PRODUCTIVITY IMPROVEMENT USING INDUSTRIAL ENGINEERING TOOLS: A CASE OF KITCHEN UTENSIL MANUFACTURING UNIT

Thesis submitted to Shri Ramdeobaba College of Engineering & Management, Nagpur in partial fulfillment of requirement for the award of degree of

Bachelor of Engineering

In

MECHANICAL ENGINEERING

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2016-17

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CERTIFICATE

This is to certify that the following students of **Shri Ramdeobaba College of Engineering and Management, Nagpur** have successfully completed the project titled **'Productivity Improvement using Industrial Engineering Tools: A Case of Kitchen Utensil Manufacturing Unit'** for the academic session **2016-17**.

The students have proposed a lean plant layout for the production of 'Ganj' & 'Dabba' that would reduce material travel. It is anticipated that incorporating this layout will boost production and accrue economic benefits as well.

We appreciate the sincere efforts of the students during this project and wish them good luck for future endeavours.

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CERTIFICATE

This is to certify that the Thesis on **"Productivity Improvement using Industrial Engineering Tools: A case of Kitchen Utensil Manufacturing Unit"** is a bonafide work of **Aniket Kulkarni, Ishaan Tiwari, Kapil Malu and Rajat Pathak** submitted to the Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur in partial fulfillment of the award of a Bachelor of Engineering, in Mechanical Engineering. It has been carried out at the Department of Mechanical Engineering, Shri Ramdeobaba College of Engineering and Management, Nagpur during the academic year 2016-2017.

Date: 15/5/17

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DECLARATION

We, hereby declare that the thesis titled **"Productivity Improvement using Industrial Engineering Tools: A case of Kitchen Utensil Manufacturing Unit"** submitted herein, has been carried out in the Department of Mechanical Engineering of Shri Ramdeobaba College of Engineering & Management, Nagpur. The work is original and has not been submitted earlier as a whole or part for the award of any degree / diploma at this or any other institution / University.

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This thesis entitled "Productivity Improvement using Industrial Engineering Tools: A case of Kitchen Utensil Manufacturing Unit" by **Aniket Kulkarni, Ishaan Tiwari, Kapil Malu and Rajat Pathak** is approved for the degree of a Bachelor of Engineering in Mechanical Engineering.

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Supervisor(s)	External Examiner(s)
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Date: 15/5/17

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ABSTRACT

The present techno-economic scenario is marked by increasing competition in all sectors, especially for small and medium scale manufacturing industries that cater to a variety of demands and expectations from customers. Apart from having access to the latest technology and all other resources, a well-designed production layout makes an equally significant contribution towards productive work. Hence, there is a need of designing industrial layouts which minimize material handling, improve efficiency and reduce worker fatigue.

Aluminium domestic utensils are used widely in both urban and rural areas. Due to their durability, low cost and other factors, these items find a market in all places without much difficulty and fetch some money even after being scrapped. Balaji Trading Company, Yerla, Nagpur is a manufacturer of aluminum utensils, trader of non-ferrous metal scrap, brass scrap, aluminum scrap and copper scrap. This project has been carried out there with the aim of boosting the plant output using Industrial Engineering Tools.

Three major problem statements were identified at the plant with the objective of utilizing various Productivity Improvement Techniques. Out of those, the problem of improving the layout arrangement using Systematic Layout Planning (SLP) was chosen as the focus of this project. For that, a comprehensive study of the existing setup was carried out. The flow processes of the two majorly manufactured products, Ganj and Dabba, were studied in detail. Thereafter, a lean layout was developed by applying the tools of Systematic Layout Planning keeping in view the productivity improvement of the two products.

The new layout, if incorporated, would considerably reduce the material travel for the Ganj and Dabba, and provide a smooth forward flow of work. It would also promote a much better utilization of the available space with the added benefit of reduced worker fatigue. The reduction in material flow itself would provide a significant reduction in the cycle times of both the products. This increased output would accrue economic gains within a short span of time.

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CHAPTER 1
INTRODUCTION

1.1 PRODUCTIVITY

The productivity is more than what its technical definition suggests. It is the driving force or dynamism behind developing and upgrading the quality of industrial activities. (Technical definition: The ratio between input and output) The concept of productivity will change depending on what is expected of industrial activities. Productivity is, above all, a state of mind-set. It is an attitude that seeks the continuous improvement of what exist. It is a conviction that one can do better today than yesterday, and that tomorrow will be better than today. Furthermore, it requires constant efforts to adapt economic activities to ever-changing conditions, and the application of new theories and methods. It is a firm belief in the progress of humanity. The term productivity can be used to examine efficiency and effectiveness of any activity conducted in an economy, business, government or by individuals. Efficiency, effectiveness and productivity can also be evaluated for businesses in service sector. Accordingly, it is essential to study productivity in order to:-

- Understand the processes of a business
- Control the business processes
- Continuously improve processes
- Assess performance of a business
- Determine a business ability to sustain in the long run

Productivity becomes the dominant issues in the market place where customers make their buying decisions based on product quality, sometimes they can pay more for what they consider as high quality product.

1.2 PRODUCTIVITY IMPROVEMENT

Productivity improvement is one of the core strategies towards manufacturing excellence and it also is necessary to achieve good financial and operational performance. It enhances customer satisfaction and reduce time and cost to develop, produce and deliver products and service. Productivity has a positive and significant relationship to

performance measurement for process utilization, process output, product costs, and work-in-process inventory levels and on-time delivery. Improvement can be in the form of elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time. Three guiding principles:
1) Increase of Employment (Later developed into the employment security concept)
2) Labour Management Consultation and Co-operation on an Equal Footing
3) Fair Distribution of Productivity gains among Management, Labour, and Consumers.

1.3 INDUSTRIAL ENGINEERING TOOLS

"Industrial engineering" is concerned with the design, improvement, and installation of integrated system of men, materials and equipment. It draws upon specialized knowledge and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems."

Various Industrial Engineering Tools are:

1) **SMED**: **Single-Minute Exchange of Die** (**SMED**) is one of the many lean production methods for reducing waste in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. This rapid changeover is key to reducing production lot sizes and thereby improving flow reducing production loss and output variability. The phrase "single minute" does not mean that all changeovers and start-ups should take only *one* minute, but that they should take less than 10 minutes (in other words, "single-digit minute"). Closely associated is a yet more difficult concept, **One-Touch Exchange of Die**, **(OTED)**, which says changeovers can and should take less than 100 seconds. A die is a tool used in manufacturing. However SMED's utility of is not limited to manufacturing. Techniques that should be considered in implementing SMED.

1. Separate internal from external setup operations
2. Convert internal to external setup
3. Standardize function, not shape

4. Use functional clamps or eliminate fasteners altogether
5. Use intermediate jigs
6. Adopt parallel operations (see image below)
7. Eliminate adjustments
8. Mechanization

2) **Systematic layout planning work**: The benefit of using procedural approach in facility layout problem is that it involves both quantitative and qualitative factors. Thus, for developing plant layout SLP is used. It provides step-by-step guidelines for plant design from input data to evaluation of plant layout. The downslide of SLP is that it requires thorough initial research on existing flows, procedures and activities of the facility.

SLP has three macro steps: (i) Analysis (ii) research and (iii) selection.

Thus, SLP is often modified with respect to system requirement and adaptability.

3) **Lean manufacturing**: **Lean manufacturing** is “A systematic approach for identifying and eliminating waste through continuous improvement by flowing the product at the pull of customer in pursuit of perfection”. Lean manufacturing concepts are mostly applied in industries where more repetitive human resources are used. In these industries productivity is highly influenced by the efficiency working people with tools or operating equipment. To eliminate waste, it is important to understand exactly what it is and where it exists. The processes add either value or waste to the production of goods. Some commonly mentioned goals are:

- Improve quality: To stay competitive in today's marketplace, a company must understand its customers' wants and needs and design processes to meet their expectations and requirements.
- Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service.
- Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.

- Reduce total costs: To minimize cost, a company must produce only to customer demand. Overproduction increases a company's inventory costs because of storage needs.

4) **Process analysis**: Process analysis is a form of technical writing and expository writing designed to convey to the reader how a change takes place through a series of stages .While the traditional process analysis and a set of instructions are both organized chronologically, the reader of a process analysis is typically interested in understanding the chronological components of a system that operates largely without the reader's direct actions, while the reader of a set of instructions intends to use the instructions in order to accomplish a specific, limited task.

5) **Standardization: Standardization** is the process of implementing and developing technical standards based on the consensus of different parties that include firms, users, interest groups, standards organizations and governments. Standardization can help to maximize compatibility, interoperability, safety, repeatability or quality. It can also facilitate commodization of formerly custom processes.

CHAPTER 2
INDUSTRY DETAILS

2.1 INDUSTRY PROFILE

Balaji trading company is a manufacturer of aluminum utensils, trader of non-ferrous metal scrap, brass scrap, aluminum scrap and copper scrap.

- Industry :- Balaji Trading Company
- Location:- Yerla, Nagpur
- Products manufactured:- Aluminium Utensils
- Raw material:-Aluminium Wires and Spray Cans.
- Average Production:- 800 Kg per day
- Number of workers:- 70
- Operating Hours:- 9AM to 5:30PM
- Turnover :- 3 cr

2.2 EXISTING PLANT LAYOUT

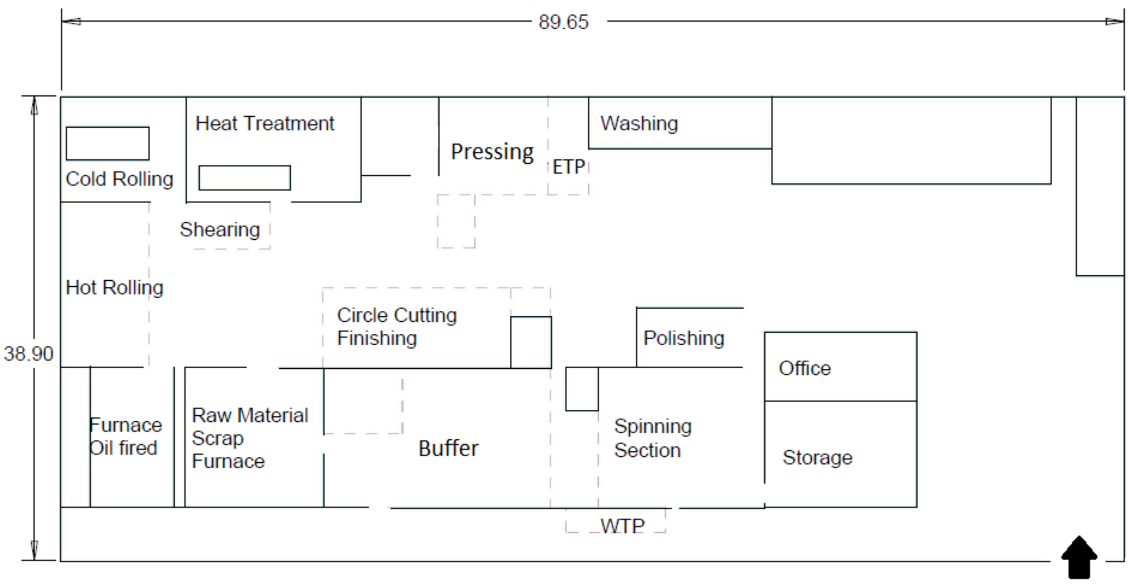

Figure 1: Existing Layout

- This is a **To The Scale** sketch of the existing plant layout sketched in CREO.
- The only entrance used in this plant is also used as the exit.
- The solid lines represent the walls and compartments occupying machineries in the industry.
- The dotted lines denote the compartments formed due to stacking of finished and semi-finished utensils.
- The top portion on the right side is reserved for an upcoming Idli pot manufacturing unit. This space was not considered for the study of the existing layout.

2.3 PRODUCTS MANUFACTURED

Apart from all the various utensils, there are 2 primary products manufactured:

1) GANJ

Figure 2: Ganj

2) DABBA

Figure 3: Dabba

SIZES: 10”-36”

2.4 PROCESSES INVOLVED IN PRODUCTION

The following section deals with the processes that are involved in the production of aluminium utensils. The primary processes in the production of Ganj and Dabba are described below:

1. MELTING IN FURNACE

The Aluminium raw material (wire & cans) along with scrap is melted in the furnace at 750ºC. Slag is removed from the top.

Figure 4: Furnace

2. CASTING

The molten metal is poured into rectangular slab moulds for casting.

Figure 5: Casting

3. HOT ROLLING

After casting, the slabs are hot rolled to increase their length. Slabs are elongated to a length of 108” and a width of 16” in 6 passes through the rollers.

