include:

- Improved quality or more predictable process results,
- Consistency in the process output,
- Increased process throughput or efficiency
- Reduced operator labor costs and indirect labor costs. (Quality- one international 2020)

DFM/A are both important. Their goal is to design the product and process to be as efficient as possible. No matter whether the product is assembled by operators or machines, the main motives is the designer and mechanical engineer work together to assure that overhead costs, the labor costs, and machines costs to reducing as much as possible. Through that, we can always produce quality products. Design of manufacturing and design for assembly always helps on producing the goods efficiently. If DFM/A is applied, a company can run greater level of efficiency, higher profits margin and higher quality. (Quality- one international 2020)

5.2 Production process for dining table:

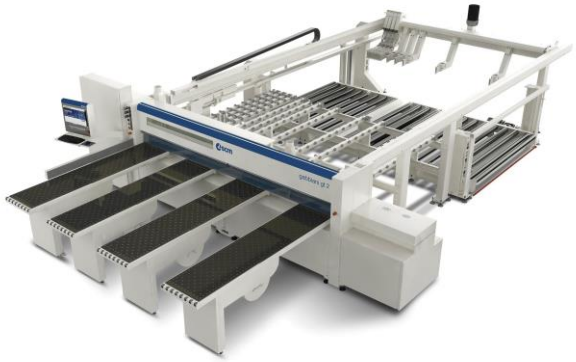
5.2.1 Inventory

Inventory is the place where the assets of the company are placed before use. The company will place all the raw material which will be used in the production process will called inventory. It can be wood, screws or the papers which are used in the office department. Inventory is the one of the important assets on the company which represent primary sources.

PICTURE 3. Inventory example (Kenton 2019)

5.2.2 Cutting in the shape

After receiving the raw material, first step is to cut in the shape of design. As we are planning for the making of a dining table than cutting is the first process where there are many resources that can be used an automatic panel saw or for design a CNC router machine. (Kenton 2019)



PICTURE 4. Automatic panel Saw (SCM woodworking technology)

PICTURE 5. CNC router machine (BOGONG MACHINE 2020)

This kind of a machine work after receiving the information shape and size to cut. All the information can be installed in the software this machine company can minimize the manpower, and this is also one-time investment. (Kenton 2019)

The company has decided to two kind of process for leg part and top part of the dining table. For that, they needed two machines for continuous process. The company is planning to process leg part and top part for the production with a different process. if the process did not separate than machine must change preference every time while cutting the leg part and top part which cause more time in production. After cutting, at the same room the cut part will took to make hole in the product to make easy to install for customer. Now after cutting and deign the wood, it will take place to another process. (Kenton 2019)

5.2.3 Painting/coating, and drying

The painting/coating/drying is placed in the same room. For painting there is also an automatic machine. There are different companies that produce such a machine. The company needs to search for the cheapest one because the company has decided to produce by two process for leg and top part for dining table. The company needs to keep in mind about the paint qualities while using the paint. The product is a home appliance so, it should be anti-microbial, color retention, water proofing and water shedding. As for the leg part it is a little, small so human resources also can be use in the process if the cost of machine is high. (Kenton 2019)

PICTURE 6. Automatic electric paint spray coating machine (paintmach.com)

After finishing the coating and painting the next place is drying room. Room can be used in low temperature to cool down.

5.2.4 Assembling

After the drying process, the next step is to assemble all the part, top part, leg part, screw, and the box. After all, before putting all the parts of dining table in the box, the company needs to inspect that all the product is processed as planned. After the inspection is done, if the product is done as planned, it will be sent to packing and if not, it will send back to the department which part is not produced as planned. In mass production, backtracking might waste the time, so some companies throw in the waste if it is not possible to repair. (Kenton 2019)

5.2.5 Packing

After the inspection is done, all the parts are assembled with any wasting time than last part is to put into one box and it to the warehouse to keep it there until the delivering date. Packaging was done without joining the parts to each other. The company wants to build the table by customers themselves. By this it saves the cardboard for packing and customers can build their table as they want. (Kenton 2019)

5.2.6 Warehouse

After packing the next phase is to take the packages to the warehouse from the packing room. Warehouse is the place where finished goods are kept until the delivering date or a customer come to collect the goods. Goods are packed and not build in final form which means it saves space in the warehouse as well as in the transportation also.

PICTURE 7. Warehouse organized in straight line. (VIA Technologies 2019*)*

6 SIMULATION PROJECT

The aim of this thesis is to formulate the plant and process for the new company. For the process of the product, a simulation by Enterprise Dynamics application was used.

