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Research Article

Application of Lean Tools in different Industries: A review

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Abstract: Many companies around the world were pressured to cut costs and become more mindful of consumer needs after the crisis hit at the turn of the twenty-first century. Industry has long seen Lean Manufacturing as a solution to these problems because it removes waste without requiring extra capital. In the current situation, Lean production principles and methods are commonly used by companies to optimise resource efficiency while minimising waste. Toyota has been recognised as one of the manufacturing techniques in improving efficiency, increasing customer loyalty, and thereby an organization's competitiveness, thanks to the Lean theory, which was developed by a Japanese scientist.

Keywords: Lean manufacturing, lean principles

1. Introduction

In the current era of globalization, to compete and to stay alive in the market, adoption of new tools and techniques to produce goods is mandatory. The most daunting issue faced by manufacturers today is the way to deliver their products or materials quickly at low cost and good quality. (A. P. Chaple) Lean is one of the strategies that Indian businesses are using to be highly competitive in both the domestic and global markets. In their research, Yadav et al. (2010) found that Indian production firms were eager to follow or learn new methods and techniques in order to increase their performance; however, this was just the start of a longer process for themselves. Panizzolo et al. (2012) researched the introduction of lean development in India in a recent report (Table 5). The Indian automobile industry has the highest degree of lean deployment, led by the electronics, information technology, and engineering industries. Other industries are operating at a mid to lower stage.

Aziza Seifullina etal.(2018) presented a conceptual framework in lean implementation in mining industries in UK. John mbogokafukuet al. (2019) did research on lean implementation in selected industries in Tanzania C. Herron and C. Hicks. In the United Kingdom, the transfer of preferred lean manufacturing process from Japanese car production to common production. Al-Akel Karam et al. (2018) investigated the role of lean production tools in reducing transition over time in the Romanian healthcare industry. I.J. Orji, S. Liu.

(2018) carried out their studies on manufacturing supply chain in China. Juthama schoomlucksana et al. In Bali, Indonesia, he conducted research on improving the efficiency of the sheet stamping subassembly region through the application of lean manufacturing concepts. Competition and resilience: Lean production in the plastic industry in Lebanon was investigated by Abdallah Nassereddineet al. (2018).

Lean principle:

Leaning thoughts is a corporate philosophy that seeks to provide an alternative mindset about how to arrange people actions in order to provide more value to communities and profit to people by reducing trash.

Define value:

- The crucial start line besides lean thoughts is valuation.
- The consumer determines the price. To put it another way, what good or service are they ready to pay for? Anything that doesn't fit that definition isn't worth something.
- lean thought must begin with a deliberate strategy to specifically identify value in terms of unique goods with specific capabilities available at specific prices via a conversation with targeted consumers.

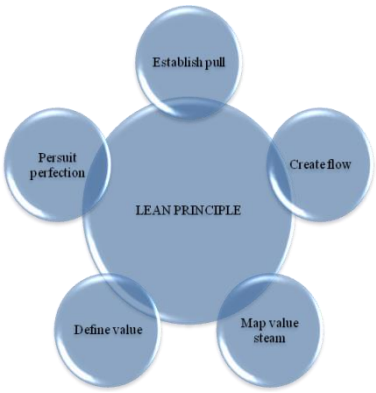

Fig.01

(Source by Shreya Shinde,2016)

Identify the Value Stream:

The value stream is defined as all actions that add up source, make, and deliver a product to customers. With that in mind, we must identify activities that add value and waste.

Make Value Flow:

- Set up just-in-time production and deliveries.
- Specialist divisions should be eliminated.
- Concentrate on the final product and whatever it takes to make one product.
- Avoid business, branch, and individual job limits in order to remove all barriers to the continuous stream of precise product.

Pull from the Customer Back:

The purpose is to bring consumers exactly whatever they need, whenever they need it, rather than pushing products out and guessing that customers might want them.

