CHAPTER - 1

STUDY, ANALYSIS AND APPLICATION OF LEAN METHODOLOGY TO A
CLASS OF IT ENABLED SERVICES
INTRODUCTION TO LEAN MANUFACTURING

1.1 INTRODUCTION

"Lean Production" a term coined by International Motor Vehicle Program (IMVP) researcher JOHN KRAFCIK as "lean" because it uses less of everything when compared to mass production-half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of productions."

Lean Manufacturing at the website of the Lean Aerospace Initiative, (LAI) discusses, 'Lean' is not a new concept. If you are reducing inventory, expanding jobs and responsibilities, participating on a multi-functional work team, benchmarking, or creating and maintaining relationships with customers, then you are practicing a part of lean production.
Ohno indicated that Lean is a manufacturing phenomenon that seeks to "maximize the work effort of a company's number one resource, the People." Lean is therefore "a way of thinking" to adapt to change, eliminate waste, and continuously improve. There are a number of tools and techniques, to be used in concert, to achieve maximizing the effort of the workforce and to operate as a "lean" company. According to them, companies that worry about immediate gains and fast growing profits achieved through the reduction of staff cannot sustain a supposedly Lean company for several years.

Womack et al. recognize the Toyota Production System (TPS) as the foundation of Lean Manufacturing and mention many of the tools and techniques used. The TPS is often represented as a house with strong foundations and solid pillars containing highly motivated people working to continuously improve. The roof of the TPS house represents the expected benefits of the complete system. Womack & Jones also suggests that companies should define a strategy to orient their growth while implementing Lean, and to assure a sustainable path of improvements through the years. Hence, Lean Manufacturing is a manufacturing philosophy which shortens the time between the customer order and the product build/shipment by eliminating sources of waste."

Womack et al discusses that, Lean manufacturing as having the following guiding attributes;

- Integrated, single piece production flow, small batches, just-in-time giving low inventory
- Defect prevention not fault rectification; Production pull not push with smoothed demand; Flexible, team-based work organisation with multi-skilled workforce and few in directs
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• Active involvement in ‘root cause’ problem solving to maximise added value
• Close integration from raw material to customer through partnership
• Reduced overhead burden through matrix teams, simplified information flow and processing, enabling flatter organisation structures.

These attributes represent the best practice principles that could be expected in a high-volume lean manufacturing company and are the outcome of recognising the external business environment facing an individual sector. There is a strong link therefore between drivers in the business environment and the strategic responses to them.

Nightingale and Mize discusses that, Lean manufacturing is a corporate activity of continuous improvement and requires effective strategies to successfully implement. Experience from lean implementation efforts shows that, these specific business strategies are significantly impacted by the stage of manufacturing. Wilson and Pearson, Kesser, discuss that, a good strategy needs to be defined and redefined dynamically according to the current circumstances of manufacturing during the lean implementation. An effective assessment tool, therefore, plays a vital role in evaluating each stage of manufacturing and further in determining the strategy and priorities of lean implementation.

Charles has discussed on the Lean metrics to be implemented in the wood manufacturing industry, based on identifying the measurement schemes on leanness of the wood products company, comparing a non-lean producer with the conventional producer of wood products and the positive impacts one can gain through the implementation. He has also identified the tangible benefits to wood products producers for successful transition to lean manufacturing.
Hay, E.J. has proposed a holistic approach to lean manufacturing, where he discusses the methods of removing waste from the system and consistent improvement in the efficiency. He opines that, Waste is "anything other than the absolute minimum resources of material, machines, and manpower required to add value to product". Customers typically do not want to pay for fatter-than-necessary money for the pace, waiting, conveyance, processing, excess stock, unnecessary motion, and correction of mistake etc. He suggests that, there is a need to identify the causes of these wastes and rectify the same to improve the productivity in the organization.

Being one of the pillars of the Toyota Production System, this Philosophy aims at eliminating manufacturing wastes so as to provide "the right parts needed, at the time they are needed and only in the amount needed" as proposed by Ohno. The lean philosophy goes further by adding the concept of value: any feature of a product or a service that does not meet exactly customer's expectations can be considered as a waste and must be eliminated. Womack and Jones have proposed the concept of lean manufacturing as compared to conventional mass production practices practiced by Ford in his book on "The machine that changed the world". They have proposed the philosophy behind lean as much older than that and better known as Just-In-Time (JIT).

Over the past 10 years lean manufacturing has been receiving an increasing amount of attention, as the source for productivity improvements and cost reductions in manufacturing. Hailed by its proponents as a breakthrough means to analyze and improve production and the factory floor environment, lean manufacturing is a broad collection of principles and practices that can improve corporate performance.
Literature survey indicates that there is great demand in the Lean implementation initiatives by many manufacturing industries in India. Further, the medium scale industries in India are running the industries with limited resource, problems of higher attrition rates and are also put under the pressure of poor infrastructural support for the transport of raw material and finished goods.

To stay competitive, many domestic manufacturers have sought to improve their manufacturing processes so that they can more readily compete with overseas manufacturers. Implementing cost-saving lean manufacturing techniques may be used to reduce the impact of imports.

This study identifies different tools and principles of lean in the industries. This research investigates how companies across a variety of industries have used lean principles in their industries to improve their productivity and the manufacturing process.