6.1 Background of the application

Enterprise dynamics is a software program, which is used for simulation, modeling, visualization and control the processes. The user can use the objects which are called atoms from the libraries which is used to build one´s own models. (Enterprise Dynamics Tutorial 2020)

Atoms can be machines, counters or the products or the non-physical characters like graphs or pie-charts. There are basic atoms which are mostly used, products, source, sink, server, queue, transport atom (conveyor, transporters) and results atoms etc. Enterprise Dynamics also has programming in language which is called 4DScript where we can use setting specific condition which are used in real-life in the model. Enterprise dynamics helps to solve problems by modeling virtually and experiment to search the solution of the problem. (Enterprise Dynamics Tutorial 2020)

Advantages of using Enterprise Dynamics are as follows:

- Helps to test future systems at an early stage
- Testing and improving proposed modification results from lean manufacturing or six sigma studies without creating in reality,
- Can do modeling and analysis of many scenarios to prepare for the future,
- Safeguarding the investment planning for the production and transport equipment,
- Estimating the influence of uncertainties and variations,
- Analysis and visualization of operational system in 2D and 3D animation. (Enterprise Dynamics Tutorial 2020)

6.2 Simulation process

6.2.1 Problem definition and setting objectives

We have already talked about the aim of this thesis which was to build the process of the production. Why we used the simulation for it. For that we must know the processes which are going to be used in production and what kinds machines will be in use. The process of the production machines probably in use and the production plant layout are already discussed in the above pages. Through that, we must procced for the layout of the process. (Enterprise Dynamics Educational 2020)

The main problem is that layout should not be time consuming and if any breakdown occurs, it would be repaired as soon as possible. Without any knowledge of the process, if people started to put machines and equipment randomly for the production than it will consume more time and cannot produce in given time which give bad impression for costumers. The plan and known the lead-time of production is handy in the production plant and process. It is quite an expensive process, but it is best to spend money before than to lose whole money after investment without a plan idea. (Enterprise Dynamics Educational 2020)

The main objective of this simulation was to observe the process whether they are in the right place, try to have minimum process time. we also must check whether every step-in process is running properly as planned. There should be as small lead time as possible. Through that we can produce maximum number of products in less time, and we can hand over to customers in time. (Enterprise Dynamics Educational 2020)

In the market, nowadays there are many machines available which make easy and fast production. We can use in alternative way for this model also. In the model, we are producing in two processes (leg part and top part), which can be integrated into done in one process. This might increase the lead time and decrease the cost of using double machines in production. (Enterprise Dynamics Educational 2020)

Production line will be in the same room which saves movement time, quality check and paperwork for one department to another. We will try to minimize the investment cost by

small number of machine or combing the step-in production. By that the lead time will be increase but we will try to minimize the process time. (Enterprise Dynamics Educational 2020)

Because our plan is to format the machine in the place and build the plant, we do not need simulation of the past. By this method is might be less cost while building. However, in the future due to incorrect placement according to production line it will increase the lead time which will cost more in movement of the product. It is always better to simulate before building the plant for production or office also. This saves time and cost. (Enterprise Dynamics Educational 2020)

6.2.2 Describing the system

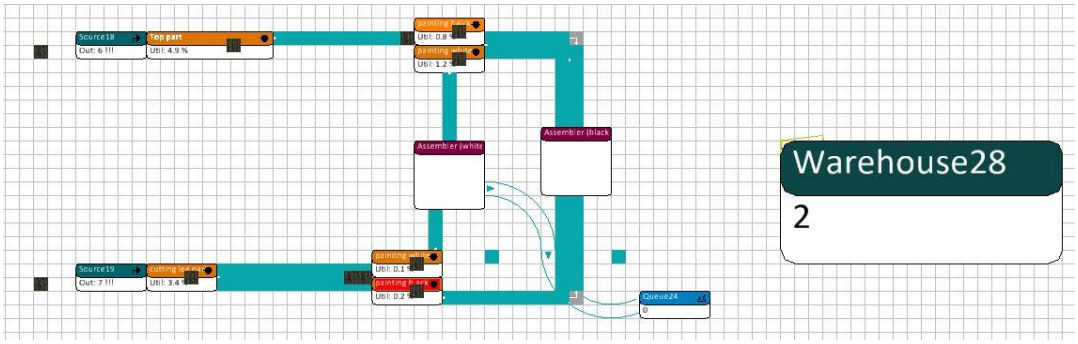
For the process, there are two different lines. One line is used for the top part of the table and the other one is for the leg part. The First process is cutting. This process will take 2 hours to process. next process is to paint the cut part. For painting and drying time is three hours. Last part is to assemble both the top part and the leg part into box. After assembled and packed, the product will send to the warehouse until the customer come to collect the goods.

