Lean Manufacturing Implementation in Material Handling System of Indian Fertilizer Industry

Bhargav C. Patel[1] , Bhrugesh Radadiya[2]

[1]*Asst. Professor, CGPIT, UTU, Bardoli*
[2]*Asst. Professor, CGPIT, UTU, Bardoli*

[1] bhargav.patel@utu.ac.in
[2] bhrugesh.radadiya@utu.ac.in

Abstract:

Lean manufacturing is "A systematic approach to identifying and eliminating waste through continuous improvement". Lean manufacturing focuses on efficiency and services at lowest cost as fast as possible. In many industries like milk dairies, sugar factories, fertilizer companies where decrease in time and elimination of labour cost in a material handling system is very important. Focus area of this research is elimination of unnecessary cycle time in material handling system of fertilizer industry by using most effective tool of lean manufacturing which is known as "Value Stream Mapping". Some important findings of the case study are interpreted after the analysis of current and future state map made from VSM software. By this report we come to conclusion that manpower is reduced from 20 person to 6 person by replacing the manual transporting of fertilizer bag transport by delivery vehicle and labours were replaced by stacker machine. Return on Investment of stacker machine and transportation time is calculated and obtained beneficial result for system.

Key word: ***lean manufacturing, Fertilizer industry, value stream mapping, material handling system, transportation cost.***

1. INTRODUCTION

Manufacturers are now a days facing intensive global competition. The key to competing in the international market place is to simultaneously improve both quality and productivity on continual bases. The major purposes of the lean production are to increase productivity, improve product quality and manufacturing cycle time, reduce inventory, reduce lead time and eliminate manufacturing waste. [1]

Lean manufacturing = half the human effort in the company + half the manufacturing space + half the investment in tools + half the engineering hours = to develop a new product in half. Benefits of Lean System in industry: Waste elimination, Work place standardization, Effective plant layout, Quality will be enhanced at source level, Increase the productivity by 30% from the existing level, Reduction of production cost & other overheads, Reduce the risk of non-compliance and late delivery. [5]

Lean manufacturing focuses on eight types of wastes which are explained below:

- Waiting: Time spent waiting for items required to complete a task (i.e. information, material, supplies, instruction etc.)
- Unnecessary Motion: Any motion that does not add value to a product or service.
- Over processing: Effort and time spent on processing material which doesn't add value.
- Excess inventory : Material that is waiting for processing or not required per customer demand.
- Transportation: Movement of materials and double handling is waste. This will affect productivity and quality issue (conveyer, forklift, trolleys.)
- Overproduction: Producing more products than the ultimate customer requires.
- Rework or defects: Time spent on reworking or repairing defective products.
- Underutilized people: Refers to more people involved in a job than necessary, not involving the associates in process improvement and losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to your employees. [5]

Tools of lean manufacturing are Scheduling, Value stream mapping, Talk time, 5S's, Kanban, Kaizen, TPM (Total productive maintenance), Flow manufacturing, Just-in-time (JIT), Total Quality Management (TQM), Jidoka

1.2 Value Stream Mapping (VSM)

Value Stream Mapping is define that it is the process of mapping the material and information flows required to co-