Figure 6: Hot Rolling Machine

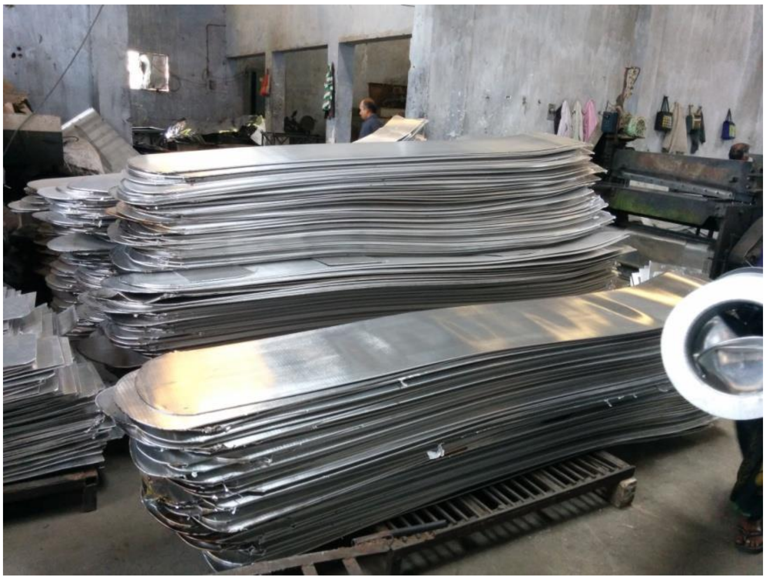

Figure 7: Hot Rolled Sheets

4. COLD ROLLING

The sheets are cooled for a day after Hot Rolling. The sheets are then cut according to the required width and then sent for Cold Rolling.

Figure 8: Cold Rolling Machine

5. SQUARE CUTTING

Cold Rolled sheets are sent to the shearing machine for cutting into squares of the required size. If a circle of diameter 19” is to be made a square of 20x20” is cut.

Figure 9: Shearing Operation

6. CIRCLE CUTTING

The circle of the required diameter is cut and then the lot is sent for annealing.

Figure 10: Circle Cutting

7. ANNEALING

Using the heat treatment process of annealing, the sheets become soft while their toughness increases. The sheets are sent in a batch size of 1000 which is according to the storage capacity of the annealing machine. The sheets are annealed for 3 hours (180 minutes).

8. STAMPING

At this station the sheets are stamped with the following things:

a) No of the sheet in that lot (batch).
b) The diameter of that sheet.

9. PRESSING

This facilitates the pressing operation. The sheets are then pressed using the press machine to create the Ganj.

Figure 11: Pressing Machine

Processes till the pressing operation constitute the common procedure adopted for making the two products. After that the products are sent through their respective procedures for manufacture of Ganj and Dabba.

1) FOR GANJ

1. COLLAR CUTTING

The Collar of the Ganj is cut to make it uniform in width.

Figure 12: Collar Cutting

2. FINISHING

The finishing process is carried out to give a smooth surface finish to the inside of the Ganj.

3. WASHING

The Utensils are washed with alternate baths of acid and water.

Figure 13: Washing Area

4. STORAGE

The finished products are stored in the storage area.

2) FOR DABBA

1. SPINNING

   The spinning process is fairly simple. A formed block is mounted in the drive section of a lathe. A pre-sized metal disk is then clamped against the block by a pressure pad, which is attached to the tailstock. The block and product are then rotated together at high speeds. A localized force is then applied to the product to cause it to flow over the block. The force is usually applied via various levered tools. Metal spinning does not involve removal of material, as in conventional wood or metal turning, but forming (moulding) of sheet material over an existing shape.

2. WASHING

   The Utensils are washed with alternate baths of acid and water.

3. POLISHING

The utensils are polished to give a final surface finish.

Figure 14: Polishing

4. STORAGE

The finished products are stored in the storage area.

2.5 PROBLEMS IDENTIFIED

This section deals with the problems (along with their potential solutions) that were identified at the industry, which could be tackled as a goal of this project.

1) To reduce the Changeover time for Pressing Die

Dies of various sizes are required to produce Ganj of different sizes. The long Changeover time is a significant obstacle that hampers the productivity of the plant.

PRESENT SITUATION

- Chain pulley block arrangement
- Weight: 100-200 kg
- Changeover Time: 60-90 min
- Operation halted
- 2 laborers engaged

Figure 15: Pressing Machine

APPROACH

Single Minute Exchange of Dies (SMED)

Single-Minute Exchange of Die (**SMED**) is one of the many lean production methods for reducing waste in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. This rapid changeover is key to reducing production lot sizes and thereby improving flow, reducing production loss and output variability.

The phrase "single minute" does not mean that all changeovers and start-ups should take only *one* minute, but that they should take less than 10 minutes (in other words, "single-digit minute"). Closely associated is a yet more difficult concept, **One-Touch Exchange of Die**, **(OTED)**, which says changeovers can and should take less than 100 seconds. A die is a tool used in manufacturing. However SMED's utility of is not limited to manufacturing.

A successful SMED program will have the following benefits:

- Lower manufacturing cost (faster changeovers mean less equipment down time)
- Smaller lot sizes (faster changeovers enable more frequent product changes)
- Improved responsiveness to customer demand (smaller lot sizes enable more flexible scheduling)

- Lower inventory levels (smaller lot sizes result in lower inventory levels)
- Smoother startups (standardized changeover processes improve consistency and quality)

In SMED, changeovers are made up of steps that are termed "elements". There are two types of elements:

1. Internal Elements (elements that must be completed while the equipment is stopped)
2. External Elements (elements that can be completed while the equipment is running)

The SMED process focuses on making as many elements as possible external, and simplifying and streamlining all elements.

2) Design of Workstation for Stamping Operation

The stamping operation involves the punching of brand logo and size on the heat treated circles before they are pressed to form the Ganj. This process employs one labourer.

PRESENT SITUATION

- Circle Cutting → Stamping → Pressing
- No proper workstation
- Ineffective Space Utilization
- Time Consuming and Labor Intensive Activity

APPROACH

The approach to overcome this problem would be to design an effective work station keeping in mind the following factors.

- Concern of Appropriate Location
- Possibility of Clubbing with Circle Cutting Operation
- Ergonomics for suitable workstation
- Time Reduction

3) To improve layout design to enhance productivity.

The processes carried out in the plant are not in harmony with the layout in place. The situation is haphazard with numerous factors hampering the overall efficiency of the plant. The layout design has serious scope for improvement in this industry.

PRESENT SITUATION

- Haphazard Arrangement
- Improper Material Handling
- No well-defined Material Flow
- Clobbering Adjustment due to Stacking at every workstation

Figure 16: Stacking of Utensils

APPROACH

Systematic Layout Planning (SLP)

The **systematic layout planning** (SLP) is a tool used to arrange a workplace in a plant by locating areas with high frequency and logical relationships close to each other. The process permits the quickest material flow in processing the product at the lowest cost and least amount of handling.

Systematic layout planning is an organized way to conduct layout planning. It consists of a framework of phases, a pattern of procedures and a set of conventions for identifying, rating and visualizing the elements and areas involved in a plan. Each layout rests on three fundamentals:

- **RELATIONSHIPS** – degree of closeness desired among things
- **SPACE** – the amount, kind, shape of configuration of the things to be laid out
- **ADJUSTMENTS** – arrangement of things into a realistic best fit

These are the heart of any layout plan regardless of products, processes or size of project.

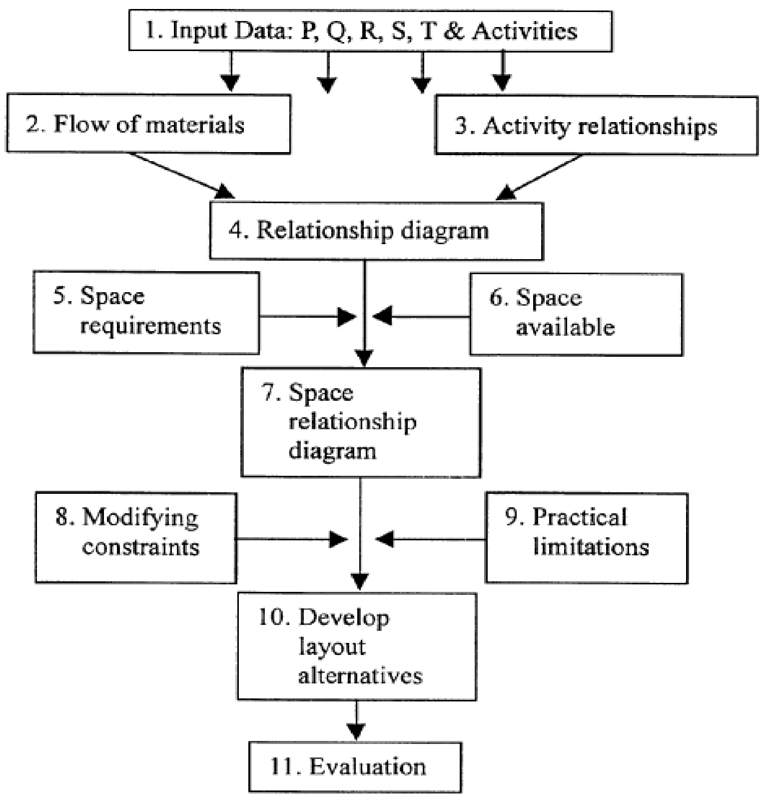

Figure 17: Systematic Layout Planning

2.6 PROJECT OBJECTIVE

Of the 3 problems identified at Balaji Trading Company, the third one of **improving the plant layout** and hence boosting productivity has been chosen as the objective of this project. The process of designing a lean plant layout involves the application of the Industrial Engineering tool of **Systematic Layout Planning (SLP).**

The technique of SLP proves to be an excellent medium for arrangement of a workplace. It involves placing workstations or areas together that share **a logical relationship with each other**. Prioritizing is done by considering the relation of each workstation with every other station. The space requirements and the space available is computed and **a lean layout** is developed considering the existing constraints and practical limitations. The layout so developed promotes the following:

1. Quickest possible material flow
2. Effective Space Utilization
3. Systematic and Convenient arrangement of workstations
4. Lower production costs
5. Least Material Handling
6. Improvement in productivity

The procedure of SLP will require the existing layout to be studied thoroughly. **Work and Method studies** will need to be carried out to study the processes taking place in the plant. **The drawbacks of the existing setup** will be identified along with the areas where improvement can be made. Following the above mentioned approach of SLP, a lean layout will be developed that would aim to **reduce or eliminate the identified drawbacks.**

The following ways of improving productivity at Balaji Trading Company have been identified:

1. Reduce Excess work content
2. Devise new and better methods to do jobs
3. Reduce Cycle Time
4. Increase workstation capacity
5. **<u>Reduce Material Handling</u>**

Of the above options, the last one of reducing material travel by developing a lean layout is the focus of this project. Reduction in material handling has been chosen because Balaji Trading Company provides a tremendous scope of improvement when it comes to their layout. The existing cumbersome and clobbering setup makes it difficult for workers to move around the plant and hence transport material. The proposed layout, if incorporated, would make better utilization of the available space. It would provide a smooth and streamlined path for material travel that would reduce the traveling time as well as worker fatigue. It will make a significant impact on the production rate and hence boost output.

CHAPTER 3

LITERATURE REVIEW

Since the project work deals with the design and development of a plant layout, study of existing processes, cycle times, and material flow were required to be done. Hence, some literature and research papers were studied to understand the logical way of developing a lean plant layout that boosts productivity.

3.1 PLANT LAYOUT

Plant layout study is an engineering study used to analyze different physical configurations for a plant. The ability to design and operate manufacturing facilities that can quickly and effectively adapt to changing technological and market requirements is becoming increasingly important to the success of any manufacturing organization. In short, manufacturing facilities must be able to exhibit high levels of flexibility and robustness despite significant changes in their operating requirements.

Plant layout or facility layout planning (FLP) of an industry means planning for the location of all machines, working areas, offices and any other utilities for efficient and smooth production. It is essential to have a well-developed plant layout for all the available resources in an optimum manner and get the maximum out of the capacity of the facilities. The efficiency of production depends on how well the various machines, services production facilities and employee's amenities are located in a plant.

3.1.1 OBJECTIVES OF A GOOD PLANT LAYOUT

- Streamline the flow of materials through the plant.
- Minimizing delays in production and making efficient use of the space that is available.
- Flexibility of manufacturing operations and arrangements.
- Having better control over the production cycle by having greater flexibility for changes in the design of the product.
- The production bottle necks and points of congestions are to be eliminated so that input raw materials and semi-finished parts move fast from one work station to another.

3.1.2 PRINCIPLES OF PLANT LAYOUT

1. **Principle of integration:** A good layout is one that integrates men, materials, machines and supporting services and others in order to get the optimum utilization of resources and maximum effectiveness.
2. **Principle of minimum distance:** This principle is concerned with the minimum travel (or movement) of man and materials. The facilities should be arranged such that, the total distance travelled by the men and materials should be minimum and as far as possible straight line movement should be preferred.
3. **Principle of cubic space utilization:** The good layout is one that utilize both horizontal and vertical space. It is not only enough if only the floor space is utilized optimally but the third dimension, i.e., the height is also to be utilized effectively.
4. **Principle of flow***:* A good layout is one that makes the materials to move in forward direction towards the completion stage, i.e., there should not be any backtracking.
5. **Principle of maximum flexibility:** The good layout is one that can be altered without much cost and time, i.e., future requirements should be taken into account while designing the present layout.
6. **Principle of safety, security and satisfaction:** A good layout is one that gives due consideration to workers safety and satisfaction and safeguards the plant and machinery against fire, theft, etc.
7. **Principle of minimum handling:** A good layout is one that reduces the material handling to the minimum.