TABLE 2. Used atoms and parameter in detail.

Atoms	parameter
Server (top part/leg part)	• Setup time: fixed setup time: every product has a setup time of 7200sec. • Cycle time: NegExp (120) • Send to specific channel: always send to channel 1 • Mttf: uniform (200,6) • Mttr: uniform (20,30)
Server (painting black/white)	• Setup time: fixed setup time: every product has a setup time of 10800sec. • Cycle time: NegExp (120) • Send to specific channel: always send to channel 1 • Mttf: NegExp (10) • Mttr: NegExp (10) • Mttr for cycles: NegExp (10)
Assembler (black/white)	• Cycle time: Negexp (10) • Send to 1 • Tigger on entry channel1: color(I) = color white / black. • Tigger on entry channel 2: color(I) = color white/black. • Trigger on exit: Name(I) = white table/ black table.
Queue	• Capacity: 10 • Send to 1 • Queue discipline: FIFO (fist in first out)
Warehouse	• Input strategy: any input channel • Queue discipline: FIFO (fist in first out) • Send to 1 • Z side (m): 10 • Number of rows: 100 • Number of columns: 8

6.2.3 Verification and validation

For the verification, we must know all the atoms are working as perfect and on given time. in conclusion we are running the model three times for the 8hr each time and here are the results.



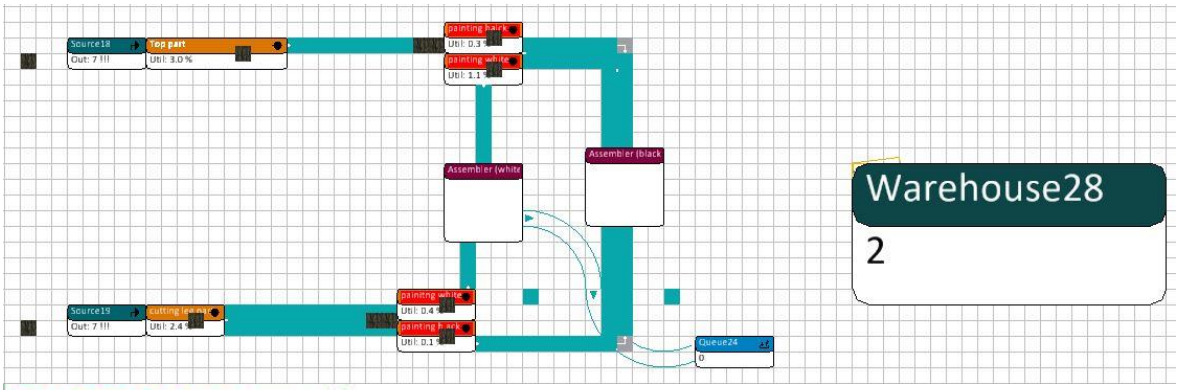
summary report

name	content current	content average	throughput input	throughput output	staytime average
Top part	1	1.000	6	5	4781.715
cutting leg par	1	1.000	7	6	4680.900
Accumulating Co	1	0.531	5	4	2599.311
Accumulating Co	2	0.551	6	4	2443.442
painting balck	1	0.672	2	1	14625.846
painitng white	1	0.681	2	1	14006.615
Accumulating Co	0	0.000	1	1	5.000
Copy of Accumul	0	0.171	1	1	4911.706
Assembler (blac	0	0.001	2	2	9.830
Transporter12	0	0.000	1	1	12.093
painting black	1	0.840	2	1	14573.892
painting white	1	0.840	2	1	14621.451
Source18	1	0.998	7	6	3976.429
Source19	1	0.997	8	7	4003.629
Accumulating Co	0	0.000	1	1	5.000
Accumulating Co	0	0.000	1	1	3.000
Assembler (whit	0	0.138	2	1	3975.219
Transporter21	0	0.000	1	1	13.000
Product	0	0.000	0	0	0.000
Product	0	0.000	0	0	0.000
Advanced Accumu	0	0.000	1	1	8.658
Copy of Advance	0	0.000	1	1	10.324
Queue24	0	0.000	1	1	13.000
Accumulating Co	0	0.000	1	1	8.000
Accumulating Co	0	0.000	1	1	7.000
Corner Transfer	0	0.000	1	1	1.000
Corner Transfer	0	0.000	1	1	1.000
Warehouse28	2	0.355	2	0	0.000

Model start time	Thursday, October 08 2020 10:40:29
Model end time	Thursday, October 08 2020 18:40:29
Runlength (seconds)	28800.00

End of report.

