RESEARCH ARTICLE OPEN ACCESS

Through Lean Manufacturing Techniques Improvement InProduction of Cement Plant

Udai Singh Chouhan[1], LalitYadav[2], Pardeshi Ram[3]
[1](M.Tech Student, Department of Mechanical Engineering, Mewar University Chittorgarh,
[2](Assistant Professor , Department of Mechanical Engineering, Sir PadampatSinghania University Udaipur,
[3](Assistant Professor, Department of Mechanical Engineering, Mewar University Chittorgarh,

ABSTRACT
The production of cement is a process industry which is distinct from manufacturing and the main objective here is to apply lean manufacturing technique to the eradicate waste to the processes and parameters which are common between process and discrete manufacturing. Lean signifies a major advance over traditional mass production methods. Value stream mapping is used first to identify different waste present in the current state. This paper will describe work undertaken investigating the application of lean thinking to a continuous production environment, in this instance exemplified by the cement industry. Implementation of lean helps many organizations to improve their productivity and efficiency Cement plays a vital role in economic development of any country. Having more than a hundred and fifty years history, it has been used extensively in construction of anything, from a small building to a mammoth multi-purpose project. The need for improving the efficiency of the cement production line is widely acknowledged in order to reduce the downtime rates, and satisfy high levels of market demand where the demand for cement is mostly second substance behind water.
This paper articulates a methodology for data collection, knowledge extraction, model creation and experimentation that combines the use of process mapping, computational simulation. A detailed description of each step of the process is given and is illustrated by results from a case study undertaken during the research.
This paper describes work undertaken to implement lean practices in the continuous process sector as represented by cement production. One of the major barriers to lean implementation is providing evidence of its potential benefit to end-users. This work aims to overcome this obstacle by producing a tool which can be used to easily visualize the benefits of adopting lean practices without requiring disruption to the production environment.
***Keywords*:**Lean manufacturing, eliminating waste, cement production, Implementation of lean and simulation model.

I. Introduction

Lean Manufacturing is the art of levitation quality, sinking costs, improving delivery, generally becoming competitive by removing waste and concentrating on activities that add value for the customer.

Lean manufacturing or lean production, often simply "lean", is a systematic method for the elimination of waste ("Muda") within a manufacturing system. Lean also takes intoaccount waste created through overburden ("Muri") and waste created through unevenness in workloads ("Mura"). Working from the perspective of the client who consumes a product or service, "value" is any action or process that a customer would be willing to pay for.

The cement industry is one of the oldest industries in the world. The demand for cement has risen rapidly since the beginning of the 20th century to become the second most consumed substance after water. India's cement demand is expected to reach 550-600 million tons per annum (MTPA) by 2025, and about 67% of total consumption in India.

The industry is characterized by high levels of consumption of raw materials and energy with fuel accounting for 30-40% of the production costs.

Cement production in Mt.
2012-13 250-251
2013-14 258-260
2014-15 270
2015- 16(E) 289 E: Estimate [1]

The objective of this paper is that the current processes have been charted, formulated and evaluated, proposals to restructure these procedures using Lean Manufacturing principles will be formulated, evaluated and implemented. The main purpose of implementing LM principles will be to reduce the quantity of line side stock, reduce obsolete stock increase the material expediting processes. This will lead to great financial savings per project.

II. Literature Study

The definitions and concept of Lean Manufacturing.

- *Continuous elimination of all waste resulting in a system of value added activity* (Internet: Best Management Articles).
- *Lean Manufacturing is the art of raising quality, lowering costs, improving delivery, generally becoming competitive by removing waste and concentrating on activities that add value for the customer* (Pullin, 2000) [2]

From these definitions and the literature study that was conducted on LM, it was clearthat the main objective was to eliminate waste in all processes to improve anorganization as a whole.

2.1 LM primarily focuses on eliminating waste

There are currently 8different types of wastes identified by the pioneers of LM and they are listed below.[5]

1. Overproduction: Producing parts or components which there are no customerorders for, which results in unnecessary holding costs, raw materials used,labour costs etc.