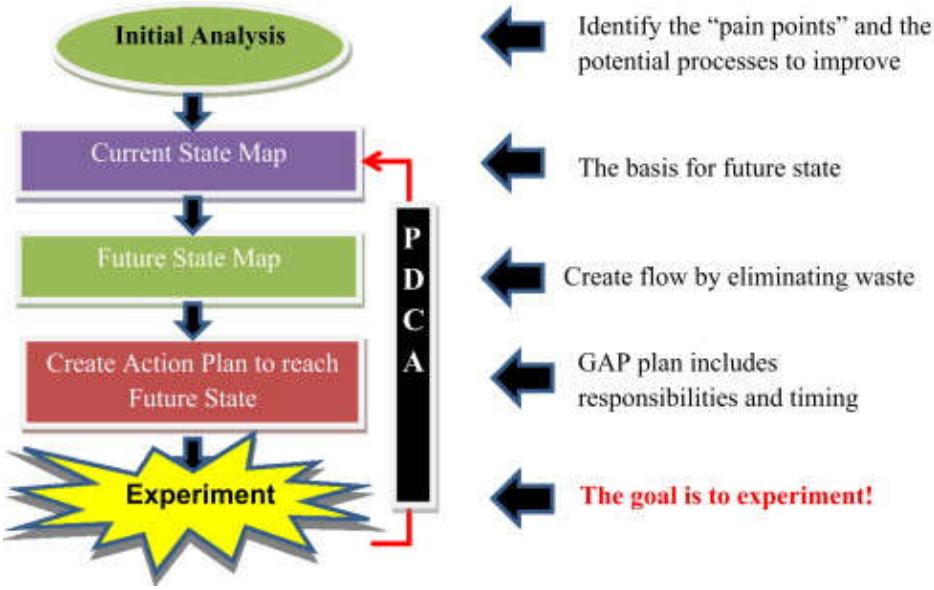

Fig.1. Steps of Value Stream Mapping (VSM) [8]

ordinate the activities perform by the manufacturers, suppliers and distributers to deliver products to customers. Value Stream Mapping is used to illustrate the flow and relationship between work processes. A key component of VSM is differentiating value adding activities from non-value adding activities. Reducing or eliminating no-value adding activities is of paramount importance and a principal goal of lean manufacturing. A current state map (CSM) is drawn by cross functional, multi-disciplined team to document how thinks actually operate. Then a Future State Map (FSM) is developed to design a lean process flow through the elimination of the root causes of wastes & non-value added activities and through process improvement all leading to and implementation plan that details the actions steps needed to support the objectives. Value Stream Map (VSM) identifies Customer requirements, Processes waste, Areas generating poor quality, Labour cost, Material cost, Inventory cost, Maintenance cost [6]. Value stream map included detailed description of the current process. For each step in a value stream, the map will detail flow time, cycle time, number of people involved, and raw materials/work. In process/finished stock inventory, change over time, yield, and other relevant information. The value stream map will identify areas in the value stream with quality problems, inventory problems, and highest levels of wastes, identification of the areas offering the greatest potential for improvement in efficiency, effectiveness and reduction in the lead time.

2. LITERATURE REVIEW

Muriati Mukhtar and Riza Sulaiman was describes a preliminary study in developing conceptual model to measure leanness in manufacturing industry. They were describes the seven main dimensions in measuring leanness in lean manufacturing practices such as manufacturing process and equipment, manufacturing planning and scheduling, visual information system, supplier relationship, customer relationship, work force and product development & technology. [4]

A.C.Yamagar and P.M.ravanan were interested in "material management by using some lean manufacturing principles." They were found how flow of material is managed by using some lean manufacturing techniques like reducing unnecessary motion by changing layout, reducing material handling providing trolleys, reducing waiting time by implementing through vendor-managed inventory (VMI) concept. [3]

J.A.Jimenez-Garcia, Tellez-Vazquez and J.M.Medina-flores studied in "material supply system analysis under simulation scenarios in a lean manufacturing environment". They were mainly focuses on supply system, lean manufacturing & simulation on Automotive industry. They are suggest that the use of simulation using pro-model software, giving flexibility to make experiments without using actual systems. [2]

Tyson R. Bowning and Ralph D. Heath interest on study of "Reconceptualising the effect of lean on production costs with evidence from the F-22 program". They were found that, F-22 program also attributed its lack of production cost reductions to the unforeseen costs of lean implementation itself. Also They find that the timing, scale, and extent of lean implementation matter, that the reduction of waste is better construed as the provision of value, and that this value is an emergent property of a process-implying that lean is not the guaranteed result of the elimination of tasks. [1]

R. Sundar, A.N. balaji and R.M. Satheeshkumar were reviewed on "lean manufacturing implementation techniques. "They were suggest that organization had to focuses on all the aspects such as value stream mapping (VSM), cellular manufacturing (CM), U-line system, line balancing, inventory control, single minute exchange of dies(SMED), pull system, Kanban, production levelling, etc. This survey reveals that the successful lean manufacturing system implementation leads integration & simultaneous implementation of lean elements along with proper sequence. [5]

Dr. Bijay Nayak (vice president, manufacturing of SAVE international USA) was proposed that importance of lean manufacturing & value management, if they are properly utilized in the manufacturing industry, will significantly improve the bottom line profit, enhance value to the customers, and eliminate non-value added and wasteful functions, features, processes, operations and activities in any system. [6]

Fawaz A. Abdulmalek and Jayant Rajgopal were studied in "Analysing the benefits of lean manufacturing and value stream mapping via simulation". They were studied in a process industries (steel). They described a simulation model that was developed to contrast the "before" and "after" scenarios in a detail, in order to illustrate to managers potential benefits such as reduce production lean-time and lower work-in process inventory. [7]