3.1.3 TOOLS AND TECHNIQUES OF PLANT LAYOUT

The quality and quantity of the data on various factors is required to develop a good layout. The data is to be collected regarding the various processes, sequence of operations, material, flow, and frequency of travel, space requirements, activities and their relationships. The following tools and techniques are to analyze the data-

1) Process charts- (operation process charts, flow process charts)
2) Travel Chart
3) Diagrams-(flow diagram and string diagrams)
4) REL-(Relationship chart)
5) Templates
6) Scaled models

3.2 RESEARCH PAPERS

1) Keerthi UR, Dr.M S Jayamohan, “**Optimization Of Plant Layout For A State Road Transport Corporation.** In this research paper some of the major problems regarding the present layout of the bus body building unit are identified. Objective of this paper include application of CRAFT (Computerized Relative Allocation of Facilities Technique) SLP (systematic layout planning), QAP (Quadratic Assignment Problem), and Basic models like Assembly line balancing. The production rate increased by 17%, the production time per bus came down by 5% and the cost of construction came down by 15% .By optimizing the layout design, the total manufacturing cost that can be saved per bus is Rs.76, 846.

2) Pramod P. Shewale, Manmath S. Shete, **“Improvement In Plant Layout Using Systematic Layout Planning For Increased Productivity”.** The objective of this research is to study plant layout of compressor manufacturing based on the systematic layout planning pattern theory (SLP) for increased productivity. The operation process chart, flow of material and activity relationship chart have been used in analysis. The problem of the plant was determined and analyzed through SLP method to plan the relationship between the equipments and the area. Finally, proposed layout decreased flow of material, resulting in reduction in waste and increased production. The new plant layout improves the process flow through the plant, and help to increase space in industry.

3) Vivekanand , et al. **“Efficiency Improvement of a Plant Layout.** The objective is to study and improve the current plant layout, analyze & design by using string diagram. An Attempt is made to simulate the current and proposed factory layout by using ARENA software. The research paper presents solving an industrial problem using the principle of string diagram and simulation software to minimize the total distance of the material travelled. A simulation study was under taken to find out the overall efficiency of the plant. The proposed plant layout efficiency is 126.05% which is greater than the efficiency of the current plant layout i.e., 68.02%. The efficiency improvement of the plant was increased up to 85.31%. And the reduction in transportation length of 46% was achieved.

4) Ravikumar Kamble, Vinayak Kulkarni, "**Productivity Improvement at Assembly Station Using Work Study Techniques".** The objective of this research is to study the cycle time and existing method of different work stations and suggesting improved method for the same so as to reduce the cycle time and to improve productivity. The existing motions are analyzed using VWS (Video works software). The unwanted motion involved in the operation of assembly has been substantially reduced by designing assembly table, fasteners tray and design of proper work place layout. The ineffective time associated with the assembly operation has been reduced by suggesting a proper sequence of operations which reduces the time of assembly of 10 inch actuator. The existing method takes a time of 45.49 minutes for the assembly of the alternator. The proposed method of assembly 10 inch actuator takes a time of 30.94 minutes**.** For one assembly of 10 inch actuator the operator saves a time 14.55 minutes.

5) Chandra Shekhar Tak, Mr.Lalit Yadav, "**Improvement in Layout Design using SLP of a small size manufacturing unit: A case study".** The paper presents an application of the SLP (System Layout Planning) method for establishing, in an efficient manner, the layout of a productive enterprise. A case study is described in the paper, referring to a factory designated for manufacturing steel almirah. The phases of the SLP method application are described in the paper together with the presentation of one particular product given as example. The optimal solution of the productive system's layout is selected by analyzing three possible identified alternatives.

6) Filippo De Carlo, Maria Antonietta Arleo, Orlando Borgia and Mario Tucci, **"Layout Design for a Low Capacity Manufacturing Line: A Case Study"**. The results of a fashion manufacturing line re-layout were compared by 24nalyzing the current situation with the solutions provided by a ″homemade″ company design, both through a systematic layout planning approach and a broader lean reengineering activity. In order to evaluate the effectiveness of each solution, the different

alternatives were compared with the help of a discrete event simulator, 25nalyzing productivity, transportation times and costs. The result of the case study showed a slight advantage with the lean approach in considering such efficiency indicators. In addition, the lean production methods allowed the designers to identify some in-efficiencies that other approaches could not see, since the latter did not focus on production in a holistic way.

7) Ajit Pal Singh, Manderas Yilma, **"Production Floor Layout Using Systematic Layout Planning in Can Manufacturing Company"**. This paper presents an analysis on a production shop floor layout of a Can manufacturing company and the application of a systematic layout planning (SLP) procedure as an approach to solve the production shop floor layout problem. The relationship between machines, operation activities and material flow are used to determine the optimal location of each machine. SLP technique has been employed to design the two alternative production shop floor layouts and compare the performance between new layout and present layout in terms of material flow distance, traveling time, and traveling cost. The existing production process was inefficient, showing bottlenecks. The alternative layouts were developed based on minimum distance traveled between each pair of machine. It improved the company existing layout by reduced total movement traveled in production for material handling. The measurements covered the actual sizes of the layout and machines, activities between machines, distance between machines, and material flow between machines in the company. The proposed procedure is illustrated to be a viable approach for solving production shop floor layout design problem through a real-world case study. From the proposed two alternative layouts which are more economical, distance of the production flow can be shortened from 389.7m to 311.2m or 360.6m. The traveling time can be reduced from 901sec. to 750sec. and traveling cost can be reduced from 3.17 Birr to 2.98 or 2.19 Birr per each travel resulting increase in productivity.

8) Orville Sutari, Sathish Rao U, **"Development Of Plant Layout Using Systematic Layout Planning (SLP) To Maximize Production – A Case Study".** The objective

of this research was to study the existing plant layout of a nacelle production unit and to design a lean plant layout using SLP (Systematic Layout Planning) to increase its productivity. Analysis of the existing plant layout was made by studying aspects like flow of materials, activity relationships and space requirements. New plant layout alternatives were designed and compared to the existing layout. The new plant layout finally selected showed a significant decrease in the distance of material and work flow travel and resulted in increasing the productivity of the unit.

9) W.Wiyaratn, A. Watanapa, and P. Kajondecha, **“Improvement Plant Layout Based on Systematic Layout Planning”**. The purpose of this research was to modify the present plant layout of canned fish. The alternative plant layout of canned fish in term of material flow, activity relationship the optimum process areas and locations has been designed by systematic layout planning (SLP) method. Factors studied in canned fish factory were consisted of numbers of machines, space requirements, and process area. The problem in term of material flow of each operation section was indentified. With the SLP method, alternative plant layout significantly decreased the distance of material flow.

10) W. Wiyaratn, and A. Watanapa, **“Improvement Plant Layout Using Systematic Layout Planning (SLP) for Increased Productivity”**. The objective of this research is to study plant layout of iron manufacturing based on the systematic layout planning pattern theory (SLP) for increased productivity. In this case study, amount of equipments and tools in iron production are studied. The detailed study of the plant layout such as operation process chart, flow of material and activity relationship chart has been investigated. The new plant layout has been designed and compared with the present plant layout. The SLP method showed that new plant layout significantly decrease the distance of material flow from billet cutting process until keeping in ware house.

11) Subodh B Patil, S.S.Kuber**, “Productivity Improvement In Plant By Using Systematic Layout Planning (SLP) – A Case Study Of Medium Scale Industry”.** The objective of this research was to study the existing plant layout of manufacturing unit and improve it using systematic layout planning theory (SLP) for better plant area utilization and increased productivity. In this paper we highlighted some problems faced by one medium scale Auto Ancillary company. The layout of the firm was the main concern regarding the operations conducted and material flow in the assembly line. Company focuses mainly to improve the productivity of plant. Systematic layout planning (SLP) approach was used to improve existing layout of the company. The detailed study of the plant layout such as operation process chart, flow of material and activity relationship chart had been investigated. Final layout was selected by installation of new machine with effective utilization of area to improve productivity.

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CHAPTER 4
DATA COLLECTION

4.1 TRAVEL DISTANCES AND TIME

Table 1: Travel Distances & Time

SR NO	FROM	TO	DISTANCE (in m)	TIME (in sec)	BATCH SIZE	TIME FOR 1 UNIT=TIME/BATCH SIZE
1	Furnace	Moulds	7	10	36	0.27
2	Moulds	Hot Rolling	15	15	36	0.41
3	Hot Rolling	Shearing	6	30	180	0.16
4	Shearing	Cold Rolling	12	30	180	0.16
5	Shearing	Circle Cutting	15	20	60	0.33
6	Circle Cutting	Heat Treatment	18	30	60	0.5
7	Heat Treatment	Stamping	21	20	60	0.33
8	Stamping	Pressing	11	10	30	0.33
9	Pressing	Spinning	40	40	30	1.33
10	Spinning	Washing	26	30	60	0.5
11	Washing	Polishing	16	20	60	0.33
12	Polishing	Storage	25	20	60	0.33

13	Pressing	Collar Cutting	7	10	30	0.33
14	Collar Cutting	Finishing	15	15	30	0.5
15	Finishing	Washing	35	45	60	0.75
16	Washing	Storage	35	60	60	1

4.2 PROCESS TIME

Table 2: Process Time

SR NO	PROCESS	TIME PER UNIT (in sec)	NO. OF MACHINES	TIME FOR 1 MACHINE=TIME/NO. OF MACHINES.(in sec)
1	Heating in Furnace	7200	1	7200
2	Pouring molten metal into moulds	10.044	4	2.51
3	cooling	3.33	_	3.33
4	Hot rolling	3.74	1	3.74
5	Storage of hot rolled plates	1 day	_	1 day
6	Shearing	4.54	1	4.54

7	Cold Rolling	6.67	1	6.67
8	Circle Cutting	5.6	1	5.6
9	Heat Treatment Process	10.8	1	10.8
10	Cooling	3.6	_	3.6
11	Stamping	6.8	1	6.8
12	Pressing	8.57	3	2.85
13	Collar Cutting	3.7	1	3.7
14	Finishing	10	1	10
15	Washing ganj	15	1	15
16	Washing dabba	5	1	5
17	Polishing	30	5	6
18	Spinning	25	5	5

4.3 PRODUCTION SPACE REQUIREMENT

Table 3: Production Space Requirement

No.	Department	Dimensions (l x b)	Area (m^2)
1	Furnace	7x11.7	81.9

2	Hot Rolling	7.4x12.2	90.28
3	Shearing	10.2x4	40.8
4	Cold Rolling	10.6x8.9	94.34
5	Circle Cutting	3.45x9	31.05
6	Annealing	14.7x8.9	130.83
7	Stamping	3.1x4.5	13.95
8	Pressing (Machine +Storage)	(8.6x8.3)+(9x3.45)	102.43
9	Collar Cutting	3.3x2.7	8.91
10	Finishing	3.45x9	31.05
11	Polishing	9x5.1	45.9
12	Spinning	12.9x11.7	150.93
13	Buffer	19.1x11.7	223.47
14	Washing	8x4.4	35.2
15	Storage	12.8x8.9	113.92
16	Office	12.8x5.9	75.52
17	ETP	3.5x8.3	29.05
18	WTP	8.4x2.1	17.64

4.4 WAITING TIME

4.4.1 CALCULATIONS

Unit	1	2	3	4	5	6	…….n
Corresponding Waiting time	0	t	2t	3t	4t	5t	…….(n-1) t

Total delay = $\sum t_r$ = n (n-1) t/2

Average delay = t (n-1)/2

Average delay per unit, D = t (n-1)/2n

n= number of units

m= number of machines

Weight of 18 inch size Ganj = **0.64 kg**

Weight of 18 inch size Dabba = **0.39 kg**

4.4.2 WAITING TIME

Table 4: Waiting Time

SR NO	PROCESS	DELAY=t*(n-1)/n(in sec)
1	Hot Rolling	1.4
2	Shearing	4.31
3	Cold Rolling	6.54
4	Trolley changeover	20
5	Circle cutting	5.5
6	Heat treatment	499.9
7	Stamping	6.76
8	Pressing	2.75
9	Spinning	4.83
10	Polishing	5.9
11	Finishing	9.67
12	Collar Cutting	3.7

4.5 ASSIGNMENT OF CODES TO DEPARTMENT

Table 5: Department Codes

NUMBER/CODE	DEPARTMENT
1	Furnace
2	Hot Rolling
3	Shearing
4	Cold Rolling
5	Circle Cutting
6	Annealing
7	Stamping
8	Pressing
9	Collar Cutting
10	Finishing
11	Polishing
12	Spinning
13	Buffer
14	Washing
15	Storage
16	Office
17	ETP
18	WTP

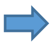
CHAPTER 5

ANALYSIS OF EXISTING LAYOUT

5.1 FLOW PROCESS CHARTS

- The flow process charts represent graphically the sequence of all operations, inspections, transportations, storage and delays occurring during a process or procedure.
- Since flow process charts clearly show all transportations, delays and storage it is helpful in reducing either the quantity or duration of these elements.
- They provide an important basis for revising an existing layout.
- The chart is also used to check the efficiency of a proposed flow plan for a new plant layout.