2. Waiting (time on hand): Workers that are waiting for a machine to perform atask, tools or parts to be issued etc.

3. Unnecessary transport or conveyance: Refers to carrying Work-in-Progress(WIP) over long distances, raw materials are located in the wrong areas of aplant and needs to be moved long distances..

4. Over processing or incorrect processing: Parts that needs to be reproduced dueto wrong tooling equipment, defect parts, producing a wrong product at thewrong time.

5. Excess inventory: Excess raw material, WIP or finished goods causing longerlead times, obsolescence, damaged goods, transportation and storage costs.

6. Unnecessary movement: Wasted motion where workers have to look for tools ormaterial, searching for lost material as well as materials that are moved from oneplace to another unnecessary.

7. Defects: Production of defective parts or correction and repair or rework of partsdue to redesigns.

8. Unused employee creativity: Losing time, employee ideas and creativity by notengaging with your employees. [4]

2.2 Cement Production

The manufacturing process of cement consists of mixing, drying and grinding oflimestone, clay and silica into a composite mass. The mixture is then heated andburnt in a pre-heater and kiln to be cooled in an air-cooling system to formclinker, which is the semi-finished form. This clinker is cooled by air andsubsequently ground with gypsum to form cement.

There are three types of processes to form cement - the wet, semi-dry and dryprocesses. In the wet/semi-dry process, raw material is produced by mixinglimestone and water (called slurry) and blending it with soft clay. In the dryprocess technology, crushed limestone and raw materials are ground and mixedtogether without the addition of water.

The dry and semi-wet processes are more fuel-efficient. The wet processrequires 0.28 tonnes of coal and 110 kWh of power to manufacture one tonnes ofcement, whereas the dry process requires only 0.18 tonnes of coal and 100 kWhof power.

There are different varieties of cement based on different compositions accordingto specific end uses, namely, Ordinary Portland Cement, Portland PozzolanaCement, White Cement, Portland Blast Furnace Slag Cement and SpecializedCement. The basic difference lies in the percentage of clinker used.

2.3Cement Manufacturing Process:

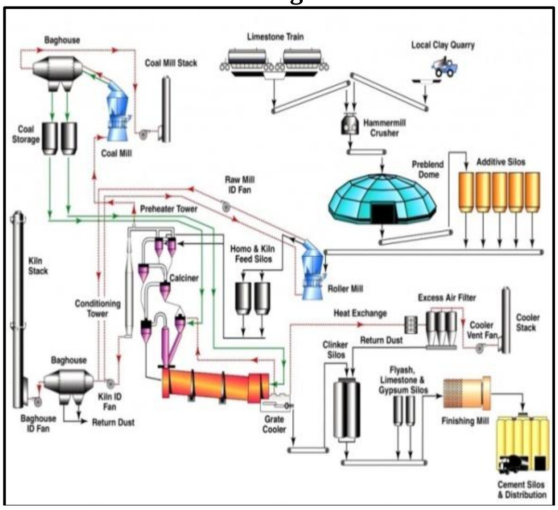


Chart -1: Process layout of Cement Plant

2.4 Global Consumption

The demand for cement is a derived demand, as it depends on industrial activity,real estate, and construction activity. Since growth is taking place all over the world, in these sectors, the global consumption is also increasing. During theperiod from 2008 to 20012, total cement consumption grew from 2,568 milliontonnes to 2,8572 million tonnes, at a Compounded Annual Growth Rate (CAGR)of close to 7%.The rapid increase in global cement consumption is led by increasing demand forinfrastructure in emerging economies, with Asia accounting for 66% of the globaldemand. China was the world’s largest consumer of cement in 2012 andaccounted for

48.7% of total cement consumption.India was second largest consumer of cement and account for 40.23 %of total cement consumption