Satish Tyagi and Kai Yang were interested in study of "Value Stream Mapping" to reduce the lean time of a product development process". They were states that the objective and associated problems with product development process for a case study unit of a gas turbine manufacturer. Specifically, VSM based method is used to develop the current state map in order to find the wastes in the process and action plan to eliminate all the wastes to reach the future state. [8]

Danijela Gracanin, Borut Buchmeister, Bojan Lalic was describes that Value stream optimizing is very important for lean manufacturing effort. Value stream mapping represents very efficient tool for visualization of activities within production flow focus on activity duration with the purpose to eliminate non-value added activities. The increasing intensity of in the global market. [9]

Christof Oberhausen, Peter Plapper studied that the lean manufacturing laboratory with the help of this manual assembly line, student gain valuable insight in the operation of a manufacturing line as well as in buffer, waste and congestion management. Further research activities in this field will enhance a flexible and efficient production flow supported by integrated IT systems. [10]

2.1 Finding from literature review:

Review of the literature suggest that the current status of lean manufacturing in Indian Fertilizer industries is not very encouraging and lots of work in terms of extensive research and development is needed to improve it.

The available literature also highlights the lack of case study based research for lean implementation in Fertilizer Industry which is needed to understand and identify the barriers and enablers for successful lean manufacturing implementation.

3. RESEARCH METHODOLOGY

Methodology Objectives:

- Collected data.
- Obtained information from various employees.
- Conducted time study.
- Observed processes during different times of the day, on different days of the week.
- We will use Microsoft Visio software to create current state map into future state map.
- We will use e-VSM software to simulate current processes.

3.1 About Case Industry:

Krishak Bharati Cooperative Ltd (KRIBHCO) was incorporated on 17th April 1980 as a national level Multi State Cooperative Society to implement first gas based high capacity Fertilizer Complex consisting of 2 x 1350 MTPD (Metric Tons Per Day) Ammonia plants and 4 x1100 MTPD Urea plants, Each with annual installed capacity of 8.91 Lakh MT Ammonia and 14.52 lakh MT of Urea at Hazira District-Surat, Gujarat, India based on natural gas from Bombay High/South Basin.

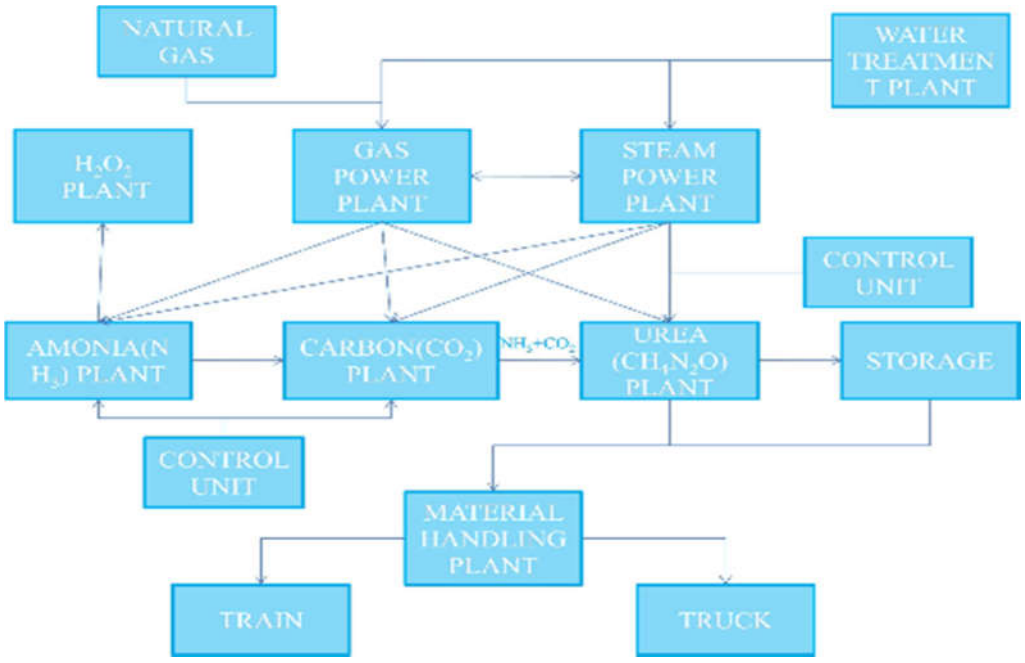

Fig. 2. Process of Fertilizer Industry

There are different types of products are manufactured by KRIBHCO as under: Urea, Ammonia. Bio-fertilizer, Argon, Seeds.

