

Implementing Lean in A Small Scale Ice Cream Manufacturing Industry

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ABSTRACT: The main objective of lean manufacturing is to provide the best possible service/product to the customers through the elimination of all forms of waste, it requires a continuous improvement process in which employees are capable of detecting and effectively solving problems swiftly. It also requires an extremely stable production system. Organizations are choosing lean production with the ultimate aim of reducing overall operating cost to barely minimum. Applying the lean manufacturing technique in Small Scale Ice Cream manufacturing company and with the help of value stream mapping (VSM) as a prime tool, the company's current state will be analyzed so to detect any non-value adding processes termed as waste. Future state VSM is developed by eliminating all the non-value added process from entire production line. Study will be carried out on production lines and how information are distributed across the entire company from suppliers to the customers and the way forward to achieve the aim of operating on lean.

Index Terms: Lean, small scale ice cream manufacturing, VSM.

I. INTRODUCTION

Ice cream is a frozen dairy product made by suitable blending and processing of cream and other milk products, together with sugar and flavor, with or without stabilizer or color, and with the incorporation of air during the freezing process [1]. Ice cream consists of at least 4 major discrete phases: ice crystals, air cells, fat globules, and liquid phase. It is a frozen mixture of a combination of components of milk, sweeteners, stabilizers, emulsifiers, and flavoring [2]. Ice cream quality is dependent on many factors, one being ice crystal size. Ice crystals form at the beginning of the freezing process. The freezing process involves rapid removal of heat while agitating vigorously to incorporate air, thus imparting the desirable smoothness and softness of the frozen product [2]. The faster the ice cream mix is frozen, placed into the final container, and sent through a blast freezer, the smaller the ice crystals are in the finished product. Smaller ice crystals (<55 μm) in ice cream are more desirable to consumers, as the product is perceived to be less icy.

II. LITERATURE REVIEW

Lean production is thought to be originated from Toyota Production System (TPS). Toyota production system conjointly referred to as Just-In-Time (JIT) system was introduced to supply solely what and when once the client desires their product. Taiichi Ohno and his mitt man Dr. Shiego Shingo are noted to be the originators of Toyota Production system (TPS) or JIT after they required to compete with alternative giants like Ford within the automobile industries [3]. With lean production, the worth of a product or service is outlined by the customer's point of view. Customers settle for your product by watching how well they satisfy their sets of needs. Customers don't want to pay for any quality defects created by the facility and so it'll be compelled to be corrected. Lean production sets priorities to straightforward, small and continuous improvement instead of huge innovations.

A. Ice cream by definition

Ice cream is formed by cooling and simultaneously beating air into (aerating) a liquid mixture that contains fat, sugar, milk solids, associated emulsifying agent, flavoring and typically coloring.

B. Formulating the Ice cream mix

It is necessary that small producers perceive a way to develop new ice cream mixes to satisfy ever-changing customer demands. 'Balancing' the combination involves maintaining the proper balance between:

- Fat and sugar that controls the 'fattiness' of the product within the mouth.

- Water and solids that controls the texture or hardness/softness.
The formulation of associate ice cream mix ought to be taken into consideration the price and availability of ingredients.

C. Ice Cream Quality

Many factors, including the flavor, appearance, color, body and texture, melting quality and package will influence quality and the overall acceptability of the product by consumers. Appearance is the initial aspect of a product to influence customers. The numerous quality factors regarding appearance influence our opinion as customers even before we have a tendency to taste it and so these factors ought to be carefully considered and adequately addressed during a quality-control program. Once the appetite is stimulated and a delightful flavor is anticipated, customers are psychologically prepared for a delicious taste impression. Texture and flavor are the foremost important quality factor in Ice creams. Associate ice cream mix with lower total solids has proportionately a lot of water to freeze than a higher total solids mix hardened to an equivalent storage temperature. Thus, ice cream mixes with high total solids content have a lot of desirable body/texture [2]. Percentage total solids of the ice cream mix is directly associated with ice crystal size distribution [4]. Ice cream quality depends on several factors including storage temperature. Currently, the industry standard for ice cream storage is -28.9°C . An ice cream production price is also minimized by increasing the temperature of the storage deep freezer, therefore lowering energy prices [5]. When ice cream is shipped from one altitude to another, a change in atmospheric pressure will contribute to shrinkage of the product. Small air cells, heat shock, high overrun, small ice crystals, improper blending of ingredients, and a good range of temperature changes throughout storage are some of the causes of shrinkage in ice cream. Issues occur once ice cream is shipped from low to high altitudes or the other way around. Shrinkage of ice cream causes a great economic loss to the ice cream manufacturer. It can be avoided by allowing the ice cream -29°C for minimum of 72 h before shipment to the sales outlets [6]. And also, it's essential to maintain the temperature of the shipment cabinet between -25 to -30°C while the product is being transported to or from high altitude. Ice cream prepared with local stabilizers/emulsifier blends comparable with the ice cream prepared from foreign and expensive blends [7]. Therefore, by using domestically made stabilizers/emulsifier blends, the price of production will be reduced and so foreign exchange will be saved.