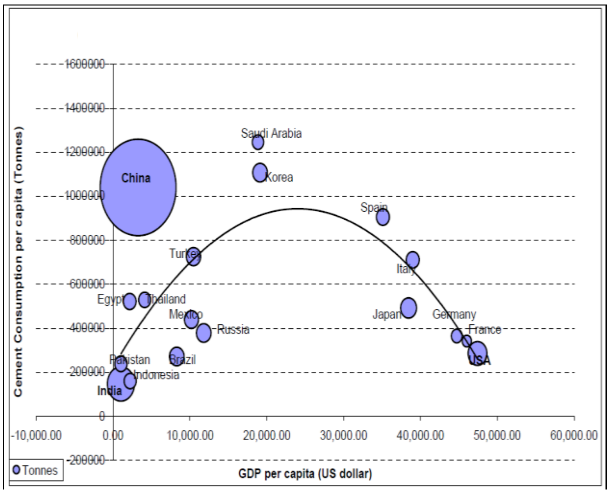


Fig -1: **SOURCE:** Consumption, exports and GDP data from USGS, ITC and IMF, respectively* Since, the cement consumption was not readily available, in the calculations above, cement consumption data has been calculated by deducting country's cement exports from its total cement production.

2.5 Global Production

Cement is produced in 156 countries across the Globe. During 2008, the globalproduction capacity of cement stood at around 2,872 million tonnes with Chinaaccounting for approximately 1,400 million tones and India a distant second withtotal production of 183 million tonnes. The production of Cement is highly skewedwith top ten countries together accounting for close to 70% of total cementproduction. These countries account for close to 70% of total population.

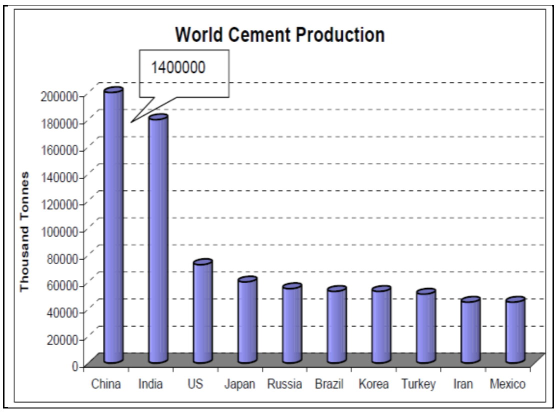


Chart -2 Word Cement Production
Source: US geological survey [4]

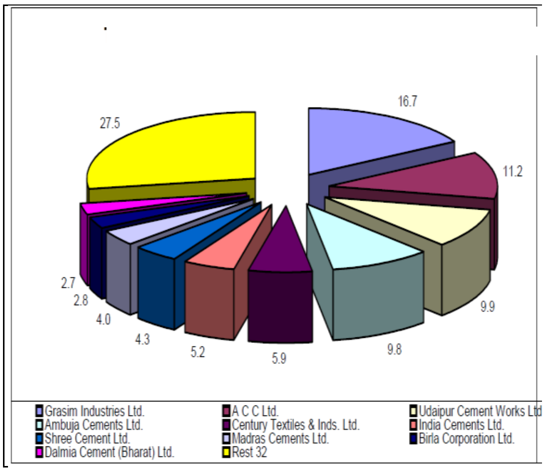


Chart -3 Top 10 Major players in cement industry
SOURCE: Prowess, CMIE [4]

Table 1: Wastes within the Cement Production

	The Cement production Line
Overproduction	Overproduction is clearly present within the cement manufacturing process resulting in very high levels
Waiting	Different batch sizes are associated with the cement production line create waiting wastes which affect flow of materials. Furthermore the
Motion	The worker+s travel long destinations between different workstations
Transportation	Materials need to be transported for a long journey starting from quarry siteto the cement silos. In addition the layout of the cement factory
Inventory	Cement industry is one of the industries with largest inventories and WIP.
Over processing	Unnecessary long time is spent for milling the hard and large particles
Defects	High levels of recirculation (rework) are associated with the both raw milling and finish grinding processes

- Between 2010 and 2014, demand for housing units is estimated to be 4.3 million, leading to a higher demand for cement for homebuilding
- It plans to increase investment in infrastructure to USD1 trillion in the 12th Five Year Plan (2012–17), compared with USD514 billion under the 11th Five Year Plan (2007–12)