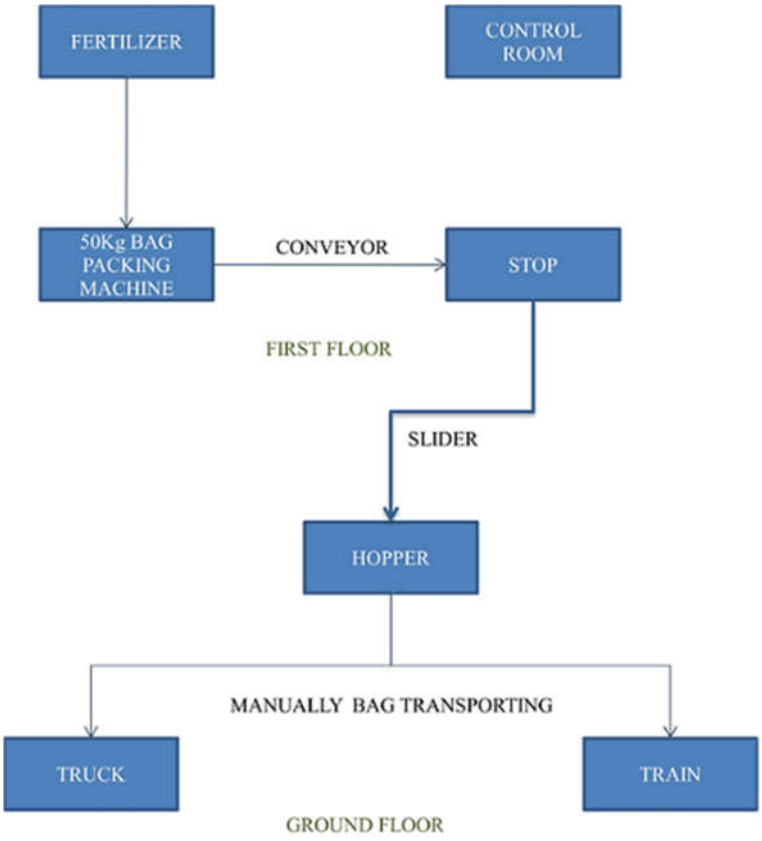

Fig. 3. Line diagram of material handling system

3.2 Data collection for this case study:

The interview questions were designed to find out if all the different types of production waste are actually present in case companies and how these waste have been reduced or eliminated. Also the questions would reveal how these companies are currently managing performance and ways it can be improved.

The interview with employees of KRIBHCO. We also had an oral interview with B.M.Patel (Maintenance Engineer) that lasted between twenty minutes. Also in a material Handling Department, We had an orally interviewed Mr. Parmar (Production Manager) that lasted for about thirty minutes. Other data for this study were also collected from the case company's website and other organizational materials. The interviewer name along with their position and the date of interview was conducted is shown in below table.

Table 1: Interviews conducted at the case company

Interviewees	**Position**	**Date of interview**
Mr. B.M. Patel	Maintenance Engineer	14/07/2015
Mr. P.N. Parmar	Production Manager	24/07/2015
Mr. D.M. Patel	Maintenance in Charge	29/07/2015
Mr. M.N. Patel	General manager	12/08/2015
Mr. J.R. Panchal	General manager	20/08/2015

We have identified the department in which waste are occur and also to some solution how to eliminate them. Identify different waste from interviews are People, Time, and Material Handling.

4. DEVELOPMENT OF CURRENT STATE MAP

First of all, fertilizer is produced by different chemical processes like mixture of ammonia (NH3) and carbon dioxide (CO2) gases. Amount of fertilizer coming out from the fertilizer producing plant and going to the material handling plant or storage through the conveyor belt. Then fertilizer is pouring in the bags of 50kg through the bag packaging machine. And then fertilizer bags are sealed with the help of machine. Packed fertilizer bags are going to the hopper. From the hopper, this fertilizer bags are manually lifted and transported by the workers till the train and trucks location.

Fig.4. Bag packing in material handling system and snap shot of manually bag transportation

4.1 Data collection methodology and process:

The following procedure used for data collecion:

- Follow the manufacturing process from start to finish to get the actual routine.
- Ask, if this is the normal routine, or if it is an alternative step.
- Observe some setups to get times and batch sizes.
- Use a stop watch or other method of getting a value and do it several times.
- Collect data on cycle times. Note that manual processes and manual/load/unload of machines can have large variations.
- Count shifts and number of operators.
- Observe or calculate the time required to transfer the fertilizers bags manually till the trucks & train.

