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IMPLEMENTATION OF LEAN MANUFACTURING IN A PLASTIC MOULDING INDUSTRY

A PROJECT REPORT

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in partial fulfilment for the award of the degree

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Department of Mechanical Engineering

PROJECT WORK

APRIL - 2012

This is to certify that the project entitled

IMPLEMENTATION OF LEAN MANUFACTURING IN A PLASTIC MOULDING INDUSTRY

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SKYPET POLYMERS

MANUFACTURERS OF PET PREFORMS, PET BOTTLES & JARS

Dt: 28.03.12

TO WHOMSOEVER IT MAY CONCERN

This is to certify that following students from Kumaraguru College Of Technology have been involved in the, "Implementation of lean manufacturing " in our organization from 21st December 2011 to 24th March 2012.

1) Mr. Gautam. M (08BME12)
2) Mr. Raghavendra Prabhu.S (08BME38)
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During this period, their character and conduct was found to be good.

Thanking you,

Yours Faithfully,

For Skypet Polymers

Authorised Signatory

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ABSTRACT

. Productivity in industries in this modern era is being improved by following simple scientific principles which do not need a lot of money to implement. Such principles require only a little time and successful implementation of such principles standardizes the processes as well as brings about appreciable improvement in efficiency. This project aims at implementation of lean principles in the production activities in an industry

In this project, an industry where such practices were not implemented was selected. The transportation between different units of this industry was standardized using Just in Time practice. Kanban system was also implemented for inventory management. Finally, the productivity of the firm was improved by implementing layout changes which were in accordance with the lean principles.

A time study of the change was also carried out and the improvement in productivity was proven numerically.

CHAPTER I

INTRODUCTION

The following steps should be implemented to create the ideal lean manufacturing system:

1. Design a simple manufacturing system
2. Recognize that there is always room for improvement
3. Continuously improve the lean manufacturing system design

i) Design a simple manufacturing system

A fundamental principle of lean manufacturing is demand-based flow manufacturing. In this type of production setting, inventory is only pulled through each production center when it is needed to meet a customer's order. The benefits of this goal include:

- decreased cycle time
- less inventory
- increased productivity
- increased capital equipment utilization

ii) There is always room for improvement

The core of lean is founded on the concept of continuous product and process improvement and the elimination of non-value added activities. The Value adding activities are simply only those things the customer is willing to pay for, everything else is waste, and should be eliminated, simplified, reduced, or integrated. Improving the flow of material through new ideal system layouts at the customer's required rate would reduce waste in material movement and inventory.

iii) Continuously improve

A continuous improvement mindset is essential to reach a company's goals. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance.

CHAPTER II

LITERATURE SURVEY

ean Manufacturing

Overview

principles come from the Japanese manufacturing industry. The term was first coined ohn Krafcik in a Fall 1988 article, "Triumph of the Lean Production System," published e Sloan Management Review and based on his master's thesis at the MIT Sloan School Management. Krafcik had been a quality engineer in the Toyota-GM NUMMI joint ure in California before coming to MIT for MBA studies. Krafcik's research was inued by the International Motor Vehicle Program (IMVP) at MIT, which produced the rnational best-seller book co-authored by Jim Womack, Daniel Jones, and Daniel Roos ed *The Machine That Changed the World.* A complete historical account of the IMVP and the term "lean" was coined is given by Holweg (2007).

many, Lean is the set of "tools" that assist in the identification and steady elimination of te (*muda*). As waste is eliminated quality improves while production time and cost are uced. Examples of such "tools" are Value Stream Mapping, Five S, Kanban (pull ems), and poka-yoke (error-proofing).

re is a second approach to Lean Manufacturing, which is promoted by Toyota, in which focus is upon improving the "flow" or smoothness of work, thereby steadily eliminating *ra* ("unevenness") through the system and not upon 'waste reduction' per se. Techniques to rove flow include production leveling, "pull" production (by means of *kanban*) and the *ijunka box.* This is a fundamentally different approach from most improvement thodologies, which may partially account for its lack of popularity.

e difference between these two approaches is not the goal itself, but rather the prime roach to achieving it. The implementation of smooth flow exposes quality problems that eady existed, and thus waste reduction naturally happens as a consequence. The advantage imed for this approach is that it naturally takes a system-wide perspective, whereas a waste cus sometimes wrongly assumes this perspective.

th Lean and TPS can be seen as a loosely connected set of potentially competing principles ose goal is cost reduction by the elimination of waste. These principles include: Pull

1.3 Objective of the Project :

While applying lean principles, the following are the objectives to be accomplished :

- Reduction of defects and wastage.
- Improve cycle times.
- Reduce Inventory levels.
- Increase labour productivity.
- Better utilization of labour and space.
- Better flexibility.
- Improved output.

In order to implement advantageous methods, the following has to be done:

- The operation of the industry should be studied. This will help in identifying areas for improvement.
- To study and analyse different methods which can be adopted and to select the most suitable one.
- To implement such principles and measure the performance.

1.4 Limitations of the Project :

The principles are implemented only for a static working condition, i.e., continuous productivity throughout the day without considering any unforeseen causes for delay.

Flexibility, Building and maintaining a long term relationship with suppliers, Autonomation, Load leveling and Production flow and Visual control. The disconnected nature of some of these principles perhaps springs from the fact that the TPS has grown pragmatically since 1948 as it responded to the problems it saw within its own production facilities. Thus what one sees today is the result of a 'need' driven learning to improve where each step has built on previous ideas and not something based upon a theoretical framework.

Toyota's view is that the main method of Lean is not the tools, but the reduction of three types of waste: *muda* ("non-value-adding work"), *muri* ("overburden"), and *mura* ("unevenness"), to expose problems systematically and to use the tools where the ideal cannot be achieved. From this perspective, the tools are workarounds adapted to different situations, which explains any apparent incoherence of the principles above.

2.1.2 A brief history on waste reduction thinking:

The avoidance of waste has a long history. In fact many of the concepts now seen as key to lean have been discovered and rediscovered over the years by others in their search to reduce waste. Lean builds on their experiences, including learning from their mistakes.

i) Pre-20th century

Most of the basic goals of lean manufacturing are common sense, and documented examples can be seen as early as Benjamin Franklin. *Poor Richard's Almanac* says of wasted time, "He that idly loses 5s. worth of time, loses 5s., and might as prudently throw 5s. into the river." He added that avoiding unnecessary costs could be more profitable than increasing sales: "A penny saved is two pence clear. A pin a-day is a groat a-year. Save and have."

Again Franklin's *The Way to Wealth* says the following about carrying unnecessary inventory. "You call them goods; but, if you do not take care, they will prove evils to some of you. You expect they will be sold cheap, and, perhaps, they may [be bought] for less than they cost; but, if you have no occasion for them, they must be dear to you. Remember what Poor Richard says, 'Buy what thou hast no need of, and ere long thou shalt sell thy necessaries.' In another place he says, 'Many have been ruined by buying good penny worths'." Henry Ford cited Franklin as a major influence on his own business practices, The concept of waste being built into jobs and then taken for granted was noticed by motion efficiency expert Frank Gilbreth, who saw that masons bent over to pick up bricks from the ground. The bricklayer was therefore lowering and raising his entire upper body to pick up a 2.3 kg (5 lb.) brick, and this inefficiency had been built into the job through long practice. Introduction of a non-stooping scaffold, which delivered the bricks at waist level, allowed masons to work about three times as quickly, and with less effort.

ii) 20th century

Frederick Winslow Taylor, the father of scientific management, introduced what are now called standardization and best practice deployment. In his *Principles of Scientific Management*, (1911), Taylor said: "And whenever a workman proposes an improvement, it should be the policy of the management to make a careful analysis of the new method, and if necessary conduct a series of experiments to determine accurately the relative merit of the new suggestion and of the old standard. And whenever the new method is found to be markedly superior to the old, it should be adopted as the standard for the whole establishment."

Taylor also warned explicitly against cutting piece rates (or, by implication, cutting wages or discharging workers) when efficiency improvements reduce the need for raw labor: "...after a workman has had the price per piece of the work he is doing lowered two or three times as a result of his having worked harder and increased his output, he is likely entirely to lose sight of his employer's side of the case and become imbued with a grim determination to have no more cuts if soldiering [marking time, just doing what he is told can prevent it."

Shigeo Shingo, the best-known exponent of single minute exchange of die (SMED) and error-proofing or poka-yoke, cites *Principles of Scientific Management* as his inspiration.[9]

American industrialists recognized the threat of cheap offshore labor to American workers during the 1910s, and explicitly stated the goal of what is now called lean manufacturing as a countermeasure. Henry Towne, past President of the American Society of Mechanical Engineers, wrote in the Foreword to Frederick Winslow Taylor's *Shop Management* (1911), "We are justly proud of the high wage rates which prevail throughout our country, and jealous of any interference with them by the products of the cheaper labor of other countries.

broaden our opportunities in foreign markets where we must compete with the products of other industrial nations, we should welcome and encourage every influence tending to increase the efficiency of our productive processes."

Ford starts the ball rolling

Henry Ford continued this focus on waste while developing his mass assembly manufacturing system. Charles Buxton Going wrote in 1915:

> Ford's success has startled the country, almost the world, financially, industrially, mechanically. It exhibits in higher degree than most persons would have thought possible the seemingly contradictory requirements of true efficiency, which are: constant increase of quality, great increase of pay to the workers, repeated reduction in cost to the consumer. And with these appears, as at once cause and effect, an absolutely incredible enlargement of output reaching something like one hundredfold in less than ten years, and an enormous profit to the manufacturer.

Ford, in *My Life and Work* (1922), provided a single-paragraph description that encompasses the entire concept of waste:

> I believe that the average farmer puts to a really useful purpose only about 5%. of the energy he expends.... Not only is everything done by hand, but seldom is a thought given to a logical arrangement. A farmer doing his chores will walk up and down a rickety ladder a dozen times. He will carry water for years instead of putting in a few lengths of pipe. His whole idea, when there is extra work to do, is to hire extra men. He thinks of putting money into improvements as an expense.... It is waste motion— waste effort— that makes farm prices high and profits low.

Poor arrangement of the workplace—a major focus of the modern kaizen—and doing a job inefficiently out of habit—are major forms of waste even in modern workplaces.

Ford also pointed out how easy it was to overlook material waste. A former employee, Harry Bennett, wrote:

> One day when Mr. Ford and I were together he spotted some rust in the slag that

> from our own furnaces. 'You know,' Mr. Ford said to me, 'there's iron in that slag. You make the crane crews who put it out there sort it over, and take it back to the plant.

In other words, Ford saw the rust and realized that the steel plant was not recovering all of the iron.