- Growing urbanisation, an increasing number of households and higher employment are primarily driving the demand for housing.
- Initiatives by the government are expected to provide an impetus to construction activity in rural and semi-urban areas through large infrastructure and housing development projects

III. EXPECTED MOVEMENT IN ADDITIONAL CAPACITY REQUIREMENT

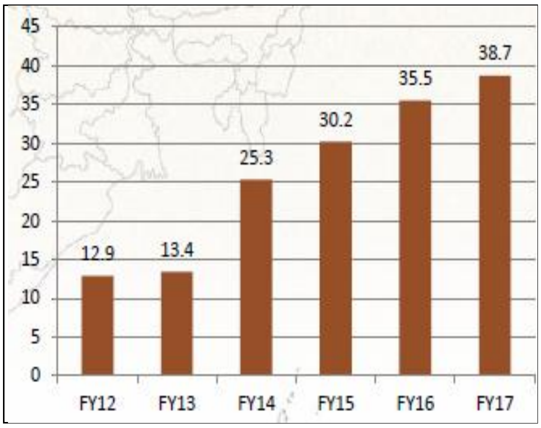
Installed capacity increased at a CAGR of 13.6 per cent over FY06-11 while production witnessed an increase of 9.1 per cent during this period

→Total capacity of 331 MT is estimated to have been created in FY12

→The strong momentum in capacity addition is not surprising given the sharp growth in construction, infrastructure and real estate in the Indian economy

→It is hence not surprising that the 12th Five Year Planestimates additional capacity requirement to touch 139.7 MT by FY17

Additional capacity creation as per the 12th Five Year Plan



Source: CMA, Kotak Institutional Equities, Aranca Research

Notes: Additional capacity creation estimates are based on increase in base lines, roads, housing and fiscal support [6]

Birla cement is India's largest exporter of cement clinker spanning export markets in countries across the Indian Ocean, Africa, Europe and the Middle East. UltraTech and its subsidiaries have a presence in five countries through 11 integrated plants, one white cement plant, one clinkerisation plant, 15 grinding units, two rail and three coastal terminals, and 101 RMC plants. It has an annual capacity of 52 MT

IV. RESEARCH METHOD & RESULTS

The research aims will be accomplished through achieving the following objectives:

1. Collect and verify the required data that needed to build-up a simulation model representing cement factory. The simulation model will give a visual image of the cement production line, highlight the value and non-value activities, and help in decision making process which improves the line efficiency.
2. Identify variables and factors, which one has a great influence or effect on the efficiency of the production line.
3. Attempt to improve and enhance the performance parameters through eliminating or reducing wastes within the cement production line.
4. In order to achieve (1) and (2) , it is very important to identify cement production line performance parameters which yield an immediate positive feedback.

First Step: Data Collection

This is initial step to identify the required data which is help in production process. Review of published literature.

The research identified different factors that are associated with or play an important role in the effectiveness of the cement production line.

Visits were arranged for data collection of the cement production line process from two selected sites.

1. Birla cements works.Chanderia ,Chittorgarh
   Annual installed capacity (Milliontonnes)- 2.00 FY2012
2. 2.Adityabirla cement industry (Ultra tech cement) Shambhupura ,Chittorgarh(Raj.).
   Annual installed capacity (Milliontonnes)- 5.00
3. J.K.CementNimbahera

Annual installed capacity (Milliontonnes)-3.30

Interviews were made with production manager , line operators, coaches and production manager of both of factors. The obtained data were used to develop the simulation modelling elements and validate the obtained results.

Interview with Industry RepresentativeIndia is the second largest producer of cement in the world and the increased focus on infrastructure and affordable housing is expected to significantlyincrease the production capacity of cement in India over the next few years.

However, before this happens statutory issues related to project executionand greater private and foreigninvestment, would require to be simplified,says Mr. Sumit Banerjee, Chairman, CII Cement Industry Division & MD,ACC Ltd

The Housing segment accounts for a major portion of the total domestic demand for cement in India

Second step: The required data that needed to build-up a simulation model representing cement factory

The simulation modelling has become a very popular analysis approach which can be applied within a wide variety of disciplines such as service domain, production lines, health and care firms, and social sciences.