Table 2. Actual Data of case industry

PROCESS	CYCLE TIME	PEOPLE
Manufacturing of fertilizer	60 min	10
Packing of fertilizer bags	20 sec	1
Manually bag transporting	1 min(per bag)	20

The above data collected by the stop watch on the shop floor and this all processes is continuous process so inventory are not calculated during the observation.

4.2 Calculations for manually transfers of fertilizer bag:

- If, 1 minute is required to transfer 1 fertilizer bag. Then in the 60 minute, there are maximum 60 bags are transferred in a shipment vehicle.
- If, 1 hour is required to transfer 60 fertilizer bags. Then in 12 hours, there are maximum 720 bags are transferred in a shipment vehicle. 12*60 =720 bags.
- Cost of the worker per person of one day is 150/Rs.
- There are around 20 workers are busy with transporting the bag through the delivery vehicle. So the cost of the worker of 1 day is 20*150 = 3000 Rs..
- This is the scenario of the one day, now if we see the monthly cost of 20 workers then monthly cost of transporting is calculated as 3000*30 = 90,000 Rs.
- Now the total cost of 20 workers for 1 year is calculated as 3000*365=10, 95,000 Rs.

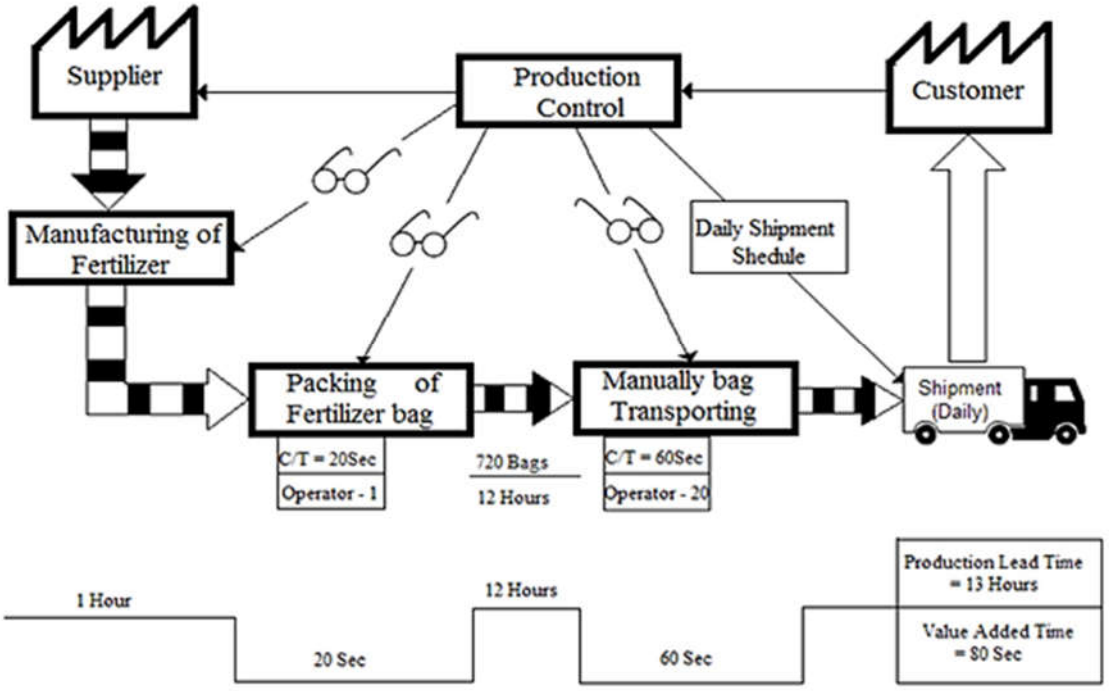

Fig.5. Current State Map

The current state map shows how things really work, this is the "as-is" condition with all of the problems, inefficiencies, and flaws displayed for the entire team to see. There must be through documentation of all non-value added activities. The mapping team should identify the wastes in the system and the root causes of those wastes. The identification of root causes of wastes leads to the elimination of problems and prevention of similar problems from reoccurring. Typically, static map only provide lead time and cycle time data, whereas computer simulations can provide data on inventory fluctuations, process waiting time, and other time base values.