Ford's early success, however, was not sustainable. As James P. Womack and Daniel Jones pointed out in "Lean Thinking", what Ford accomplished represented the "special case" rather than a robust lean solution. The major challenge that Ford faced was that his methods were built for a steady-state environment, rather than for the dynamic conditions firms increasingly face today.[14] Although his rigid, top-down controls made it possible to hold variation in work activities down to very low levels, his approach did not respond well to uncertain, dynamic business conditions; they responded particularly badly to the need for new product innovation. This was made clear by Ford's precipitous decline when the company was forced to finally introduce a follow-on to the Model T (see Lean Dynamics).

Design for Manufacture (DFM) also is a Ford concept. Ford said in *My Life and Work* (the same reference describes just in time manufacturing very explicitly):

> ...entirely useless parts [may be]—a shoe, a dress, a house, a piece of machinery, a railroad, a steamship, an airplane. As we cut out useless parts and simplify necessary ones, we also cut down the cost of making. ... But also it is to be remembered that all the parts are designed so that they can be most easily made.

This standardization of parts was central to Ford's concept of mass production, and the manufacturing "tolerances", or upper and lower dimensional limits that ensured interchangeability of parts became widely applied across manufacturing. Decades later, the renowned Japanese quality guru, Genichi Taguchi, demonstrated that this "goal post" method of measuring was inadequate. He showed that "loss" in capabilities did not begin only after exceeding these tolerances, but increased as described by the Taguchi Loss Function at any condition exceeding the nominal condition. This became an important part of W. Edwards Deming's quality movement of the 1980s, later helping to develop improved understanding of key areas of focus such as cycle time variation in improving manufacturing quality and

While Ford is renowned for his production line it is often not recognized how much effort he put into removing the fitters' work to make the production line possible. Until Ford, a car's components always had to be fitted or reshaped by a skilled engineer at the point of use, so that they would connect properly. By enforcing very strict specification and quality criteria on component manufacture, he eliminated this work almost entirely, reducing manufacturing effort by between 60-90%. However, Ford's mass production system failed to incorporate the notion of "pull production" and thus often suffered from over-production.

Toyota develops TPS

Toyota's development of ideas that later became Lean may have started at the turn of the 20th century with Sakichi Toyoda, in a textile factory with looms that stopped themselves when a thread broke, this became the seed of autonomation and *Jidoka*. Toyota's journey with JIT may have started back in 1934 when it moved from textiles to produce its first car. Kiichiro Toyoda, founder of Toyota, directed the engine casting work and discovered many problems in their manufacture. He decided he must stop the repairing of poor quality by intense study of each stage of the process. In 1936, when Toyota won its first truck contract with the Japanese government, his processes hit new problems and he developed the "Kaizen" improvement teams.

Levels of demand in the Post War economy of Japan were low and the focus of mass production on lowest cost per item via economies of scale therefore had little application. Having visited and seen supermarkets in the USA, Taiichi Ohno recognised the scheduling of work should not be driven by sales or production targets but by actual sales. Given the financial situation during this period, over-production had to be avoided and thus the notion of Pull (build to order rather than target driven Push) came to underpin production scheduling.

It was with Taiichi Ohno at Toyota that these themes came together. He built on the already existing internal schools of thought and spread their breadth and use into what has now become the Toyota Production System (TPS). It is principally from the TPS, but now including many other sources, that Lean production is developing.

2.1.3 Types of Waste :

While the elimination of waste may seem like a simple and clear subject it is noticeable that waste is often very conservatively identified. This then hugely reduces the potential of such an aim. The elimination of waste is the goal of Lean, and Toyota defined three broad types of waste: *muda*, *muri* and *mura*; it should be noted that for many Lean implementations this list shrinks to the first waste type only with corresponding benefits decrease. To illustrate the state of this thinking Shigeo Shingo observed that only the last turn of a bolt tightens it—the rest is just movement. This ever finer clarification of waste is key to establishing distinctions between value-adding activity, waste and non-value-adding work. Non-value adding work is waste that must be done under the present work conditions. One key is to measure, or estimate, the size of these wastes, to demonstrate the effect of the changes achieved and therefore the movement toward the goal.

The "flow" (or smoothness) based approach aims to achieve JIT, by removing the variation caused by work scheduling and thereby provide a driver, rationale or target and priorities for implementation, using a variety of techniques. The effort to achieve JIT exposes many quality problems that are hidden by buffer stocks; by forcing smooth flow of only value-adding steps, these problems become visible and must be dealt with explicitly.

Muri is all the unreasonable work that management imposes on workers and machines because of poor organization, such as carrying heavy weights, moving things around, dangerous tasks, even working significantly faster than usual. It is pushing a person or a machine beyond its natural limits. This may simply be asking a greater level of performance from a process than it can handle without taking shortcuts and informally modifying decision criteria. Unreasonable work is almost always a cause of multiple variations.

To link these three concepts is simple in TPS and thus Lean. Firstly, *muri* focuses on the preparation and planning of the process, or what work can be avoided proactively by design. Next, *mura* then focuses on how the work design is implemented and the elimination of fluctuation at the scheduling or operations level, such as quality and volume. *Muda* is then discovered after the process is in place and is dealt with reactively. It is seen through variation in output. It is the role of management to examine the *muda*, in the processes and eliminate the deeper causes by considering the connections to the *muri* and *mura* of the system. The *muda* and *mura* inconsistencies must be fed back to the *muri*, or planning, stage for the next project.

A typical example of the interplay of these wastes is the corporate behaviour of "making the numbers" as the end of a reporting period approaches. Demand is raised to 'make plan,' increasing (*mura*), when the "numbers" are low, which causes production to try to squeeze extra capacity from the process, which causes routines and standards to be modified or stretched. This stretch and improvisation leads to *muri*-style waste, which leads to downtime, mistakes and back flows, and waiting, thus the muda of waiting, correction and movement.

The original seven *muda* are:

- Moving products that are not actually required to perform the processing.
- All components, work in process and finished product not being processed.
- People or equipment moving or walking more than is required to perform the processing.
- Waiting for the next production step.
- Production ahead of demand.
- Resultant of poor tool or product design creating activity.
- The effort involved in inspecting for and fixing defects.

Later an eighth waste was defined by Womack et al. (2003); it was described as manufacturing goods or services that do not meet customer demand or specifications. Many others have added the "waste of unused human talent" to the original seven wastes. These wastes were not originally a part of the seven deadly wastes defined by Taiichi Ohno in TPS, but were found to be useful additions in practice. For a complete listing of the "old" and "new" wastes see Bicheno and Holweg (2009)

Some of these definitions may seem rather idealistic, but this tough definition is seen as important and they drove the success of TPS. The clear identification of non-value-adding work, as distinct from wasted work, is critical to identifying the assumptions behind the current work process and to challenging them in due course. Breakthroughs in SMED and other process changing techniques rely upon clear identification of where untapped opportunities may lie if the processing assumptions are challenged.

2.1.4 Lean implementation development from TPS :

The discipline required to implement Lean and the disciplines it seems to require are so often counter-cultural that they have made successful implementation of Lean a major challenge. Some would say that it was a major challenge in its manufacturing 'heartland' as well. Implementations under the Lean label are numerous and whether they are Lean and whether any success or failure can be laid at Lean's door is often debatable. Individual examples of success and failure exist in almost all spheres of business and activity and therefore cannot be taken as indications of whether Lean is particularly applicable to a specific sector of activity. It seems clear from the "successes" that no sector is immune from beneficial possibility.

Lean is about more than just cutting costs in the factory. One crucial insight is that most costs are assigned when a product is designed. Often an engineer will specify familiar, safe materials and processes rather than inexpensive, efficient ones. This reduces project risk, that is, the cost to the engineer, while increasing financial risks, and decreasing profits. Good organizations develop and review checklists to review product designs.

Companies must often look beyond the shop-floor to find opportunities for improving overall company cost and performance. At the system engineering level, requirements are reviewed with marketing and customer representatives to eliminate those requirements that are costly. Shared modules may be developed, such as multipurpose power supplies or shared mechanical components or fasteners. Requirements are assigned to the cheapest discipline. For example, adjustments may be moved into software, and measurements away from a mechanical solution to an electronic solution. Another approach is to choose connection or power-transport methods that are cheap or that used standardized components that become available in a competitive market.

2.1.5 Differences from TPS

Whilst Lean is seen by many as a generalization of the Toyota Production System into other industries and contexts there are some acknowledged differences that seem to have developed

1. **Seeking profit** is a relentless focus for Toyota exemplified by the profit maximization principle (Price – Cost = Profit) and the need, therefore, to practice systematic cost reduction (through TPS or otherwise) to realize benefit. Lean implementations can tend to de-emphasize this key measure and thus become fixated with the implementation of improvement concepts of "flow" or "pull". However, the emergence of the "value curve analysis" promises to directly tie lean improvements to bottom-line performance measuments.
2. **Tool orientation** is a tendency in many programs to elevate mere tools (standardized work, value stream mapping, visual control, etc.) to an unhealthy status beyond their pragmatic intent. The tools are just different ways to work around certain types of problems but they do not solve them for you or always highlight the underlying cause of many types of problems. The tools employed at Toyota are often used to expose particular problems that are then dealt with, as each tool's limitations or blind spots are perhaps better understood. So, for example, Value Stream Mapping focuses upon material and information flow problems (a title built into the Toyota title for this activity) but is not strong on Metrics, Man or Method. Internally they well know the limits of the tool and understood that it was never intended as the best way to see and analyze every waste or every problem related to quality, downtime, personnel development, cross training related issues, capacity bottlenecks, or anything to do with profits, safety, metrics or morale, etc. No one tool can do all of that. For surfacing these issues other tools are much more widely and effectively used.
3. **Management technique rather than change agents** has been a principle in Toyota from the early 1950s when they started emphasizing the development of the production manager's and supervisors' skills set in guiding natural work teams and did not rely upon staff-level change agents to drive improvements. This can manifest itself as a "Push" implementation of Lean rather than "Pull" by the team itself. This area of skills development is not that of the change agent specialist, but that of the natural operations work team leader. Although less prestigious than the TPS specialists, development of work team supervisors in Toyota is considered an equally, if not more important, topic merely because there are tens of thousands of these individuals. Specifically, it is these manufacturing leaders that are the main focus of training efforts in Toyota since they lead the daily work areas, and they directly and

true. Emphasis is put on developing the specialist, while the supervisor skill level is expected to somehow develop over time on its own.

2.1.6 Lean services

Lean, as a concept or brand, has captured the imagination of many in different spheres of activity. Examples of these from many sectors are listed below.

Lean principles have been successfully applied to call center services to improve live agent call handling. By combining Agent-assisted Automation and Lean's waste reduction practices, a company reduced handle time, reduced between agent variability, reduced accent barriers, and attained near perfect process adherence.

Lean principles have also found application in software application development and maintenance and other areas of information technology (IT). More generally, the use of Lean in IT has become known as Lean IT.