D. Lean Manufacturing

Lean manufacturing relies on the Toyota Production System developed by Toyota that focuses on eliminating waste, reducing inventory, improving throughput, and inspiring employees to bring attention to issues and recommend enhancements for fixing them [8]. A core conception of lean manufacturing is pull production during which the flow on the factory floor is driven by demand from downstream pull production upstream. A number of the changes needed by lean manufacturing are often troubled if not enforced properly and a few aspects of it don't seem to be applicable for all companies [9].

E. Lean manufacturing Tools

Many tools are employed in reducing or eliminating wastes within the production lines or organizations. It's been established that when any of the lean tools is employed as standalone, it doesn't offer the desired impact and most of the time these tools are needed together to have the required effects. The sequences of implementing lean have an effect on the overall impact of the system. Additionally using some of these lean tools incorrectly affects the system negatively and so needs to be studied very well before selecting the right lean tools for the organization.

- [1] Kanban: It will be seen as a simple card commonly placed at a well-chosen position so all the info on that will be viewed by people who need them during production or it can even be on a monitor where operator and staffs can log in to the required information for next production [10].
- [2] Just-In-Time: JIT is a term referred to the production of products to satisfy customer demand precisely, in time, quality and quantity, whether or not the customer is the final consumer of the product or another process further on the assembly line. Just-In-Time in its totality incorporates continuous improvement, eliminating of wastes, smart housekeeping, reduction of set-up times etc.
- [3] Work Cells: It is a technique of organizing operations and/or individuals in a cell instead of straight production line. Work cell is quicker and economical in production than the normal technique of batch and queue style of production. Cellular manufacturing helps to attain JIT and eliminates buildup of

- inventory because it depends on pull system whenever products created by a workstation are instantly pulled by the preceding work station.
- [4] Total Productive Maintenance (TPM): The ultimate goals of TPM are zero breakdowns and zero defects. It is an extremely structured approach that uses variety of tools and techniques to realize extremely effective plants and machinery.
Through TPM process focus, the cost and quality were improved considerably by reducing and minimizing equipment deterioration and failures. Cost of rework and repairs reduced because of very limited product rejection owing to equipment failure. Thus, the total effectiveness of equipment also improved considerably.
- [5] The 5S: It is a terminology that originated from Japan stands for 5 terms that are smart housekeeping in a company. It's one among the simplest lean tools that create a discipline, clean and well-ordered work atmosphere. Lack of a sturdy 5S system makes other lean tools ineffective [11]. Also it's a vital part of TPM. The term 5S stands for sort, straighten, shine, standardize and sustain.
- [6] Single Minute Exchange of Die: It is abbreviated as SMED, a technique accustomed reduce machine set-up time by the utilization of recent engineering technology, simplicity and standardization of the processes of production. It makes production lines versatile by simply changing over from one product to a different. The frequent changeovers can extend production flexibility and permit smaller batch sizes [12].
- [7] Total Quality Management (TQM): It is a management system accustomed to continuously improve all areas of a company's operation. It is applicable to each operation within the company and acknowledges the strength of employee's involvement [12].
TQM is an efficient system for desegregation of the quality development, quality maintenance and quality improvement efforts of the varied teams in a company thus enabling production and repair at the foremost economical levels that permits for full customer satisfaction [13].
- [8] Batch Size Reduction: It is one of the lean tools that require to follow in a continuous manner to attain the most effective minimum batch size. Reducing batch size results in reduced work-in-progress (WIP) which then results in reduce inventory cost. In larger batch size if error happens it cost the organization severely because then they have to rework all the affected product or perhaps typically need to discard all product as a result of not meeting the specification [10].
- [9] Value Stream Mapping: Although several tools exist, VSM has demonstrated its effectiveness [14, 15, 16]. It's a tool that has communication solutions for practitioners to get most potency. It is an efficient tool for distinguishing the process wastes.
VSM is a lean manufacturing technique and it's emerged as the most popular way to support and implement the lean approach. VSM is totally different than typical recording techniques, because it captures the data at individual stations regarding station uptime or utilization of resources, cycle time, WIP inventory, setup time, work force requirement and also the information flow from raw material to finish product.