In the current state map the activities are shown in rectangle boxes. First the customer gives the order about requirement of fertilizer bags to the production control department. Then production control department gives the order to supplier. Then manufacturing of the fertilizer is starts. After manufacturing the fertilizer, packing of the fertilizer bag is done. The packing time of the one bag is 20 second. Which is packed by automatic machine and only one Operator is required for

packing the bag. As per above calculation, There are 720 bags were transported in a delivery vehicle in 12 hours with manually transportation. Hence the production lead time is 13 hours and value added time is 80 sec.

Table 3. Waste Check list

Factor Inspection	Waste Identify
Handling and movement	Yes
Balance product supply with end user demand	No
Physical Fault	No
Wasting and damages	Yes
Layout	No

Table 4.Area of improvement

Area of Improvement	Suggestion
Handling and movement	Stacker machine
Wasting and damage	Proper inspection and procedure

From the current state map, Identification of the waste in the some task which is mention in above table and suggestion also given. In the material handling waste suggestion is the stacker machine instead of manually transporting.

4.3 Reduce handling and movement:

Each time the product is handled or moved, it adds cost but does not always add value. It can also impair quality. One of the most difficult challenges of supply chain management in any industry is to minimize handling and movement and this is particularly true for fertilizer in which production is so widely depressed. Reducing handling and movement can save costs both directly (through cheaper distribution) and in directly (by reducing quality problems). However, later in the process there are various ways in which flow can be disrupted including.

- Packing lines interrupted by equipment breakdowns, low running speed or defective sealing.
- Complex layout in retail packing and labelling areas that result in extra handling
- Manually transporting of the product.

At a packing time of urea bag there were some amount of fertilizer is dropped on the floor. If proper inspection and accuracy will be maintained then product wastages and damaging is reduced.

5. DEVELOPMENT OF FUTURE STATE

Future State Map improves the flow and reduces waste in the value stream. This future state must meet the customer requirements and it includes necessary process improvements to achieve the value stream vision. In the current state map manually transporting of fertilizer bag is replaced by stacker machine. The reduction in time and less people requirement occurs. A future state map identifies the improvement to be made in the value stream and this will shorten the overall cycle time.

From the future map the procedure is same as current state map till the packing of fertilizer bag.

- There are 720 bags are manually transferred in a current state map within 12 hours. Here in a future state map. There are 720 bags are transferred in a delivery vehicle within 4 hours and 2160 bags are transfer within 12 hours.
- The cycle time of manually transferring the bag is 60 sec and operators or workers are busy with transferring the bag is about 20 in a current state map.

- Now in future state map the cycle time of transporting the bag thorough stacker machine is 20 sec and operators or workers were busy with stacker machine is only 5 person.
- Hence at the last the value-added time is 40 seconds and production lead time is decrease from 13 hours to 5 hours.

Table 5. Cycle time of all process

Activity	**Bag packing**	**Bag transportation**
Current State	20 sec	60 sec
Future State	20 sec	20 sec