A study conducted on behalf of the Scottish Executive, by Warwick University, in 2005/06 found that Lean methods were applicable to the public sector, but that most results had been achieved using a much more restricted range of techniques than Lean provides.

A study completed in 2010 identified that Lean was beginning to embed in Higher Education in the UK (see Lean Higher Education).

The challenge in moving Lean to services is the lack of widely available reference implementations to allow people to see how directly applying lean manufacturing tools and practices can work and the impact it does have. This makes it more difficult to build the level of belief seen as necessary for strong implementation. However, some research does relate widely recognized examples of success in retail and even airlines to the underlying principles of lean. Despite this, it remains the case that the direct manufacturing examples of 'techniques' or 'tools' need to be better 'translated' into a service context to support the more prominent approaches of implementation, which has not yet received the level of work or publicity that would give starting points for implementors. The upshot of this is that each implementation often 'feels its way' along as must the early industrial engineers of Toyota.

2.1.7 Objectives of Lean Manufacturing

Lean Manufacturing, also called Lean Production, is a set of tools and methodologies that aims for the continuous elimination of all waste in the production process. The main benefits of this are lower production costs, increased output and shorter production lead times.

The strategic elements of Lean can be quite complex, and comprise multiple elements. Four different notions of Lean have been identified:

1. Lean as a fixed state or goal (Being Lean)
2. Lean as a continuous change process (Becoming Lean)
3. Lean as a set of tools or methods (Doing Lean/Toolbox Lean)
4. Lean as a philosophy (Lean thinking)

More specifically, some of the goals include:

1. **Defects and wastage** - Reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, costs associated with reprocessing defective items, and unnecessary product characteristics which are not required by customers;
2. **Cycle Times** - Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times;
3. **Inventory levels** - Minimize inventory levels at all stages of production, particularly works-in-progress between production stages. Lower inventories also mean lower working capital requirements;
4. **Labour productivity** - Improve labour productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible (including not doing unnecessary tasks or unnecessary motions);
5. **Utilization of equipment and space** - Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though existing equipment, while minimizing machine downtime;

7. **Output** – Insofar as reduced cycle times, increased labor productivity and elimination of bottlenecks and machine downtime can be achieved, companies can generally significantly increased output from their existing facilities.

Most of these benefits lead to lower unit production costs – for example, more effective use of equipment and space leads to lower depreciation costs per unit produced, more effective use of labor results in lower labor costs per unit produced and lower defects lead to lower cost of goods sold.

2.1.8 Key implications of Lean Manufacturing

	Traditional Batch Manufacturing	**Lean Manufacturing**
Orientation	Supply driven.	Customer driven.
Planning	Orders are pushed though factory based on production plan/forecast.	Orders are pulled through factory based on customer/downstream demand.
Batch size	Large.	Small.
Quality inspection	Checking of samples by QC inspectors.	In-line inspection by workers.
Inventory	Buffer of work-in-progress between each production stage.	Little or no work-in-progress between each production stage.
Handoff of works	Materials after each stage accumulate.	Materials handed off directly from one stage to the next.

Table 2.1 Implication of Lean Manufacturing

2.2 Just in Time (JIT) :

Just in time (JIT) is a production strategy that strives to improve a business return on investment by reducing in-process inventory and associated carrying costs. Just-in-time production method is also called the Toyota Production System. To meet JIT objectives, the process relies on signals or Kanban between different points in the process, which tell production when to make the next part. Kanban are usually 'tickets' but can be simple visual signals, such as the presence or absence of a part on a shelf. Implemented correctly, JIT focuses on continuous improvement and can improve a manufacturing organization's return on investment, quality, and efficiency. To achieve continuous improvement key areas of focus could be flow, employee involvement and quality.

2.2.1 Philosophy

The philosophy of JIT is simple: inventory is waste. JIT inventory systems expose hidden cost of keeping inventory, and are therefore not a simple solution for a company to adopt. The company must follow an array of new methods to manage the consequences of the change. The ideas in this way of working come from many different disciplines including statistics, industrial engineering, production management, and behavioral science. The JIT inventory philosophy defines how inventory is viewed and how it relates to management.

Inventory is seen as incurring costs, or waste, instead of adding and storing value, contrary to traditional accounting. This does not mean to say JIT is implemented without an awareness that removing inventory exposes pre-existing manufacturing issues. This way of working encourages businesses to eliminate inventory that does not compensate for manufacturing process issues, and to constantly improve those processes to require less inventory. Secondly, allowing any stock habituates management to stock keeping. Management may be tempted to keep stock to hide production problems. These problems include backups at work centers, machine reliability, process variability, lack of flexibility of employees and equipment, and inadequate capacity.

In short, the Just-in-Time inventory system focus is having "the right material, at the right time, at the right place, and in the exact amount"-Ryan Grabosky, without the safety net of inventory. The JIT system has broad implications for implementers.

2.2.2 Benefits

Main benefits of JIT include:

- Reduced setup time. Cutting setup time allows the company to reduce or eliminate inventory for "changeover" time. The tool used here is SMED (single-minute exchange of dies).
- The flow of goods from warehouse to shelves improves. Small or individual piece lot sizes reduce lot delay inventories, which simplifies inventory flow and its management.
- Employees with multiple skills are used more efficiently. Having employees trained to work on different parts of the process allows companies to move workers where they are needed.
- Production scheduling and work hour consistency synchronized with demand. If there is no demand for a product at the time, it is not made. This saves the company money, either by not having to pay workers overtime or by having them focus on other work or participate in training.
- Increased emphasis on supplier relationships. A company without inventory does not want a supply system problem that creates a part shortage. This makes supplier relationships extremely important.
- Supplies come in at regular intervals throughout the production day. Supply is synchronized with production demand and the optimal amount of inventory is on hand at any time. When parts move directly from the truck to the point of assembly, the need for storage facilities is reduced.
- Minimizes storage space needed.
- Smaller chance of inventory breaking/expiring.

CHAPTER III

A BRIEF ABOUT THE INDUSTRY

3.1 About the industry:

M/s SKYPET POLYMERS is an industry which deals with the production of plastic goods from raw material. They produce products such as PET bottles, plastic caps and impellers and have recurring orders from well known companies like SABOLS and AAVIN.

They have two units. One unit is present in Saravanampatti near Sankara Nethralaya. This unit is concerned with the conversion of raw material such as PET into plastic bottle's preforms and Polypropylene into bottle caps and impellers. There are two automatic injection moulding machines which are responsible for production. Human labour is necessary only for loading of raw material into the machines and to remove flash from bottle caps.

The second unit, which is relatively new, is situated near Dr. NGP College off Kalapatti road. This unit has three blow moulding machines which use compressed air to convert the preforms produced at the first unit into bottles. The two units are 9km. apart and rely on goods carrying vehicles for transport. This unit also receives preform from other producers to manufacture different types of products. The products which are manufactured in this unit are then packed and are shipped to the customers. Each machine in this unit requires a labourer to continuously feed the preform and remove the bottles from the machines. It also requires six to seven labourers to pack the bottles for dispatch as well as unload preforms when they arrive.

