

# Lean Supply Chain Performance Metrics for the better Manufacturing Process

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## Abstract

Manufacturing sectors are facing more problems due to globalization; especially in cases of SMEs (Small and Medium scale Enterprises) are struggling against consistency and competitiveness in market. They want more challenges in the field of production and marketing areas for the product accuracy and quality. Maintaining the machine tools with minimum waste in manufacturing process and identifying supply chain problems in supply line activities are the most essential factor for the employers. In this regard, the evidences of many authors' views, the lean supply chain techniques and their tools have helped more in manufacturing and service enterprises in the areas of operations and work processes. But taking the help of efficient lean supply chain performance measures and advanced inspection technologies for the betterment of productivity are also an important criterion. Assortment is a leading indicator for a manufacturing system. Which is the process of measuring product efficiency, effectiveness and capability against the standard norms fixed by the organization in time based aspect. In this work we discussed the lean supply chain performance importance, application and their effectiveness which are useful for the current manufacturing trends.

**Keywords:** Lean Supply Chain Performance Metrics, Performance Indicators, Productivity Measurement

## 1. Introduction

In this globalization era, the manufacturing sectors especially the Small and Medium Enterprises (SMEs) are facing new challenges day by day for their survival in market. Decision making factors in right time due to lack of information and inconstancy in system which directly affects the product performance. And also the prediction of product performance is most critical factor<sup>1</sup>. In broad view the manufacturing system, which is a set of machine tools, elements required for the transportation, storage buffers, and computers along with people also part of this group, which are sometimes called work stations. Due to more inventories, excess cycle time, unexpected deliveries and poor maintenance of machine tools are caused by the lack of proper arrangements and its synchronization. To

avoid this, main possibilities are reducing waste in work process and develop customer values to the products is the one way and other is to adopt the standard performance measurement techniques to the manufacturing system. In this regard both practices are most useful and challenging task to the manufacturing enterprises productivity. In this work we initially discussed about the introduction and problems faced by the SMEs. Section two discusses the literature review of Lean Manufacturing (LM) and Supply Chain Management (SCM) performance metrics related to product efficiency. In section three the discussions on LM and SCM performance measurement techniques and their classifications are made. Section four explores the most affecting performance metrics factors useful for the efficiency of productivity and their current trends. Section five indicates the conclusion and future works.

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## 2. Literature Review

To achieving superior quality, timely deliver and competitive cost to sustain customer satisfaction the lean manufacturing is an integrated approach to manufacturing and service enterprises. Initially in 1950s Japan developed the Lean concept and concept originated in Toyota production system (TPS). The goal of lean manufacturing is to reduce waste in human effort, time to market, manufacturing space and inventory which leads to high demand from customer side while giving most and world class products with minimum cost. In lean manufacturing waste removal and incorporation of new methods to work process is the main component and market response is the subsequent component. The focus on lean manufacturing plants and its developments are addressed clearly<sup>2</sup>. Lean means developing a value stream to eliminate all waste, including time, and to ensure a production level. Lean include JIT, TQM, equipment management and Total Preventive Maintenance, Kaizen, design for manufacturing and assembly, supplier management, human resource training and involvement, decision support systems, and variability reduction<sup>3</sup>. The reflection of lean operations is quality, delivery speed, reliability and product efficiency with reduced lead time. Seven types of waste in process are identified with proper reasons are overproduction, defects, unnecessary inventory, excessive transportation, waiting, unnecessary motions, underutilization of employee (skilled training needed for employees). SCM concept is originated in the manufacturing industries in the early 1980s. It was developed from innovations such as Just in Time (JIT) and Total Quality Management (TQM)<sup>4</sup>. According to Council of Supply Chain Management SCM the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities, this also includes coordination and collaboration with channel partners, suppliers, intermediaries. The supply chain system is linked with material suppliers, production facilities and distribution mode with all forward and backward information flow within a manufacturing cycle and the supply line can be analyzed into three segments like manufacturing, sourcing and delivery<sup>5</sup>. Supply Chain Management is a modern multidisciplinary business management technique and research environment for the enterprises profit and productivity with new philosophies with sustained competitiveness<sup>6</sup>.