Table 6: Symbols & Meanings

SYMBOLS	MEANING
	OPERATION
	TRANSPORT
	DELAY
	INSPECTION
	STORAGE

5.1.2 GANJ

Table 7: Flow Process Chart - Ganj

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Heating in Furnace	—	120 min	•					
2.	Carrying the molten metal to the mould	7 m	0.27 sec		•				4 workers
3.	Pouring molten metal into the mould	—	2.51 sec	•					4 workers
4	Cooling period		3.33 sec	•					
5.	Transporting the slabs to the hot rolling m/c	15 m	0.41 sec		•				Batch size=4, 1 worker
6.	Waiting for Hot Rolling	—	1.4 sec			•			
7.	Hot Rolling	—	3.74 sec	•					Batch size=4, 2 workers
8.	Storage of hot rolled plates for cooling	—	1 day					•	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Carrying the plates from storage to shearing m/c	6 m	0.16 sec		•				Batch size=20, 2 workers
2.	Waiting for Shearing	—	4.31 sec			•			
3.	Shearing operation	—	4.54 sec	•					Batch size=20, 2 workers
4.	Shifting sheared plates to cold rolling m/c	12 m	0.16 sec		•				Batch size=60, 2 workers
5.	Waiting for Cold Rolling	—	6.54sec			•			
6.	Trolley Changeover time	—	20 sec			•			2 workers
7.	Cold rolling operation	—	6.67 sec	•					Batch size=60, 2 workers
8.	Carrying the cold rolled plates to the shearing m/c	9 m	0.16 sec		•				Batch size=60, 1 worker

9.	Waiting for Shearing	—	7.14 sec			•			
10.	Shearing operation	—	7.27 sec	•					Batch size=60, 2 workers
11.	Transporting the sheared plates to circle cutting m/c	15 m	0.33 sec		•				Batch size=60(Doubt)
12.	Waiting for Circle Cutting operation	—	5.5 sec			•			
13.	Circle cutting operation	—	5.6 sec	•					Batch size=60, 1 worker
14.	Shifting circles to heat treatment area	18 m	0.5 sec		•				2 workers
15.	Waiting for Heat treatment process	—	499.5 sec			•			
16.	Heat treatment process (Annealing)	—	10.8 sec	•					Batch size=1000
17.	Storing the heat treated plates for cooling	—	3.6 sec					•	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Carrying plates to stamping workstation	21 m	0.33 sec		•				Batch size=60, 1 worker
2.	Waiting for Stamping	—	6.76 sec			•			
3.	Stamping operation	—	6.8 sec	•					1 worker
4.	Carrying the plates to pressing m/c	11m	0.33 sec		•				Batch size=30, 1 worker
5.	Waiting for Pressing	—	2.75 sec			•			
6.	Pressing operation	—	2.85 sec	•					Batch size=30, 2 workers

7.	Transporting the pieces to collar cutting m/c	7 m	0.33 sec		●				Batch size=30, 1 worker
8.	Waiting for Collar Cutting operation	—	3.57 sec			●			
9.	Collar cutting	—	3.7 sec	●					Batch size=30, 1 worker
10.	Carrying the pieces to finishing m/c	15 m	0.5 sec		●				Batch size=30, 2 workers
11.	Waiting for finishing	—	9.67 sec			●			
12.	Finishing process	—	10 sec	●					Batch size=30, 1 worker
13.	Carrying the pieces to washing area	35 m	0.75sec		●				Batch size=60, 4 workers
14.	Washing	—	15 sec	●					Batch size=60, 2 workers
15.	Shifting the product to storage area	35 m	1 sec		●				Batch size=60, 4 workers
16.	Storage	—	—					●	
17.	Inspection	—	—				●		

5.1.2 DABBA

Table 8: Flow Process Chart - Dabba

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Heating in Furnace	—	120 min	●					
2.	Carrying the molten metal to the mould	7 m	0.27 sec		●				4 workers
3.	Pouring molten metal into the mould	—	2.51 sec	●					4 workers
4	Cooling period		3.33 sec	●					
5.	Transporting the slabs to the hot rolling m/c	15 m	0.41 sec		●				Batch size=4, 1 worker
6.	Waiting for Hot Rolling	—	1.4 sec			●			
7.	Hot Rolling	—	3.74 sec	●					Batch size=4, 2 workers
8.	Storage of hot rolled plates for cooling	—	1 day					●	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Carrying the plates from storage to shearing m/c	6 m	0.16 sec		●				Batch size=20, 2 workers
2.	Waiting for Shearing	—	4.31 sec			●			
3.	Shearing operation	—	4.54 sec	●					Batch size=20, 2 workers
4.	Shifting sheared plates to cold rolling m/c	12 m	0.16 sec		●				Batch size=60, 2 workers
5.	Waiting for Cold Rolling	—	6.54sec			●			
6.	Trolley Changeover time	—	20 sec			●			2 workers
7.	Cold rolling operation	—	6.67 sec	●					Batch size=60, 2 workers
8.	Carrying the cold rolled plates to the shearing m/c	9 m	0.16 sec		●				Batch size=60, 1 worker
9.	Waiting for Shearing	—	7.14 sec			●			
10.	Shearing operation	—	7.27 sec	●					Batch size=60, 2 workers
11.	Transporting the sheared plates to circle cutting m/c	15 m	0.33 sec		●				Batch size=60(Doubt)
12.	Waiting for Circle Cutting operation	—	5.5 sec			●			
13.	Circle cutting operation	—	5.6 sec	●					Batch size=60, 1 worker
14.	Shifting circles to heat treatment area	18 m	0.5 sec		●				2 workers
15.	Waiting for Heat treatment process	—	499.5 sec			●			
16.	Heat treatment process (Annealing)	—	10.8 sec	●					Batch size=1000
17.	Storing the heat treated plates for cooling	—	3.6 sec					●	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Carrying plates to stamping workstation	21 m	0.33 sec		•				Batch size=60, 1 worker
2.	Waiting for Stamping	—	6.76 sec			•			
3.	Stamping operation	—	6.8 sec	•					1 worker
4.	Carrying the plates to pressing m/c	11m	0.33 sec		•				Batch size=30, 1 worker
5.	Waiting for Pressing	—	2.75 sec			•			
6.	Pressing operation	—	2.85 sec	•					Batch size=30, 2 workers
7.	Transporting the pieces to spinning m/c	40 m	1.33 sec		•				Batch size=30, 2 workers
8.	Waiting for Spinning	—	4.83 sec			•			
9.	Spinning Operation	—	25/5=5 sec	•					Batch size=30, 3 workers
10.	Carrying the pieces to washing area	26 m	0.5 sec		•				Batch size=60, 2 workers
11.	Washing	—	5 sec	•					Batch size=60, 2 workers
12.	Carrying the pieces from washing area to polishing	16 m	0.33 sec		•				Batch size=60, 1 worker
13.	Waiting for polishing	—	5.9 sec			•			
14.	Polishing	—	30/5= 6 sec	•					Batch size=60, 1 worker
15.	Shifting the product to storage area	25m	0.33 sec		•				Batch size=60, 4 workers
16.	Storage	—	—					•	
17.	Inspection	—	—				•		

5.2 CALCULATIONS

5.2.1 GANJ

- From the flow process chart, production time per unit = **50.12 sec/unit**.
- We know that, Total working hours per day = **8 hours**
- Therefore daily total production of Ganj =8 x (3600/50.12) = **574.62 units**.
- Daily production in kgs = 574.62 x 0.64 = **367.75 kg**

5.2.2 DABBA

- From the flow process chart, production time per unit = **34.82 sec/unit.**
- We know that, Total working hours per day = **8 hours**
- Therefore daily total production of Dabba =8 x (3600/34.82) = **827.11 units**.
- Daily production in kgs = 827.11 x 0.39 = **322.57 kg.**

5.3 VALIDATION

- The validation of the above calculations was done by using the **SIMUL8** software.
- Simulations are created by drawing the flow of work with the computer mouse, using a **series of icons and arrows** to represent the **resources and queues** in the system.
- The main focus of **SIMUL8** is **service industries** where people are processing transactions.
- Components are **user-defined icons** that can be reused and shared across a company's simulations.
- SIMUL8 saves its simulation model and data in XML format so that it will be easy to transfer it **to and from other applications.**

5.3.1 GANJ

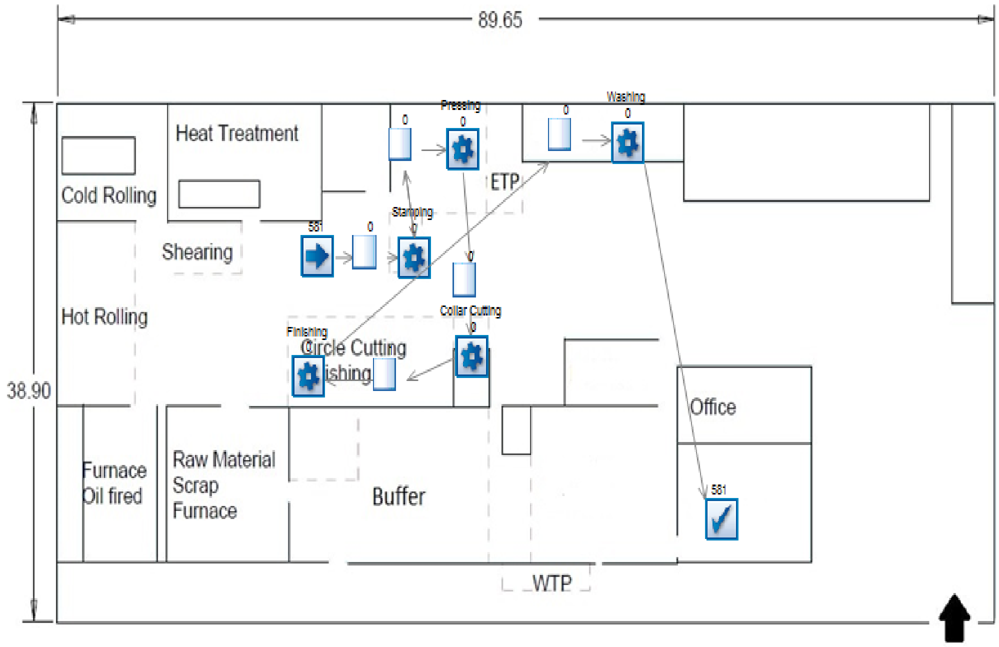


Figure 18: Simulation of Current Ganj Production

According to the software, no of Ganj manufactured came out to be 581 which is almost equal to our calculated value of 574.62. Hence our calculations are validated.

5.3.2 DABBA

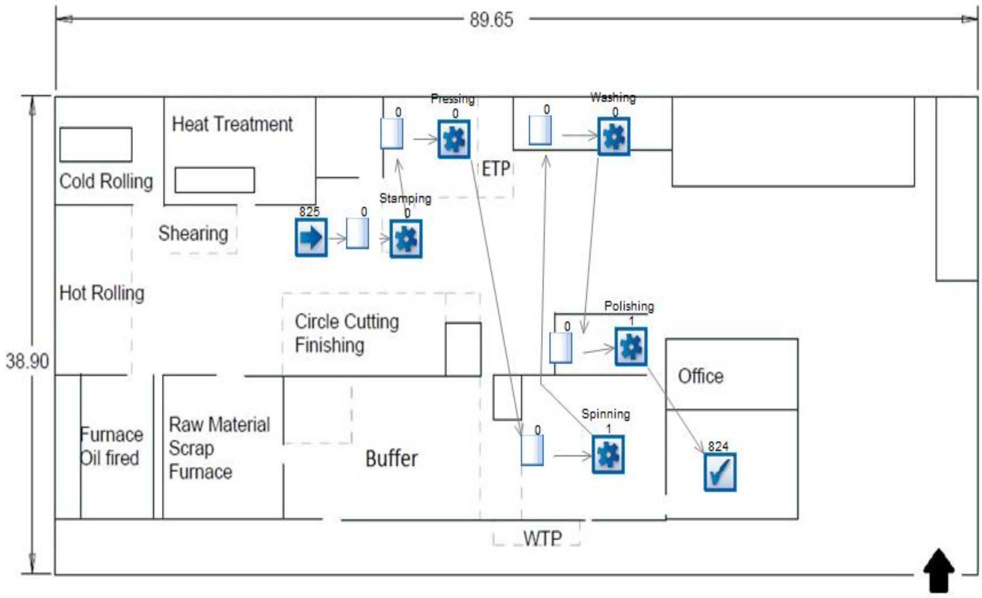


Figure 19: Simulation of Current Dabba Production

According to the software, no of Dabba manufactured came out to be 824 which is almost equal to our calculated value of 827.11. Hence our calculations are validated.

5.4 FLOW DIAGRAMS

- Although flow process chart gives most of the pertinent information related to a manufacturing process, it does not show a pictorial plan of the work area indicating the current positions of machines and working positions.
- The best possible way to provide this information is to take an existing drawing of the plant layout and trace the movement of the material from one activity to another.
- A flow diagram consists of the flow lines superimposed on the floor plan of the area under study.
- The direction of flow is indicated by placing small arrows periodically along the flow lines.
- The analysis of flow diagrams will show where the long handling, bottlenecks and confusion exists in the present arrangement and where the production operations and service activities are located in essence.
- The flow diagram checks the effectiveness of the overall arrangement of plant activities for material handling and suggests where revisions can be made.

