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Role of lean manufacturing and supply chain characteristics in accessing the manufacturing performance

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A B S T R A C T

The improvement in manufacturing process is never ending effort, which is being derived by the culture of the organization. Therefore, an attitude of perfection, innovation and devotion is an essential part for the process improvement of an organization. Recently, innovations in the field of engineering help an entrepreneur sell the products through competitive environment. Moreover, the timely delivery of goods and cost effective product is the yardstick, which contributes to the performance index. These improvements resulted from continued performance enhancement efforts, helps in producing right quality in the right times which means providing stability to the organization performance. The role of lean thinking and supply chain characteristics is to create an effective marked on the organizational performance including bonding of all the participants where-so-ever possible. The purpose of this work is to examine the challenges, which integrate the Lean Principles to Supply Chain Characteristics for the real world situation to achieve better utilization of resources, timely delivery to the customer, and deletion of non-value added items including the control on all type of wastages as linked with supply chain systems.

1. Introduction

Global sourcing due to mechanization and automation in the field of manufacturing processes has originated a lot of opportunities for manufacturing industries for growth. Every individual organization has employed various improvement ideologies for their processes such as SCM, Lean Manufacturing, TPM, TQM etc. Each ideology has its own different organizational structures, multiple customer expectations, different product types, etc. Yet, these ideologies have one thing similar i.e. their principle of working, such as all the ideologies centered on the improvements in process such as better control on inventory, reduced downtimes, increased productivity etc., still there are differences in planning and execution part for these ideologies. Lean Thinking is a business initiative to reduce the wastes from the manufacturing operation through its key concepts such as

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Continuous Flow, work standardization, VSM, Pull production etc. (Womack & Jones, 1993). The justification of Lean Principles is structured around seven levels: system, object, operation, activity, resource, characteristic and application etc. Each level is linked systematically so that the adoption of Lean Principles helps in making improvements in different areas such as inventory management; employee involvement; manufacturing processes; maintenance; layout/handling; suppliers; and planning and scheduling etc. (Alteker, 2005).

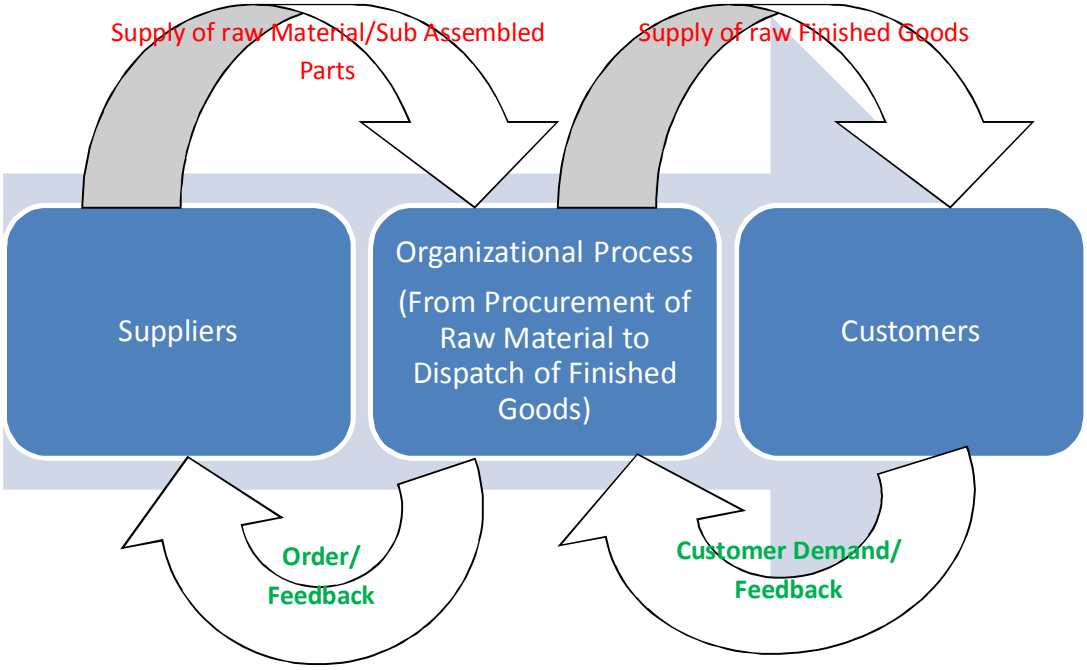

Fig. 1. Lean Thinking Concept (VSM Methodology)