A typical Supply Chain (SC) commonly involves a network of tiered suppliers producing raw materials, parts, components, subassemblies, assemblies and final products together with business process and customers, SC performance for a firm as the performance of the various processes included within the firm's functions<sup>7</sup>.

## 3. Lean Manufacturing Performance Measures

The different author's are discussed and concluded the lean practices into one indicator known as leanness. D score card is considered For measuring leanness JIT, quality control, kaizen principles are used in SMEs organizations<sup>8</sup>. The non-financial manufacturing performance measures mediate the relation between the financial performance and lean manufacturing practices<sup>9</sup> found that the author's work presented in this paper investigates the effect of JIT, TPM, autorotation, kaizen which are considered lean strategy on the most important measures of operational performance, i.e. cost, speed, quality and flexibility. Performance measurement system for lean enterprises is discussed in many views. This is the process of measuring capability, efficiency, and effectiveness a process or a system, against given set of standard norms. The good metrics are strategic planning and qualitative concern is total commitment of whole organization. Performance measurement is defined as the process of quantifying the efficiency and effectiveness of action<sup>10</sup>. The main objectives of the firm which leads o better efficiency and effective performance are minimized total time required for the task, set up costs, due date, machine idle time ad set up costs are more considerable factors for the good results<sup>11</sup>. The Role of Performance Measurement is integrating with the following factors

- Monitoring: Measuring and recording the actual performance
- Control: Identifying and attempt to close the gap between planned target and actual performance indicators
- Improvement: Identify critical improvement opportunities
- Coordination: Information for decision making, Leading Indicators, Internal communication across processes, External communication with stakeholders

- Motivation: Align behaviour and encourage transformation

The main classification of performance metrics are divided as per the following criteria on lean aspects are discussed in below Table 1

**Table 1.** Classification of performance metrics

Strategic	Tactical	Operational
Return on investment capital, Inventory, revenue, Cash flow, market position.	Productivity, financial turn over, supply chain, quality cost, regularity,	Safety, Quality, Delivery, Time to market, Manufacturing efficiency

## 4. Supply Chain Management Performance Measures (SCPM)

In consistency measures how economically a firms resources are utilized to achieve a predetermined level of customer satisfaction which Specifies on combine decision making levels with financial and non-financial criteria and measures with too many number of metrics and measures The Balanced score card perspectives for supply chain management in SMEs applications in India can determine the proposed perspectives & the SCPM developmental criteria is given per Table 2

**Table 2.** Evolution of SCPM

Before 1980	1980-1990	1990-2000	200-2010
Financial aspects	Operational and value added perspective	Financial & Non financial orientation	Balanced score card activities

The SCPM is the process of quantification and actions leads to performance by satisfying customers with greater efficiency and effectiveness than their competitors. Performance measurement systems are extended in to structural extended and balanced score card.<sup>12</sup> Evaluation processes of SCPM which described on basis of decision making.<sup>13</sup> The By the above many author's review, it is possible to select the following principal approaches for SC M performance measures

- Management approach
- Time base approach
- Quantitative qualitative approach

Strategic, operational and tactical are comes under management level, in concerned with time base approach lead time, order cycle time and time to market are the relevant factors but for quantitative and qualitative based measures are resources, utility and customer satisfaction , responsiveness respectively<sup>14</sup>.

## 5. Case Study

### 5.1 Company and Process Background

The Hassan city municipal council is in between Bangalore Mangalore national highway, about the distance of 180 kilometers. The city belongs to Karnataka state. Hassan City consists of 35 wards, 35 councilors, 5 Nominated councilors. As per the 2011 census the city population is 15, 5006 area stretches about an area 26.5Sq Km.