III. METHODOLOGY

F. Problem Statement

In both manufacturing industries and service sectors, there are considerable amount of waste which are not easily identified but they form part of the daily processes. This has generated the need for analyzing the processes within a company to identify these hidden wastes and find means to eliminate them. XYZ ice cream manufacturing company which produces variety of premium ice creams on small scale has aim of expanding their production systems which needs to be flexible to meet the challenging expectations of customers and also being competitive. To meet customer's demand on time and conjointly to provide fine quality product at a minimum cost desires operating on lean principles. XYZ Company starts it methodology of production from taking deliveries from varied suppliers who offer the ingredients, then to the process department to manufacture ice creams, followed by transporting the prepacked ice creams to retail outlet. This issue desires continuous improvement of the system to be able to meet customer's expectations forever.

G. Objectives of This Project

The objectives of this project work are to analyze XYZ Company's manufacturing system and try to find out if there are any non-value-adding processes and then suggest which lean principles are best suited for this company. It is therefore divided into three main points as follows:

- Analyzing the current processes at the company by studying them (working in the company for some time)
- Find out any hidden wastes in the company's current production system
- Determine the best suited lean principles for the company by discussing it with management

H. Methodology

The research methodology used in this project is a case study methodology. The case study method allows the researchers to retain its holistic and meaningful characteristic of real life events. Since lean manufacturing and its techniques are already present in large and medium scale industries, the small scale industry is selected where lean techniques aren't widely employed. There are two reasons for choosing ice cream industry in particular, one is because everyone loves ice cream and second is availability of known ice cream manufacturer. As the manufacturer requested, the company's name will be known as "XYZ Company". As a first step in the project work, an extensive study on literature review on topics of lean manufacturing as well as characteristic of ice cream and its quality factors are studied. Ice cream manufacturing process is studied and various activities involved are noted through brain storming. Value stream mapping is an ideal lean tool for capturing these processes, which will help in segregation of value added processes from non-value added. Thus, it provides ways to eliminate those non-value added activities from the system. Current state VSM is drawn for the present manufacturing system. Future state VSM will be drawn once the identification and elimination of waste from present system is done. Since lean is a continuous improvement philosophy, from future state the next-future state will be drawn and so on.

I. Limitations of this Work

This study is limited to XYZ Company only and any recommendation may not be necessarily be helpful to any other company as it has been established that lean principles helpful to companies differ from one another.

IV. CURRENT OPERATING STATE

The current operating state at XYZ Company is the traditional form of production right from suppliers to the final customer. Almost all the departments within the company try to reach their own targets without considering the next department or the entire company's targets.

J. Current Inventory

Raw materials or ingredients for the production of ice cream are stored in a room as inventory. After production, ice creams are kept in hardening cum storage room until the ice cream is shipped to customer/retail shops. The ingredients are sorted out based on types such as milk, natural flavors & essence, stabilizer, emulsifier, sugar and other ingredients.

K. Suppliers

There are various suppliers to the company with each one supplying one or more of the ingredients used by the company. The natural flavoring agent is the important ingredient which is imported from Italy directly. Other ingredients are sourced from local suppliers and milk is procured directly from the local farmers.

L. Information Flow

Information flow within the company does not take any formal form. Between the major supplier and the company, information is transfer normally between the supplier's sales persons and the manager of XYZ Company or by through telephone calls. Within the production section, information is passed from co-worker to another verbally and vice versa. Sometimes the supervisor is the one who carries most of this information either from operators to the manager or sometimes from manager to operators. Also manager communicates straight to the worker when needed and he is also open to all workers who want to communicate with him concerning the company, co-worker or even personal issues. Communication between the company and its distribution centers (Outlets) is done through telephone. This means when a retail outlet want to place order, the outlet manager makes a call to the supervisor or the manager. The one who receives the call makes all the necessary checks and well informed about inventory, production and availability of transport to confirm when the order can be delivered.