5.4.1 GANJ

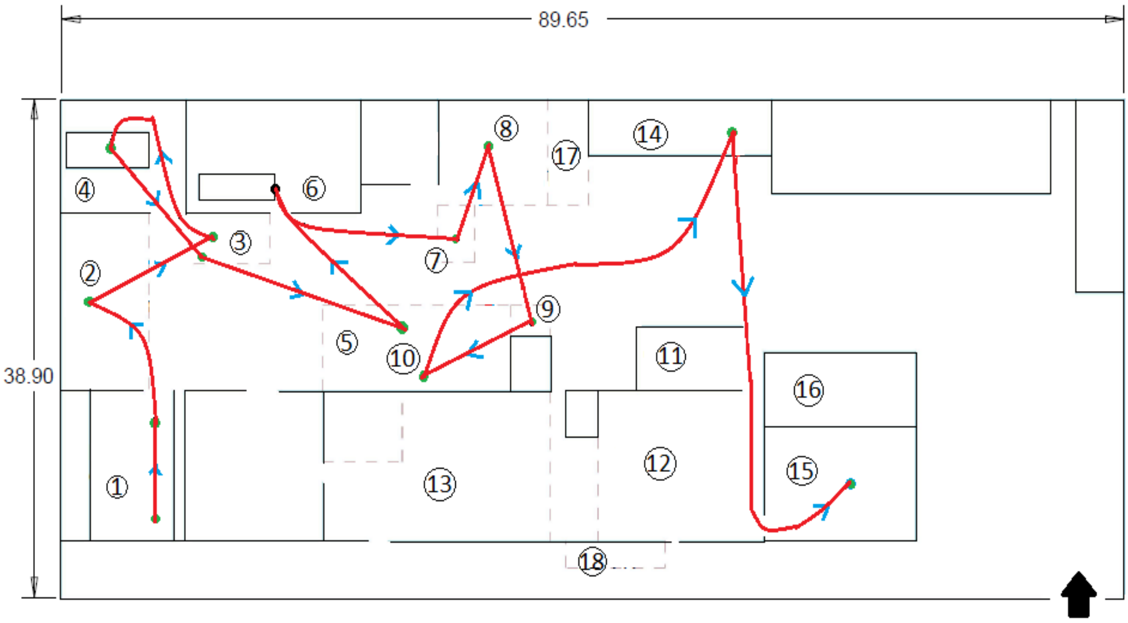


Figure 20: Current Flow Diagram - Ganj

- This flow diagram shows the flow of materials while making a Ganj from the first workstation of furnace till the last station of storage.
- The numbers indicate the sequential numbering of workstations.
- Clearly from the above figure, **backtracking** for flow of materials can be seen.

5.4.2 DABBA

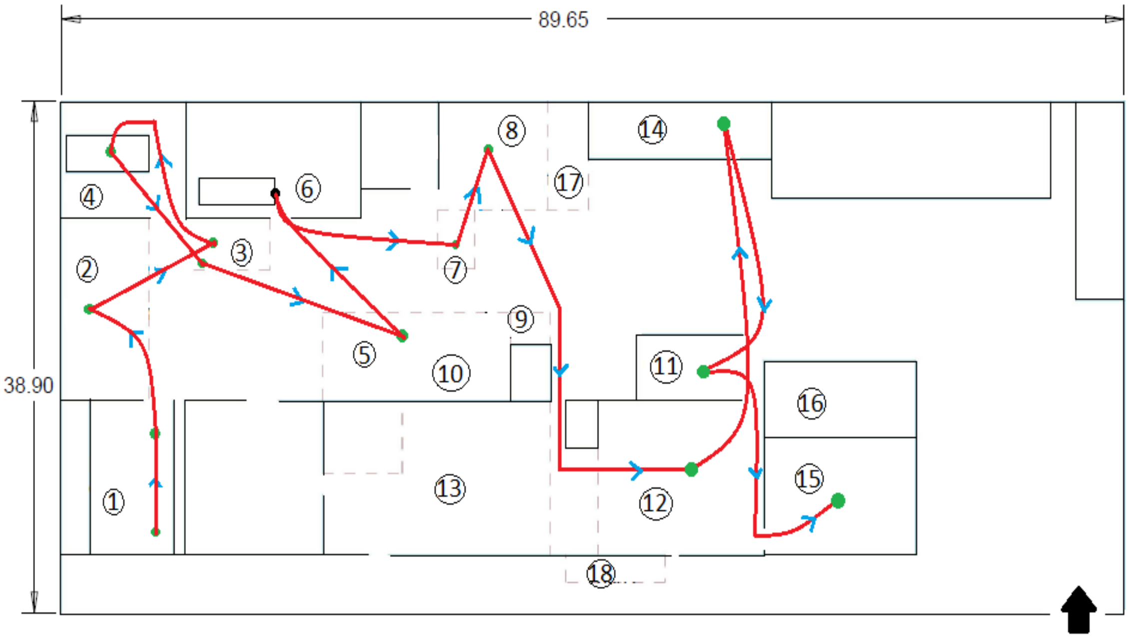


Figure 21: Current Flow Diagram - Dabba

- This flow diagram shows the flow of materials while making a Ganj from the first workstation of furnace till the last station of storage.
- The numbers indicate the sequential numbering of workstations.
- Clearly from the above figure, **backtracking** for flow of materials can be seen.

5.5 TRAVEL CHART

- When multiple movements along with complex paths are involved, a travel chart is an easier and quicker method to calculate total movements.
- It is a technique which can reduce large quantities of data into a compact form so that it may become readable to the user.
- A travel chart is a tabular record for presenting quantitative data about the movement of workers or materials between work stations over a given period of time.
- Travel charting points out graphically the inefficiencies of material handling such as backtracking and indicates potential bottlenecks where special attention may be required.

- Travel charting makes it possible to actually measure how efficient is with respect to material handling.
- Travel charting is very useful in analyzing the movement of materials and the locations of different departments.
- The departments to which there is a high frequency of movements are studied and situated nearest to reduce handling of material and to shorten the manufacturing cycle.

5.5.1 GANJ

	TO																
FROM	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18
1		22															
2			6														
3				12	15												
4			9														
5						18											
6							21										
7								11									
8									7			40					
9										15							
10													35				
11														25			
12													26				
14											16			35			
15																	
16																	
17																	
18																	

Figure 22: Current Travel Chart – Ganj

- The figure shows the travel chart for a Ganj.
- The values (distances) marked in red are for Ganj.
- The backtracking is seen below the diagonal line.
- Total Material Travel for Ganj = **206 m**

5.5.2 DABBA

FROM \ TO	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18
1		22															
2			6														
3				12	15												
4			9														
5						18											
6							21										
7								11									
8									7			40					
9										15							
10													35				
11														25			
12													26				
14											16			35			
15																	
16																	
17																	
18																	

Figure 23: Current Travel Chart - Dabba

- The figure shows the travel chart for a Dabba.
- The values (distances) marked in red are for Dabba.
- The backtracking is seen below the diagonal line.
- Total Material Travel for Dabba = **221m**

5.6 CONCLUDING REMARK

- The above study of the existing layout highlights the excess and unnecessary material flow that hampers the plant from attaining its full production capacity.
- The backtracking present in the material travel consumes time all the while making movement within the plant cumbersome and labor intensive.
- A better and systematic layout arrangement with the same machine setup would significantly improve the plant output.
- Hence, from the aforementioned study it is evident that a constructive change in the layout is imperative.

CHAPTER 6

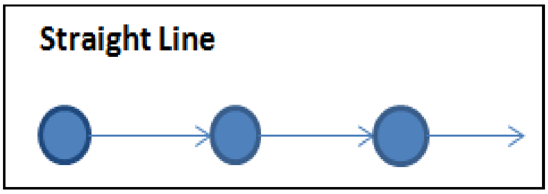
DEVELOPMENT OF PROPOSED LAYOUT

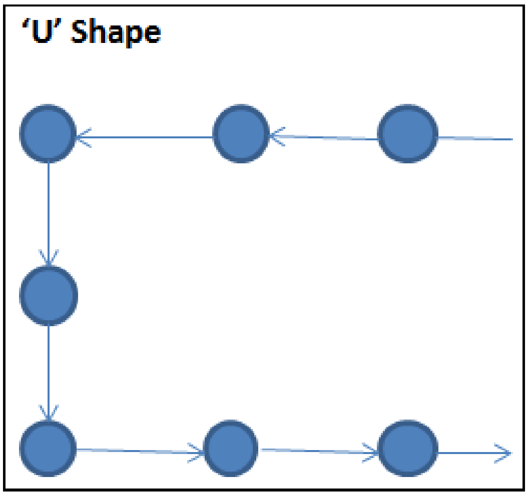
6.1 OBJECTIVES FOR REVISING LAYOUT.

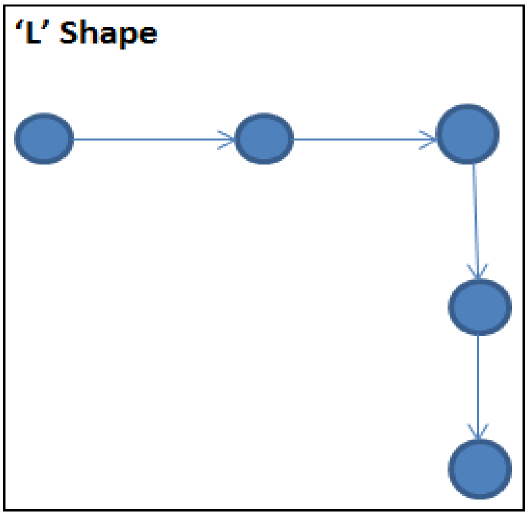
Some compelling reasons that call for a change in the layout of Balaji Trading Company are as follows:

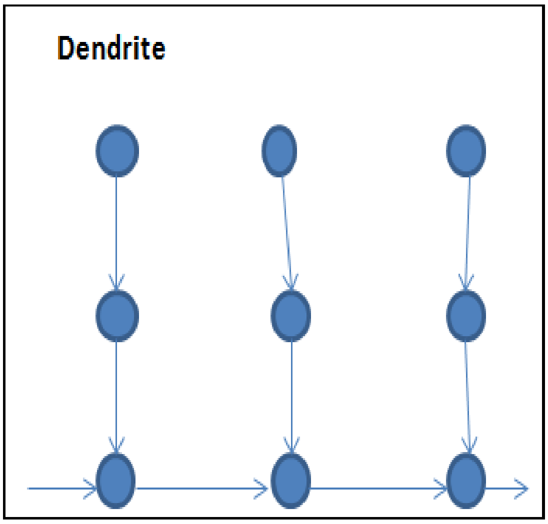
1. Poor work environment
2. Excessive material handling
3. Excessive in-process time
4. Improper utilization of plant space
5. No provision for future low-cost expansion
6. Frequent bottle-necking operations
7. Increased back and side tracking
8. Excessive amount of walking around by operators
9. Inconveniently located workstations
10. Wasted floor space

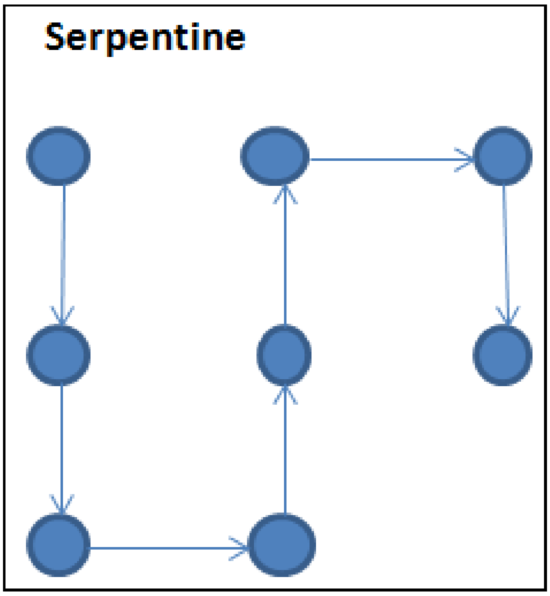
6.2 TYPES OF LAYOUT






‘L’ Shape


Dendrite


Serpentine

6.3 SELECTION OF FEASIBLE LAYOUT

The plant at Balaji Trading Company has only one entrance which is also used as an exit. Hence, it is imperative that the last workstation of the flowline (i.e. storage) is near it to allow convenient dispatch. Therefore, from the above mentioned arrangements, the **SERPENTINE** layout is chosen which ensures forward flow of material.

6.4 INITIAL PROPOSED ARRANGEMENT

After selection of the serpentine layout as suited for convenient material flow, an initial rough arrangement of the workstations in the available stations was sketched in CREO.

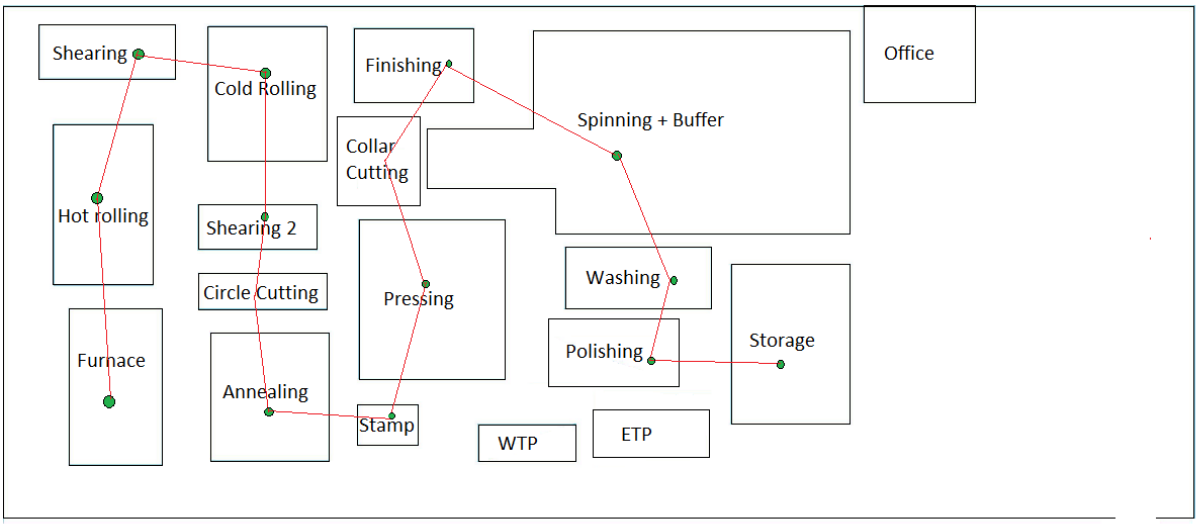


Figure 24: Initial Proposed Arrangement

The various inter-station distances were measured in the software itself to get an estimate of the targeted material travel reduction.