1.2. HISTORY OF LEAN

The Machine That Changed the World published in 1990 by WOMACK, & JONES, and all three members of the MIT International Motor Vehicle Program (IMVP), dramatically changed and revolutionized the way people thought about 'traditional' car industry so far. The concept Lean was essentially coined by this case study, which has been the largest and most thoroughly ever undertaken in automotive industry. The goal was to compare the performance differences between car companies operating with traditional mass manufacturing systems and those using the Toyota Production System (TPS) (SALZMAN, 2000).
The Toyota Production System which most people now associate with the term Lean or more with the Just-in-time (JIT) principle was already developed in the 1950s when Japanese car industry stuck in a severe crisis. At that time it became clear that the only way to escape from the possible impending doom of the automotive industry in Japan were drastic changes in efficiency and productivity (SALZMAN, 2000). This was the hour of birth of the theories and principles of lean manufacturing, a production philosophy that focus on the streamlining of value added activities and eliminating waste within the process with the goal to better meet customer demand. Furthermore, it represents a holistic and consistent approach that bears on the Japanese cultural and geographic boundary conditions. This, for instance, includes Japanese people's attitude to the conservation of material, but also to their more clan oriented culture. These are factors that made it easier to implement policies to control material or to work in a team which is very fundamental for cross training of floating workers and total quality management (SALZMAN, 2000). Another factor playing a major role was for example the proximity of supplier companies allowing more frequent deliveries in smaller batches. Two of the famous and genius thinkers of the Toyota production system were Shigeo Shingo (1909-1990) and Taiichi Ohno (1912-1990). Meanwhile, lean manufacturing principles have been adopted by diverse sectors of industry such as aerospace, consumer products, metal processing and industrial products (SPEAR & BOWEN, 1999). Despite of the very openness of the Toyota Company about its practices, only few manufacturers have it really managed to successfully imitate or rather implement the Toyota system. This is no wonder. Once you look closer at the TPS you will begin to understand that the success of this approach is not just driven by the implementation of the identified various practices, control functions, and tools such as the pull system, kanban, andon lights, visual control boards or...
mistake proofing. Rather, it is the coherence and harmony of and with the underlying structure, organization and people’s mentality how tasks are arranged and performed. SPEAR & BOWEN (1999) designate that phenomenon as the 'DNA of the Toyota Production System' and suggest a set of rules that describe it. Those are inter alia explained briefly in the next chapter since the publication of the case study in 1990, concentration is being focused to adopt the lean manufacturing principles from car industry to the manufacturing section of various businesses, partially with considerable improvements.

General Electric for instance made it to 100% on-time deliveries; other companies could reduce floor space by 50-97 % and/or improve their cycle times by 60-80 % (SALZMAN, 2000). Since people began to study the field of Lean, they gradually began to realize that the Success of that system approach was not only limited to the manufacturing section but could be Lean in Manufacturing also be expanded to other sections of business bearing a high potential of cost reduction and quality improvements. Current research deals with the applicability of lean principles and lean improvement tools to different levels and sections of business but also tries to develop and go ahead with new ideas based on the Lean approach. One of those sections of business is product development. Due to its particular nature of high uncertainty and risk and low repetitiveness compared with manufacturing processes, the realization of such principles and tools but also the development of new ones turns out as much more challenging. To get a better understanding of the Lean philosophy but also to provide the reader with some more background information about the author's work, the basic five lean principles identified by WOMACK & JONES (Lean Thinking, 1996), Toyota's fundamental rules and the
most significant practices used within the TPS are briefly explained in the following chapter.

1.3. INTRODUCTION TO FIVE LEAN PRINCIPLES:

Lean is lean since 'it provides a way to do more and more with less and less', that is to say less human effort, less equipment, less time and even less space while simultaneously producing products that customer really want. In this way it facilitates increasing value while decreasing waste at the same time. Waste means any human activity, which absorbs resources but creates no value. For instance, mistakes that require additional effort for rectification, production of items that nobody wants leading to inventories and remaindered products piling up, processing steps that are not required, movement of employees and transportation of goods from one place to another without any purpose, people in a downstream process waiting because one of the upstream activities has not delivered on time, goods and services which do not meet customers' needs). A powerful toolkit against waste is provided by Lean Thinking which suggests a way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption when someone requests them, perform them more and more effectively and so eliminate wasteful activities consequently. Compared with some other measures to rationalize the workflow, which oftentimes just take away jobs, this approach rather creates new ones and makes work more satisfying to the people through immediate feedback on efforts to convert waste into value). The single steps of this proceeding are the matter of the following section.

1.4. FIVE LEAN PRINCIPLES

1.4.1. Specifying value
Providing the customer with the wrong good or service means waste irrespective if
the process per se is performed right and efficiently or not. To further prevent this
waste, the first step in lean thinking must be a thorough analysis of and dialog with
specific customers in order to understand what their particular needs are at a
certain time and what they are ready to pay for. Once customer needs are identified
it becomes easier to define value in terms of specific products with specific
capabilities offered at specific prices. Finally, value can only be defined by the
ultimate customer and is only meaningful when determined in terms of a specific
product that meets the customer’s needs at a specific price at a specific time. To
accomplish this first goal might necessitate ignoring existing assets and
technologies and introducing more strong and dedicated product teams. Reality
often looks differently where the specification and creation of customer value gets
hindered by immediate needs of shareholders and the prevailing financial mindset
of senior management. Another issue frequently consists in the strong role of
companies’ technical experts. This may result in very complex, customized designs
with sophisticated underlying processing technologies, which finally exceed
customers’ budgets, and furthermore rarely meet their real desires Even though it is
quite unrealistic that companies will successfully implement those changes
overnight, it is important for them to get a clear understanding what the customer
needs really are. Since all business processes within a company can be considered
as a big network of supplier-customer relations, the current principle may also apply
to in-house customers.

1.4.2. Identify the value stream

The next step in lean thinking is to identify the actual value stream i.e. the whole set
of activities required producing the specific product independent if it is a good, a
service or a combination of both. This is a kind of a door-to-door perspective applied to the three major fields of activity in any business): Problem-solving task: From concept through design and engineering to production launch Information management task: From order-taking through detailed scheduling to delivery Physical transformation task: From raw materials to the finished product of the customers During the value stream analysis there will mostly appear three different types of actions along the value stream:

- Value adding activities (VA): Painting a car, assembling of a bolt
- Necessary but not value adding activities (NNVA): Inspecting painting to ensure quality
- Non value adding activities (NVA): Activities that can be eliminated instantly.

The key of the value stream analysis is that you look at the entire value stream for each Product or product family, beginning with the first supplier in the chain up to the ultimate Customer. The potential of this procedure is based on a holistic view that goes beyond the single company. Once firms decide to do so, they almost always reveal huge amounts of non value adding activities that is termed as waste. In literature this kind of integral approach is called lean enterprise. One of the reasons why firms still avoid this approach is the matter of confidentiality and the fear that any revealed information about internal processes and costs could be used against them by up or downstream partners. Concentrating on the own business but not on the whole value stream including the consequences of their internal activities for other companies along the stream is the logical result of this fear. That attitude actually proves to be very dangerous in an age, when companies are outsourcing more due to an increasing product complexity and shorter cycle times. rather, this development calls for a 'voluntary alliance' of all the different
parties involved to examine each value creating step, to detect and prevent disconnects in the value stream. Of course, this requires a change of thinking about business networks and relations, and the establishment of some simple rules for regulating how companies interact with each other.