3.2 Unit A layout :

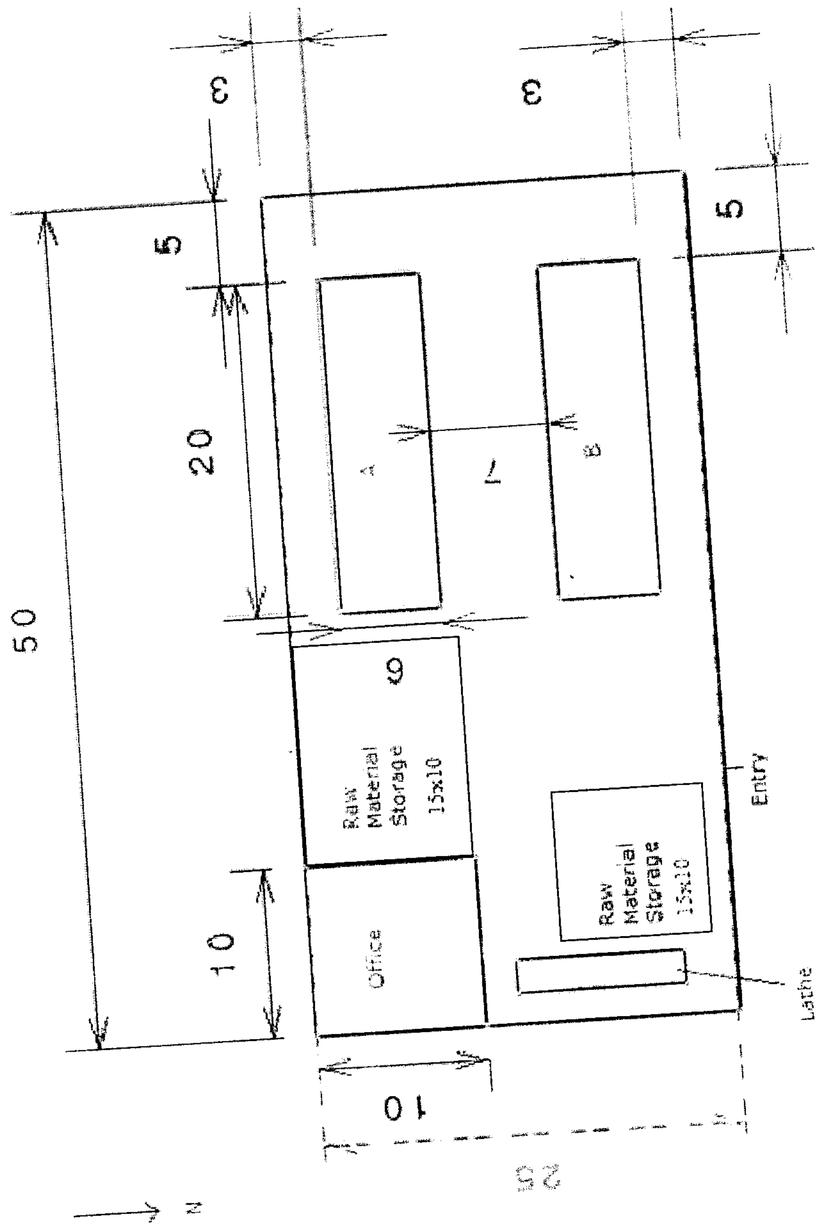


Fig. 3.1 Layout of Unit A

3.3 Unit B layout :

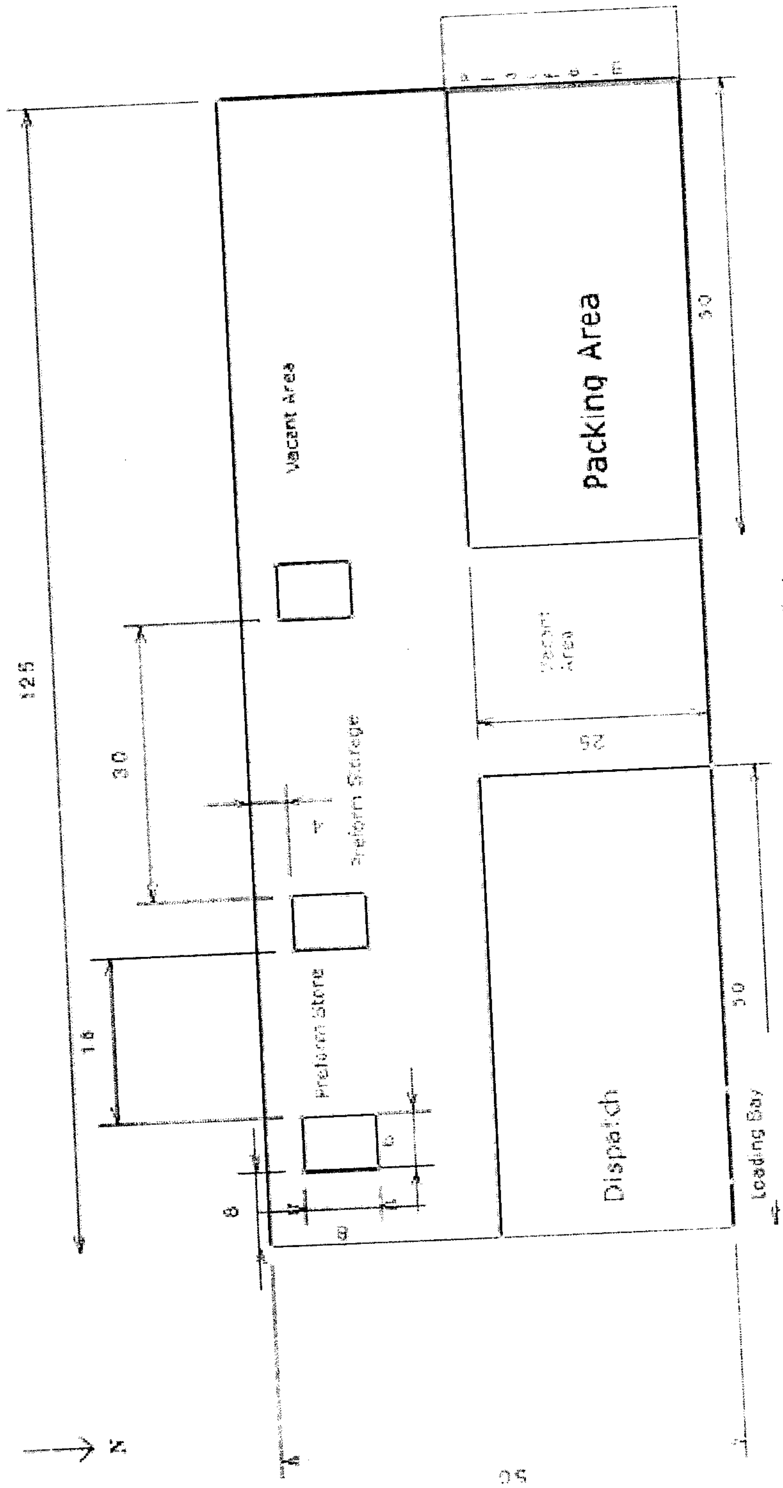
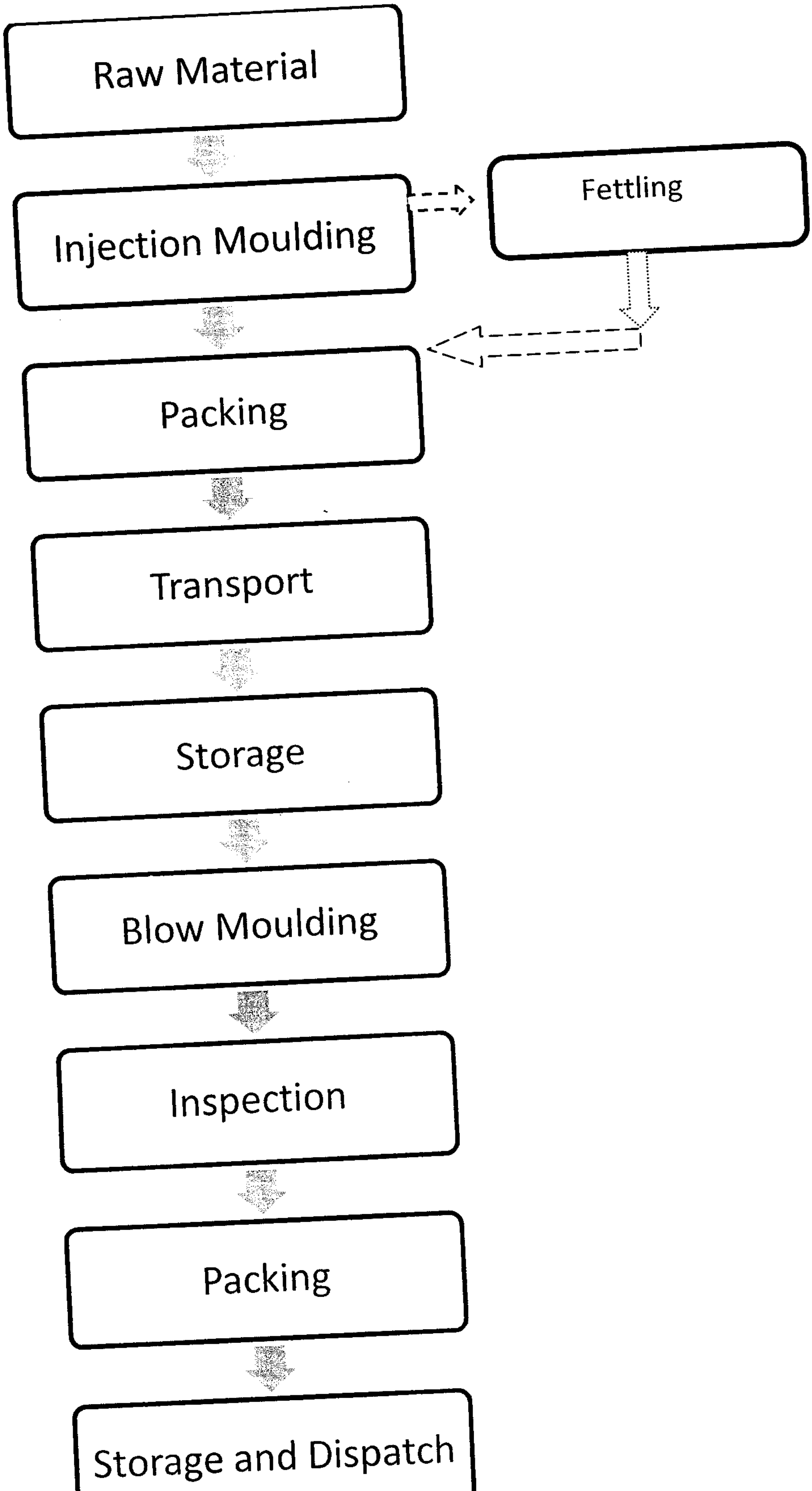


Fig. 3.2 Layout of Unit B

3.4 Processes carried out :



The following are the processes carried out :

1. Raw Material Storage :
   The raw plastics (Polypropylene and PET) are unloaded from trucks and stored in Unit A.
2. Injection Moulding :
   These raw materials are fed periodically into the automated injection moulding machines where they are converted to preforms or bottle caps.
3. Fettling (Only for Bottle Caps) :
   The bottle caps which are produced in the machines are accompanied by flash since six bottle caps are produced per cycle. This is removed manually.
4. Packing :
   The preforms and bottle caps are then packed in cartons which are transported to Unit B.
5. Transport :
   The cartons from Unit A are delivered usually by a minivan to Unit B which is located 9 km. away.
6. Storage :
   The preforms delivered to Unit B are usually stored for some time since the firm obtains different types of preforms and hence, die changing is required.
7. Blow Moulding :
   The preforms from the carton are fed into the blow moulding machine after passing through a preheating circuit. The operator feeds two preforms per cycle, usually, and the bottles form from the preforms.
8. Inspection :
   Blow Moulded components usually form without any defects and hence, only a simple visual inspection is carried out to identify any non-conformities.
9. Packing :
   The bottles are stacked in plastic bags manually after the caps are screwed onto them. They are then moved to the storage.
10. Storage :
    Another storage area is present for the finished product and it is stored there until the ... rranges appropriate transport to collect the same.

3.5 Problems Identified :

The following observations have been made so far:

- The two types of raw material in use have no proper location for their storage. They are placed wherever space is available and in an unorganized manner.
- The caps as well as preforms are transported from unit A to unit B at irregular intervals and in varied means of transport like trucks and auto rickshaws.
- At unit B, the preforms are not stacked in an ergonomical manner near the machinery.
- There is a lot of unnecessary movement between processes in the layout.
- In spite of a lot of space available, the cartons for dispatch are stacked very close to each other and are not easily accessible.
- The industry is also affected by insufficient manpower.