Strive for Perfection

Performance management is a never-ending process; you must always work to procure, manufacture, and produce a superior product while increasing productivity.

Lean process improvement tools

We must not lose sight of the primary aim of using lean tools, which is to eliminate the seven wastes; however, it is critical to comprehend how any of them will assist in the quest for cycle enhancement and make it slimmer.

JIT: Just in time

JIT is also one of the lean tools with tremendous ability being used, particularly with the prevalence of e-transactions and massively stretched and sophisticated logistical chain.

Its idea is simple: have exactly the required amount to supply orders and strive to ensure that they are only required when they are.

Jidoka

This concept may be loosely described as "automation with a human touch." This lean tool is connected to inner management which helps human operators to disrupt automatic systems as quickly as they detect a malfunction.

As a result, Jidoka eliminates the need for a large quantity of great inspectors by delegating a portion of this responsibility to the operators itself.

Takt Time

Takt Time aspires to describe the time spent on output as a result of the most significant consumer requirement

By matching supply and requirement a balanced process known as the "pull mechanism" emerges, in which the economy "pulls" output rather than the other way around.

Heijunka

This lean tool, also known as lean scripting, aspires to reduce manufacturing uncertainty as a result of changing consumer demands.

This necessitates the development of a consistent order scheduling system and a limited manufacturing cycle, with the aim of supplying an equal mix of products every day, allowing for quicker, smaller stocks and the creation of a diverse variety of materials at the similar period.

Poka-yoke

It implements "proof of error" systems to prevent the emergence of manufacturing flaws. A realistic instance will be the inability to launch the vehicle if your safety belt is not buckled.

Lean Poka-yoke instruments, like our case, use some fairly physical control and detectors to avoid the mistake from happening, halting output if possible.

5S

5S is a platform that can help you achieve absolute efficiency. It reflects on a company's entire mobilisation around five main productivity improvement variables. In Japanese, those were terms that begins from a letter S

1. Seiri = Usage: avoid waste of resources and space

2. Seiton = Organization: organize the workspace effectively

3. Seiso = Cleaning: always keep the environment clean

4. Siketsu = Standardization and Health: to determine norms that facilitate ergonomic and healthy work

5. Shitisuke = Discipline: encourage collaboration and continuous improvement

Kaizen

This tool aspires to scale back expenses and enhance the quality through ongoing enhancement.

The well-known PDCA loop is one time to phrase this method into use.:

• *Plan*

• *Do*

• *Check*

• *Act*

VSM (Value stream mapping)

The distribution of goods and resources via the system is depicted in value stream maps. using a data flow diagram to log each phase of the process. VSM is seen by many lean professionals as a critical method for identifying trash, reducing production processing periods and implementing process change.

EIGHT WASTES

Waste is anything that happens to a product that doesn't add value from the customer’s perspective

Overproduction – Making too much than the buyer requirements or making sooner than expected. Item of any type is probably waste.

- Queues – time delay, storing, and pending are waste products
- Transportation – It is wasteful to transfer materials among factories, job centres, and to handle them numerous times.
- Inventory – surplus raw materials, work-in-progress, completed products and working supply
- Motion – instruments or individuals in action

- Over processing – job done on a commodity that doesn't bring much benefit.
- Defective product – comes back, warranties, reconfigure and wastage.
- Human potential -In more of the organization they can‘t utilizes 100% human potential

Literature review:

The lean manufacturing makes a corporation ready to sustain competition by eliminating non-value activities. Sustainability of any company should specialize in safeguarding the companies' resources by eliminating wastes. However, companies have been under increasing pressure to seriously think about sustainable business practices specifically in manufacturing. Manufacturing sustainability includes managing processes with sustainable inputs such reducing waste, rework, inventory, and setup time

Reviewing the literature and even this summarization, we conclude that:

- The available research is unanimous in recognising proper waste management as the prime objective of LM.
- Waste is recognised as each task or events which does not add benefits to customers or community as a whole;
- In contexts of scrap types, there is widespread consensus;
- LM has evolved, and its implementation currently requires the simultaneous usage of a multitude of instruments and procedures.