Transparency as regards the process steps along the value stream might be one of the key issues since it does not only help to synchronize value creating activities more and more but also allows the participants to verify if the other companies act upon the agreed rules.

1.4.3. Flow

After specifying the value, mapping the value stream and eliminating not value adding activities, the next step in lean thinking consists in making the value-creating activities flow. This is a very critical step as it requires a change in thinking, away from the traditional batch thinking in the direction of continuous flow thinking. The first people who absolutely realized the potential of flow were Henry Ford and his partners in 1913: By applying the continuous flow principle to the final assembly, Ford could reduce the effort required to mount a Model T Ford by 90 percent. Even this was an outstanding result; it only is a special case since Ford's approach 'only worked when production volumes were high enough to justify high-speed assembly lines, when every product used exactly the same parts, and when the same model was produced for many years'). In contrast, introducing continuous flow into low-volume production when only dozens or hundreds of copies of a certain product were needed proves to be a much bigger challenge. It represents the general case as it more exactly describes the real situation with customers demand. Ohno and his associates recognized this challenge and worked out
strategies and techniques to achieve continuous flow in small-lot production, in the majority of cases without the use of assembly lines. Mastering the quick change over of tools from one product to the next, and 'right-sizing' or rather miniaturizing machines in a way that processing steps of different production stages such as molding, painting, assembly, etc. could be conducted very close-by to each other, are two of those techniques. That this procedure is beneficial, some plants in North America and Europe proved where people involved in lean applied kaikaku which is some kind of radical improvement, compared with kaizen which more means continuous incremental improvement. In those cases, the production activities for a specific product were rearranged from departments and batch-and-queue fashion production to continuous flow what not only doubled productivity but also reduced product errors and scrap enormously. Even if reengineering approaches tried to more focus on the value-creating process instead of organizational categories or departments, the concepts still adhere to disconnected and aggregated processes like order-taking for a whole range of products, instead of streamlining the entire flow of value-creating actions for the specific product. What's more, those approaches often stop at the boundaries of a company and do not integrate the value streams of up and downstream process partners, even though major breakthroughs are achieved by considering the whole value stream. The target of the flow principle consists in redefining the work of functions, departments and companies in a way that they positively contribute to value creation and to meet the real needs of the process participants at every point along the value stream so it is actually in their interest to make the value flow. To do this successfully not only requires to focus on the specific product or service, and to create a lean enterprise for each product but also to ignore or rather to rethink traditional boundaries of jobs, functions, departments, careers, companies, specific work practices and tools in
order to eliminate backflows, scrap and stoppages of any sort and thus to make the flow more smooth. Once employees and managers begin with ‘flow thinking’ and learn to see it, it becomes also possible to apply flow to any activity performed. In principle, the procedure is in every case the same

- Concentrate on managing the value stream for the specific service or good
- Eliminate organizational barriers by creating a lean enterprise
- Relocate and right-size tools, and
- Apply the full complement of lean techniques so that value can flow continuously

A short overview of lean manufacturing tools and flow techniques primarily used in the flow context is provided in a chapter beneath. Applying the flow principle to business processes also seems to have some impact on the psychological state of employees. In a survey conducted by the psychologist Mihaly Csikzentmihalyi, University of Chicago, people consistently report those activities as most rewarding which were associated with a clear objective, a need for concentration so intense that not attention is left over, a lack of interruptions and distractions, clear and immediate feedback on progress toward the objective, and a sense of challenge – the perception that their own skills are adequate and sufficient to accomplish the task at hand. It was also found out that people experiencing these conditions are in a highly satisfying psychological state of flow. In contrast, conventional batch-and-queue organized work scarcely facilitates psychological flow. The worker can only see a piece of the entire task, there often is no knowledge of whether the task was performed right or what the status of the entire system is, the assigned task only requires a small portion of the worker’s concentration and skills, and there are frequent interruptions with other tasks the worker is in charge of. As a result, an
organization that focus on the continuous flow of work and accordingly value, might also lay the foundations for psychological flow. The challenge to sustain a smooth flow without interruptions but also the focus on perfection, the last lean principle in this row, put the whole system in a very creative tension which demands concentration on the part of each worker and the whole product team (Womack & Jones 1996).

1.4.4. Pull

Lean thinking however is not only concerned with the question how to provide the exact goods and services the customer really wants, but also how to provide it when the customer really wants it. The strategy behind is the pull principle, which means that you let the customer pull the product from your company as needed instead of pushing products onto the customer and so accumulating huge stocks of products that no one wants. Even though primarily looked at the end customer, this principle applies along the whole value stream and thus means that no upstream station should produce a good or service until the downstream station asks for it.

An essential precondition for it is laid by the realization of the flow principle which can significantly reduce throughput times in product development, order processing and physical production by 50, 75 and 90 percent respectively. This creates high flexibility and thus the ability to design, schedule and produce exactly what the customer wants and when he wants it. Furthermore, the short response time to customer demand makes it also possible to accelerate the return on investment and to reduce inventories to a minimum even in a complex production and value stream. The secret for the latter can be seen in the ability to get parts resupplied very quickly from the next level of the system, which in turn enables to reorder in small batches. A special tool to control the resupply and to optimize inventories is
kanban and JIT (Just in time), which is briefly explained beneath. What in theory sounds very comprehensible and simple might be a little bit more complicated in practice and takes a good while to implement. It is supposed that companies have more adopted JIT supply and not JIT production. Consequently, inventories of the same quantity were moved one step back towards upstream processes, which are product components or raw materials of suppliers.