Computational modelling technique can significantly contribute to a high-performance product development system. The simulation techniques provide the decision-maker with a quick feedback on ideas, result in a faster convergence of designs and ensure integration among different modules (Dennis et al, 2000). The appropriately use of simulation technique can strongly contribute to identifying and solving problems at a faster rate (Carley, 2002). Fowler (2003) has mentioned that the simulation model is able to create causal structures and analyze real-world organizationalbehaviours in order to identify sources of variation, wastes, and problems that may occur within the system. The simulation technique provides a powerful digital modelling methodology and helps to identify the right improvement opportunity within the firm (Cho et al 2005). [8]

The model included the following working areas:

- Raw milling working area, which includes raw materials store, mill feed building, raw milling workstation, and raw meal silo.
- Thermo-chemical working area, which includes the kiln system and clinker storage area
- Cement grinding working area, which includes finish grinding workstation, packing house, and cement silos. [3]

Table -2 The Simulation Model Produced had the Following Properties:

Plant Running Time	The simulation model runs for 43200 minutes (equivalent to one month (30 days) of real timeoperation).
Working Shift	The plant works on non-stop base, i.e. 24 hours per day.
Well maintained Schedule	The factory is planned to schedule maintenance stoppage for six weeks per year, i.e. theActual Available Time for the three working areas is 46 weeks per a year.
Results Collection Period:	The results will be collected after 43200 minutes
Probability distribution:	Triangular distribution was chosen to be the probability distribution type within the undertaken research as it provides an acceptable trade-off between accuracy results (Khalil et al, 2008

V. IMPLEMENTATION OF LEAN IN CONTINUOUS PROCESS-BASED INDUSTRIES

The research identified several variables and factors, which control and govern the cement production line. To investigate the nature of the interrelationship between these factors, brainstorming sessions were carried out with industry experts and led to the development of Cause-Effect matrices identifying non-relations, indirect-relations, and direct-relations between the variables. During the brainstorming sessions many creative ideas were generated and evaluated. This led to an agreed list of most effective variables, their interrelationships and their effects on production.

Subsequent to the determination of variables and factors that control each process within the cement production line; all interrelationships types between these variables were identified using cause and effect matrices. [7]

RawMilling Process Varaibles	Air Flow Rate (cm³/min)	Temp. (C°	Press. (Psi)	Material Grindability	Material Moisture (% of weight)	Material Bed Depth (cm	Particles Size	Product Fineness (cm³/gr)	Recirculation Rate (% of feed	Roller Number Roller Radius (cm)	Mill Table	Diameter	separator Speed (rpm
Air Flow Rate (cm³/min)		DI	DI		DI	DI	DII	DI	DI	A	A	A	DI
Temperature (C°)	DI		A	DI	DI	A	A	A	A	A	A	A	A
Pressure (Psi)	DI	A		A	A	DI	A	A	A	A	A	A	DII
Material Grindability	A	DI	A		DI	DI	DII	DI	DI	A	A	A	A
Material Moisture			A	DII			A	A	A	A	A	DI	A
Material Bed Depth (cm)	DI		A	DI	DI		DII	A	A	A	A	A	DI
Particles Size	DII	A	DI	DI	A	DII		DI	DI	A	A	A	DII
Product Fineness (cm³/gr)	DI	A	A	DI	A	DII	DII		DII	A	A	A	DI
Recircul-ation Rate (% of Feed)	DI	A	A	DI	A	A	DII	DI		A	A	A	DI
Roller Number Roller Radius (cm)	A	A	A	A	A	A	A	A	A		DII	DII	A
Mill Table		A	A	A	A	A	A	A	A	DII		DII	A
Diameter	DI	A	A	A	A	DI	A	A	A	DII	DII		A
separator Speed (rpm)		A	DII	A	A	DII	DII	DI	DII	A	A	A	

Table 4: Raw Milling Process Cause & Effect Matrix

Similarly preparation Connectivity Matrix for Raw Milling Process.