PICTURE 8. The first run of simulation (summary and simulation)



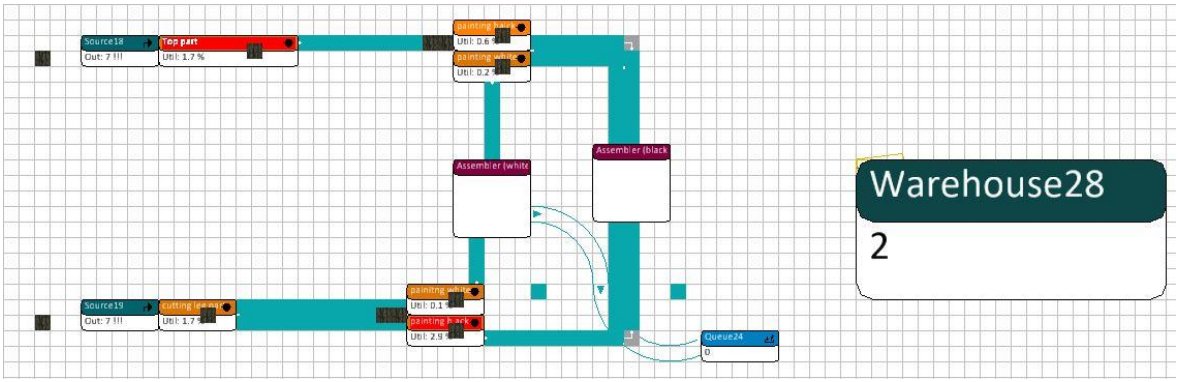
summary report

name	content current	content average	throughput input	throughput output	staytime average
Top part	1	1.000	7	6	4643.957
cutting leg par	1	1.000	7	6	4593.604
Accumulating Co	2	0.597	6	4	2719.282
Accumulating Co	2	0.598	6	4	2570.190
painting balck	1	0.833	2	1	15078.449
painitng white	1	0.687	2	1	14643.102
Accumulating Co	0	0.000	1	1	5.000
Copy of Accumul	0	0.038	1	1	1091.088
Assembler (blac	0	0.001	2	2	11.471
Transporter12	0	0.000	1	1	12.093
painting black	1	0.841	2	1	14213.642
painting white	1	0.678	2	1	14538.421
Source18	1	0.997	8	7	3971.963
Source19	1	0.997	8	7	3928.803
Accumulating Co	0	0.000	1	1	5.000
Accumulating Co	0	0.005	1	1	136.996
Assembler (whit	0	0.002	2	1	68.685
Transporter21	0	0.000	1	1	13.000
Product	0	0.000	0	0	0.000
Product	0	0.000	0	0	0.000
Advanced Accumu	0	0.000	1	1	8.658
Copy of Advance	0	0.000	1	1	10.324
Queue24	0	0.000	1	1	13.000
Accumulating Co	0	0.000	1	1	8.000
Accumulating Co	0	0.000	1	1	7.000
Corner Transfer	0	0.000	1	1	1.000
Corner Transfer	0	0.000	1	1	1.000
Warehouse28	2	0.479	2	0	0.000

Model start time	Thursday, October 08 2020 10:44:06
Model end time	Thursday, October 08 2020 18:44:06
Runlength (seconds)	28800.00

End of report.

PICTURE 9. The second run of simulation (summary and simulation)



summary report

name	content current	content average	throughput input	throughput output	staytime average
Top part	1	1.000	7	6	4556.250
cutting leg par	1	1.000	7	6	4546.630
Accumulating Co	2	0.649	6	4	2818.240
Accumulating Co	2	0.700	6	4	3134.264
painting balck	1	0.835	2	1	14380.815
painitng white	1	0.843	2	1	14418.921
Accumulating Co	0	0.000	1	1	5.000
Copy of Accumul	0	0.000	1	1	8.000
Assembler (blac	0	0.223	2	2	3213.920
Transporter12	0	0.000	1	1	12.093
painting black	1	0.685	2	1	16485.904
painting white	1	0.677	2	1	15005.882
Source18	1	0.997	8	7	3896.786
Source19	1	0.997	8	7	3888.540
Accumulating Co	0	0.000	1	1	5.000
Accumulating Co	0	0.187	1	1	5384.108
Assembler (whit	0	0.001	2	1	20.503
Transporter21	0	0.000	1	1	13.000
Product	0	0.000	0	0	0.000
Product	0	0.000	0	0	0.000
Advanced Accumu	0	0.000	1	1	8.658
Copy of Advance	0	0.000	1	1	10.324
Queue24	0	0.000	1	1	13.000
Accumulating Co	0	0.000	1	1	8.000
Accumulating Co	0	0.000	1	1	7.000
Corner Transfer	0	0.000	1	1	1.000
Corner Transfer	0	0.000	1	1	1.000
Warehouse28	2	0.265	2	0	0.000