2. Data Collection & Anaylysis

Table 1- List of Top Journals selected for literature study

Top 3 journals selected for literature study 2010–2020	
Name of the Journal	**No. of Publications**
Material today preceding	15
Procedia Manufacturing	10
International Journal of production economy	5

Table 2-Different industries selected from Literature search 2010–2020.

Different industries selected from Literature search 2010–2020.	
TYPE OF INDUSTRIES	**NO. OF PUBLICATION**
Automobile industries	5
3D printing industries	4
Green lean industries	4
Construction industries	3
Machine tool industries	3
Plastic bag industries	2
Banking	2
Power plant	1
Garment industries	1
Steel industries	1
Mining industries	1
Electronic industries	1
Aerospace industries	1

The work's further plan is to adapt visual control, among the most commonly used lean tools, to increase task performance and verify its suitability across industries.

3. Results of the descriptive analysis

Listed and evaluated a most critical publications for lean production and various industries. From 2010 to 2020, 78 articles were investigated by researchers. Between 2010 and 2020, the amount of literature written increased.

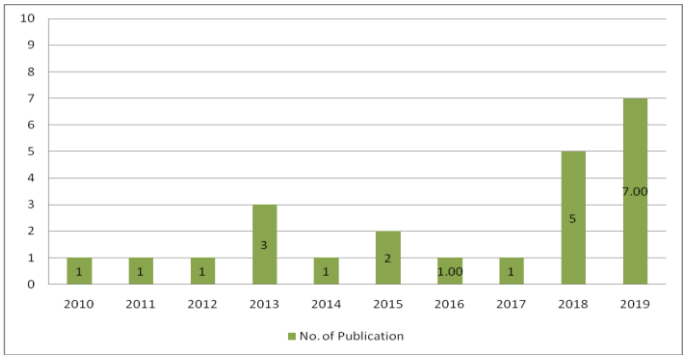

Table-3 List Of Industries Practicing On Lean For Litearature (2010-2020)

S.no	Author	Year	Focused industries
1	B. Venkat Jayanth et al.	2020	electronics/electrical industry
2	L. Mulugeta et al.	2020	Garment industry
3	R.S. Barot et al.	2020	water heater manufacturing industry
4	P. Sivaraman et al.	2020	engine assembly
5	R. Balamurugan et al.	**2020**	Connecting rod manufacturing industry
6	S.M. Sutharsan et al.	**2020**	pump industry
7	Sivakumar Annamalai et al.	2019	Textile industry
8	A A Fattah et al.	2019	Power industry
9	C. Singh et al.	2019	Green lean in manufacturing industry
10	A. Ghobadian, et al	2019	3d printing industry
11	Kaio Jordon et al.	2019	Hospital
12	Aziza Seifullina et al.	2018	Mining industry
13	Al-Akel Karam et al.	2018	Pharmaceuticalindustry
14	Adwait et al.	2018	Plastic bag industry
15	L.B. et al.	2018	Food Industry
16	Jéssica Xavier dos Santos et al.	**2016**	banking industry
17	Juthamas Choomlucksana et al.	2015	sheet metal stamping industry
18	Indrawati et al.	**2015**	Iron Ores Industry
19	Y Sujatha et al.	2013	Silk production industry
20	B Haque	**2003**	Aerospace Industry
21	Jagmeet Singh et al.	**2018**	Automobile sector

Table 4 gives the list of lean tool adopted by different authors in their research. The first column contains the serial numbers. Next, to that respective name of the researchers shown in the column to the immediate right their year of publication & next to that adopted lean tools . In the table charted,

21 lean tool are reported along with the respective name of the researchers shown in the column to the immediate right of the respective enablers.