In addition, the close monitor on the manufacturing process is needed to reduce process variability (defect free production), efficient planned maintenance of all machines (for increased availability) and reduction in non-value added activities such as setup times, movement of material in between the work processes and additional processing of material. The efficient utilization of machines while producing is reducing WIP inventories and throughput times that lead to reduce the lead times. The wastages in industries includes the inventory waste, transportation waste, waiting time, inefficient utilization of space, waste in motion, waste of over processing, waste due to defects, waste of resources, waste of talent etc. The five lean manufacturing principles are as under:

1. Accurately specific values from the customer's perspective for both products and services.
2. Identify the value stream for products and services and remove non-value-adding waste along the value stream.
3. Make the product and services flow without interruption across the value stream.
4. Authorize production of products and services based on pull by customer.
5. Strive the perfection by constantly removing the waste (Burton & Boeder, 2003).

The demand of Supply Chain Management (SCM) in industries is grown up due to Liberalization, Privatization and Globalization of the market. The other facts like modern marketing system, introduction of products with short life cycles, and the discriminating expectations of customers have enforced business enterprises to invest in and focus on their Supply Chains (SCs). The proper Supply Chain of the system regulates the various factors like decision making phases, performance, identifying drivers and

obstacles in manufacturing process, network designing for manufacturing process, planning & managing for inventory, proper utilization of resources, pricing the final products, and transported the products to customers as per current demand that can stimulate the firm remain competitive in the market (Carreira, 2007).

Fig. 2. Supply chain characteristics

Therefore, to drive the overall advantage and the necessary goals, the simultaneous implementation of both the methodologies can provide tangible results such as in developing manufacturing strategies, improved planning horizon, effective utilization of resources, better scheduling, lowering inventory status in the organization, delivery to customer end with in the acquired time, better cash flow, and reduction in wastages etc. However, the product durability, adaptability, and reliability are very critical for the implementation of lean supply chain and in measurement of effectiveness.

The important business competitive driving forces such as speed (Rate of Production and delivery to customers, etc.), quality, flexibility in the facilities, efficiency of the processes and the advanced innovation, are the guiding factors for effective implementation of lean supply chain. Therefore, in order to meet challenges and stay competitive in business, it is necessary for a company to adopt lean supply chain principles that incorporates these factors. The integration of lean principles with supply chain characteristics is of great importance as these methods addressed almost all the short comings so far as manufacturing strategy is concerned. The proper fitment of the principles may vary for one organization to other organization and need to be linked with the language of the participants to have meaning full results.

2. Literature Review

The philosophy of lean was originated by Toyota Company in the 1950's. The term was originally defined in the book, *The Machine That Changed the World*, in 1990 (Womack et al., 1990) which documented the research results of a study performed at the Massachusetts Institute of Technology

(MIT) on the vehicle industry (Amoako-Gyampah, 2000; Hopp & Spearman, 2008). Lean practices were implemented based on several ideologies that appeared prior to it, including TQM, JITm etc. In the early stage, Lean Principles were performed at Toyota Motor Corporation for eliminating waste from the process of automotive engine manufacturing, then to the assembly of the automobile, and later to other parts of the Toyota supply chain by Taiichi Ohno. Later the new lean principles were developed to identify the value that has to be paid to the customer. The implementation of value stream mapping through the system develops the flow production capabilities and a pull-based system to identify and eliminate all forms of waste in the system (Hines et al., 2004). SCM works as a network of facilities that performs the functions of product development, procurement of material, transformation of material to intermediate and finished product, distribution of finished products to customers and after-market support for sustainment, etc. (Christopher & Towill, 2000; Chopra & Peter, 2003)