M. Ice Cream Production

Current ice cream production at XYZ Company is running on single shifts with operators operating all the machines for the production. The production rate is also quite able to meet current market demand. The ice cream production facility supplies few external customers as well as the company’s own outlet centers. Production of quality ice cream consist of seven key steps/processes such as

- [1] Blending
- [2] Continuous pasteurization, homogenization & cooling
- [3] Ageing
- [4] Continuous freezing
- [5] Packaging
- [6] Hardening
- [7] Storage and Distribution

N. Current State Value Stream Mapping for Ice Cream

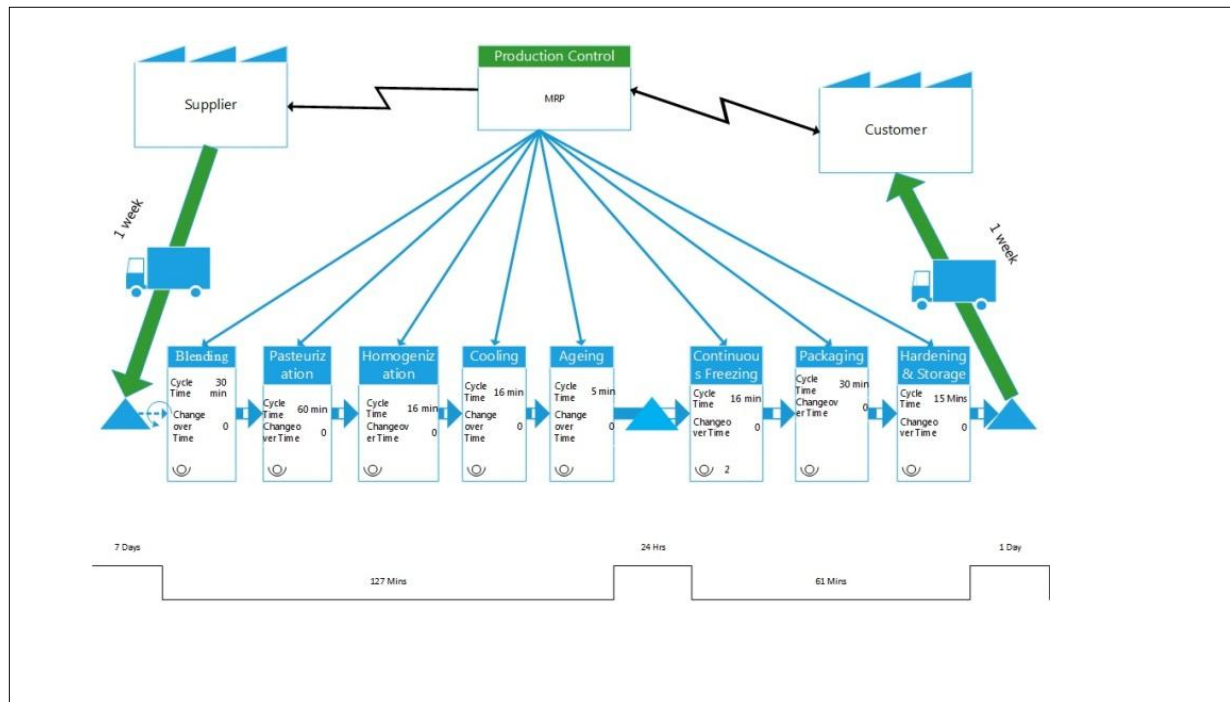
The value stream mapping of the current ice cream production within the company is illustrated in Fig. 1 shows how the product move during production. The procedures start by taking delivery of raw materials on weekly basis to the raw material inventory. At the raw material inventory, materials are stored to cater for weekly production except milk which is procured the day before production.

TABLE I. PROCESS CYCLE TIME
 TABLE II.

S.No	Process	Cycle Time	No.of Operators
1	Blending	30 Mins	1
2	Pasteurization	60 Mins	1
3	Homogenization	16 Mins	1
4	Cooling	16 Mins	1
5	Ageing	24 Hours	1
6	Continuous freezing	16 Mins	2
7	Packaging	30 Mins	1
8	Hardening & Storage	24 Hours	1