1.4.5. Striving for perfection

The final principle in this row is striving for perfection which is some kind of reminder that there is no end in reducing effort, time, space, cost and mistakes while simultaneously producing more and more products which the customer really wants. Indeed, the above mentioned four principles interact with each other in a way that improvements in one of these often lead to some improvements in the others. For instance, product teams which are in direct contact with customers almost always find better and better ways to define customer value more concisely and thereby also find some new ways to advance flow and pull techniques. Another aspect in this context concerns new technologies in manufacturing and other areas which often reveal new ways to increase value and eliminate waste that again redefines the prevailing picture of perfection a company has. Besides setting specific targets for improvement driven by kaizen, the lean philosophy also uses impossible targets for the improvement process, and paints the picture of a perfect process situation for the people. Even if it might be impossible to get to there, just the imagination provides a great deal of inspiration and in particular direction to the people what is essential to making progress along the path and to pull together one of the most important and fundamental principle on the way to perfection is transparency, which was already mentioned earlier. Based on the fact that every
member of the lean system whether subcontractor, first-tier-supplier, assemblers, distributors or even customer can see everything, it is much easier to find out better or even new ways to create value or rather to prevent waste above that, visual control boards often used in production, provide workers with nearly instant feedback of made improvements, which is very basic for the lean approach and a very powerful incentive for the people to further continue with improvements.

1.5. TOYOTA'S FUNDAMENTAL RULES

As established at the beginning of the chapter, the success of the Toyota Production System (TPS) is not just driven by the implementation of the identified various practices, control functions, and tools such as the kanban, andon lights, visual control boards or mistake proofing observed by a lot of people during their plant visits at Toyota. Rather it appears that those practices are just created as means to an end, which is to support a set of rules implicit with the TPS. Those were established and designated by SPEAR & BOWEN as the DNA of the TPS and especially focus on how work at Toyota is arranged and performed. The following five sub-chapters are an outline of SPEAR & BOWEN'S article Decoding the DNA of the Toyota Production System (1999). When looking at the TPS for many people a paradox is arising: How is it possible that activities, connections and production flows in a Toyota factory are rigidly specified, but at the same time operations are highly flexible and adaptable? The key to resolve this problem might not be found in the practices themselves but more in understanding that the TPS is made up of a 'community of scientists' using the scientific method within their work. The scientific method differs from the engineering method, which is more problem specific, and can be generally captured by the following steps:

- Observe some aspect of the universe
• Invent a tentative description, called a hypothesis, that is consistent with what you have observed
• Use the hypothesis to make predictions
• Test those predictions by experiments or further observations and modify the hypothesis in the light of your results.
• Repeat steps 3 and 4 until there are not discrepancies between your hypothesis and experiment and/or observation.

For this reason, each time there is made a specification, there are also established new Hypotheses, which can be tested for changes, Toyota prescribes a rigorous and standardized problem-solving process including a detailed assessment of the current state of affairs and a plan for improvement i.e. a plan for the experimental test of the suggested changes. Without such a rigorous and systematic procedure, improvement would be nothing more than 'random trial and error'. This approach also suggests that workers and managers at Toyota experience their daily work as kind of a big experiment in which each of them plays his certain role. Finally it is this attitude, the readiness to experiment, that makes the system so flexible and that is widely recognized as the cornerstone of a learning organization. In particular, SPEAR AND BOWEN established three rules of design which show that Toyota designs all its operations and processes as experiments, and one rule of improvement which characterizes how Toyota teaches the scientific method to people at every level of the organization.

1.6. LEAN MANUFACTURING TOOLS, PRACTICES AND FLOW TECHNIQUES:

Tools and practices like kanban, JIT, mistake proofing were copied by many companies and widely understood as the secret of the TPS. Quite contrary, Toyota
itself calls them 'countermeasures' and considers them rather as temporary responses to specific problems used as long as a better approach is found or conditions change. It is important to recognize that those countermeasures are designed to support the above established set of rules and lean principles. They are supposed to counter very specific categories of problems occurring and to provide the system with some kind of 'built-in tests' to display problems immediately when and where they occur. This is especially true for the aforementioned unusual high levels of inventories sometimes observed in Toyota plants. For instance, in some cases it would be possible to reduce inventory by pooling it since the same type of product is kept in different types of inventory. The result of this approach however would be that the link between these high levels of inventory and the reason for maintaining it, that is safety stock due to unreliability, or buffer stock due to fluctuations in customer demands, would be lost Consequently, keeping these inventories provides not only information about the ownership but also visual control of existing problems requiring some improvements. The following list of tools, practices and techniques gives the reader a brief review how Toyota tries to realize the above mentioned set of lean principles and rules.

1.7. LEAN -TOOLS AND PRACTICES:

Lean manufacturing technique consists of four steps. The first step is to realize that there are wastes in the system to be removed. Many organizations do not realize that they have tons of hidden wastes with them; therefore they do not have the requirement to remove them from the system. So they will have their problems forever and finding solutions for these problems continues. Once it is realized that there are wastes to be removed from the system. The second step is to identify the different forms of the waste. Further, in this step, the causes for these wastes are
identified. This is very important step in the process. Lean manufacturing never promotes treating the symptoms rather it believes treating the causes and cures the problems permanently. In this step, tools like Ishikawa diagrams or cause and effect diagrams can be used to a large extent. In the third step, the solutions for the identified root causes are carried out. One golden rule to be followed in this step is adhering to the basic lean manufacturing principle of seeing the total picture. It is important to identify the effect of the solution to the entire system. The final step is the implementation process and making sure things are going in the intended way. Here the solutions are tested and implemented. Prototypes are prepared to validate the results obtained from simulation studies. Then, these solutions are tweaked to accommodate practical difficulties occurring in the implementation process. User training and follow-up are among the two most important things in this step of lean manufacturing technique.

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Model plan for the Lean Implementation
1.7.1 Kaizen

Kaizen means a continuous, incremental improvement process for process flow and workmanship with the goal to create more value with less waste. Also called point kaizen and process kaizen. Kaikaku also called breakthrough kaizen, flow kaizen and system kaizen. These procedures aim significantly improve activities with the target to eliminate waste. An example would be the radical reorganization of processing operations from previous queue and batch production to Single-piece flow, and thus the change from large space to short space shop floors.