Table 9: Initially Estimated Material Travel

DEPARTMENTS		ESTIMATED TRAVEL DISTANCE (M)
FROM	**TO**	
Furnace	Hot Rolling	15
Hot Rolling	Shearing 1	12.83

Shearing 1	Cold Rolling	12.5
Cold Rolling	Shearing 2	10.53
Shearing 2	Circle Cutting	5.3
Circle Cutting	Annealing	7.9
Annealing	Stamping	9.22
Stamping	Pressing	10.64
Pressing	Collar Cutting	11.03
Collar Cutting	Finishing	8.68
Pressing	Spinning	22.15
Finishing	Washing	25
Spinning	Washing	12.27
Washing	Polishing	6.41
Polishing	Storage	14.46
Washing	Storage	13.36

Using the above values, the following assessment was made:

Estimated Material Travel for Ganj: **141.9 m**

Estimated Material Travel for Dabba: **139.21 m**

6.5 ACTIVITY RELATIONSHIP CHART.

- An activity relationship chart is a cross section form where the relationship between each activity (function or machine) and other activities can be recorded for construction of an activity relationship chart.

- All the significant activities needed, to support the major production function of the enterprise are recorded and factors or sub factors which determine the relationship are identified.
- While recording activities, they need not be in order of importance. It is better if they are placed in a logical sequence.
- Then the degree of closeness for every pair of activities is entered in the square at the intersection of the lines to represent the relative importance of the relationship.
- While deciding the degree of closeness, care and judgement should be exercised in assigning letters to be sure that there are not too many A’s or E’s. Since this will cause difficulty later when the activities are arranged to satisfy the desired relationship i.e. if everything must be close at everything else.

Table 10: Code Table

CODE	REASON
1	Flow of materials
2	Ease of supervision
3	Common personnel
4	Contact necessary
5	Convenience

Table 11: Rating Table

RATING	REASON
A	Absolutely necessary
E	Especially important
I	Important
O	Ordinary closeness
U	Unimportant
X	Undesirable

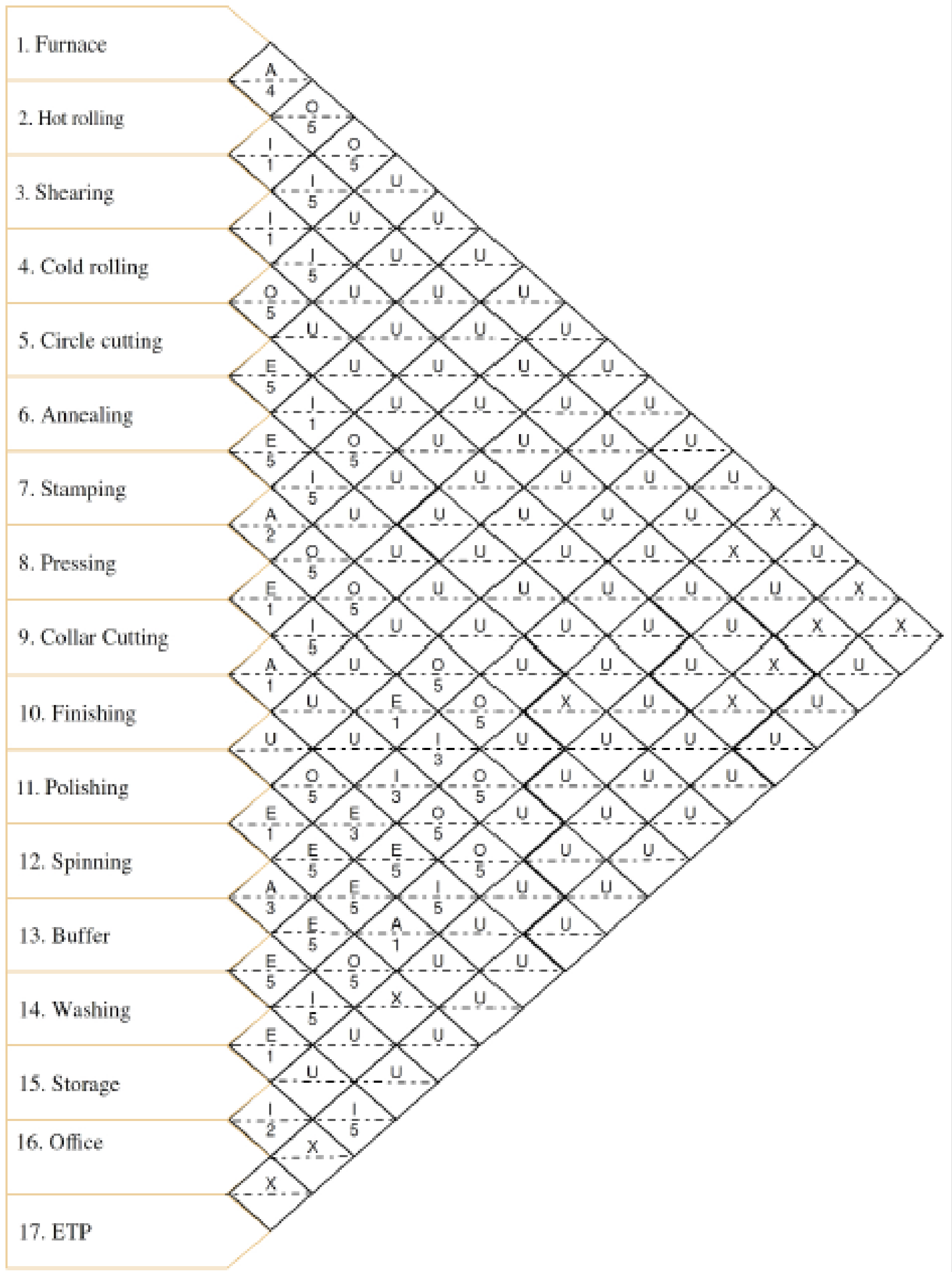


Figure 25: Activity Relationship Chart

6.6 WORKSHEET FOR ACTIVITY RELATIONSHIP DIAGRAM.

From activity relationship chart, a worksheet for the activity relationship diagram is prepared.

Table 12: ARD Worksheet

ACTIVITY	A	E	I	O	U	X
1. FURNACE	2			3,4		
2. HOT ROLLING	1		3,4			
3. SHEARING			4,5,2	1		
4. COLD ROLLING			3,2	5,1		
5. CIRCLE CUTTING		6	7,3	8,4		
6. ANNEALING		7,5	8			
7. STAMPING	8	6	5	9,10,12,13		
8. PRESSING	7	9,12	10,13,6	14		
9. COLLAR CUTTING	10	8	13	14,15,7		
10. FINISHING	9	13,14	15,8	12,7		
11. POLISHING	15	12,13,14				
12. SPINNING	13	14,11,8		15,10,7		
13. BUFFER	12	14,11,10	15,9,8	7		
14. WASHING		15,13,12,11,10	17	9,8		
15. STORAGE	11	14	16,13,10	12,9		
16. OFFICE			15			
17. ETP			14			

6.7 ACTIVITY RELATIONSHIP DIAGRAM.

- In the activity relationship diagram, each activity is represented by an equal sized block or circle.
- The blocks/circles are connected by a number of lines according to their closeness rating.
- The blocks/circles are shifted around until the proper relationship between activities is obtained.

Table 13: Line Rating Table

LINE	RATING
	A
	E
	I

——	O
	U
VVVVVV	X

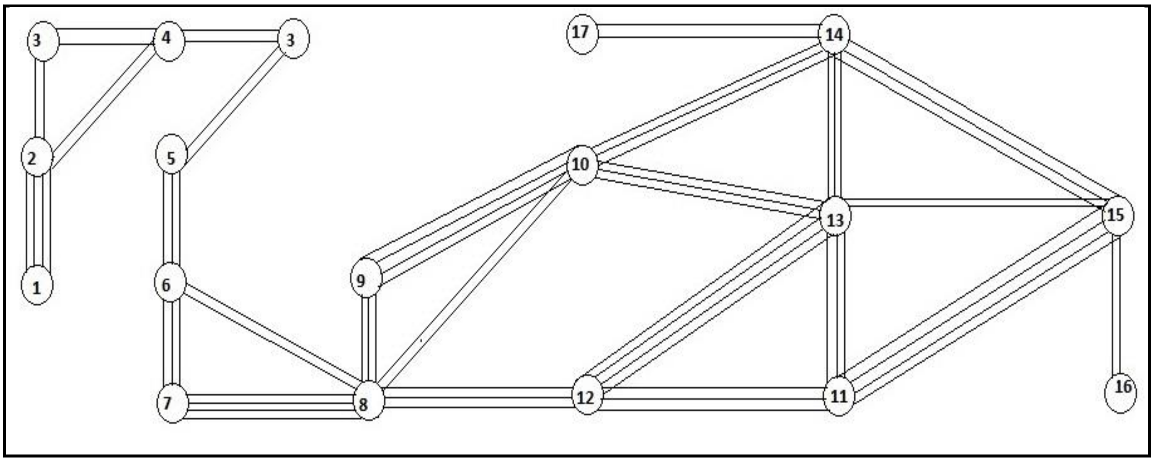


Figure 26: Activity Relationship Diagram

6.8 PROPOSED LAYOUT

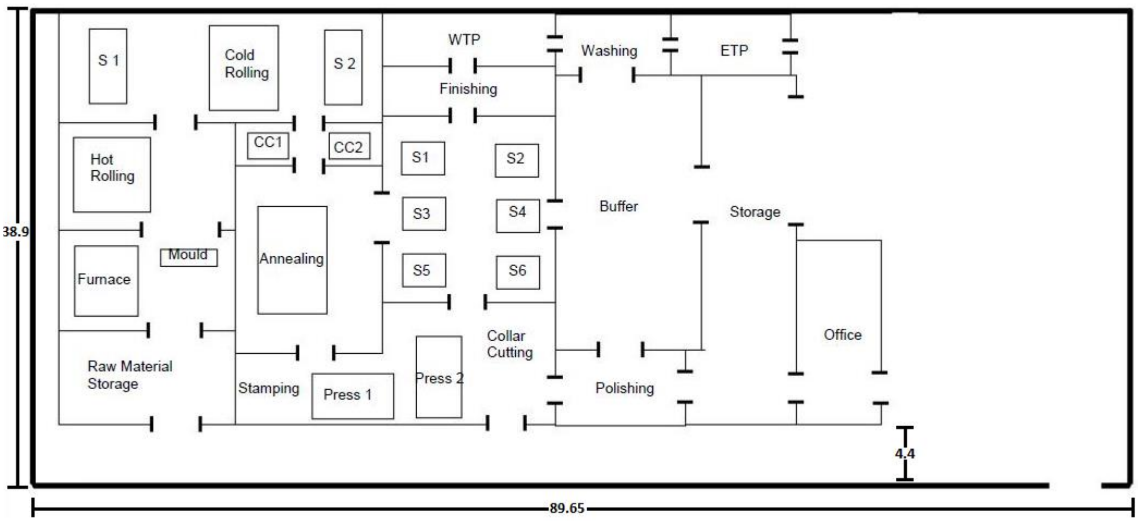


Figure 27: Proposed Layout

A **to the scale** sketch of the proposed layout was drafted in CREO. The serpentine arrangement completely eliminates backtracking thereby providing a smooth forward flow work. It is evident that the new layout provides better and effective utilization of space which would be sufficient for carrying out all operations.