Model start time	Thursday, October 08 2020 10:49:53
Model end time	Thursday, October 08 2020 18:49:53
Runlength (seconds)	28800.00

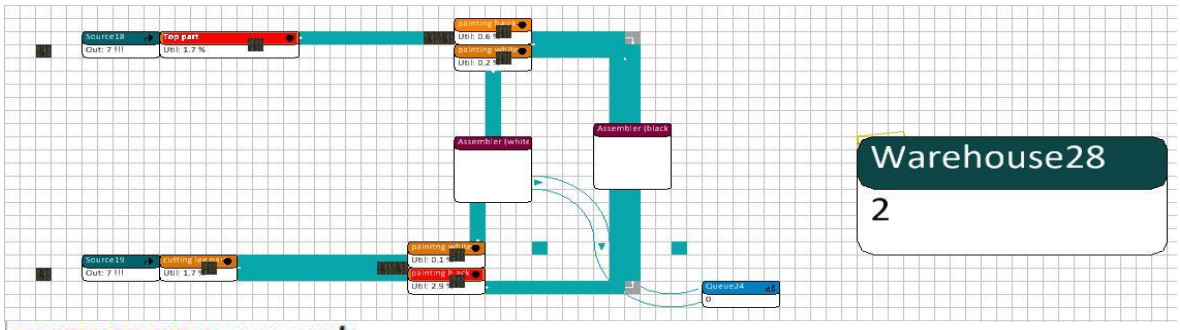
End of report.

PICTURE 8. The third run of simulation (summary and simulation).

According to the result, there is no difference in the result in the final product but there is little difference in the server of cutting place and painting room. Differences in small amount in result does not affect in mass production. As we are focus on the customer satisfaction and quality base product, this result might not affect the company because we will not build the whole table in one day.

6.2.4 Experimenting with alternatives simulation.

While experimenting at first, we did not change anything parameter of the atom. After that I changed a few things time, parameters. In every new experiment we changed only one parameter in the server where we can find difference in the experiment easily. Below there is the first and simple experiment:



summary report

name	content current	content average	throughput input	throughput output	staytime average
Top part	1	1.000	7	6	4556.250
cutting leg par	1	1.000	7	6	4546.630
Accumulating Co	2	0.649	6	4	2818.240
Accumulating Co	2	0.700	6	4	3134.264
painting balck	1	0.835	2	1	14380.815
painitng white	1	0.843	2	1	14418.921
Accumulating Co	0	0.000	1	1	5.000
Copy of Accumul	0	0.000	1	1	8.000
Assembler (blac	0	0.223	2	2	3213.920
Transporter12	0	0.000	1	1	12.093
painting black	1	0.685	2	1	16485.904
painting white	1	0.677	2	1	15005.882
Source18	1	0.997	8	7	3896.786
Source19	1	0.997	8	7	3888.540
Accumulating Co	0	0.000	1	1	5.000
Accumulating Co	0	0.187	1	1	5384.108
Assembler (whit	0	0.001	2	1	20.503
Transporter21	0	0.000	1	1	13.000
Product	0	0.000	0	0	0.000
Product	0	0.000	0	0	0.000
Advanced Accumu	0	0.000	1	1	8.658
Copy of Advance	0	0.000	1	1	10.324
Queue24	0	0.000	1	1	13.000
Accumulating Co	0	0.000	1	1	8.000
Accumulating Co	0	0.000	1	1	7.000
Corner Transfer	0	0.000	1	1	1.000
Corner Transfer	0	0.000	1	1	1.000
Warehouse28	2	0.265	2	0	0.000

Model start time Thursday, October 08 2020 10:49:53
Model end time Thursday, October 08 2020 18:49:53
Runlength (seconds) 28800.00

End of report.