### 5.2 Problem Descriptions

Here the present work focuses with public problems and their requirements in the office of City Municipal Corporation (CMC) at Hassan. The most of the customer problems and their needs are associate with public related and answering them in documentation form in CMC office is very difficult problem. To resolving the public problem, maintenance of records in record room in systematic manner is needed, and also searching files within a short time is also essential to minimize the cycle time in office. in CMC office the files are stored in bulk manner randomly at record room which is very difficult to searching the required files within a short time and the maintenance is also very poor manner as shown in below Figure. 1



**Figure 1.** Poor Maintenance of Record Room.

### 5.3 Objectives

In current days, the customers are highly concern with the expectation of quick and quality service from the

organization. This research work is related to problems of CMC office, Hassan for their poor maintenance of record documentation for public's requirements, hence which is required to improve the working system in the CMC office through the incorporation of 5S principle from the lean manufacturing. Here in this case study the main objective is to reducing the total cycle time required to searching the required record from the record room. For which analysis of old records maintenance and its searching is essential after that finding a technical solution and apply the simple and systematic approach is proved in simple manner is considered.

## 5.4 Methodology

Here getting productivity by reducing the file searching time and its maintenance using simple 5S concept is used to improve the problem of public's. Here study of old system of record maintenance and its service to public's are considered. Hence the sorting technique is applying through the incorporation of 5S principle. Then the removal of waste in work flow CMC office, Hassan and showing the improvement in the record maintenance and its service to public's are the major factors.

**Table 3.** Papers descriptions of municipal guidance

Paper type	Validity	Descriptions of papers
"A" Papers	Permanent	Register of proceedings of municipal council Records connected with expenditure on works Settlement of sites reserved for public purposes
"B" Papers	30 years	Collection of register of taxes Register of licenses Assessment list of buildings and lands liable to tax
"C" Papers	10 years	Work files with estimation of municipal works Register of public improvement funds Register of objections to assessed taxes
"D" Papers	5 years	Bill of payment of suppliers Statement showing the construction, reconstruction Receipts for goods deposited in warehouse

"E" Papers	1 year	Daily reports of plague, cholera, and small pox Periodical returns Papers related to annual administration report
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## 5.5 Data Collection, Analysis and 5s Implementation

To improve the efficiency in a simple manner in any system or organization is the most challenging task, which requires the previous data's and its analysis with the real documentation. Here the following record room data's like descriptions of all papers of 5 years to 30 years documentations are needed as per the guidance of municipal act of 1967, mentioned in Table 3.

### 5.6 5s Implementation to Process

After the data processing, the different 5S terminologies are suitable with the functions of CMC hassan and the details of the various functionalities are described in the below table for the exact 5S applications to reducing the wastes through the proper destruction of files after that the exact systematic arrangement of files and maintain consistency throughout the work environment process is obtained in simple manner is explained in the Table. 4

**Table 4.** 5S implementation to CMC functions

5S Terminologies	Suitable CMC functions
SEIRI (Sorting and disposing unnecessary items)	Segregation of files
SEITON (Set in order, Orderliness)	Numbering, Labeling, Bundling of files
SHITSUKE (Sustain, realization of the above set of rules in order)	Preparation of check lists and files arrangement in proper racking system
SEIKETSU (Consistent and Standardized work environment along with Cleanliness)	Application of software
SEISO: (Shining, Cleaning, Removal of waste and dust)	Closing or destruction of files

## 5.7 Data Processing Approach

After collecting respective files of papers descriptions, the files segregation process in record room starts with sys-

tematic manner through the following different steps as follows.

- Segregation of files
- Numbering of files
- Preparation of check lists
- Application of software
- Labelling of files
- Bundling of files
- Files arrangement in proper racking system
- Closing or destruction of files

### 5.8 Segregation of Files

Initially segregation process starts systematically as per the year wise, ward wise, subject wise and type wise as per the Table 5.