1.7.2. Hoshin kanri

This is also called policy-deployment. It is a tool for strategic decision-making and helps executive teams to concentrate on the critical and most important factors to accomplish the company’s business objectives. Similar to quality function deployment, a visual matrix diagram is supportive to select between three and five key objectives, which then get translated to specific projects and subsequently broken down to the respective level for implementation. Thus, this method essentially helps to align resources and to establish clearly measurable targets against which progress is measured in dedicated time intervals.

1.7.3. Five‘S

Five rules that help to create a high efficient workplace, each rule beginning with the Letter S.

- Sort through and sort out: Separate needed tools, parts, materials and instructions from unneeded ones; remove, relocate or discard what is not necessary.
• **Set in order**: Neatly arrange parts and tools so that they are easy to find, use and return in order to streamline work and prevent searching for them.

• **Shine**: Conduct a cleanup campaign and thereby inspect equipment and work area.

• **Standardize**: Organize all work areas in a similar way so that procedures are obvious, and defects are signaled automatically.

• **Sustain**: Always follow the first four rules that they become habit. Only this will provide the total benefit of that practice.

1.7.4. SMED (Single Minute Exchange of Dies)

Shigeo Shingo developed a number of techniques for changeovers of production machines in less than ten minutes. Changeovers that require less than a minute are called one-touch setups. As Toyota strives for perfection, the long-term objective is zero setup, which means that changeovers can be immediate and thus will not interrupt the production flow in any way. Only that will finally make it possible to disengage pure mass production for small and continuously changing series.

1.7.5. VSM (Value Stream Mapping)

This is a Mapping method to identify all the specific activities and process steps along the value stream of a specific product or product family. Value stream mapping is conducted in three steps: Mapping the current value stream, mapping the future value stream, and creating an implementation plan. An official workshop brings together people from engineering, manufacturing, sales and supply.
1.7.6. Poke-Yoke (Mistake-proofing)

A mistake-proofing device or a procedure is to prevent defects during order-taking or manufacturing. Examples from manufacturing are devices that survey the shape of product parts. Deviations will instantly result in a stop of the dedicated machine. That will also apply if failures occur in processing of the machine itself, or if a specific Sequence of operations is not followed. To ensure error-free order taking, there was developed an order input system based on traditional ordering patterns signaling orders that deviate from that pattern and thus have to be examined. In the majority of cases the reasons are input errors or orderings due to misinformation. The survey and Improvement process itself is called Poke-yoke.

1.7.7. Jidoka

Term that originally characterized the application of poka-yoke devices, and means not allowing defective parts to leave the station or machine that produced them. In particular, it referred to machines or the production line itself, which should be able to stop automatically when a problem occurs. For this reason it is also called autonomation, and deals with the transfer of human intelligence to automated machinery. Jidoka also refers to the situation when an individual worker is facing a problem with the assigned task. If he cannot correct the problem by his own or because the designated assistant is not available, he is prompted to draw a cord to stop the line in place of risking that this is done at a later point in time by the defect. Jidoka often is followed by a root cause analysis.

1.7.8. U-Cell-Layout/ L-Shape-Layout:

Work or machines of different types performing different processing steps are organized in cells, typically in a U-shape layout. Especially within the cells, that enables the flexible deployment of workers in a way that they can operate several
machines at the same time (multi-machine working). The catenation of several cells may again exhibit a U-shape, or a L-shape. This kind of layout drastically reduces used space on the shop floor and thus enables shorter distances between single cells, which again better worker’s communication. Foremen and supervisors can reach stations with occurring problems in only a few moments assuring instant help, and because of the proximity of the start and end point of the work area they are responsible for, each walkabout is almost a closed loop and thus contains only little idle time for them.

1.7.9. Five Whys

Question practice of asking ‘why’ five times always people encounter a problem. One Question cycle not only contains ‘why’ but also a whole series of questions: who, what, When, where and how? By conducting this cycle five times at least, it should be possible to identify the real root causes of a problem and to devise and realize effective Countermeasures

1.8. SEVEN TYPES OF PRODUCTION WASTE

To easier identify waste in production a set of seven waste types was established. This includes

1. Waiting for the next operation,
2. Transport of materials and parts,
3. Unnecessary movement by workers while they perform their job due to looking for parts, tools, assistance etc.,
4. Over processing of component parts due to poor tool and product design,
5. Higher levels of inventories than the possible minimum,
6. Overproduction of parts and products before ordered, and
7. Defective products.
1.9. MANUFACTURING FLOW TECHNIQUES

1.9.1. Systems capability

The integration of core team members all along the value stream with a good understanding of the process steps and systems capabilities is the basic precondition for enabling a smooth product flow through all process steps from the start to the finish (SLACK, 1998).

1.9.2 Takt time

Technique used to synchronize the rate of production with the rate of customers. It sets the pace of production and helps to prevent over or even underproduction and thus to reduce inventories.

1.9.3. Visual control

Visual control, also called transparency, pursues the goal that every person involved must be able to see and fully understand the different aspects of the process and its status at any time. This reaches from neatly organized workplaces (5Ss), status indicators like andon boards (lighted overhead displays providing information about the current status of production and emerging problems), updated standard work charts, displays with key measures to financial status reports about process costs. Transparency plainly is one of the key principles of the TPS, enabling immediate feedback of current work and thus immediate adjustment if necessary to finally meet customer demand.

1.9.4. Just-in-time (JIT)

Flow technique that aims at minimum stocks and inventories by providing the right material and parts in the right quantity and at that point in time when it is needed. The key elements of JIT are flow, pull, standard work (standard in-process...
inventories) and takt time. Just-in-sequence (JIS) is a special case of JIT and means that in addition to the above characteristics for delivery also the sequence of delivered parts is defined. A good example for this may be the supply of car companies with seats when it is vital to install the right seats in the right cars without any interruptions in the flow because of a wrong order.

1.9.5. Kanban:

Kanban is a small card attached to parts’ container, and is part of a control system used to practice pull for the in-plant material flow by signaling upstream processes new demand which results in production and/or supply of the particular parts.

1.9.6. Heijunka (Level scheduling):

Level scheduling is used to sequence orders in a repetitive pattern and so to smooth the day-to-day variations in total orders in terms of longer-term demand. Some type of level scheduling is inevitable for every producer, whether mass or lean, unless he and all his suppliers have unlimited human and machine resources and zero changeover times so they can immediately respond to demand. Nevertheless, since lean producers continually try to create excess capacities and to reduce changeover times through continuous improvement efforts, the short-term discrepancy between the level schedule and effective demand can be minimized step-by-step.