CHAPTER 7
ANALYSIS OF PROPOSED LAYOUT

7.1 FLOW PROCESS CHART
7.1.1 GANJ

Table 14: Proposed Flow Process Chart - Ganj

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Heating in Furnace	—	120 min	•					
2.	Carrying the molten metal to the mould	7 m	0.27 sec		•				4 workers
3.	Pouring molten metal into the mould	—	2.51 sec	•					4 workers
4	Cooling period		3.33 sec	•					
5.	Transporting the slabs to the hot rolling m/c	9.43m	0.257 sec		•				Batch size=4, 1 worker
6.	Waiting for Hot Rolling	—	1.4 sec			•			
7.	Hot Rolling	—	3.74 sec	•					Batch size=4, 2 workers
8.	Storage of hot rolled plates for cooling	—	1 day					•	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Carrying the plates from storage to shearing m/c 1	9.33m	0.248 sec		•				Batch size=20, 2 workers
2.	Waiting for Shearing	—	4.31 sec			•			
3.	Shearing operation	—	4.54 sec	•					Batch size=20, 2 workers
4.	Shifting sheared plates to cold rolling m/c	10 m	0.133 sec		•				Batch size=60, 2 workers
5.	Waiting for Cold Rolling	—	6.54sec			•			
6.	Trolley Changeover time	—	20 sec			•			2 workers
7.	Cold rolling operation	—	6.67 sec	•					Batch size=60, 2 workers
8.	Carrying the cold rolled plates to the shearing m/c 2	10 m	0.177 sec		•				Batch size=60, 1 worker

9.	Waiting for Shearing	—	7.14 sec			●			
10.	Shearing operation	—	7.27 sec	●					Batch size=60, 2 workers
11.	Transporting the sheared plates to circle cutting m/c	6.18m	0.135 sec		●				Batch size=60(Doubt)
12.	Waiting for Circle Cutting operation	—	5.5 sec			●			
13.	Circle cutting operation	—	5.6 sec	●					Batch size=60, 1 worker
14.	Shifting circles to heat treatment area	8.5m	0.236 sec		●				2 workers
15.	Waiting for Heat treatment process	—	499.5 sec			●			
16.	Heat treatment process (Annealing)	—	10.8 sec	●					Batch size=1000
17.	Storing the heat treated plates for cooling	—	3.6 sec					●	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	◗	■	▼	
1.	Carrying plates to stamping workstation	10m	0.157 sec		●				Batch size=60, 1 worker
2.	Waiting for Stamping	—	6.76 sec			●			
3.	Stamping operation	—	6.8 sec	●					1 worker
4.	Carrying the plates to pressing m/c	11m	0.33 sec		●				Batch size=30, 1 worker
5.	Waiting for Pressing	—	2.75 sec			●			
6.	Pressing operation	—	2.85 sec	●					Batch size=30, 2 workers
7.	Transporting the pieces to	9m	0.424						Batch

	collar cutting m/c		sec		•				size=30, 1 worker
8.	Waiting for Collar Cutting operation	—	1.78 sec			•			
9.	Collar cutting	—	1.85 sec	•					Batch size=30, 1 worker
10.	Carrying the pieces to finishing m/c	20 m	0.67 sec		•				Batch size=30, 2 workers
11.	Waiting for finishing	—	9.67 sec			•			
12.	Finishing process	—	10 sec	•					Batch size=30, 1 worker
13.	Carrying the pieces to washing area	13.5 m	0.289sec		•				Batch size=60, 4 workers
14.	Washing	—	15 sec	•					Batch size=60, 2 workers
15.	Shifting the product to storage area	23 m	0.657 sec		•				Batch size=60, 4 workers
16.	Storage	—	—					•	
17.	Inspection	—	—				•		

7.1.2 DABBA

Table 15: Proposed Flow Process Chart - Dabba

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Heating in Furnace	—	120 min	•					
2.	Carrying the molten metal to the mould	7 m	0.27 sec		•				4 workers
3.	Pouring molten metal into the mould	—	2.51 sec	•					4 workers
4	Cooling period		3.33 sec	•					
5.	Transporting the slabs to the hot rolling m/c	9.43m	0.257 sec		•				Batch size=4, 1 worker
6.	Waiting for Hot Rolling	—	1.4 sec			•			
7.	Hot Rolling	—	3.74 sec	•					Batch size=4, 2 workers
8.	Storage of hot rolled plates for cooling	—	1 day					•	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				⬤	➡	D	■	▼	
1.	Carrying the plates from storage to shearing m/c 1	9.33m	0.248 sec		●				Batch size=20, 2 workers
2.	Waiting for Shearing	—	4.31 sec			●			
3.	Shearing operation	—	4.54 sec	●					Batch size=20, 2 workers
4.	Shifting sheared plates to cold rolling m/c	10 m	0.133 sec		●				Batch size=60, 2 workers
5.	Waiting for Cold Rolling	—	6.54sec			●			
6.	Trolley Changeover time	—	20 sec			●			2 workers
7.	Cold rolling operation	—	6.67 sec	●					Batch size=60, 2 workers
8.	Carrying the cold rolled plates to the shearing m/c 2	10 m	0.177 sec		●				Batch size=60, 1 worker
9.	Waiting for Shearing	—	7.14 sec			●			
10.	Shearing operation	—	7.27 sec	●					Batch size=60, 2 workers
11.	Transporting the sheared plates to circle cutting m/c	6.18m	0.135 sec		●				Batch size=60(Doubt)
12.	Waiting for Circle Cutting operation	—	5.5 sec			●			
13.	Circle cutting operation	—	5.6 sec	●					Batch size=60, 1 worker
14.	Shifting circles to heat treatment area	8.5m	0.236 sec		●				2 workers
15.	Waiting for Heat treatment process	—	499.5 sec			●			
16.	Heat treatment process (Annealing)	—	10.8 sec	●					Batch size=1000
17.	Storing the heat treated plates for cooling	—	3.6 sec					●	

Sr. no.	Description	Dist.	Time	Symbols					Remarks
				●	➡	D	■	▼	
1.	Carrying plates to stamping workstation	10m	0.157sec		•				Batch size=60, 1 worker
2.	Waiting for Stamping	—	6.76 sec			•			
3.	Stamping operation	—	6.8 sec	•					1 worker
4.	Carrying the plates to pressing m/c	11m	0.33 sec		•				Batch size=30, 1 worker
5.	Waiting for Pressing	—	2.75 sec			•			
6.	Pressing operation	—	8.57/3= 2.85 sec	•					Batch size=30, 2 worker
7.	Transporting the pieces to spinning m/c	14.4m	0.478 sec		•				Batch size=30, 2 workers
8.	Waiting for Spinning	—	4.02 sec			•			
9.	Spinning Operation	—	25/6= 4.167 sec	•					Batch size=30, 3 workers
10.	Carrying the pieces to washing area	25 m	0.48 sec		•				Batch size=60, 2 workers
11.	Washing	—	5 sec	•					Batch size=60, 2 workers
12.	Carrying the pieces from washing area to polishing	27m	0.556 sec		•				Batch size=60, 1 worker
13.	Waiting for polishing	—	4.91sec			•			
14.	Polishing	—	30/6= 5 sec	•					Batch size=60, 1 worker
15.	Shifting the product to storage area	13m	0.171 sec		•				Batch size=60, 4 workers
16.	Storage	—	—					•	
17.	Inspection	—	—				•		

7.2 CALCULATIONS

7.2.1 GANJ

- From the flow process chart, production time per unit = **45.94 sec/unit**.
- We know that, Total working hours per day = **8 hours**
- Therefore daily total production of Ganj =8 x (3600/45.94) = **626.9 units**.
- Daily production in kgs = 626.9 x 0.64 = **401.21 kg**

7.2.2 DABBA

- From the flow process chart, production time per unit = **30.382 sec/unit.**
- We know that, Total working hours per day = **8 hours**
- Therefore daily total production of Dabba =8 x (3600/30.382) = **947.93 units**.
- Daily production in kgs = 947.93 x 0.39 = **369.7 kg.**

7.3 VALIDATION

7.3.1 GANJ

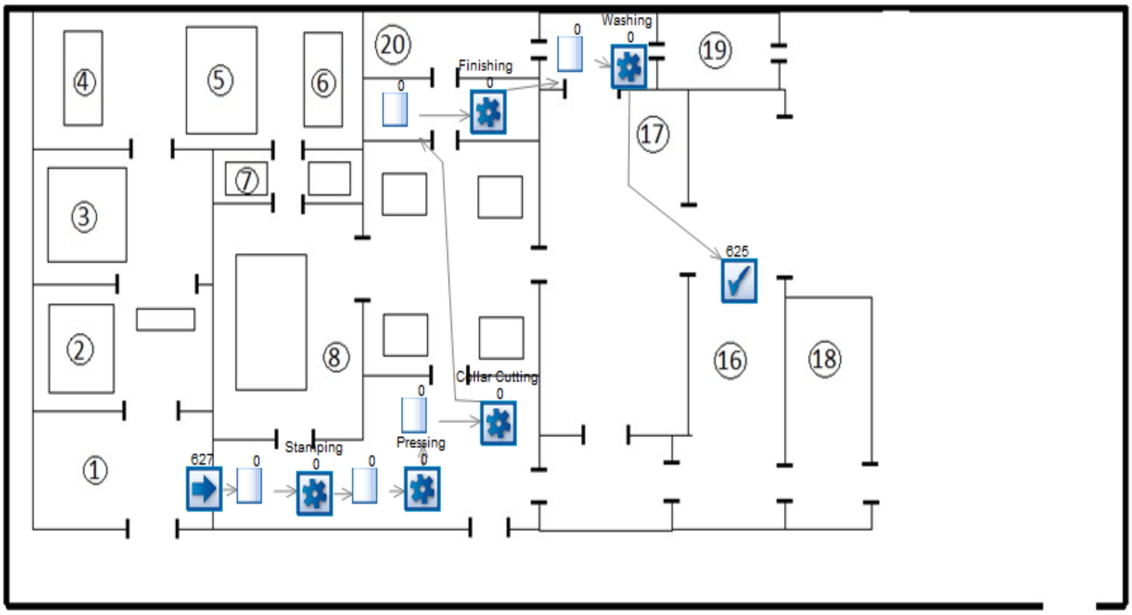


Figure 28: Simulation of Anticipated Ganj Production

According to the software, no of Ganj manufactured in a day came out to be **625** which is almost equal to our calculated value of **626.9**. Hence calculations are validated.

7.3.2 DABBA

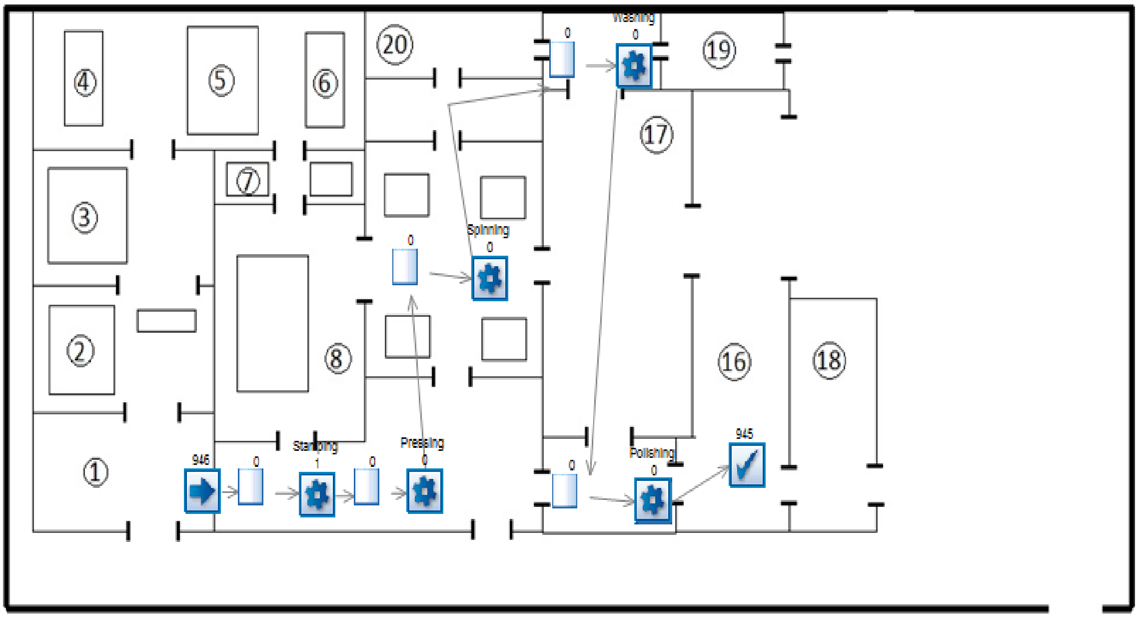


Figure 29: Simulation of Anticipated Dabba Production

According to the software, no of Dabba manufactured in a day came out to be **945** which is almost equal to our calculated value of **947.93**. Hence calculations are validated.

7.4 FLOW DIAGRAM

7.4.1 GANJ

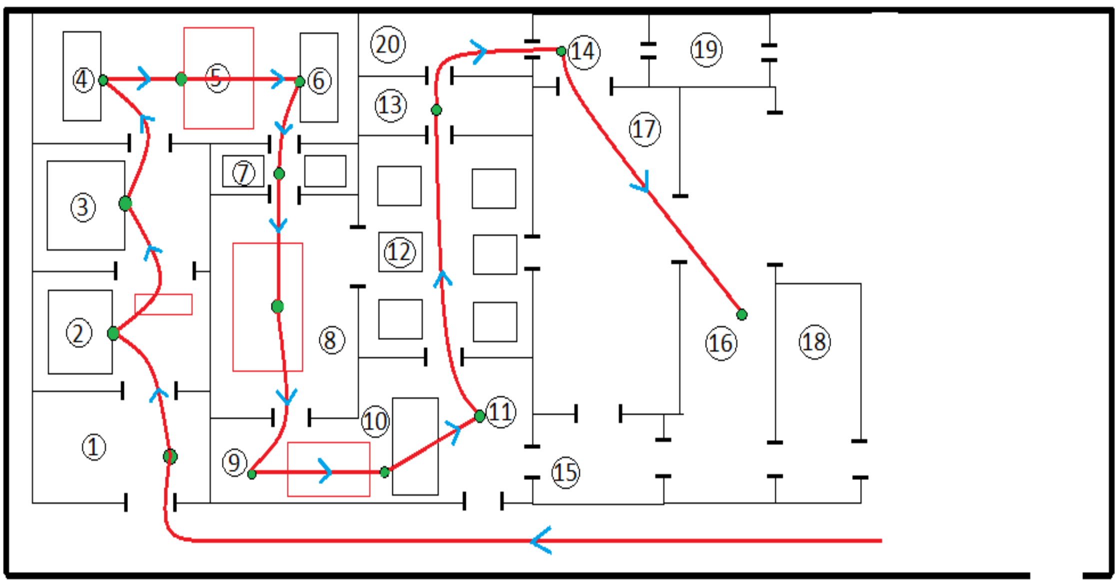


Figure 30: Proposed Flow Diagram - Ganj

- This flow diagram shows the flow of materials while making a Ganj from the first workstation of furnace till the last station of storage.
- The numbers indicate the sequential numbering of workstations.
- As compared to the earlier flow diagram (for the existing plant layout) we can clearly see some improvement in terms of flow of materials.
- Also **backtracking** is eliminated for the proposed layout.