**Table 5.** File segregation descriptions

Sl. No.	Descriptions
Year wise	From 85-86 to 2014-15
Ward wise	Total 35 ward wise
Subject wise	Engineering, SAS declaration, accounts, mutation
Type wise	A type, B type, C type, D type, E type as per permanent, 30, 10, 5, and 1 year storage types respectively

### 5.9 Preparation of Check Lists

Check list follows the 18 columns with their details as follows in Table 6.

**Table 6.** Check list formulation

Sl. No.	Contents	Details
1	Office name	Hassan municipality
2.	subject type	Mutation, bill payment.
3.	date of file commencement	Date of first page of file
4.	File number	Type, year, ward wise.
5.	Ward number	Respective ward
6.	subject details	Name, address..
7.	Movement	Type of files
8.	Date of closing	Date of last page of the file
9.	Total number of pages in file	First page to last page
10.	Paragraph	

11.	Color scanning pages	
12.	White and black scanning	
13.	Date of file destruction	Type wise
14.	Date of receive in record room	Date of file transfer to record room
15.	Date of acknowledgement receipt	
16.	Racking numbers	As per 35 wards
17.	Roll number	Mention rack number
18.	Bundle number	Mention bundle number (100 files per bundle)

### 5.10 Labelling of Files

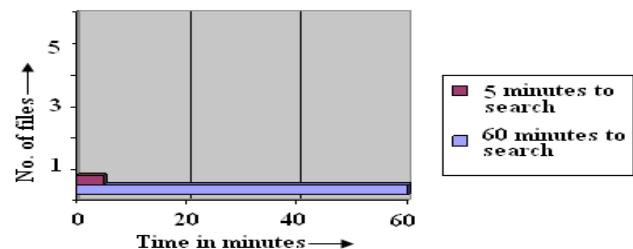
Different colors are used to label the files as per their types, 100 files per one bundle and each bundles are with separate label should prepare. And labels are highlighting the details of check list as per color code of files are given in Table 7.

**Table 7.** Color codes for files

Type of files	Colors used
A type	Red (Permanent files)
B type	Green (30 years )
C type	Yellow (10 years)
D type	White (5 years)
E type	Blue ( 1 year)

### 5.11. Comparative Study

The comparison results of reduction of searching a file process time given by graphical method after the implementation of 5S technology to a file searching process at record room of CMC, hassan from previous to current status is as shown below Figure 2.



**Figure 2.** File Search Comparison.

## 6. Results and Discussions

After the implementation of lean tools like 5S technology to the file searching process of CMC, Hassan, the total reduction time comparing with previous manual searching of file method is 60 minutes and after implementation of 5s to file searching process using software application the total file searching time for the public(customer) is reduced to 5 minutes only. This increases the time efficiency in terms of 91.6% .Especially in public organization like CMC, Hassan , in this way the customer is getting maximum benefit using 5s application like segregation, labelling, checklist preparation, software application and closing of destructive files through the seiry, sheiton, shit-suke, seiketsu and seiso respectively. In these way simple changes in any process using lean manufacturing technology in supply chain activities can make better results and giving more satisfaction to the customer can achieve easily.

### 6.1 Suggestions and Opinions of the Organization

During the proceedings of the developmental stages of the implementation study, assistant engineer and manager city municipal council were approached together their suggestions and options in this research work. This task

was accomplished by supplying a systematically designed questionnaire. An excerpt of questionnaire used during this stage of research is shown in Table 7.1.

After gathering filled in questionnaires, their reactions were summarized. This summary containing the mean responses as well as range of experts opinions are shown in Table 7.2.

**Table 7.2.** Summary of the reactions of Practitioners

Question no.	Questions	Mean response	Range
1	To what extent do you believe that the proposed 5S technique is feasible	7.5	2
4	To what extent do you believe that the proposed Advanced manufacturing technique would improve the productivity level of your organization?	8	2

The overall opinion about the research reported in this paper was described using texts. Those texts are presented in Table 7.3.