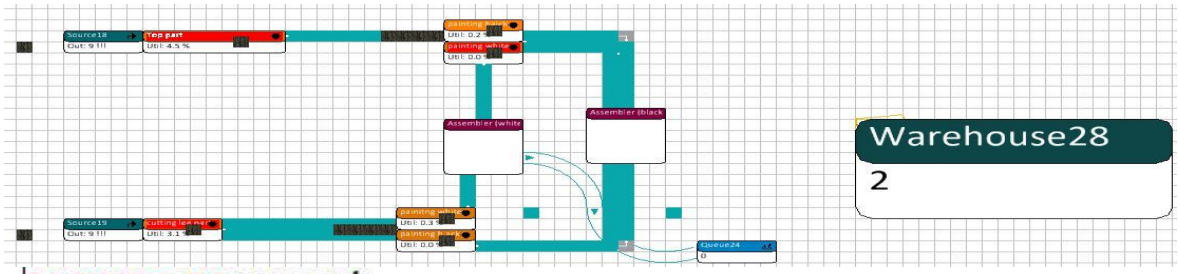
PICTURE 9. The first experiment run (simulation and summary)

In second experiment, we changed the cutting time in the server and other parameters were the same as before.

TABLE 3. Atom`s parameter changes in detail

Atom	Parameter	Before	After
Cutting top part	Setup time: fixed.	setup time: every product has a setup time of 3600sec	setup time: every product has a setup time of 3600sec
Cutting leg part	Setup time: fixed	setup time: every product has a setup time of 2700sec (45min)	setup time: every product has a setup time of 2700sec (45min)

After applying those changes, the following result was achieved



summary report

name	content current	content average	throughput input	throughput output	staytime average
Top part	1	1.000	9	8	3589.353
cutting leg par	1	1.000	9	8	3508.393
Accumulating Co	4	1.220	8	4	3514.221
Accumulating Co	4	1.362	8	4	3801.030
painting balck	1	0.754	2	1	14002.646
painitng white	1	0.763	2	1	14655.240
Accumulating Co	0	0.000	1	1	5.000
Copy of Accumul	0	0.110	1	1	3177.605
Assembler (blac	0	0.002	2	2	30.373
Transporter12	0	0.000	1	1	12.093
painting black	1	0.879	2	1	14425.059
painting white	1	0.880	2	1	14639.699
Source18	1	0.997	10	9	3181.647
Source19	1	0.997	10	9	3109.683
Accumulating Co	0	0.000	1	1	5.000
Accumulating Co	0	0.000	1	1	3.000
Assembler (whit	0	0.117	2	1	3363.893
Transporter21	0	0.000	1	1	13.000
Product	0	0.000	0	0	0.000
Product	0	0.000	0	0	0.000
Advanced Accumu	0	0.000	1	1	8.658
Copy of Advance	0	0.000	1	1	10.324
Queue24	0	0.000	1	1	13.000
Accumulating Co	0	0.000	1	1	8.000
Accumulating Co	0	0.000	1	1	7.000
Corner Transfer	0	0.000	1	1	1.000
Corner Transfer	0	0.000	1	1	1.000
Warehouse28	2	0.518	2	0	0.000

Model start time Monday, October 19 2020 11:07:21
Model end time Monday, October 19 2020 19:07:21
Runlength (seconds) 28800.00

End of report.

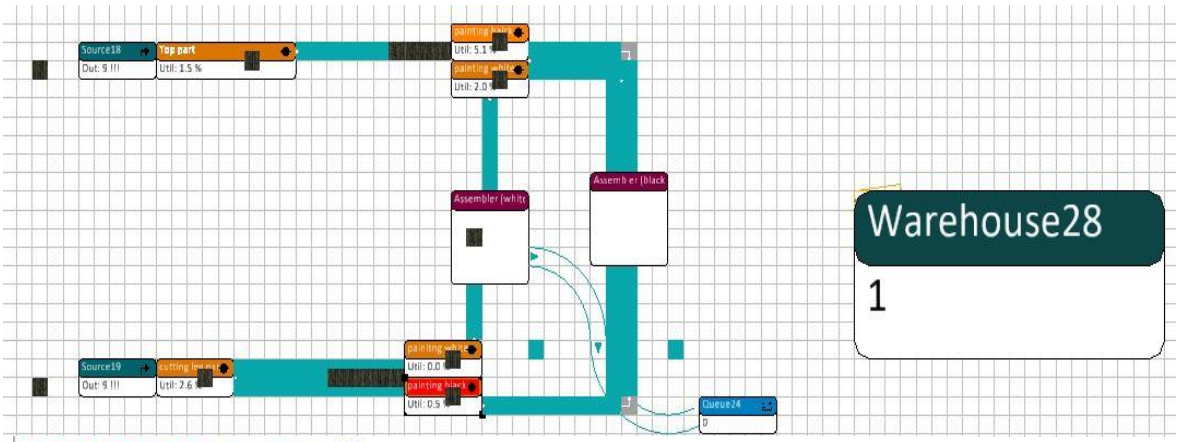
PICTURE 10. The second experiment run (simulation and summary)

After we got result of the 2nd experiment, we can analysis how much different we can see on it. As we can see on the top part of the 1st experiment, there is only 1,7% utility (PICTURE 11) but in the second experiment we got 4,5% utility (PICTURE 12). And in leg part we can see same thing it changes from 1.7% (PICTURE 11) to 3.1% (PICTURE12) utility. At the end, the output was the same. Still, we decided to do a 3rd experiment.