1.9.7. Physical proximity:

Production steps are arranged in close physical proximity and in sequence to reduce excessive transport actions (U-Cell-Layout/ L-Shape-Layout) but also excessive movement of the workers. On the macro level, this may refer to the...
proximity of the engineering departments to the shop floor, or the proximity of suppliers to their customers. Either way leads to better mutual integration and communication (SLACK, 1998).

1.9.8. Single-piece flow

A process in which the incrementally finished products, one at a time, flow along the pre specified pathways of order-taking, design and production without any interruptions, loops or scrap. This model is in stark contrast with conventional batch-and-queue processing and thus eliminates inventories between the process steps. Furthermore, quality problems can be detected and eliminated on a single piece basis.

1.9.9. Capable processes

Capable processes, equipment and employees are the precondition for high process performance with low levels of variability, defects and scrap. To ensure capability, certification processes of both process equipment and workers are conducted at regular intervals (SLACK, 1998).

1.9.10. Standard work

Each activity is concisely specified regarding to cycle time, takt time, content and sequence of the different sub-tasks, and the minimal number of parts (inventory) required accomplishing the particular job. Performing work as specified counts among the basic conditions to reduce variability through a continuous Improvement process with the goal to achieve fully capable processes. Additional, standardized work helps other workers to learn new tasks more quickly.
1.9.11. Cross training:

Cross-trained workers are intended to sustain flexibility in task assignments. This flexibility is required to encounter any resource shortfalls along the flow that may occur for any reason. Thus it helps to reduce the risk that the process gets interrupted due to resource bottlenecks (SLACK, 1998).

1.9.12. Total productive maintenance (TPM):

Set of methods to ensure 100% availability of every machine and equipment used within the production process. Since it not only eliminates wait time waste due to 'normal' machine breakdowns, but also defect waste and rework associated with non-conforming parts due to machine or tool wear and tear, it is one of the basic strategies for capable processes (SLACK, 1998). Finally, it is important to understand that neither the five lean principles, nor Toyota’s basic rules, nor the number of different tools, practices and flow techniques gives the TPS its unique performance. Rather it is the way how all of these elements are orchestrated and consistently linked with each other.

1.10. Lean Services:

Lean, as a concept or brand, has captured the imagination of many in different spheres of activity. Examples of these from many sectors are listed below.

Lean principles have been successfully applied to call center services to improve live agent call handling. By combining Agent-assisted Voice solutions and Lean’s waste reduction practices, a company reduced handle time, reduced between
agent variability, reduced accent barriers, and attained near perfect process adherence

Lean principles have also found application in software application development and maintenance and other areas of information technology (IT). More generally, the use of Lean in IT has become known as Lean IT.

A study conducted on behalf of the Scottish Executive, by Warwick University, in 2005/06 found that Lean methods were applicable to the public sector, but that most results had been achieved using a much more restricted range of techniques than Lean provides.

A study completed in 2010 identified that Lean was beginning to embed in Higher Education in the UK. The challenge in moving Lean to services is the lack of widely available reference implementations to allow people to see how directly applying lean manufacturing tools and practices can work and the impact it does have. This makes it more difficult to build the level of belief seen as necessary for strong implementation. However, some research does relate widely recognized examples of success in retail and even airlines to the underlying principles of lean. Despite this, it remains the case that the direct manufacturing examples of 'techniques' or 'tools' need to be better 'translated' into a service context to support the more prominent approaches of implementation, which has not yet received the level of work or publicity that would give starting points for implementers. The upshot of this is that each implementation often 'feels its way' along as must the early industrial engineers of Toyota. This places huge importance upon sponsorship to encourage and protect these experimental developments.
1.11. LEAN GOALS AND STRATEGY

The espoused goals of Lean manufacturing systems differ between various authors. While some maintain an internal focus, e.g. to increase profit for the organization, others claim that improvements should be done for the sake of the customer.

Some commonly mentioned goals are: Improve quality: To stay competitive in today’s marketplace, a company must understand its customers’ wants and needs and design processes to meet their expectations and requirements.

- Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service. See Types of waste, above.

- Taking the first letter of each waste, the acronym "TIM WOOD" is formed. This is a common way to remember the wastes. The other alternative name that can used to remember is "DOT WIMP".

- Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.

- Reduce total costs: To minimize cost, a company must produce only to customer demand. Overproduction increases a company’s inventory costs because of storage needs.

The strategic elements of Lean can be quite complex, and comprise multiple elements. Four different notions of Lean have been identified.
1. Lean as a fixed state or goal (Being Lean)

2. Lean as a continuous change process (Becoming Lean)

3. Lean as a set of tools or methods (Doing Lean/Toolbox Lean)

4. Lean as a philosophy (Lean thinking)

1.12. TRAINING REQUIREMENTS FOR THE EFFECTIVE IMPLEMENTATION OF LEAN MANUFACTURING

For organizational productivity training assumes great significance. Training in the organization is usually organization specific and practice based. Change of technology like lean manufacturing implementation, agile manufacturing, change management, concurrent management, etc demands that employees update their knowledge, skills, abilities and technical expertise. Jobs are becoming more interdependent, demanding high interpersonal and problem solving skills, which can be acquired through training. The concepts of Fredrick Taylor in his principles of Management, Henry Fayol in his principles of Modern Management, Henry L Gantt, Gilberth etc, who invented a better method of “doing a thing”, a concretized the need for training.

Hamblin defines training as any activity which deliberately attempts to improve a person’s skill on a job as opposed to education which is mainly concerned with personal development and not related directly to the job.

Taylor M.H in his article “Training of trainers” defined training as a means to bring about a continuous improvement in the quality of work performed, it would equip them with necessary knowledge, skill, abilities and attitude to perform their jobs.

The training & development is the planned learning experiences designed to
provide workers with the competencies needed to perform their current & future jobs.