SCM also refers as "the systematic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole." (Mentezer et al., 2001). SCM is an integration strategy, focusing on benefit for all players in the supply chain and value for the final customer. With the competition in today's marketplace, having effective SCM is critical for business success. Technology advancements in particular have allowed companies to make significant improvements. Communication via the internet has opened up a number of opportunities for faster business transactions and real-time information exchange. (Mentezer et al., 2001) Three steps to aligning supply chain and business strategy:

a) Understanding customer requirements,

b) Defining core competencies and the roles the company will play to serve customers, and

c) Develop supply chain capabilities to support the roles the company has chosen. (Hugos, 2003)

Further, research on how companies must "make decisions individually and collectively regarding their actions in five areas: Production, Inventory, Location, Transformation, and Information" is made. When evaluating these five business drivers, the goal is to find the best mix of responsiveness and efficiency for the market being served (Alteker, 2005; Lambert & Cooper, 2000). A lean supply chain encompasses all the processes and phases a product goes through on its way to final customer delivery. It includes the flow of information, material, and services. The coordination among the various business units is denoted by the term lean supply chain management (LSCM). This term became widely receives much attention in study as well as practice for improved results.

The integration of Lean principles to Supply Chain characteristics provides a key to improve business opportunities such as satisfaction of end users through, good relation between suppliers who provide products, services and information that adds value for customers and other stakeholders etc. The efficient utilization of machines while producing can results in reduced WIP inventories, reduced throughput times and reduction in lead times for leading the organization to competitive environment. (Gupta et al., 2012)

3. Problem Formulation

Complexity of the business and uncertainty in market demands are the main reasons for the manufacturers in order to compete better through providing faster and better service level. Even more, in the face of the ongoing global economic downturn in which most companies are facing shrinking sales volume and have to lay-off most of their employees, it is expected that the lean supply

chain will provide way to maintain the stability of the product in market through cut down the operational costs, reduce inventory level, and rendering the organization as efficient and effective as possible. To validate the proposed work, the study was done in XYZ company manufacturing rims for automotive vehicles.

Fig. 3. Wheel Rim(14 ″× 25″)

3.1 Methodology

- Lean Tool VSM that is helpful in creating the difference between present status of the research and proposed status of the research.
- The principles of 5S are used to identify, analyze and evaluate the existing manufacturing system and the basic analysis on inventories for controlling the planning and scheduling process. Therefore, the data for the last six months need to be examined.

4. Analysis

Lean thinking tool especially VSM is needed to be worked out for this segregation between value added and non-value added items, so that the non-value items are eliminated in the process itself. The structure of the present study was divided in two halves i.e. theoretical frame work designing and the empirical work performing on data as Shown in Fig. 4. The theoretical frame work design basically depends on three major factors as follows: a) General resource required for manufacturing process of Rim i.e. Men, Machine, Material, Money, Method, Management etc. b) Lean Production System includes the study of segregation process between value added and non-value added activities i.e. Removal of wastes like WIP, Over production, Over processing, Unnecessary motion, Defect, Waiting time etc. c) Supply Chain System includes the study of drivers i.e. Inventory, Facility Planning, Transportation, and Information that are required for a good supply chain and also the study on identifying the obstacles in SCM implementation.

Further, the empirical research of this present case mainly based on the integration of Lean principles into Supply Chain Characteristics and detail of outcomes of the research work.