In the third experiment we decided to change parameters in the painting part as follows.

TABLE 4. Atom`s parameter change in detail

Atom	Parameter	Before	After
Painting black/white	Cycle time	Negexp (120) 2min	Negexp (1200) 20min
	Mttf	Negexp (10)	Negexp (1200) 20min
	Mttr	Negexp (10)	Negexp (2400) 40min



summary report

name	content current	content average	throughput input	throughput output	staytime average
Top part	1	1.000	9	8	3406.486
cutting leg par	1	1.000	9	8	3490.570
Accumulating Co	4	1.584	8	4	4817.049
Accumulating Co	5	1.608	8	3	2610.211
painting balck	1	0.694	2	1	14855.301
painitng white	1	0.739	1	0	0.000
Accumulating Co	0	0.000	1	1	5.000
Copy of Accumul	0	0.218	1	1	6276.578
Assembler (blac	0	0.001	2	2	11.266
Transporter12	0	0.000	1	1	12.093
painting black	1	0.858	2	1	13303.912
painting white	1	0.826	2	1	11144.504
Source18	1	0.997	10	9	3019.098
Source19	1	0.997	10	9	3093.840
Accumulating Co	0	0.000	1	1	5.000
Accumulating Co	0	0.000	0	0	0.000
Assembler (whit	1	0.439	1	0	0.000
Transporter21	0	0.000	0	0	0.000
Product	0	0.000	0	0	0.000
Product	0	0.000	0	0	0.000
Advanced Accumu	0	0.000	0	0	0.000
Copy of Advance	0	0.000	0	0	0.000
Queue24	0	0.000	0	0	0.000
Accumulating Co	0	0.000	1	1	8.000
Accumulating Co	0	0.000	1	1	7.000
Corner Transfer	0	0.000	1	1	1.000
Corner Transfer	0	0.000	1	1	1.000
Warehouse28	1	0.177	1	0	0.000

Model start time	Monday, October 19 2020 11:46:42
Model end time	Monday, October 19 2020 19:46:42
Runlength (seconds)	28800.00

End of report.

PICTURE 11. The third experiment run (simulation and summary)

.

6.2.5 Analysis the result

From the above experiment, we did not find big differences for running only 8hrs but there were some changes in the server where we change the parameter. If the process runs for a long time, we can the difference on those changed parameters and the process of the production. Even though there are a few changes in the simulation than it might bring some big different result in the real life. Here is the result we have seen in the above results.

TABLE 5. Difference between 1st, 2nd, and 3rd experiment in Atoms

First experiment	Second experiment	Third experiment
Top part: 1,7 utility	Top part: 4,5%utility	Top part: 1,5% utility
Leg part: 1,7% utility	Leg part: 3,1% utility	Leg part: 2,6% utility
Top part black: 0,6% utility	Top part black: 0,2% utility	Top part black:5,1% utility
Top part white: 0,2% utility	Top part white: 0,0% utility	Top part white: 2,0% utility
Leg part black:2,9%utility	Leg part black:0,0 utility	Leg part black:0,5% utility
Leg part white:0,1utility	Leg part white:0,3%utiltiy	Leg part white:0,0% utility

As we can see, the differences between three experiments. Some servers have huge difference in the utility, but some has not big difference in percentage even after some changes in parameters. Those change might be seen in a real-life process in week or month while process are in action.

7 CONCLUSION

This thesis has two motives; the first one is to find out the best layout for the production house. Layout of the production has always play most vital role in production. Because through layout planning it determine the process of the production which calculate the time of the production and shows the most effective and efficiency of work. If the production consumes the time than it would not be economical where production cost will be high and product also. The high production cost will directly affect in the customer price also. While company motive is to sell in medium where any customer can afford.

The second motive is planning the process to produce dining table. Production process is the second most important thing. In the process, every small part which take vital role on it. If one thing fails, it has an effect for the whole process. So, every step must plan according the process and the design. Same with layout: if this also took extra time, it might lead same result as layout did. And every machinery or the equipment must be placed according to the process.