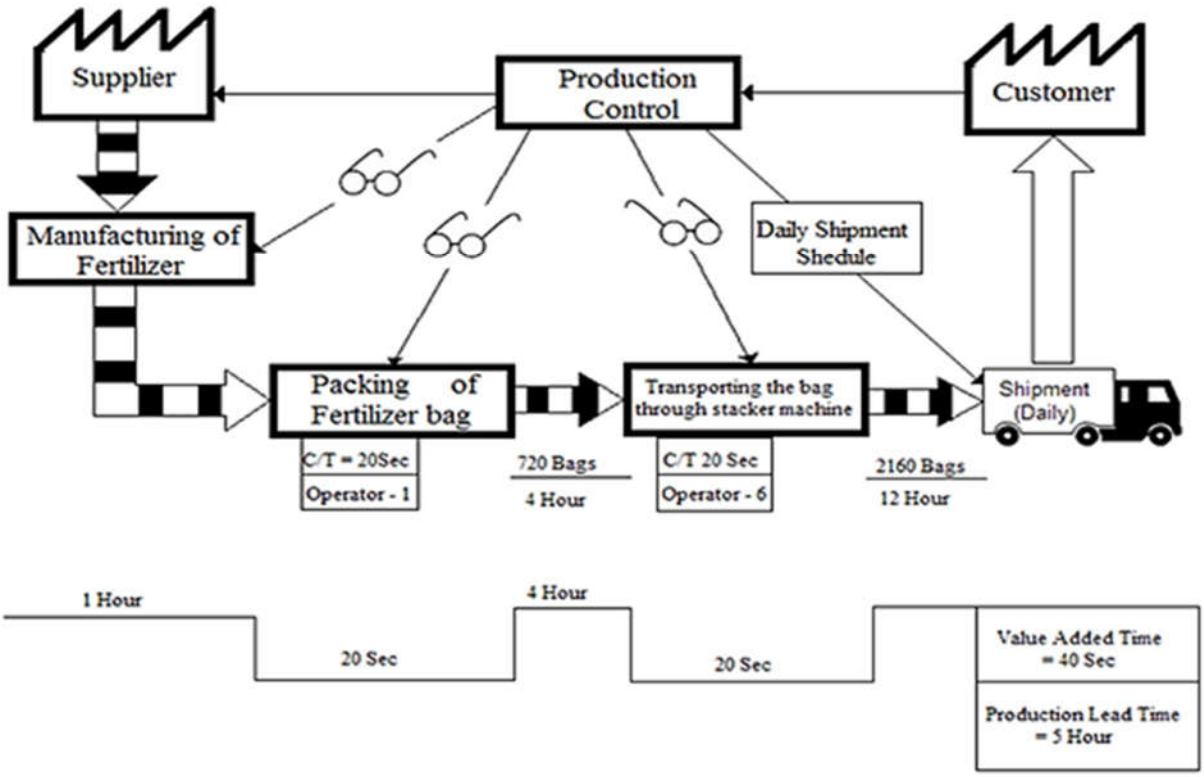

Fig. 6. Future state map

- In the above table. The bag transporting time till the delivery vehicle is 60 sec per bag in a current state map. The capacity of the delivery truck to carry the load is approximately 50 bags, each bags has 50 kg weight so total load is carried by truck is 2500 kg.
- There are 40 minutes is required for fully loaded of truck. This is counted by stop watch in a case industry. While in future state map, only 20 sec is required to transport the bag till the delivery vehicle.
- One minute is require in the manually transporting the each bag while with the stacker machine there are three bags are transported in a one minute.
- So, for the fully load the truck with stacker machine maximum 17 min is required.
- Hence, the saving in time = manually transporting time - transporting with stacker machine time.

  = 40 min – 17 min = 23 min. (saving time)
- So, process of loading the truck is 23 min faster than manually transportation.
- In whole day for loading the trucks, we get the benefit around 480 min (8 hours) process become faster with compare to manually transporting.

Fig. 7. Snapshot of transferring fertilizer bag through stacker machine

6. RESULT AND DISCUSSION

After the analysis of current and future state map some important findings of the case study are interpreted.

- Manpower is reduced from 20 to 6.
- By replacing the manual transporting of fertilizer bag till delivery vehicle is replaced by stacker machine. It directly reducing the manpower which is associated with manually material handling by replacing the stacker ROI and transportation time is calculated and obtained beneficial for system.
- ROI with energy cost: 20 person associated with transferring the bag till delivery vehicle whose wages are 150 Rs. Total cost of workers per year 10,95,000 Rs. The stacker machine cost is approximately 1,00,000 Rs. The operating and energy cost including maintenance cost of the stacker machine of the year is 2,00,000 Rs and only 6 workers are required for handling stacker machine and 6 workers cost per year is 3, 28,500 Rs. So the total cost of transferring the bags with machine is 6,28,500 Rs. So the Return of Investment approximately 1 year which is clear by below graph.