Table-4 Lean Tool Reviewed from Literature Search

S.NO.	AUTHOR	YEAR	LEAN TOOL
1	B. Venkat Jayanth et al.	2020	5S + Safety, Root Cause , lean six Sigma DMAIC
2	L. Mulugeta et al.	2020	time study, work standardization, and line balancing continuing
3	R.S. Barot et al.	2020	Value stream mapping, String diagram
4	P. Sivaraman et al.	2020	Value stream mapping
5	R. Balamurugan et al.	2020	Fish bone diagram, Failure Mode Effect Analysis (FMEA)
6	S.M. Sutharsan et al.	2020	VSM
7	Sivakumar Annamalai et al.	2019	LINE BLANCING
8	A A Fattah et al.	2019	Value stream mapping
9	C. Singh et al.	2019	Key performance parameters
10	A. Ghobadian, et al	2019	Kaizen
11	Kaio Jordon et al.	2019	VSM
12	Al-Akel Karam et al.	2018	(SMED) Single Minute Exchange of Dies
13	Adwait et al	2018	Value Stream Mapping (VSM),(TAKT Time)
14	L.B. et al.	2018	Lean Six Sigma
15	Aziza Seifullina et al.	2018	Value Stream Mapping (VSM)
16	Jéssica Xavier dos Santos et al.	2016	Brainstorming Value stream mapping,
17	Indrawati et al.	2015	Lean Six Sigma
18	JuthamasChoomlucksana et al.	2015	Value Stream Mapping (VSM
19	Y Sujatha et al.	2013	5S, Kaizen, PDCA, TPM and JIT
20	B Haque	2003	**Kaizen,** Value stream mapping, single piece ¯ow and Takt times.
21	Jagmeet Singh et al.	2018	Value stream mapping,2) Kaizen, s total quality management (TQM) and benchmarking

Table 5 describes about the finding that hinder in different research industries.

Table 5 provides data about the identified finding of research paper and name of the researchers who identified those finding. The first column contains the serial numbers, next to that the second column bears the identified finding in various manufacturing industries. In the table charted, 20 finding were cited along with the respective name of the researchers shown in the column to the immediate right of the respective problems.