CHAPTER IV

IMPLEMENTATION OF LEAN PRINCIPLE OF OPTIMIZATION OF SPACE AND MOVEMENT

4.1 Improvements in Unit A :

4.1.1 Original Layout :

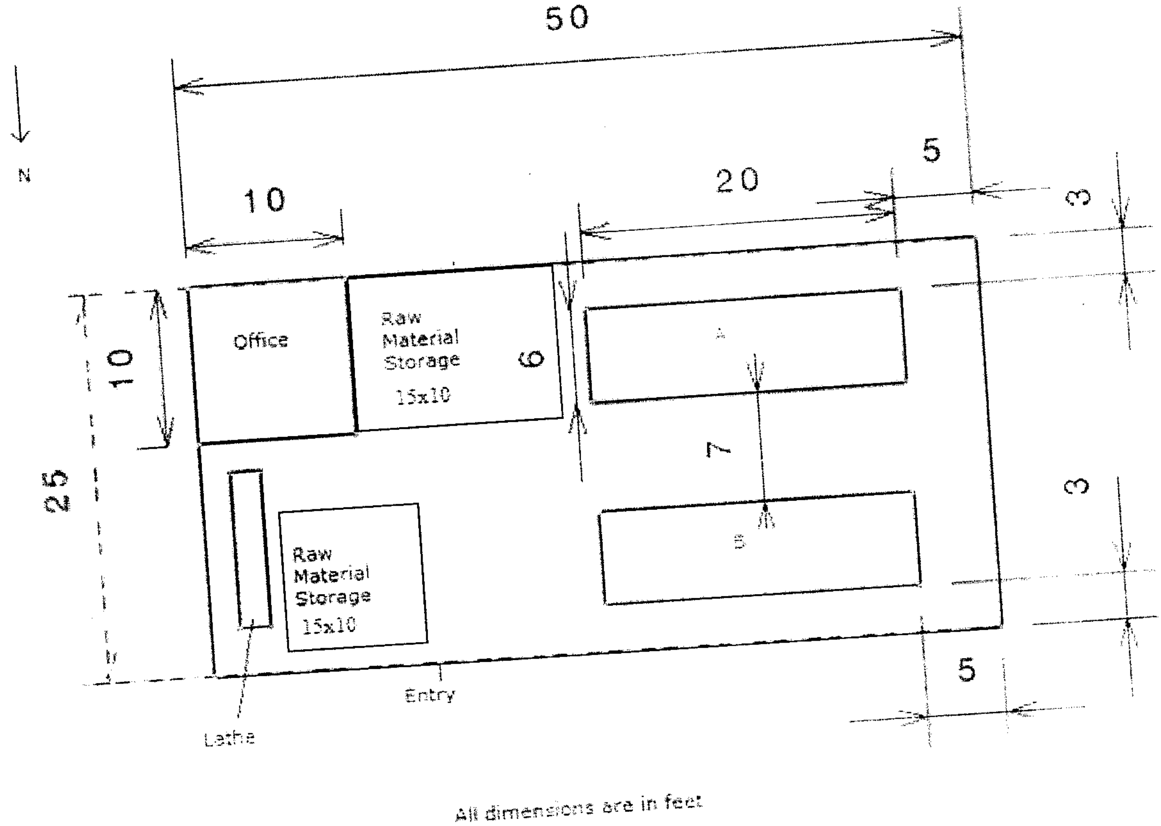


Fig. 4.1 Unit A before layout change

- In Unit A, the raw material, i.e., PET and Polypropylene were not stored in an organized manner.
- Once storage near the Office wall was filled, material would be stored near the lathe.
- Such a setup will result in confusion since the different materials are mixed and no proper stock of material can be maintained.

4.1.2 Improved Layout :

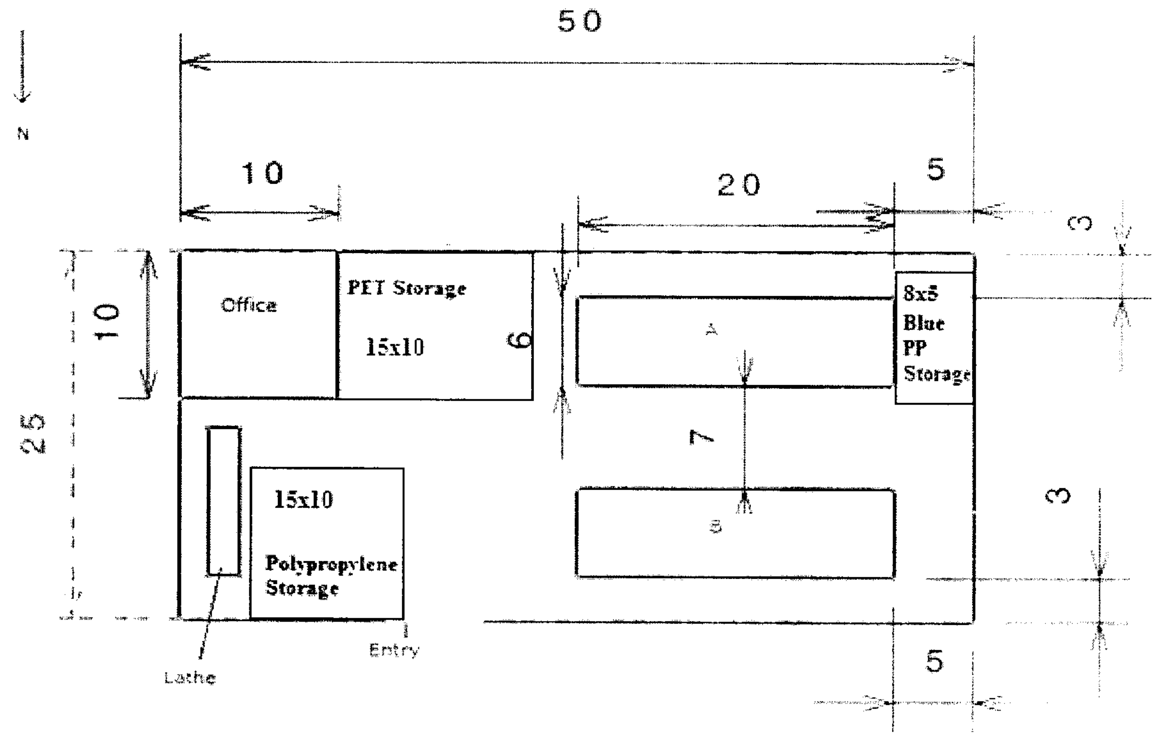
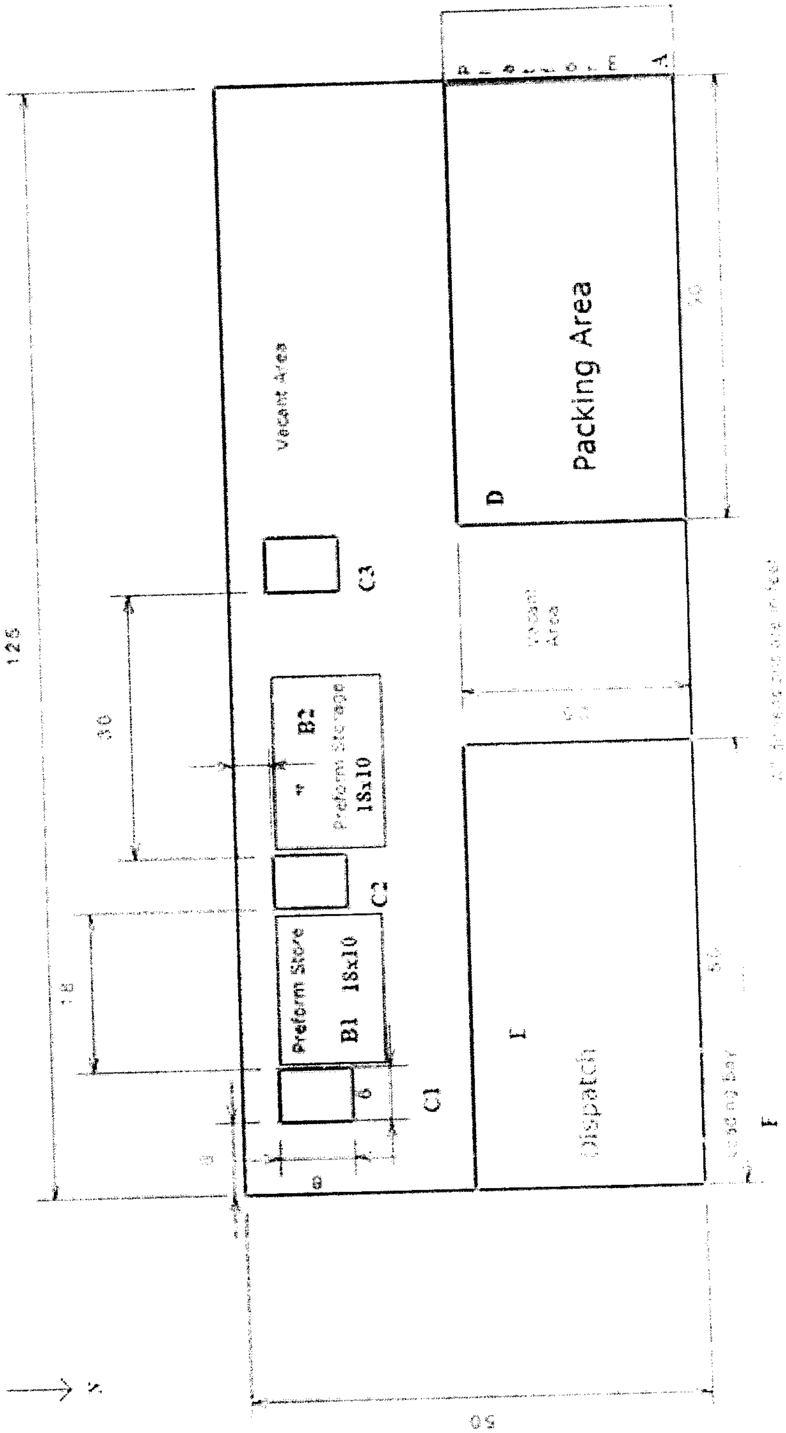


Fig. 4.2 Unit A after layout improvement

- In the improved layout, PET storage is made near the office and Polypropylene is stored near the lathe.
- Also, bags containing blue coloured pellets of Polypropylene (1 bag of blue pellets is mixed with every 5 bags of white coloured ones for bottle caps) is assigned a separate storage near the west wall.
- Hence, such a change provides pre-defined storage space and also helps avoid confusion and keep stock of material with ease.