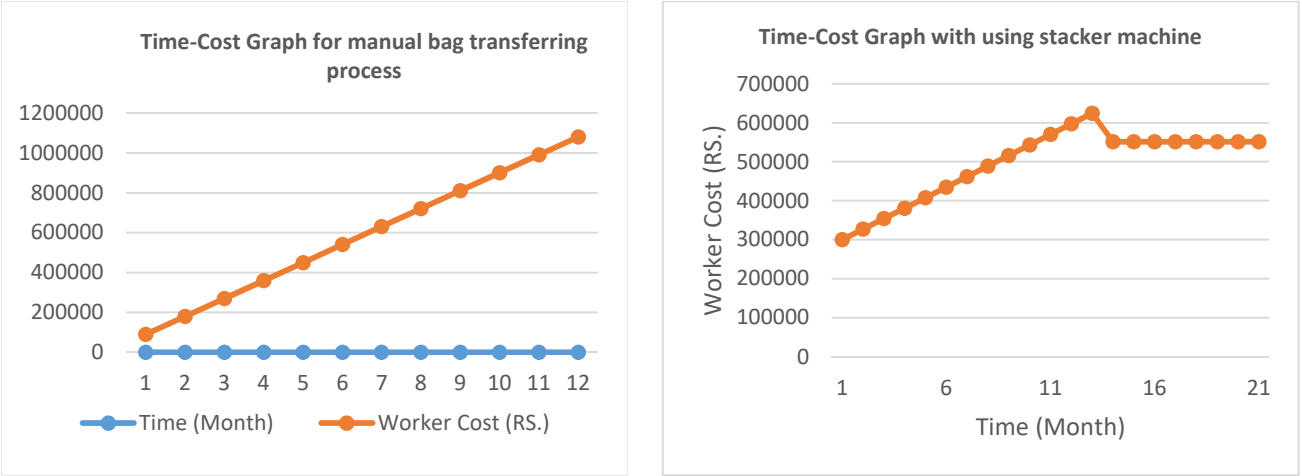

Fig. 8. Time-Cost Graph for manual bag transferring process and with using stacker machine

In manually material handling the yearly cost for transporting fertilizer bags 10, 95,000 Rs. As shown in above graph. This is the Time versus Cost graph in which bag transferring with stacker machine data are included. In the graph

shown that if we use the stacker machine instead of manual transporting then the initial investment cost, 6 workers cost and energy and operating cost including maintenance of machine is 6,28,500 Rs for 1 year. Then after 1 year initial investment cost of machine which is 1, 00,000 Rs. is neglected and only other costs are included. So the cost of the machine after one year is only 5, 28,500 Rs. So we can understand that if bags are transferred through manually then total cost is 10, 95,000 Rs. and if we use stacker machine then the total cost after 1 year is 5, 28,500 Rs. So the clear benefit of using stacker machine is = 10, 95,000 Rs -5, 28,500 Rs. = 5, 66,500 Rs.

Above research work will also helpful in application of a lean manufacturing in a material handling of Sugar factories, Rise mills, Cement factories, Fertilizer industry, Milk dairies, Other food industries

7. CONCLUSION

This research work has discussed the process which take place in material handling and highlighted the problems which exists in a fertilizer industries. This research work has highlighted appropriate material handling which affected to the product quality and also transportation facilities of final product. Fertilizer bags were transported by manually and it was time consuming and labour cost is also more. Product damage ratio decrease and man power were also reduce due to the use of stacker machine. The Stacker machine's electricity consumption and total cost were calculated and compare with the ROI and One year will be require for the ROI and also to improve the quality. This research provide the frame work for the material handling system of Indian fertilizer industries.

8. REFERENCE

1. *Tyson R. Browning, Ralph D. Heath., 2008. "Reconceptualizing the effects of lean on production costs with evidence from the F-22 program".*
2. *J.A. Jimensez-Garicia, S. Tellez-Vazquez, J.M. Medina-Flores., 2011. "Materials Supply System Analysis under Simulation Scenarios in a Lean Manufacturing Environment".*
3. *A.C Yamagar, P.M. Ravanan., ISSN 1792-4693. "Material management by using lean manufacturing principles a case study".*
4. *Amelia Natasya Abdul Wahab, Muriati Mukhtar, Riza Sulaiman., 2013. "A Conceptual Model of Lean Manufacturing Dimensions".*
5. *R.Sundar, A.N. Balaji, R.M. Satheeshkumar., 2014. "A Review on Lean Manufacturing Implementation Techniques".*
6. *Dr. Bijay Nayak (Vice President, Manufacturing of SAVE International, USA.) "Lean Manufacturing and Value Management Convergence of Divergent Tools".*
7. *Fawaz A. Abdulmalek, Jayant Rajgopal., 2006. "Analizing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study".*
8. *Satish Tyagi, Alok Choudhary, Xianming Cai, Kai Yang., 2014. "Value stream mapping to reduce the lead-time of a product development process".*
9. *Krishak Bharati Cooperative Ltd (KRIBHCO). [Online]. Available: https://www.kribhco.net*
10. *Danijela Gracanin, Borut Buchmeister, Bojan Lalic., 2013. "Using Cost-Time Profile for Value Stream Optimization".*
11. *Christof Oberhausen, Peter Plapper, "Value Stream Management in the Lean Manufacturing Management", 2015.*