Table-5 Finding Reviewed from Literature Search

S.NO	FINDING	REFERENCE
1	After thoroughly evaluating the findings in the specified field this study is a sparking phase that has formed a foundation. The system is underpinned by a thorough examination of existing standards and designs. The proposed structure is still not checked due to period limitation After all, given that a rigorous analysis was undertaken previous to its development, and that other frameworks have been established relying on literature analyses this may not negate its realistic significance.	Aziza Seifullina et al.(2018)
2	line balancing & throughput time of the system enhance.	Sivakumar Annamalai et al.(2019)
3	Flushing oil accounts for 59% of non-value added operations, bolts warming for 16%, hauling operation for 7%, instrument planning and safety gear for 4%, orientation preparation for 4%, movement from the toolkit to each 3 percent work place for 4%, and other events for 4%.	A A Fattah et al.(2019)
4	Lean tool huge boost to the effectiveness and efficiency of operation.	B. Venkat Jayanth et al. / 2020
5	Green Lean in an age of protecting the atmosphere. Ecological concerns have grown in prominence, prompting manufacturers to improve and refine their construction practises as well as optimise their procedures, in order to decrease their environmental impact	*A. Singh et al.* 2020
6	combining CAD modelling and CFD computational fluid dynamics simulation thrives to clarify difficult presumptions and reinterpret challenges in order to develop novel methods and approaches in reactors that are both cost- and time-effective.	A. Ghobadian, et al. (2020)
7	There is an excessive amount of rotation and transfer of work parts among workspaces, and the line's processing time is not matched with takt time, resulting in significant WIP around operations.	L. Mulugeta / et al.(2020)
8	For improving medicare infrastructure efficiency, consider quality, expense, and delivery times, as well as demographic, cultural, and environmental conditions. Reduced space volume lowers costs while still improving commodity consistency.	Kaio Jordon et al. / (2019)
9	Since employing lean production principles, the time was cut by 62.5 percent, from 6,582 seconds to 2,468 seconds. Non-value adding operations were also decreased by 66.53 percent, from 1,086 to 261 activities. In addition, the rate of overtime was cut by $1,764 a year.	JuthamasChoomlucksana et al. 2015
10	Waiting duration is decreased by 69.04 percent, non-value added duration is decreased by 34.23 percent, process duration is decreased by 8.74 percent, lead duration is decreased by 28.37 percent, and inventory transfer is decreased by 45.63 percent.	R.S. Barot et al. (2020)
11	This development task intends to include specific studies on best resource handling practises by using a kitting system and its effect on assembly.	P. Sivaraman et al. (2020)
12	SMED uses specific procedures and resources to achieve a faster and more reliable transformation, resulting in increased versatility and item performance	Al-Akel Karam et al. (2018)
13	To remove non-value-adding operations and build a potential state diagram, VSM tools were used. The percentage of value-added time in overall lead time has risen from 15% to 89.85%. The TAKT time was cut in half, from 46.6 minutes to 26 minutes. The number of rolls produced each day has risen to 50.	Adwait et al./ (2017)
14	It has been found that after implementation 95.41 per cent reduction of production lead time, total 87.59 per cent reduction in C/T, 76.47 per cent reduction in WIP, 70.67 per cent reduction in C/O time and manpower reduction 57.41 percent. In future, VSM along with simulation will be implemented for different product lines to have holistic view of the organization.2)gave an average saving of £106,000. Total returns were eight times total costs.	Jagmeet Singh (2008)
15	Optimum layout for the connecting rod manufacturing was found out, The manufacturing time of the component was reduced by rectifying the problems in the process of manufacturing.	R. Balamurugan et al. 2020.
16	The findings of the study conducted revealed that a lean based approach has potential to promote a greater operational efficiency of a banking process	Jéssica Xavier dos Santos et al. 2016
17	This scenario happened in a 94% decrease in lead time (2 weeks to 1 day) and annual file storage savings of millions of dollars. It has had a	B Haque* 2003

	substantial effect on the expense and time involved with handling technological improvements and other non-value adding operations, with a 25% to 50% decrease in lead period calculated on v	
18	The food industry applied a large number of different tools to implement Lean Six Sigma initiatives, mainly to reduce process variation and cost, to increase productivity and competitiveness.	L.B. et al. 2018
19	The companies are found to have a good understanding of lean manufacturing, and since its implementation, they have gained many benefits such as reduced cost and improved productivity	Y Sujatha et al. 2013
20	From the production activity, non-value-added activity (NVA) consist of 33.67% and non-necessary non value added activity (NNVA) consist of 14.20%. Since the processing quality is only 52 percent, the drying iron ore manufacturing is not satisfactory. Improper handling and fault are the most popular and prominent wastes. The cycle capacity is at a 2.96 sigma standard.	Sri Indrawati et al. (2015)

4. Conculsion: -

The paper successfully reviewed the benefits that a company may obtain by the implementation of Lean Production.

The study has provided important insights into the current status of lean among different industrial sectors. This study also provides the reasons of lean implementation in industries. The manufacture recommended lean due to its characteristics of quality improvement and customer satisfaction. Other reasons of lean implementation are waste elimination, decrease production costs, and increase demand management and efficiency. While utilization of space and equipment, supply chain efficiency and JIT production received very low rating by manufacturers. The first segment of this review paper describes lean principle and its implementation tools. In second segment focused on various industries, lean tools and their finding of research paper by different author.

The paper conclude about various tools of lean as JIT,VAM ,5s,Kaizen, Kanban, PCDA, Line balancing, SMED,FMEA,Takt Time. Tools give various Application reductions in lead time, waiting time, inventory quantity, etc. LM increase quality, productivity enormously production efficiency.

Despite of implementation of lean tool achieve ultimate goal of customer satisfaction, still there is future opportunities by developing lean model..

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