4.2 Improvements in Unit B:

4.2.1 Original layout:

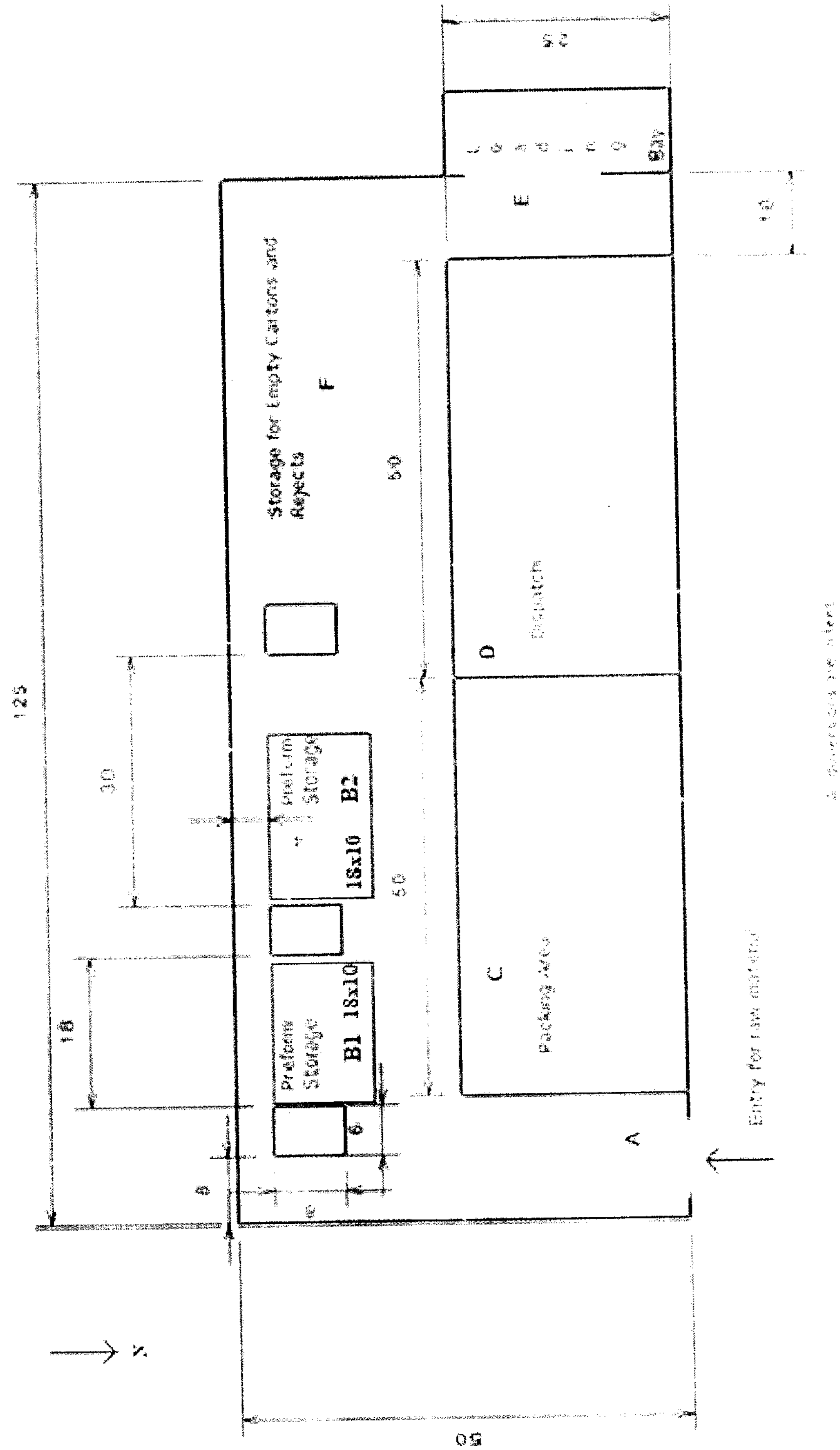


- Preform is unloaded at platform A.
- It is then transported manually from A to the storage areas B.
- From there, it passes through the pre-heater and into the machine at C.
- The finished bottles are moved to D where they are visually examined and packed.
- The packed containers are stacked at E.
- Once, the customer's collection vehicle arrives, it is delivered through the loading bay F.

Problems in this practice :

- There is a lot of cross movement of material, i.e., preform moves through packing area, and also unnecessary movement of material for comparatively long distances. This creates confusion as well as takes a lot of time.
- A lot of space is also left unused.

4.2.1.2 Intermediate Modification :



Sequence of operations :

- The raw material now enters through the entry at A (Previously F).
- It is then transported to the preform storage at B.
- The preform is then blow moulded and transferred to the packing area at C.
- It then moves to the dispatch area D.
- It is stored here temporarily until the customer's collection vehicle arrives and is loaded into the vehicle at E.
- The empty cartons as well as rejects are stored at F from where they are disposed.

Objectives Accomplished :

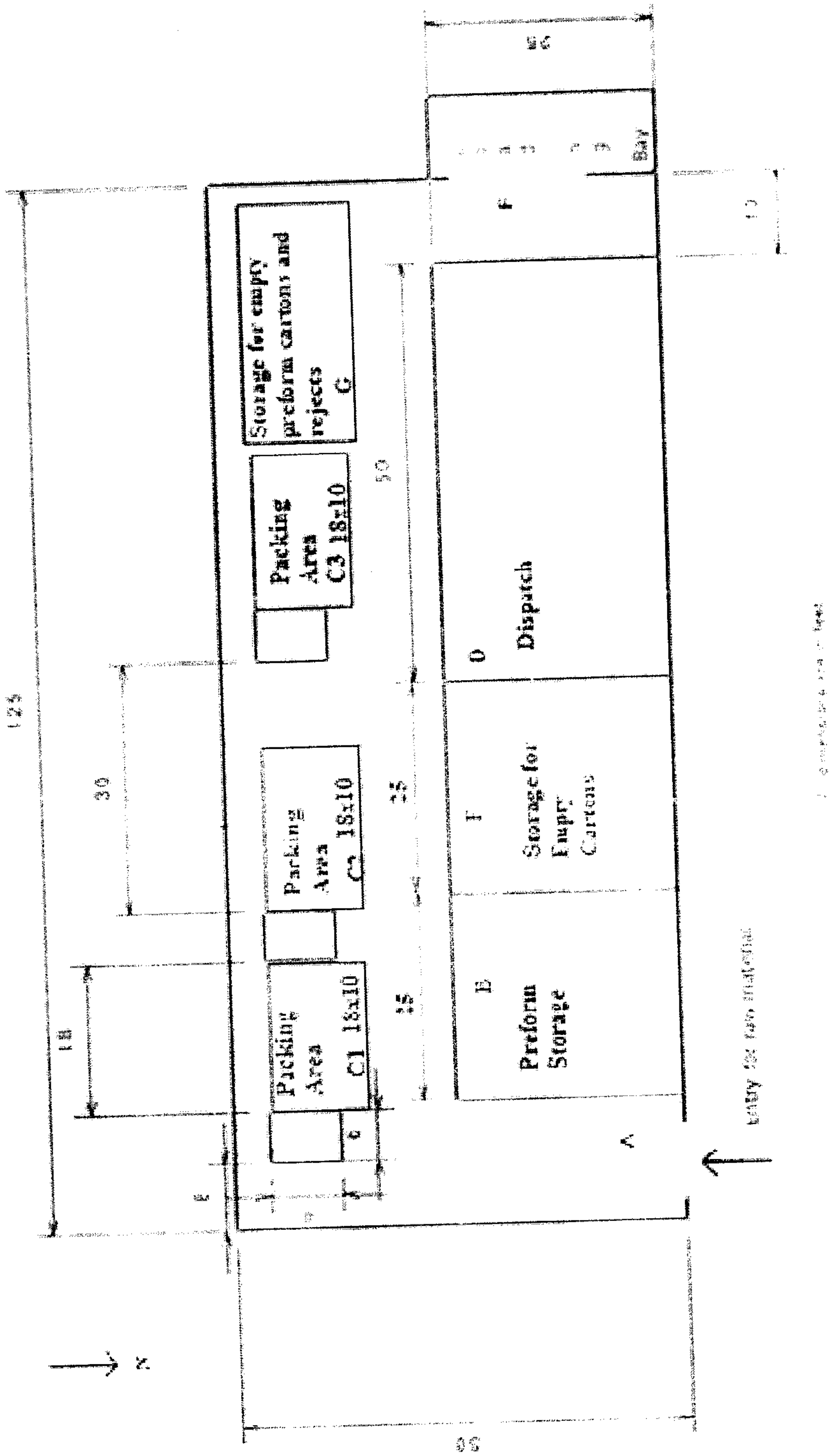
- Unnecessary movement of material is avoided.
- The time taken to carry out the processes has reduced.

Scope for improvement in proposed layout :

After the implementation of the first layout change and observing the results, a few discrepancies were identified :

- The storage of preform near the machinery was unnecessary since each machine would consume only a carton of preform per hour.
- Hence, the space can be used for more productive work.
- Secondly, the packing area was away from the machines so movement of material became necessary and it was very inefficient to move the bottles.
- So, a layout change was made and implemented and this helped to increase the productivity further.

4.2.1.3 Final Layout :



Sequence of operations :

- The preform enters through A.
- It is stored temporarily at preform storage B.
- The preform cartons are then moved to where the machines are located.
- The bottles pass through a pre-heater and are blow moulded.
- The bottles are then packed at C.
- Each machine has a separate packing area exclusively for it.
- The packed bottles are then stored at dispatch D.
- A space F is also provided to store polythene bags and cartons used for packing purpose.
- Once the customer's collection vehicle arrives, it is loaded into it at E.
- The cartons, rejects and other unwanted material is placed at G from where is disposed periodically.

Objectives Accomplished :

- The layout has been optimized further.
- Space has been utilized to the maximum.

4.3 Time Study in Unit B :

4.3.1 Data Collected for Time Study in Original Layout :

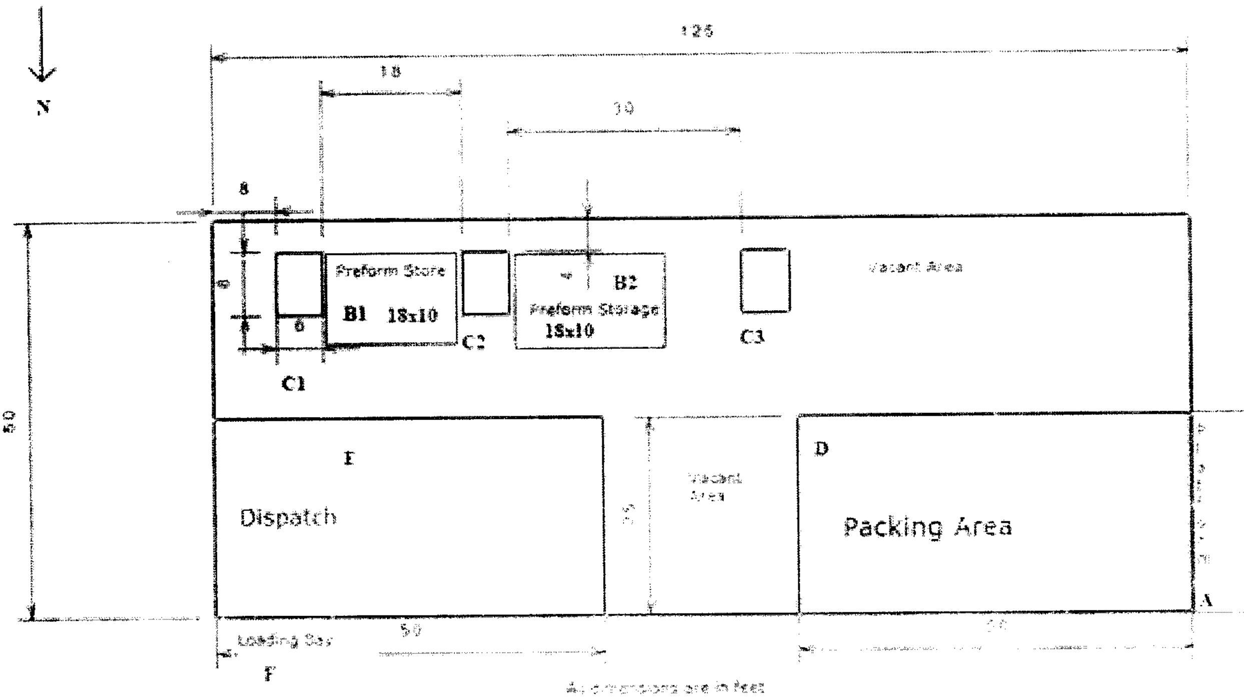


Fig. 4.6 Time study – Layout B original

- Distance covered for movement of cartons to Preform Storages

  A – B1 = 120 ft.