4.1 Value Stream Mapping Introduction

VSM is the creation of manufacturing system, which starts with the concept of value addition in the entire process and ends at scheduled delivery to the customer end. Mapping is just identifying the value added and non-value added (i.e. waste) activities from the value stream aids. In the present case, 14 models were identified (During the period from Jan’2013 to June’2013) for comparison

purpose between plan production and actual production. The month wise and model wise planned v/s actual production data of these 14 models is as given in Table 1. The comparison reveals that the company monthly production (in actual) for Rims of various sizes, is far below from the planned production.

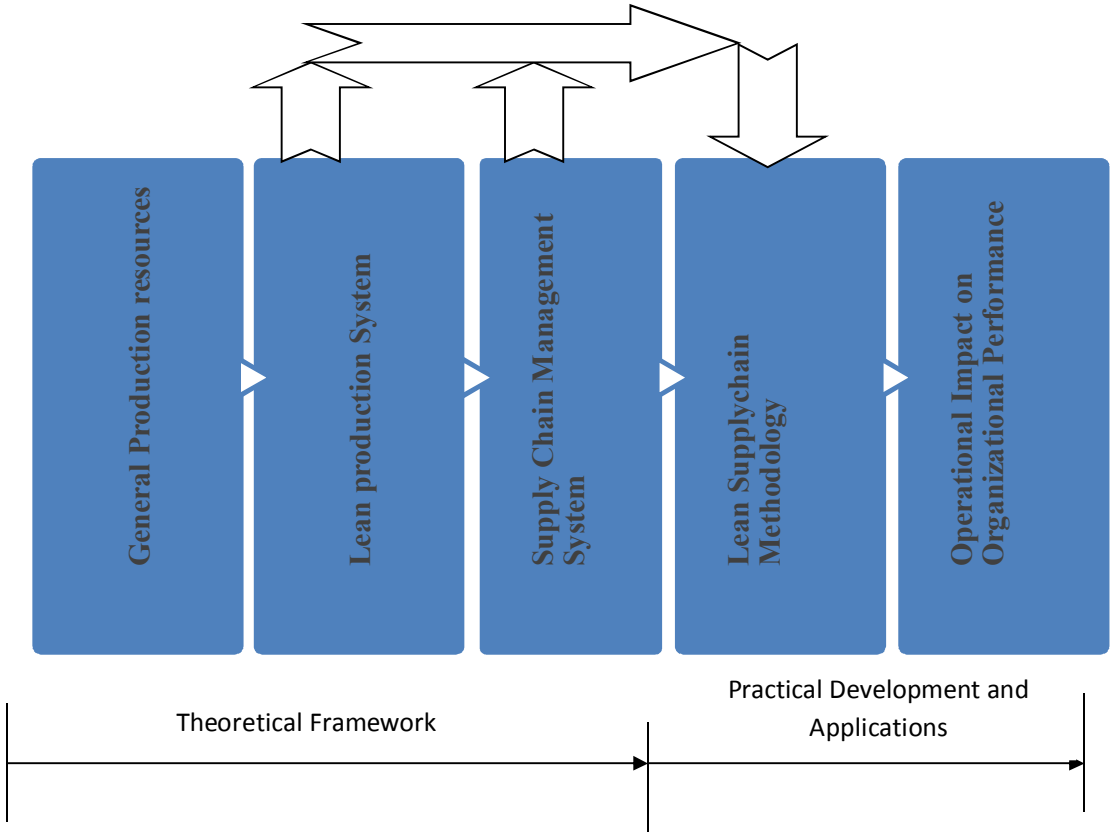

Fig. 4. Structure of the study

Table 1
Production Data: Planned v/s Actual

Model Serial No.	Jul'12		Aug'12		Sept'12		Oct'12		Nov'12		Dec'12	
	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual
1	650	155	175	185	290	0	490	200	110	0	240	310
2	350	150	280	210	100	35	100	0	510	330	0	48
3	230	230	300	210	80	300	180	50	75	58	100	115
4	110	180	300	75	280	110	250	228	375	30	115	50
5	400	250	200	175	280	250	420	370	410	230	475	300
6	225	350	400	405	530	200	450	140	285	320	210	957
7	115	170	300	240	400	450	500	430	350	480	190	115
8	310	250	300	180	265	250	400	250	470	350	670	145
9	245	330	320	410	600	870	200	560	225	170	250	200
10	570	375	600	505	410	180	400	295	300	390	480	520
11	350	180	150	110	410	100	505	300	480	580	525	140
12	250	320	475	230	520	225	440	300	200	205	435	145
13	470	190	370	225	190	140	200	90	400	150	540	165
14	300	190	200	100	400	570	240	185	395	190	410	200
Total	4575	3320	4370	3260	4755	3680	4775	3398	4585	3483	4640	3410

Table 2
Actual production month wise

Month's	Jul'12	Aug'12	Sept'12	Oct'12	Nov'12	Dec'12	Total