1.12.1. Training the workers for the effective implementation of Lean Manufacturing Tools

Toyota Production Systems frames every manager's job very strongly as regards to building the performance mindset, in establishing the standard method, to track actual performance (make problems or abnormalities visible), to teach a basic way for analyzing work, to develop employees through solving problems or improvement tasks. Solving the problem at hand is important. Problem resolution is the test or confirmation of the learning.

TPS mentors have asked these questions that force the trainee to a higher level:

- Why did you choose to work on this problem when there were more important problems elsewhere?
- What is the specific goal of your activity?
- How do you know this is the root cause of the problem?
- By what method did you conduct your analysis?
- Why did you choose this particular solution?
- Did you test any other possible solutions?
- What effect has this solution had so far versus the previous method?
- How were operators involved in the process?
- Are you certain there are no other factors you should consider?
- What remains to be addressed to achieve your goal?
- How will you train everyone to the new method?
In TPS, a problem or any deviation from a standard requires immediate attention. For a supervisor or manager, however, it is not only a matter of solving the problem; it is a matter of training and development as well. A true measure of a manager is said to be when he hands over duties to a subordinate. If performance stays on track after the hand off, the manager has done his job correctly. If performance falls, the manager is viewed by everyone as having done a poor job in terms of employee development.

S. Spear has discussed the case carried out at TPS. A question was asked by TPS as to the possibility to train the entire employee of the organization. From a corporate staff perspective, this is an impossible task. However, in Toyota, implementing TPS is not just a staff issue but a line role, starting with the plant manager. Indeed, within Toyota establishing work standards and fostering kaizen is a key supervisory role; and supervisors, not engineers, are accountable for both work instructions and line performance in terms of productivity and quality. Consequently, deploying TPS through a firm is not about how many areas have been "kaizened" but how many plant managers, and then supervisors and team leaders, have been trained by a sensei and can start training people on their own.

Gary Convis, President, Toyota Motor Manufacturing, USA states that "Management has no more critical role than to motivate and engage large numbers of people to work together toward a common goal, assisting them by removing obstacles (to their success)". In Edgar Schein's ground breaking book, "Organizational Psychology", the author opines that: "The first major problem of groups in organizations is how to make them effective in fulfilling both organizational goals and the needs of their members. The second major problem is how to establish conditions between groups which will enhance the productivity
of each without destroying intergroup relations and coordination. This problem exists because as groups become more committed to their own goals and norms, they are likely to become competitive with one another and seek to undermine their rivals' activities, thereby becoming a liability to the organization as a whole.

The overall problem is to identify the methods to establish the collaborative intergroup relations in those situations where task interdependence or the need for unity makes collaboration a necessary prerequisite for organizational effectiveness.

1.12.2. Lean Manufacturing Challenges in Training.

Lean transformation and training are conceived and deployed, on five main points. They are,

- Track implementation progress using customer focused metrics that gauge performance improvement, not simply tool deployment or tool evaluation.
- Find out what is really limiting performance, and where specifically. Focus on the vital few first and not the trivial many.
- Identify the problems one-at-a-time, as they arise in the areas limiting performance, and address them with the “right” methods and principles.
- Since each new problem is an opportunity to develop someone as well as improving performance, ask people to solve problems rather than apply specific solutions.
- Establish a system of training in which every manager has a coach, works on problem solving and coaches his own people in turn.
simply, every front line employee works on problem solving with the guidance of a coach.

Truly empowering people doing the work means, they have clear purpose and direction—a sense of meaning aligned to corporate vision/direction, boundaries for the empowerment given and considerable self determination within those boundaries, openness and teamwork when doing the work, skills to operate within the boundaries, or any related training needs, measures of effectiveness of the empowerment and its impact on the business, continuing feedback and support from management, and flexibility to address the changing needs that may affect the boundaries, training, measures, and so on.

In *Leading Teams*, Hackman J. Richard provides an excellent set of guidelines for creating and managing effective teams after carrying out research. Surprisingly, his research found that, when you compare the performance of teams with what is produced by an equivalent number of individuals who work individually, the individuals almost always outperform the teams. He proposes that, the reason for the reduced performance is not that teams cannot, or even should not; outperform individuals, but rather, that most teams perform poorly because their leaders have focused on the wrong things in designing or supporting them during the training & implementation. In essence, he proposes need for a good leader in the team.

1.12.3 Team Leader Execution Skills

Hackman explains that, team leaders need the following skills for effective execution of training to the employees in the advanced manufacturing fields in the organization. They are,
- **Envisioning Skill**: Envisions the end state and clearly communicates that to others.
- **Inventive Skill**: Thinks of non-obvious ways to get things done.
- **Negotiation Skill**: Works persistently and constructively with peers and superiors to get resources and assistance needed to support the team.
- **Decision-Making Skill**: Has the ability to choose among various options and uncertainty using perspectives and data.
- **Teaching Skill**: Helps team members learn both experientially and didactically.
- **Interpersonal Skill**: Communicates, listens, confronts, persuades, and generally works constructively with others, especially in high stress situations.
- **Implementation Skill**: Gets things done. At the base level, follows up on the details. At the highest level, manages power and relationships.

### 1.12.4 Challenges for achieving higher standard of excellence

According to Ron Moore, the strategy for achieving a much higher standard is to expect excellence, and to rigorously apply the following fundamentals:

<table>
<thead>
<tr>
<th>Align the organization</th>
<th>Manage change</th>
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<tbody>
<tr>
<td>Innovate</td>
<td>Improve succession Management</td>
</tr>
<tr>
<td>Apply leadership and management principles</td>
<td>Use the business level</td>
</tr>
<tr>
<td>Apply teamwork principles</td>
<td>Apply tools like Failure Mode analysis</td>
</tr>
</tbody>
</table>

### 1.13 LEAN IMPROVEMENT TOOLS:

According to Ron Moore, the following tools can improve the production plan & can lead to effective implementation of right manufacturing improvement & Lean
Manufacturing tools. They are listed as shown in the Table 2.4. He has proposed broad spectrum of the areas of lean manufacturing.