  A – B2 = 90 ft.

- Time taken for movement,

  A – B1 = 33s.

  A – B2 = 25s

- Amount of preform which the unit consumes every 8 hrs.,

  = 27 cartons (i.e., 1 carton of preform/machine per hour x 8 hrs. x 3 machines + bottle caps, i.e., 3 cartons)

- To B1, where 8 cartons are stored, 33*8 + 25*7 = 439s.

  Since manual labour is involved, let us assume 130% of theoretical time is taken = 439*1.3 = 571s = 9min. 30s.

- To B2, where 16 cartons are stored, 25*16 + 20*15 = 700s

  Since manual labour is involved, assuming 130% of theoretical time = 700*1.3 = 910s = 15min. 10s.

- Time taken to move the load = 9min 30s + 15min 10s = 24min 40s.
- Time taken for blow moulding = 14s for every 2 bottles.
- No. of bottles produced/hr. = 3600/14 = 500 bottles approx.
- Time taken for packing = 15 min. for every package containing 50 bottles.
- Distance to packing area, from C1 – D = 60 ft.

  From C2 – D = 35 ft.

  From C3 – D = 10 ft.

- No. of bottles packed/person per hour = 60/15*50 = 200 bottles

  But, practically, assuming only 80% efficiency, = 160 bottles.

- Distance to be travelled to move bottles to loading bay = 50ft. max
- Time taken to move 1 package = 20s.
- Assuming 500 bottles to be shipped, = 20*10 = 200s = 3min 20s.

  But, practically time taken = 5 min. since bottles stacked irregularly.

4.3.2 Data Collected for Time Study in Intermediate Layout :

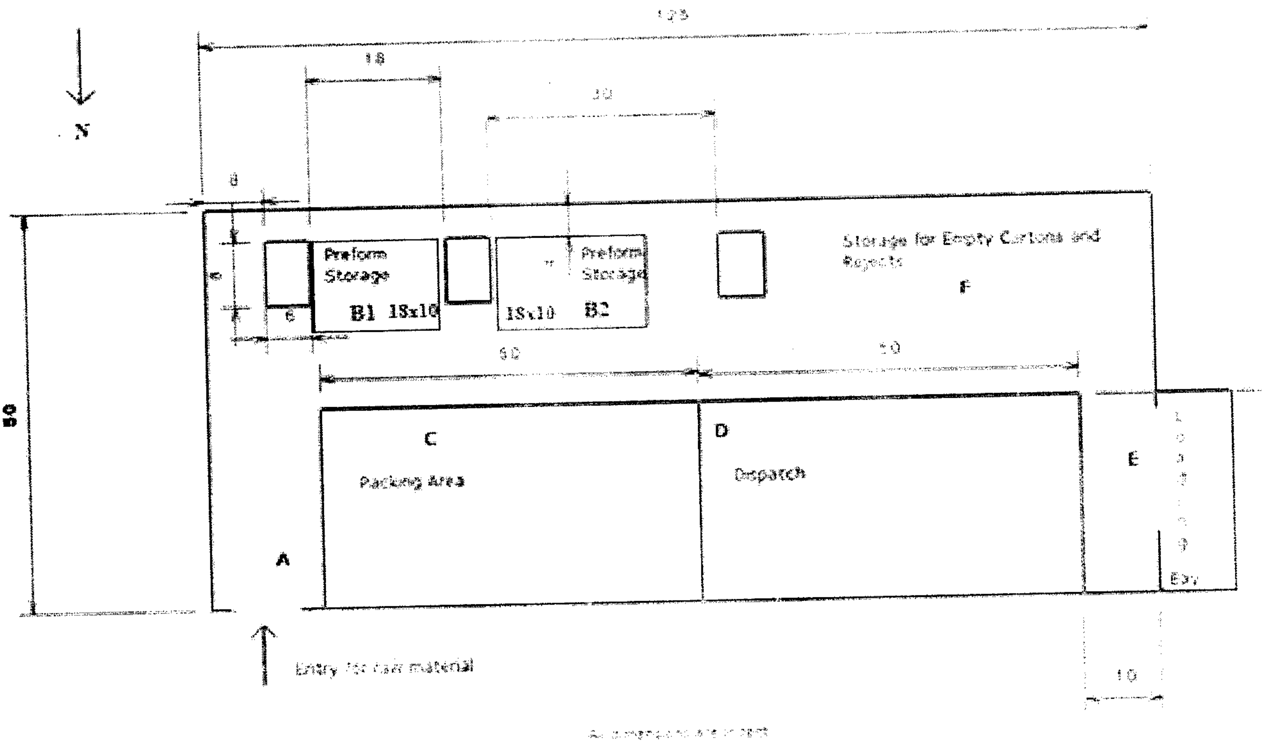


Fig. 4.7 Time study – Layout B intermediate

- Distance covered for movement of cartons to Preform Storages

  A – B1 = 40 ft.

  A – B2 = 70 ft.

- Time taken for movement,

  A – B1 = 12s.

  A – B2 = 20s

- Amount of preform which the unit consumes every 8 hrs.,

  = 27 cartons (i.e., 1 carton of preform/machine per hour x 8 hrs. x 3 machines + bottle caps, i.e., 3 cartons)

  Time taken to move this load from A

- To B1, where 8 cartons are stored, 12*8 + 9*7 = 159s.

  Since manual labour is involved, let us assume 130% of theoretical time is taken = 439*1.3 = 207s = 3min. 30s.

- To B2, where 16 cartons are stored, 20*16 + 16*15 = 560s

  Since manual labour is involved, assuming 130% of theoretical time = 560*1.3 = 728s = 12min. 10s.

- Time taken to move the load = 3min 30s + 12 min. 10s = 15min. 40.
- Time taken for blow moulding = 14s for every 2 bottles.
- No. of bottles produced/hr. = 3600/14 = 500 bottles approx.
- Time taken for packing = 12 min. for every package containing 50 bottles.
- Distance to packing area,

  From machines – D = 10 ft.

- No. of bottles packed/person per hour = 60/12*50 = 250 bottles

  But, practically, assuming only 80% efficiency, = 200 bottles.

- Distance to be travelled to move bottles to loading bay = 50ft. max
- Time taken to move 1 package = 20s.
- Assuming 500 bottles to be shipped, = 20*10 = 200s = 3min 20s.

  (No time loss since bottles are accessible easily).

4.3.3 Data Collected for Time Study in Final Layout :

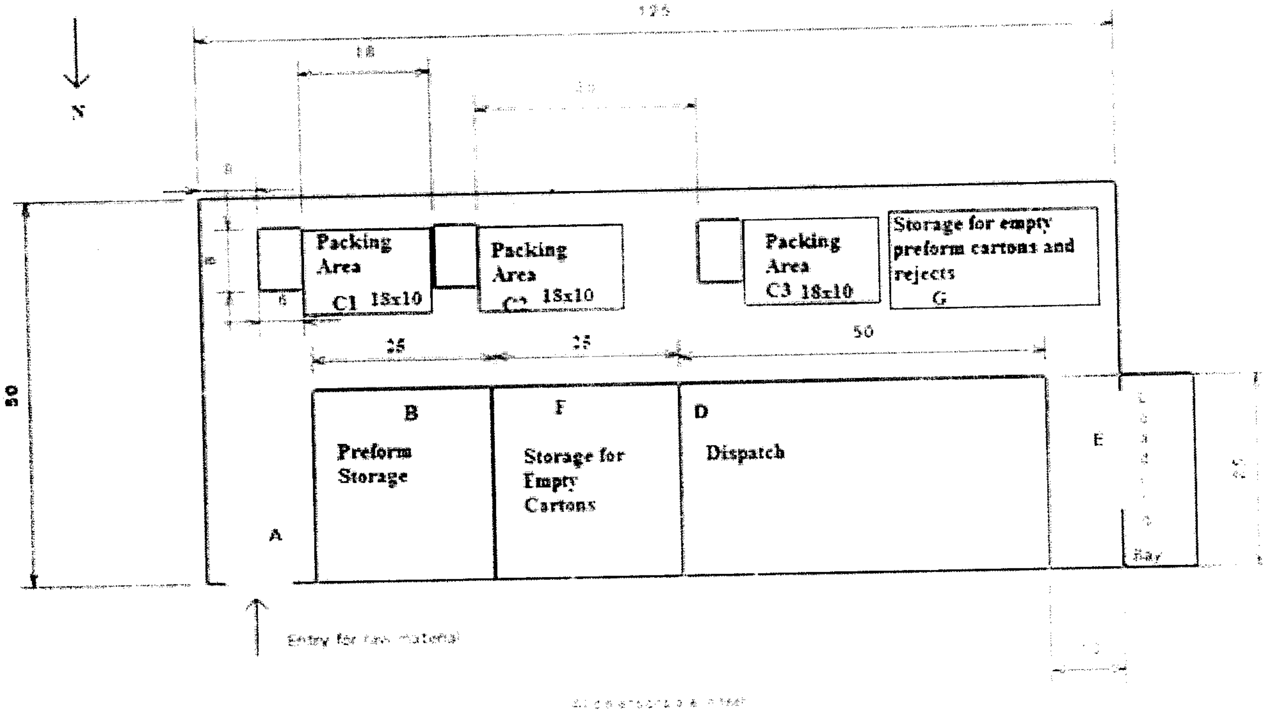


Fig. 4.8 Time study – Layout B final

- Distance covered for movement of cartons to Preform Storages

  A – B = 25ft.

- Time taken for movement,

  A – B = 7s.

- Amount of preform which the unit consumes every 8 hrs.,

  = 27 cartons (i.e., 1 carton of preform/machine per hour x 8 hrs. x 3 machines + bottle caps, i.e., 3 cartons)

- Time taken to move this load from A,

  - To B = 24*12 + 23*9 = 495s.

    Since manual labour is involved, let us assume 130% of theoretical

- Time taken for blow moulding = 14s for every 2 bottles.
- No. of bottles produced/hr. = 3600/14 = 500 bottles approx.
- Time taken for packing = 10 min. for every package containing 50 bottles. (No movement to packing area necessary).
- No. of bottles packed/person per hour = 60/10*50 = 300 bottles

  But, practically, assuming only 80% efficiency, = 240 bottles.
- Distance to be travelled to move bottles to loading bay = 50ft. max
- Time taken to move 1 package = 20s.
- Assuming 500 bottles to be shipped, = 20*10 = 200s = 3min 20s.

  (No time loss since bottles are accessible easily).