For the production design we have used simulation application which helps to avoid the failures in real life. Through this, we can avoid the real-life failure and improve the processes also. Everything is not perfect, there is always small room for the improvement but if we can avoid the big incident for the process which can cause more cost and time than small amount investment is always better. Through simulation work, a fully development product model and smoothly running production process can give solution to almost every question (Sharma 2015).

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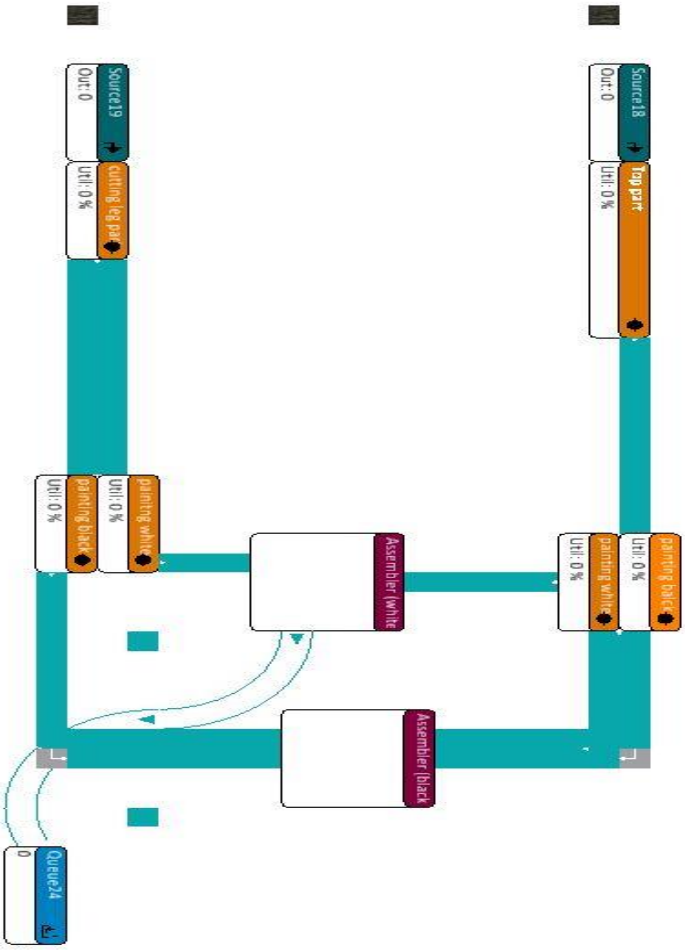
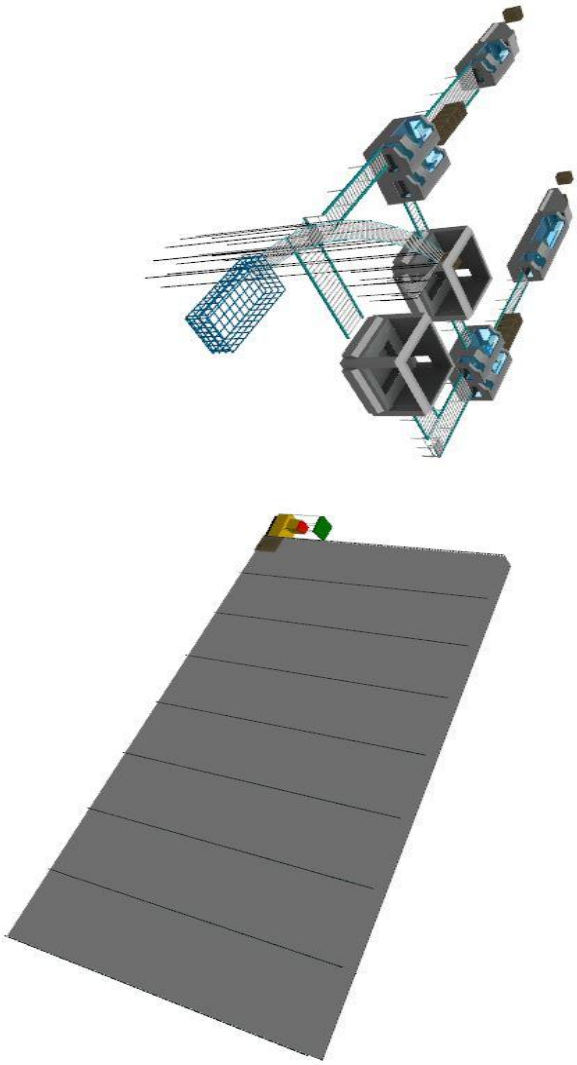
2D view of the simulation project



3D view of simulation project



Used atoms in simulation project