Plan Production	200	200	150	420	410	475	1855
Actual Production	250	175	250	370	230	300	1575

For drawing the current stage of the process, the precedence diagram for the assembling of Rim manufacturing have been studied for the knowledge of the production flow and to be familiar with the activities being performed in the shop floor. It was observed during the process study used for fabrication wheel rim, that there is a wide gap between actual production and the available capacity of the plant. The main problem is to find out the area where improvement needed to balance the capacity with the actual production rate. This gap also results in creating the gap between demand and supply of the product not to meet customer satisfaction.

Average plan production per month = $\Sigma X_i / n = 1855/6 = 309.2$ say 310 Nos.
Average actual production per month = $\Sigma X_i / n = 1575/6 = 262.5$ say 260 Nos.

The following observations are made on the basis of current stage analysis:

- The workforce of the company is still unaware of the problems for low performance index, large WIP, inventory and large breakdowns, which cost to the company.
- In existing circumstances, it is difficult to access and segregate the non-productive wastages from the overall process.
- The observations revealed the periodic review is necessitates for effective control on inventories.
- The main issue is regarding the performance index linked with human performance. Though the operations performed on the rim are often linked with press work, yet the operation of the press is in the hands of operator only. Therefore, the targets may be set and standardized and duly endorsed by the work force making it logically more acceptable so-far-as targets are concerned. The various causes assigned for less performance rate are shown in Fig. 5.