4.3.4 Change in Productivity :

Operation	Original Layout	Intermediate Layout	Final Layout
Preform Movement			
Per Carton	50s approx.	30s approx.	11s
Per Load	24 min.	15min. 40s.	11 min.
Efficiency Improvement	Nil	35% improvement	54% improvement
Packing			
Per Package	15 min.	12 min.	10 min.
Per Hour	160 bottles	200 bottles	240 bottles
Efficiency Improvement	Nil.	25% improvement	50% improvement.
Movement To Loading Bay			
Per Load of 10 Packages	5 min.	3min. 20s.	3min. 20s.
Efficiency Improvement	Nil	33% improvement	33% improvement

Table 4.1 Time Study conclusion

4.4 Storage Space Economization :

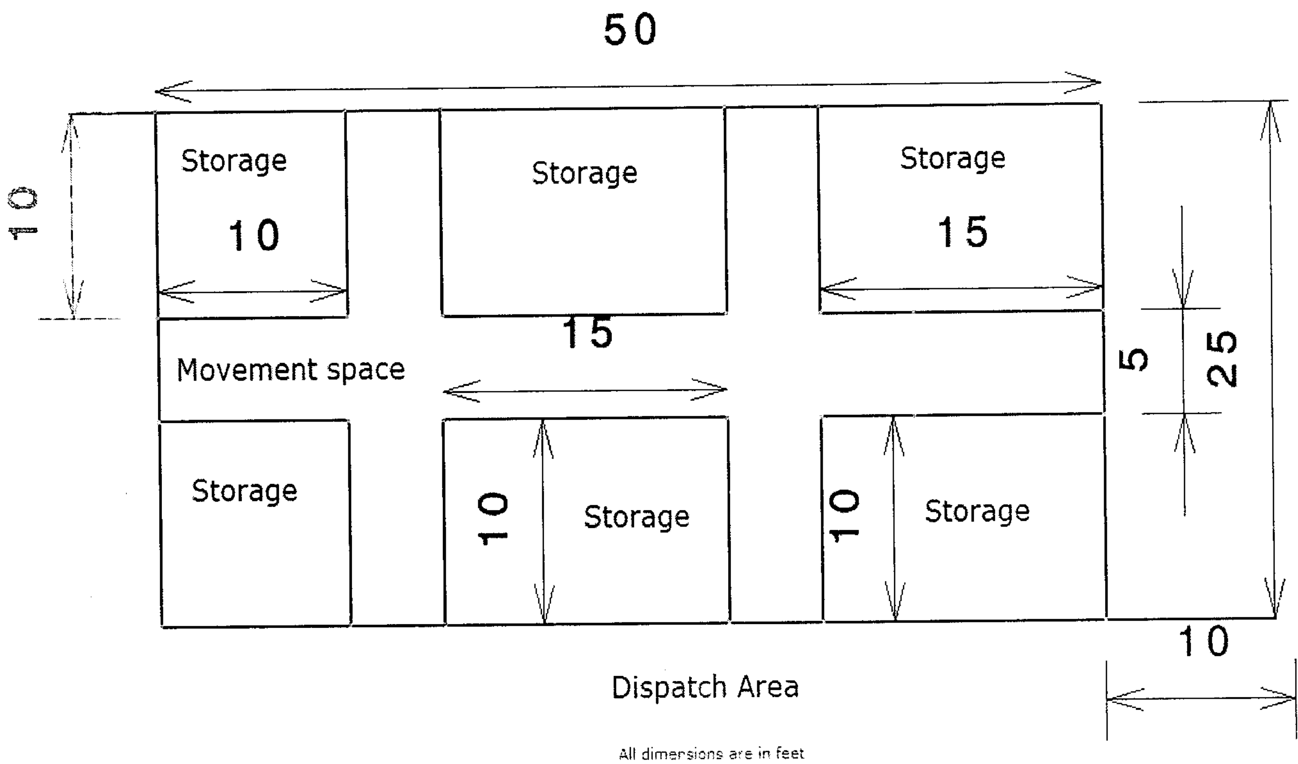


Fig. 4.9 Storage space economized

- The dispatch area can be split into areas as shown.
- The displayed layout has provision to store 6 different types of products.
- A pathway of 5ft is also present for easy access.
- Two areas can also be combined in case of presence of large quantities of a single item.
- Hence, by splitting the floor area as such, material movement is fast and takes place without any confusion.

CHAPTER V

IMPLEMENTATION OF INVENTORY MANAGEMENT SYSTEM

5.1 Usage of a management system to maintain stock :

The industry relied only on physically counting the material to maintain stock. This was a time consuming process and since it was carried out by labourers who were not well educated and so, it would not be accurate.

The company produces six different types of products. They inventory includes:For SABOLS,

- 1 litre bottles.
- 500 ml. bottles.
- 5 litre bottles.
- 2 litre bottles.

For AAVIN,

- 250 gm. bottles.
- 100 gm. bottles

5.2 Inventory Card Design :

A simple inventory card was designed which displays the essentials. The design is as shown.

<table>
<tr><td colspan="3">SKYPET Polymers</td></tr>
<tr><td colspan="2">Item Name</td><td>Bottles 1 Litre capacity</td></tr>
<tr><td colspan="2">Client Name</td><td>Ms. SABOLS</td></tr>
<tr><td>Quantity</td><td colspan="2">50 Units</td></tr>
<tr><td colspan="3">Card No. 1
SKYPET POLYMERS</td></tr>
</table>

5.3 Collection Bins Position:

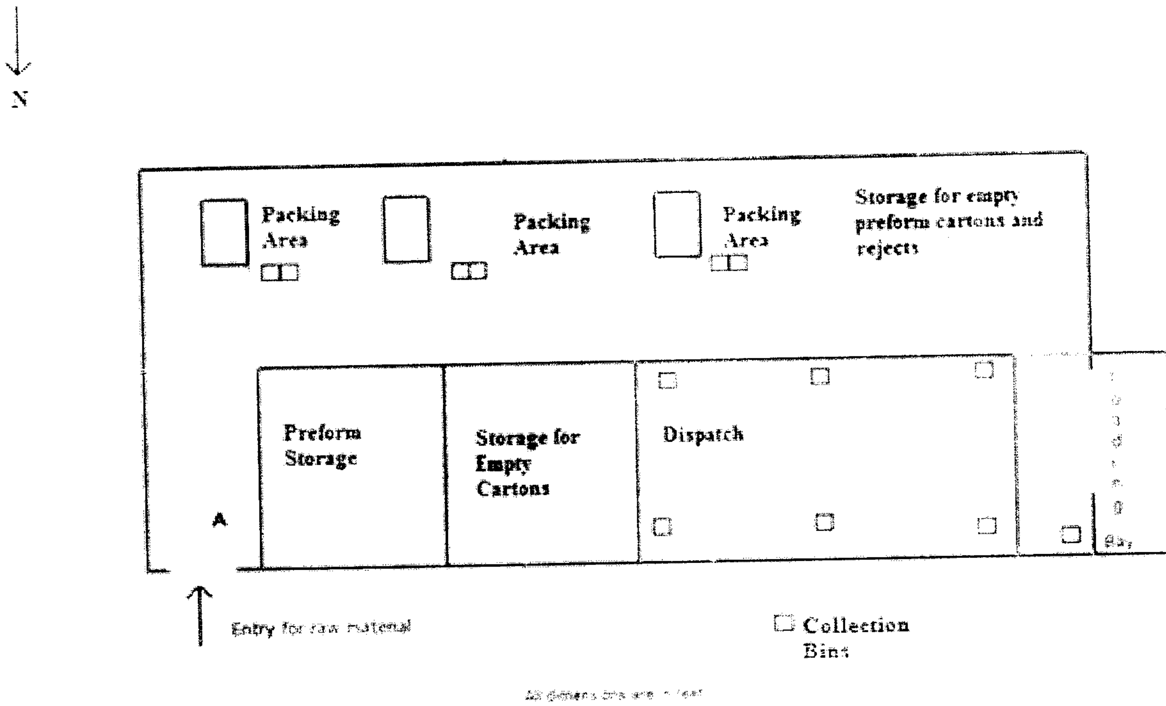


Fig. 5.2 Bin position in layout

- There are 2 collection bins provided in each packing area.
- One bin is for the number of bottles packed and the other one is for the rejects.
- There is also a bin at each of the sections in the Dispatch area to keep track of the inventory present.
- A bin is also placed at the exit so that the number of items shipped can also be kept track of.

5.4 Procedure :

- One card is issued for every 50 preforms shipped from factory 1 to factory 2.
- For every 50 bottles packed, the worker takes a card from the preform bin and places it in the Packing Area bin.
- For every 50 bottles moved to the Dispatch area, a worker takes a card from the Packing area and places it in the bin at the respective section in the Dispatch area.
- For every 50 bottles dispatched, i.e., for every package, the worker takes 1 card from the dispatch bin and places it in the Loading Bay bin.
- Hence, by counting the number of cards, the number of bottles that have been packed, the inventory present in the dispatch area and the quantity that has been shipped can be made note of.
- If there are cards present which have not been transferred to the "Dispatch" bin, the number of rejects can be known.
- At the end of each shift or at periodic intervals, the cards will be returned to unit A and will be recycled.

CHAPTER VI

IMPLEMENTATION OF JUST IN TIME FOR TRANSPORTATION

6.1 Original Practice :

The movement of preform from Unit A to Unit B was highly irregular and would take place every day at unspecified intervals by numerous kinds of transport. This material would then be stored at Unit B regardless of the inventory present. Hence, the quantity present at Unit B would always have large fluctuations. In order to standardize this process, Just-in-Time was implemented so that transportation was done at predetermined intervals and no ambiguity would be present.

6.2 Practice after JIT Implementation :

The process adopted works as follows :

- In unit B, each machine consumes 1 box, i.e., 500 preforms per hour.
- So, per hour, 3 boxes of preform are consumed.
- Unit A produces 1000 preforms per hour.
- It also produces 2100 bottle caps per hour from which flash has to be removed. Hence, it takes 2 hours to produce and pack 2100 bottle caps.
- So, in Unit A, 4 cartons (2000 preforms) are packed every 2 hours along with the caps.
- Unit B operates in two 12 hour shifts and so, it was decided to transport raw material for every shift so that the productivity can be monitored according to a shift basis.
- Unit B will consume 3*12, i.e., 36 boxes of preform per shift.
- Hence, Unit A will ship 36 boxes by a Mini Van one hour prior to the beginning of each shift.
- By implementation of this procedure, unnecessary inventory storage was eliminated and the productivity during each shift was also kept in check.

CHAPTER VII

CONCLUSION

7.1 Objectives Accomplished :

By implementing the principles of lean manufacturing in the various processes, standardization was achieved as well as improved productivity in a few areas. The management was satisfied with the results the changes were able to produce.

The following goals were accomplished :

- The storage space in Unit A was standardized.
- The productivity in Unit B improved after changing the layout. This was in the areas of packing and material handling.
- The inventory could be maintained better owing to a simple inventory management system.
- The storage space was accessible easier due to the partition.
- The transportation time was also standardized by using Just-in-Time.

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