7.4.2 DABBA

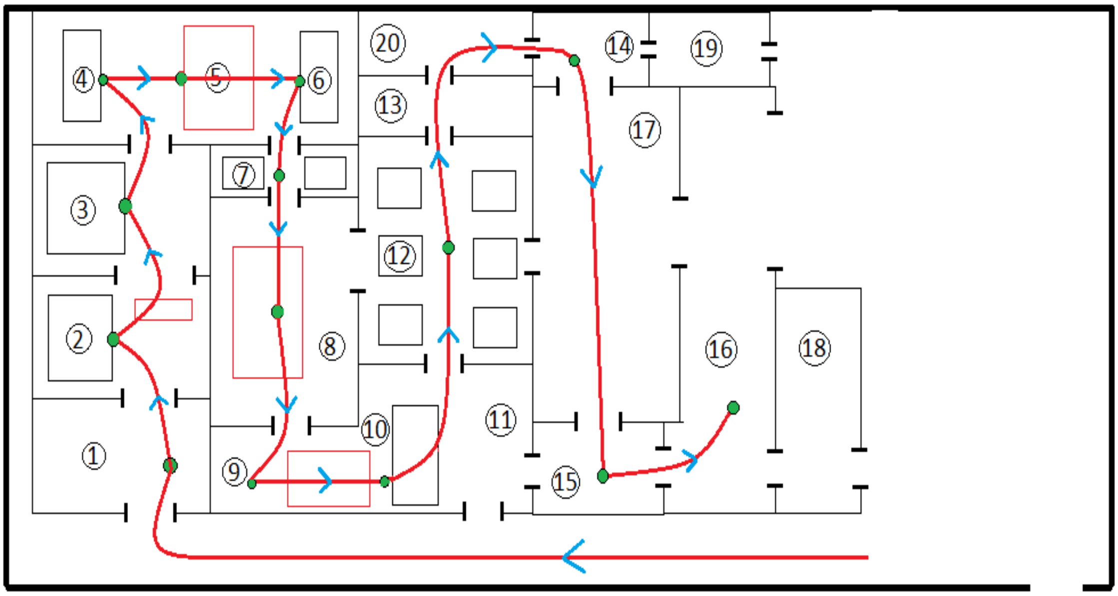
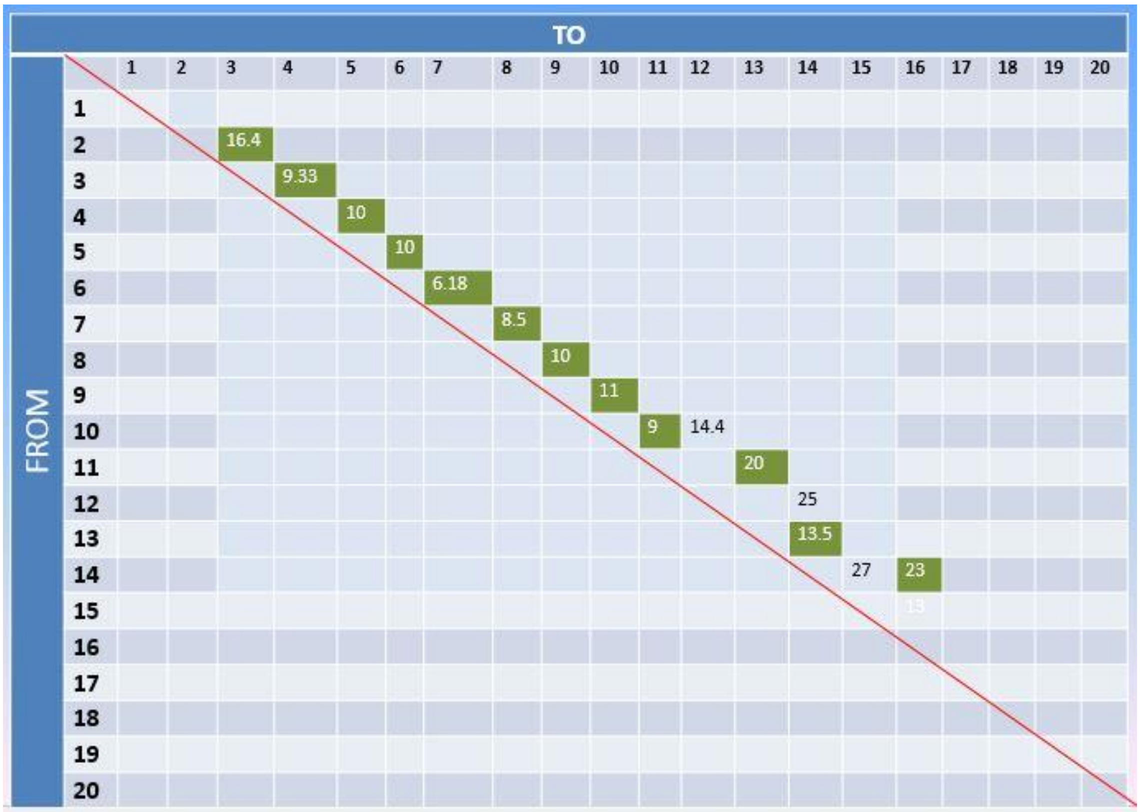


Figure 31: Proposed Flow Diagram - Dabba

- This flow diagram shows the flow of materials while making a Dabba from the first workstation of furnace till the last station of storage.
- The numbers indicate the sequential numbering of workstations.
- As compared to the earlier flow diagram (for the existing plant layout) we can clearly see some improvement in terms of flow of materials.
- Also **backtracking** is eliminated for the proposed layout.

7.5 TRAVEL CHART

7.5.1 GANJ



FROM \ TO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2			16.4																	
3				9.33																
4					10															
5						10														
6							6.18													
7								8.5												
8									10											
9										11										
10											9	14.4								
11													20							
12														25						
13														13.5						
14															27	23				
15																13				
16																				
17																				
18																				
19																				
20																				

Figure 32: Anticipated Travel Chart - Ganj

- The figure shows the travel chart for a Ganj.
- The values (distances) marked in green are for Ganj.
- **No backtracking** is seen below the diagonal line.
- Total Material Travel for Ganj = **146.91 m**

7.5.2 DABBA

	TO																			
FROM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2			16.4																	
3				9.33																
4					10															
5						10														
6							6.18													
7								8.5												
8									10											
9										11										
10											9	14.4								
11													20							
12														25						
13														13.5						
14															27	23				
15																13				
16																				
17																				
18																				
19																				
20																				

Figure 33: Anticipated Travel Chart - Dabba

- The figure shows the travel chart for a Dabba.
- The values (distances) marked in green are for Dabba.
- **No backtracking** is seen below the diagonal line.
- Total Material Travel for Dabba = **160.81 m**

CHAPTER 8

RESULTS, DISCUSSION & CONCLUSION

This chapter discusses the results of the work carried out during our study, the project summary, economic implications of the proposed solution, benefits and the future scope of work.

8.1 PROJECT SUMMARY:

This project was carried out at **Balaji Trading Company**, an aluminium utensils manufacturing firm. The objective of this project was to study the production floor layout and to suggest an improved alternative solution using SLP and to evaluate this alternative using SIMUL8.

8.2 RESULTS:

From among different Productivity Improvement Techniques, SLP was selected and the material travel for the two concerned products, i.e. **Ganj** and **Dabba**, were considerably reduced. The material travel for ganj was reduced by **28.68%** and for Dabba by **27.23%**.

Table 16: Material Travel for Current & Proposed Layouts

PRODUCT	CURRENT LAYOUT	PROPOSED LAYOUT
Ganj	206 m	146.91 m
Dabba	221 m	160.81 m

The above shown material travel reduction resulted due to the following changes in the inter-station distances (in meters):

Table 17: Material Travel Breakdown

Departments		Material Movement		Difference
From	**To**	**Existing**	**Proposed**	**(E-P)**
Furnace	Hot Rolling	22	16.43	5.57
Hot Rolling	Shearing 1	6	9.33	-3.33
Shearing 1	Cold Rolling	12	10	2
Cold Rolling	Shearing 2	9	10	-1
Shearing 2	Circle Cutting	15	6.18	8.82
Circle Cutting	Annealing	18	8.5	9.5
Annealing	Stamping	21	10	11
Stamping	Pressing	11	11	0
Pressing	Collar Cutting	7	9	-2
Collar Cutting	Finishing	15	20	-5
Finishing	Washing	35	13.5	21.5
Washing	Storage	35	23	12
Pressing	Spinning	40	14.4	25.6
Spinning	Washing	26	25	1
Washing	Polishing	16	27	-11
Polishing	Storage	25	13	12

There is a significant overall decrement of the material flow in the proposed solution. The new shearing workstation would reduce the backtracking of the products as shown earlier, that ultimately leads to smooth flow of work. This improved flow of work led to a decrease in production time per unit.

Table 18: Production Time Comparison

PARAMETERS	GANJ	DABBA
Existing production time per unit	50.12 sec	34.82 sec
Anticipated production time per unit	45.94 sec	30.382 sec

This led to an increase in production which is shown in following table:

Table 19: Output Comparison

PARAMETERS	GANJ	DABBA
Existing production (in units)	574.62	827.11
Existing production (in kgs)	367.75	322.57
Anticipated production (in units)	626.9	947.93
Anticipated production (in kgs)	401.21	369.7
Increase in production(in units)	52.28	120.82
Increase in production(in kgs)	33.46	47.13
% increase in production	9.09	14.61

8.3 DISCUSSION:

8.3.1 ECONOMIC VIABILITY OF PROJECT:

The layout was redesigned and the material handling was reduced by app. **27%** for the two products. The production increase for Ganj was **33.46kg/day** and for that of Dabba, it was **47.13kg/day**. The total increase of production per day was **80.59 kg** (net increase in production is 11.67%) with profit per kg of **140 rupees**, thereby increasing the profit per day by approximately by **11,000 rupees**. Considering the no. of hours the plant operates in month, the estimated monthly profit was around **2.82 lakhs.**

8.3.2 PAYBACK PERIOD FOR THE NEW LAYOUT:

The cost of implementation would be around **20, 00,000 rupees** taken into account the displacement of heavy machineries and new workstations with the cost of redesigning of new boundary walls for the layout. Hence, taking into account the profit that would be gained in excess, which is around **11,000 rupees** in a day, the time period in which the money could be recovered is **7.09 months.**

8.3.3 CONTENTS OF IMPROVEMENT:

According to the different technology processes, conditions and limitations, the application of the SLP method in the facility layout rearrangement will be various. Moreover, the design is usually very subjective. It is highly dependent on the designers' opinion, idea and empirical skills.

One design group may have thousands of plans. In all, the improvement contents of the design of layout rearrangement of enterprise logistics based on SLP are:

- Build the conception which combines the facility layout design and material handling analysis into consideration.
- Totally consider the actual situation or realities to have the excellent and exact target designs.
- Make a detailed and comprehensive selection option so that all the related factors will be taken into account.

8.4 CONCLUSION:

To conclude this project, based on the results generated from the analytical treatment by work study, method study and simulation, the objectives of this case study have been achieved. The problems faced by this company have been identified and a new layout has been proposed using SLP.

With the help of this thesis, the enterprise can obtain an integrated analysis solution for the facility layout rearrangement to fulfil their development plan. The idea is rather theoretical but it is feasible in the practical environment when every related factor can be comprehensively taken into account.

8.5 FUTURE DEVELOPMENT AND IMPROVEMENT:

As mentioned earlier, facility layout is a very complicated technological art, which involves a series of complicated procedures such as design, selection, measurement, calculation, implementation, construction, evaluation and so on.

Hence, in the next stage, new workstations can also be added which will make use of new, efficient machinery. Carrying out an energy audit, along with the implementation of new machines, will provide a better understanding of the energy dynamics to reduce power consumption.

For the space which would now be available, a separate plant for other utensils, particularly an *idli* maker can be installed.

Use of CNC and other automated machines will produce the standard and more precise products along with reduction of labour cost.

Another study applying the principles of Single Minute Exchange of Dies (SMED) can be carried out to reduce the excess changeover time at the pressing machines.

CHAPTER 9
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