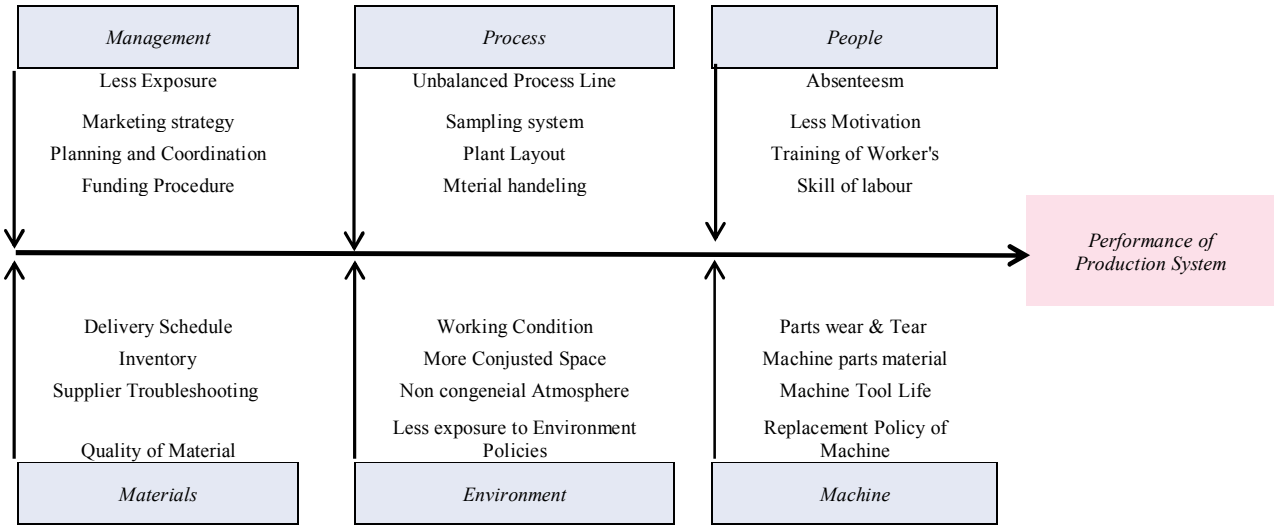

Fig. 5. Cause and effect Diagram

Table 3
Cycle time data at each station

Station No.	Station Name	Maximum Cycle Time (In seconds)
1	Blank	120
2	Die Location Bore	70
3	Draw	80
4	Valve Body Cutting	70
5	Hole Punching and Lathe	70
6	Lathe	130
7	Bolt tagging	130
8	Chemical wash and Primer	90
9	Assembly	120
Total		880

Before drawing the future stage of the assembling plan 5'S methodology i.e. Sorting, Straighten, Sweep, Standardize and Sustain, is introduced to examine the value added and non-value added activities from the entire process. While going through the precedence, it was clear that the performance level of the line is much below the expectation. The reasons for this low productivity could not be satisfactorily answered by the management. Therefore, it became necessary to access the prevalent parameters to assess the blockages, which are contributing in the low output. The steps for assessment for the required technique the Cycle-time Calculation (Total amount of time consumed for assembling one unit of Rim) has also been done as shown in Table 3.

The very first observation regarding working efficiency is integrated of intentional slow down and this may be obvious because of change of hands. The various types of losses were found during the survey at initial stage of proposed study as: Equipment failure loss, Setup and adjustment loss, Startup loss, Minor stoppage and idling loss, Speed Loss, and Defect and rework loss. Now drawing future stage on the basis of recommendations made from the Brainstorming and Experimental Analysis (Work sampling etc.)

1. The cutting of blanks out of sheets is being carried out by using Oxy-Acetylene Torch which is slow and will create starvation for subsequent operations. This can be improved by using Plasma Arc Methodology where in the cutting at the edges shall be sharp and also the production nos. will increase tremendously.

2. The punch size at blanking has to be reviewed so-that rework on lathe for bore machining is avoided. In addition, while cowling the trimming tool must be added to eliminate shifting of material on to lathe. These two actions shall improve and eliminate working on lathe including productivity improvement as the operation on lathe creates blockage while other operation are starving.

3. The cycle time for bolts tagging is high. Therefore, need to be augmented by using additional set of welding machine.

4. The solution for material handling process was suggested. This problem can be answered by using 500 kg's capacity in jib cranes, also the machines need to be laid out in a sequential manner so as to avoid back freighting of the material

5. Gap between actual and planned production can be filled by motivating the workforce so that the idleness amongst workers this eliminated this can be achieved by categorizing some of incentives so that a worker gets more earning per 8 hours as compared to existing earning this mutual interest between the worker and the management shall lead to congenial atmosphere including the healthy environment.

The proposed solution (recommendation) are implemented through the worker training with some goals like general awareness about the company plans in future, the empowerment to workers, the proposals for new resources, quick response on customer demand, and also for the Continual Improvement Plans like Kanban System, JIT etc. Such a methodology will help in economic planning and smooth flow of material without any bad tracking. This will also help in reducing the accidents as the environment can be made for safe working. This will also help to management to address the problem of shortages and blockages. It becomes easy to find out net material input at each station and therefore it provides viable backgrounds for cost determinations.

4.2 Design the supply chain for the current process

In manufacturing organizations, SCM addresses the limitation in improving demand chain performance through the transfer of demand information especially when the lead times are long enough. On the other hand, the Lean Principles addresses the types of wastes, which are associated with manufacturing processes for the same conditions. SCM emphasizes the overall and long term benefits for all parties through cooperation and information sharing. SCM helps in maintaining the right flow of material, money and information for effectively managing the business requirements.