**Lean Improvement Tools**

<table>
<thead>
<tr>
<th>ABC Inventor Control</th>
<th>High Performance Teams</th>
<th>Predictive Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity-Based Costing (or Accounting)</td>
<td>Inventory Reduction</td>
<td>PDM</td>
</tr>
<tr>
<td>Aggregate Planning</td>
<td>Just in Time</td>
<td>Project Management</td>
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<tr>
<td>Agile and Quick Response</td>
<td>Kaizen</td>
<td>Quality Function</td>
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<tr>
<td>Andon</td>
<td>Kanban</td>
<td>Deployment (QFD)</td>
</tr>
<tr>
<td>Automation</td>
<td>Leadership Supervisor</td>
<td>Quality System and Accreditation</td>
</tr>
<tr>
<td>Benchmarking</td>
<td>Development</td>
<td>Re-Engineering</td>
</tr>
<tr>
<td>Capacity Planning</td>
<td>Lean Manufacturing</td>
<td>Reliability-Centered</td>
</tr>
<tr>
<td>Capability Index</td>
<td>Machine Efficiency</td>
<td>Maintenance (RCM)</td>
</tr>
<tr>
<td>Cellular Manufacturing</td>
<td>Nationally Accredited</td>
<td>Risk Analysis</td>
</tr>
<tr>
<td>Concurrent Engineering</td>
<td>Training</td>
<td>Root Cause Analysis (RCA)</td>
</tr>
<tr>
<td>Design for Manufacturing and Assembly</td>
<td>Networking</td>
<td>Sales and Operations Planning</td>
</tr>
<tr>
<td>Design for Maintenance</td>
<td>New Equipment</td>
<td>Setup Reduction</td>
</tr>
<tr>
<td>Design of Experiments</td>
<td>Operator Maintenance</td>
<td>Seven Tools of Quality</td>
</tr>
<tr>
<td>Enterprise Resource Planning</td>
<td>Open Book Management</td>
<td>Single Minute Exchange of Die (SMED)</td>
</tr>
<tr>
<td>Factory Layout</td>
<td>Overall Equipment</td>
<td>Skills Analysis</td>
</tr>
<tr>
<td>Failure Modes and Effects Analysis (FMEA)</td>
<td>Effectiveness (OEE)</td>
<td>Skills Matrix</td>
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<tr>
<td></td>
<td>People Development</td>
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<td></td>
<td>Planned Maintenance</td>
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<td></td>
<td>PokaYoke</td>
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<td></td>
<td>Postponement</td>
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1.14. **LEARNING OF LEAN CONCEPTS AND IMPLEMENTATION IN INDIAN INDUSTRIES**

Mohanty has opined that, in Indian companies, we could observe the following factors as the major impediments in promoting lean practices. The Power politics between various functional departments, Low investment in human resource development, Short term interests of business leaders, Quick-fix expectations & shallow thinking of most managers and Emphasis over administration over learning and knowledge transfer.

There are three aspects of this internally focused lean approach:
• Culture: the mindset that allow individuals and teams to think imaginatively and competitively to take prudent risks to seek out, create and introduce lean projects.

• Process: the business processes and practices that enable people to operate effectively and collaborate towards a common purpose- as well as a robust set of lean tools.

• Structure: organizational structures and supporting technologies that enable collaboration across the company.

Finally, Indian companies have to learn more and more about structural integration, process integration, and external integration.

1.15. CRITICAL SUCCESS FACTORS FOR THE LEAN IMPLEMENTATION

Newman [64], focused on dimensions related to cultural change in the public sector, which is a critical component of any quality or productivity program. She identified several areas to focus on to successfully change an organization. The areas are value proposition, customer focus, culture & change management, Human resource management, infrastructure & methodology, quality & lean tools and measurements. The critical success factors play an important role. There is a need for top management commitment & dedication for the successful implementation of the lean implementation. Change strategy that builds flexibility to respond to customers, and focuses on the technical, political, individual and organizational elements of change. Training and education, employee empowerment, employee involvement and participation, recruitment and selection, reward and recognition systems that support the culture and program, upward mobility and well-defined career path are some of the critical success factors in the
Mohanty states that the linking of Lean principles to critical success factors is achieved if the system.

Suresh Chandar, et al. and Foster have identified twelve dimensions that were crucial to a Lean Manufacturing/Total Quality Management philosophy in organizations. The twelve dimensions identified are:

- **Top Management commitment and visionary leadership:** In many articles, this factor is considered to be the most important to the success of any organization's change effort. Defining a vision of what the organization will look like after implementing Lean Manufacturing and embracing the change is also a critical factor.

- **Human Resource management:** There are many components of Human Resource management that are necessary for successful implementation of Lean Manufacturing, including: recruitment and selection, training and education, employee empowerment, and employee involvement. This is the core concept for the successful implementation of lean as training plays an important role.

- **Technical System:** The technical system includes the design of services and management of key business processes.

- **Information and Analysis System:** The Information and Analysis system helps to disseminate information and enable communication of the program goals and successes.
• **Benchmarking:** Benchmarking compares an organization against best of class related to processes, products, and financials as well as other issues related to customer and employee satisfaction.

• **Continuous Improvement:** Continuous improvement is a critical factor that is a concept of Lean (Kaizen) and other Quality Management programs, encouraged by Deming's philosophy.

• **Customer Focus:** The customer's needs and satisfaction are critical in a service-oriented organization.

• **Employee Satisfaction:** Several studies have found a relationship between employee and customer satisfaction and the teamwork leads to improved employee and customer satisfaction.

• **Union Intervention:** Employee relations issues impact the success of a Six Sigma program. This factor encourages union and management to work together to affect change.

• **Social Responsibility:** This dimension impacts the organization's image and goodwill and potentially impacts customers' satisfaction.

• **Services:** The services include the tangible components of the organization providing the services.

• **Service Culture:** The organizational culture that stresses service quality throughout the organization can establish seamless service delivery.

Hoffman and Mehra, identified six areas that are important to avoid failure in productivity improvement programs, as follows:

• **Top management support through leadership:** This factor includes management's setting of goals and providing leadership and direction.
• **Education and training**: Educate and train management and the workforce in the concepts and tools for improvement.

• **Empowerment**: Empower the employees to make decisions and solve problems.

• **Performance Measurement Systems**: Measure the performance and improvement gains.

• **Total employee involvement**: All employees should be involved in the improvement effort.

• **Reward systems**: The reward system should be tied to and support the improvement program.