**Table 7.1.** Excerpt of the questionnaire

Name -----		
Organization -----		
Company name -----		
Date -----		
To what extent do you believe that the 5S implementation is practically feasible?		
0	0 10	Completely
Not at all	Practically	

**Table 7.3** Overall opinions about the research

SI.No	Designation of the respondent	Overall opinion about using Advanced -manufacturing techniques
1	Manager CMC	The overall file searching process time can be reduced by implementing 5S technique
2	Assistant engineer	By using 5S technique overall public satisfaction increases with minimum time

## 7. Conclusion

Implementation of lean manufacturing principle to the supply chain line activities that means using lean manufacturing tool like 5S principle to the file searching process of CMC organization which helps to reduce the process time, manpower, and errors during searching operation and achieving minimum time towards the customer or public service in smooth manner of daily activities of their needs. In other way application of 5s principle to the file documentation in systematic manner using advanced racking system is possible. And its colour coding system with proper segregation of files and its storage will helps towards maintaining files for a longer time with safe and secured way. Erlier it takes 2 days to search a single file but after implementing 5s principle using software which takes not more than half an hour. The CMC organization activities of file searching process time reduces and movement of supply line activities are increased very fast manner.

## 8. References

- Gershwin SB. 'Design and Operation of Manufacturing Systems: The Control-Point Policy. IIE Transactions. 2000;32(10):891-906. Crossref
- Taz S, Ghorahyzadeh Y.Strategic Issues for Planning Manufacturing Plants/Facilities. proceedings of the European applied business research conference, Venis , Itali. June 10-15.
- Shah R, Chandrasekaran A, Linderman K.In Pursuit of Implementation Patterns: The Context of Lean and Six Sigma. International Journal of Production Research. 2008;46(23): pp. 6679-99. Crossref
- Soo S, Aspinwall D.Developments in Modelling of Metal Cutting Processes. Proceedings of the Institution of Mechanical Engineers. Part L: Journal of Materials Design and Applications. 2007;221(4):197-211.
- Agarwal R. Shankar MK, Tiwari.Modeling Agility of Supply Chain. Industrial Marketing Management. 36(4):443-57. Crossref
- Gunasekaran A, Patel C, Tirtiroglu E. Performance Measures and Metrics in a Supply Chain Environment. International Journal of Operations and Production Management. 2001;21(1-2):71-87. Crossref
- Srinivasan M, Mukherjee D, Gaur AS. 'Buyer-Supplier Partnership Quality and Supply Chain Performance: Moderating Role of Risks, and Environmental Uncertainty. European Management Journal. 2011; 29(4): 260-71. Crossref
- Bhasin S. 'Performance of Lean in Large Organisations. Journal of Manufacturing Systems. 2012;31(3): 349-357.
- Fullerton R R, Wempe WF.Lean Manufacturing, Non-financial Performance Measures, and Financial Performance. International Journal of Operations and Production Management. 2009;29 (3): 214-40. Crossref
- Tangen S.An Overview of Frequently Used Performance Measures. Work Study. 2003;5(7): 347-54. Crossref
- Desrochers AA. Modeling and Control of Automated Manufacturing Systems. Washington, DC: IEEE Computer Society Press;1990.
- Robb DJ, Xie B, Arthanari T.,Supply Chain and Operations Practice and Performance in Chinese Furniture Manufacturing. International Journal of Production Economics.2008; 112(2):683-99.
- Folan P, Browne J. 'A Review of Performance Measurement: Towards Performance Management Computers in Industry.2005; 56 (7): 663-80. Crossref
- Gunasekaran A, Kobu B.Performance Measures and Metrics in Logistics and Supply Chain Management. A Review of Recent Literature (1995-2004) for Research and Applications. International Journal of Production Research. 2007; 45 (12):2819-40. Crossref