The supply chain in the present study covers the four drivers i.e. Inventory Management, Facility Planning, Transportation (Material Handling) and Flow of Information. The supply chain design consists of:

- Change the manufacturing strategy from the rhetoric based to fact based.
- Sharing information at a very detailed level to help the suppliers for getting potential benefits.
- Demonstration of commitment level for long term production planning in place of 'Flavours of the month'.
- Providing support to the suppliers in terms of Training and trouble shooting.
- Maintaining a good supplier customer relationship through establishing the two way service level agreement that includes the Service Description, Goals of Service, Roles and Responsibilities and Escalation Procedure etc.

4.3 Integrating the Lean Thinking to Supply Chain Characteristics

The integration of Lean Principles and Supply Chain Characteristics are the essential tool for developing manufacturing strategies and to coordinate the manufacturing activities of a product at various stages with an objective of timely delivery to the customer at an economic cost. It has also been established from the literature that lean and supply chain practices individually holds potential for improvements in almost all the sectors. The integration of both methodology is generally based on training provide to company worker as well as to suppliers. The efficient Training program to workers will enhance the performance index by making the process more acceptable from the workers side, resulting in better utilization, timely delivery and higher profitability. Further, this will also help in planning and scheduling the production data so-as determined lot size is maintained. The Training to suppliers leads to overcome from the troubleshooting/uncertainties like more lead time, market demand fluctuation, quality of the product etc. The information sharing between employees and employer is the best way to achieve the desired goal. During integration of both methodologies, the sector of information flow need to be designed in very strong and effective manner that response in very quicker time. This results in outlining the uncertainties or non-value added activities in process and throughout from the process. The efficient resource utilization that includes material handling and inventory management is another aspect of integrating the Lean Thinking and Supply Chain. While implementing both the methodologies simultaneously, the effective control has been achieved by getting the present status of all the resources (Inventory, WIP, Material in orders etc.) and their utilization. This will further reduced the Takt time of each workstation and the cycle time for a single unit of the product as in Table 4.

Table 4
Cycle time data at each station

Station No.	Station Name	Maximum Cycle Time (In seconds)
1	Blank	92
2	Die Location Bore	58
3	Draw	74
4	Valve Body Cutting	65
5	Hole Punching and bore	61
6	Bolt tagging	88
7	Chemical wash and Primer	90
8	Assembly	120
Total		648

Table 5
Actual production month wise

Month's	Jan'13	Feb'13	Mar'13	Apr'13	May'13	June'13	Total
Plan Production	240	410	250	365	300	410	1975
Actual Production	235	392	265	390	340	430	2052

Average plan production per month = $\Sigma X_i / n = 1975/6 = 329.2$ say 330 Nos.
Average actual production per month = $\Sigma X_i / n = 2052/6 = 342$ Nos.

The present study (Table 4 and Table 5) reveals that the average actual production level of Rim is increased from the average plan production per month level i.e. 12 Nos. app. Earlier the average actual production level was less than the average plan production per month of 50 Nos as shown in Table 2.

5. Conclusion

The purpose behind coupling and using these ideologies is to bring improvements in the organizational efficiencies. Lean implementation has supported manufacturer views, which results in significant increases in productivity and quality, while SCM reducing lead times. It was also revealed from this work that both the Lean and supply chain has most significant objectives of profit, customer satisfaction, and quality of the product including timely delivery to customer hand. These are three drivers behind the application of a lean supply chain in the industry. In present study, the total cycle time producing one unit of rim is reduced to 648 second [Refer Table 4] which was 880 sec. [Refer to Table 3] in previous six month data. In addition, one process is extracted from the precedence of rim manufacturing process. This will results in time saving because a lot of time was wasted for setup the rim on lathe and Takt time on lathe process earlier, and reduce the WIP. Moreover, the present output has encouraged the entrepreneur to expand the business by taking additional orders for the same products and adopting few more new product orders.

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