The first main process is weighing and the mixing or blending together of the raw materials before going to pasteurizing process. The blending process takes about thirty minutes before it is ready to be moved to the next process. The pasteurizing process requires averagely sixty minutes as normally it is allowed to continue to work when the next process is not ready to take new product to process. This has been because the more pasteurizing process goes on, the better mixing of the cooked product. The next process is homogenization, processed product are transferred to homogenization machine from previous step. Then output from this step is transferred automatically to cooling machine. In cooling stage, where the hot mix caused by the pasteurizing process is cooled by cooling system, where temperature drastically dropped to 4 °C from 80 °C in homogenization phase. Cooling is followed by the ageing process which is also a form of cooling. In ageing semi-processed mix left in ageing machine for minimum 24 hrs before it is moved to continuous freezer where actual ice cream making of the mix takes place. At this step flavor is added to the ice cream mix in the flavoring chamber. This is the most important step in producing varieties of ice cream. Continuous freezing process is followed by packing the ice creams into respective cups. Then packed ice cream is moved to hardening cum storage room which is maintained at -28 °C. Ice cream must be allowed to harden for atleast 24 hours. This is the final process in the converting into the finished product. This room also acts as storage and finished product inventory. Thus manufactured ice cream is kept in this storage room until the product is shipped to customer. Production planning and control department currently communicates to customers, distribution centers and also suppliers through the use of mobile phone.

Most of the time it is only the company, who initiates the communication by checking on whether there are enough stocks of raw materials which they need but not from the suppliers. However, it is two-way communication between customers and the company to place order and also check on stock and again negotiate for when an order can be delivered. Information from planning and control section to the shop floor is manually done at the beginning of each shift through a supervisor on the shop floor.



Total lead time = 15 days
 Total Value added time = 188 mins

Fig. 1. Current State VSM

V. ANALYSIS OF THE CURRENT STATE

The current practices within the company are analyzed to find out where improvement can be done to achieve lean in the company's ice cream production system.

O. Analysis of Current Ice Cream Production

- ✓ The production orders and planning is being done traditionally by paper and introduction of a production order that will be displayed on screen will be beneficial.
- ✓ The orders are received from the customer using normal communication devices rather than a standardized system, introduction of online order, receipt and communication may improve this process.
- ✓ The delivery from the suppliers is received on a weekly basis creating a lot of inventory for the raw materials, if the delivery is standardized and planned on a daily basis; inventory and waste can be prevented also the lead time for production can be reduced.
- ✓ Rather than having a huge weekly inventory, it is better to have safety stock for a few days as buffer between supply and production.
- ✓ We can group Pasteurization, homogenization, cooling and ageing into a single cell with one worker and also continuous freezing, packaging, hardening & storage into another group with three workers so that we can do packing faster and as well as constant monitoring of continuous freezer is possible.
- ✓ The cell formation will reduce production time and inventory.

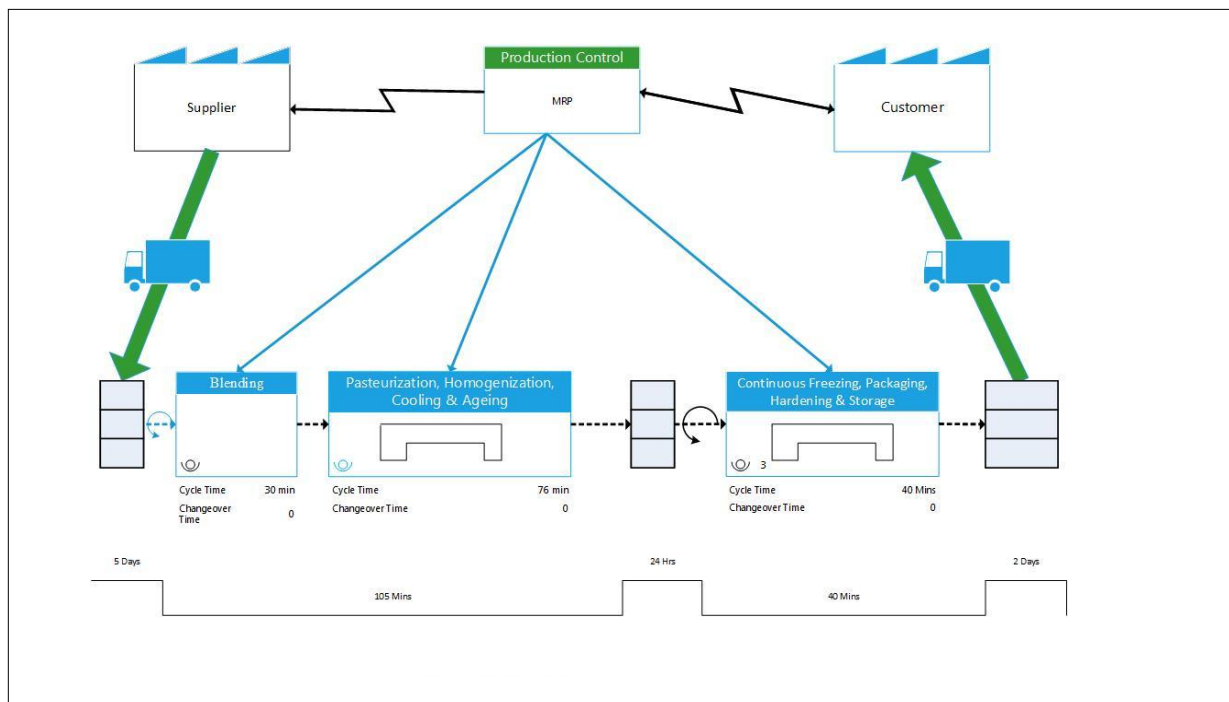
- ✓ The delivery is benefited from a refrigerated truck. This helps the ice cream to be transported to far distances without melting. Well-designed racks or shelves provide more space for packing more ice creams as compared to the current one without it.