Table-3: Dry Raw Milling Process Variable Levels

Raw Milling Process Factors	Level 1	Level 2	Level 3
Air flow rate (cm3/min)	7200	7300	7400
Recirculation rate (% of feeding rate)	20	25	30
Material moisture content (% of weight)	14	18	22
Material grind-	Easy	Normal	Hard
Material bed depth (cm)	5	7	8
Product fineness (cm3/g) 3900 3950 4000	3850	3950	4020
Separator speed (rpm)	65	70	80

The reduction of the cycle time can be obtained by eliminating or minimizing all kinds of wastes and non-valueadded activities within the given system

VI. FORMULA USED

Equipment Utilization[Jambekar, 2000). Lee et al (1994]

% Utilization =(available time– unused time) x 100

Available.time

Available time = Monthly Available time (MAT) 43200mins

Unused time = PMT + BT

PMT= Planned maintenance time

BT=Break down time

Therefore the percentage of machine utilisation can be determined as[Braiden et al, 1996].

% Machine Utilization = MAT – (PMT+BT) x 100

MAT

Throughput (tons)= SRT - BT [Hopp et al, (2001)]

CT

Where:

SRT =Schedule running time

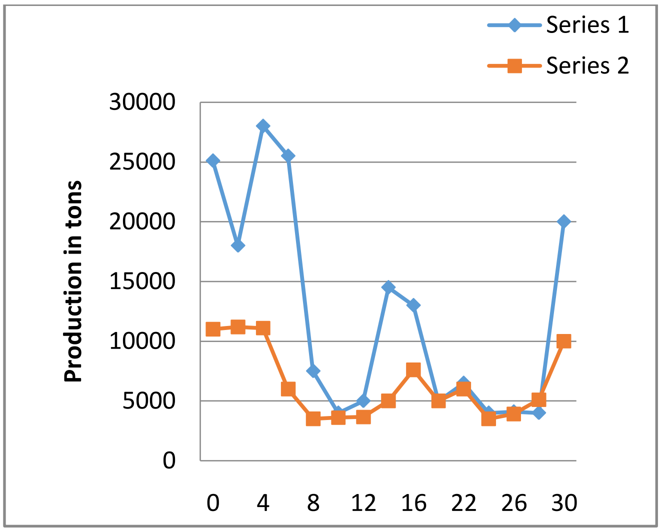
Breakdown time (BT in mins)

Cycle time (CT in mins per ton)

VII. EXPERIMENTAL RESULTS – AFTER IMPLEMENTING LEAN, IMPROVEMENT IN PRODUCTION (IN TONS)]

Throughput beforeWIP Reduction

Throughput After WIP Reduction



No. of Experiments

VIII. CONCLUSIONS

The effects of reducing WIP for the rest of the cement production line clearlydemonstrating the potential efficiency gains that could be made by implementing lean in the cement industry.

The research used cement production, a typical example of a continuous process industry, where massproduction is currently adopted using inflexible and expensive machines to produce, transport, and accumulate largeamounts of materials within each working area. Results from the simulated experiments carried out showed how leanchanges could produce significant positive benefits to key performance measures and were validated by industry experts.3

REFERENCES

[1]. www.outlook.com(Outlook 2015)
[2]. www.leanmanufacture.net (Best Management Articles)
[3]. Khalil R.A., Stockton D.J., ,International Journal of Mechanical Engineering (IJME) Vol.1, Nov.2012
[4]. Cement Industry in India: Trade PerspectivesUS geological survey. Prowess, CMIE
[5]. LIKER, J. K. 2004. The Toyota Way: 14 Management principles. United States ofAmerica: CWL Publishing. 330p.
[6]. ICR-GlobalCement Report 8th Edition,CMA, Kotak Institutional Equities, Aranca Research
[7]. www.simul8.com.
[8]. Carreira, B., 2005, Lean Manufacturing that works: powerfull tools for dramatically reducing waste andmiximizing profits, 2nd edition, AMACOM, New York, USA, pp. 49-61.