VI. FUTURE STATE

After thoroughly learning the current state of operation and improvement is made by the analyzing of the present state in order to work in line with lean principles, a proposed future state of operation has been developed. Most of the processes that can be grouped as work cell and also wherever there are additional staffs few of them are moved to wherever they're required to reduce cycle time at those processes. Inventory on the assembly lines are either removed or replaced with a safety stock as an aid to avoid delay in delivery of customer's orders.

P. Recommended Future value Stream Map for Ice Cream Production

The raw material inventory that takes a mean of seven days has been redesigned to possess a safety stock. The safety stock is to avoid any unforeseen disruptions that may occur to prevent supply of raw material. This has become possible due to effective discussions that happened between major suppliers and the company. Suppliers are able to deliver on day to day and if by any reason delivery can't be done on a specific day, the organization will be notified before close of noon, to avoid stops of productions. The numerous processes on the ice cream production are reduced to solely 3 processes with some process from the current processes grouped into work cell of similar or subsequent processes which might extend the efficiency of the production system.



Total lead time = 7 days
 Total Value added time = 145 mins

Fig. 2. Current State VSM

As shown in Fig. 2, the future state value stream mapping shows all the recommended processes with the blending process pull raw materials from the safety stock applying first-in-first-out principles. Blending followed by a workcell comprises of pasteurizing, homogenization, cooling & ageing with single worker, is followed by another workcell comprises of continuous freezing, packaging, hardening & storage with three operators. These have been prominent as these processes are interconnected and they don't need much

supervision except continuous freezing. Grouping them additionally helps to reduce the overall cycle time and improves efficiency. This has contributed to reduced overall value added time. The inventory for the finished ice cream is currently changed into a safety stock which will hold two days buffer stock to take care for any short coming on the production line. Also information between distribution centers and the company on placing of orders is suggested to be done through email that is cheaper and reliable to avoid error in processing orders. Production data is written on a bulletin board placed at an area for everyone to be able to read so all operators can know how much they're required to produce within a shift and work in-line with that data. This paves way for continuous process improvement.

VII. CONCLUSION

Q. Brief Summary

Present situation of XYZ Company is analyzed and current state VSM is drawn. Further analysis is carried out to eliminate various non-value activities from the system. Implementing lean improves the process quality and decrease lead time which ultimately leads to cost saving. Through lean implementation the company's aim of producing premium quality ice creams consistently is fulfilled.

R. Recommendation & Conclusion

As the first step towards lean implementation, a task team has been formed with people from different parts of organization including management, all having rich knowledge and information pertaining to the process, production, equipment and planning. With objective of reducing the level of non-value activities present in any form by implementing various lean tools. Current ice cream production process is captured in value stream mapping tool. VSM helps in identification and elimination of waste from the current production system. This tool shows the possibilities for improvement in current process. Further improvement work carried out leads to continuous process improvement. Also future state VSM is constructed, which clearly indicates the decreased lead time, improved process efficiency and decreased operating cost, as excess operators were reduced based on lean principle.

S. Scope for Future Work

Lean manufacturing is based on continuous process improvement philosophy. Further process improvement is possible by introduction of lean six sigma methodology. Lean six sigma tools can be applied at blending process, pasteurization and continuous freezing processes where process efficiency can be maximized. It is an established fact that lean tool integrated with six sigma tool might have a tremendous impact on organization's performance during its growth.

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