

Application of Lean Manufacturing in the Energy Sectors

Prabhakar Uprety

Department of Automotive and Manufacturing Engineering Technology

Minnesota State University

Mankato, MN 56001, USA

Prabhakar.uprety@mnsu.edu

Pawan Bhandari, Ph.D.

Department of Automotive and Manufacturing Engineering Technology

Minnesota State University

Mankato, MN 56001, USA

Pawan.bhandari.2@mnsu.edu

Abstract

Globally, many industries are using lean manufacturing concept in their production system to identify and eliminate the waste and to support customers value. Especially, automotive, manufacturing, healthcare, service sectors and many others have embraced lean principles. This study aims to interpret application of Lean techniques in various industries especially in energy sectors. In order to evaluate the application of lean, this paper aims to explain importance of lean manufacturing in the context of energy sectors transformation into lean process and giving example of implementation of lean manufacturing in one of the energy sectors. A case study example from an energy sector company is also presented as a part of the study. This research was conducted by reviewing published peer review literatures and articles through using resource from university library. Based on the findings of this research, industries leaning towards Lean manufacturing are producing goods efficiently and cost-effectively, achieving financial goals and customer satisfaction.

Keywords

Lean manufacturing, production system, industry, energy sector

1. Introduction

According to American Society for Quality (ASQ), Lean is defined as a set of management practice to improve efficiency and effectiveness by eliminating waste. Its core principle is to reduce and eliminate nonvalue added waste as well as activities (ASQ, 2024). As described in the book *The Machine That change the world* (Womack, J et al., 1990), Lean manufacturing (production), is the concept that was introduced by the Japanese at Toyota production system in 1930.

The concept of lean production differs for different organization but underlying same principal with removing or minimizing all non-value-added activities and waste from business. Industries has seen lot of revolution over the past decade and the concept of lean process has been through a dramatic evolution. Lean techniques help industrial manufacturers to reduce eight different types of waste also known as “DOWNTIME” such defects are overproduction, waiting, unused talent, transportation, inventory, motion, and extra processing. Any organization which targets to introduce lean helps in all directions, quality of product, service, reducing production cost and overall employee satisfaction with working conditions. The basic principles of lean are determining value of product, VSM (value stream Mapping) of a product, Continuous flow, pulling the value from customers, and continuous improvement

(Badrieva et al., 2020). As the lean thinking craze continues to increase to every part of the world and industries beyond the manufacturing industries, it has seen peak into other sectors as well. The adapting sectors are logistic distribution, health services, construction, retail business, maintenance, and government sides (Cunningham, J, 2018). Lean system has also started to implement in energy management fields. Lean ideologies are also used to improve energy waste by production industries. It has used to reduce energy intensity of production activities and supporting in low operation manufacturing process. Eliminating energy waste and its environmental impacts through lean can help reducing carbon emission (EPA, 2023).

Objectives

The objective of study is focused on identifying benefits with the application of lean manufacturing in industries and how different industries transform into lean application with the help of lean techniques. To perform this study following research questions were proposed.

Research Questions

1. What are benefits of Lean manufacturing in industries?
2. How does energy industries can transform into Lean manufacturing to improve performance?
3. How does a multi billionaire companies (Rolls Royce) urge to use the lean manufacturing techniques in production to meet the customer values.

2. Methodology

This research is based on the literature search by using various available online articles, journals published on google and Minnesota state University library. Many articles were studied and analyzed first, based on the keyword different articles were selected and used on the relevant topic for final analysis. For this reason, study was based on a qualitative analysis for this paper.

3. Findings

The findings are based on three research questions, and that has been summarized in this section.

Benefits of Lean Manufacturing in Industries

As described on lean manufacturing tools organization Lean implementation has a wide range of benefits. Any industries that are or willing to implement the lean means they are moving towards the reducing and eliminating waste in there manufacturing processes. As described in introduction section waste has been categorized into eight different types (DOWNTIME). These types of waste are directly linked with customer satisfaction as well as profit costs on the industries. Lean helps to reduce non-value-added activities. Many studies have shown that around 5% of the activities are only value-added work and remaining around 95% are just waste as show in Figure 1.

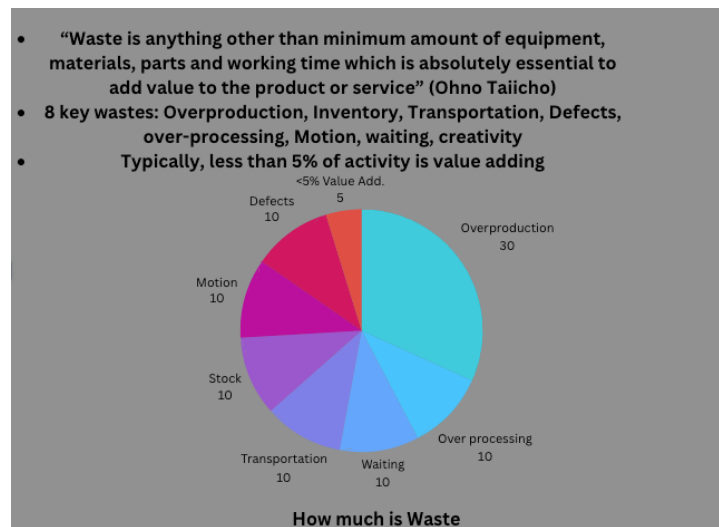


Figure 1. Ratio of Value-Added Vs nonvalue added

Figure 1 shows the different distribution of non-value-added activities also known as waste. It almost consists of 95% with 8 key wastes whereas only value-added work is around 5% (Lean Org, n.d.).

Lean methodology approach is continuous improvement. Transition into this does have many advantages. Some advantages are as follows (Melton, 2005):

- Less process wastes.
- Reduce inventory.
- Increased process understanding.
- Financial Savings.
- Less rework.
- Reduce lead time.

There are many industries that are benefited from the lean manufacturing philosophy. As an example, Lean implemented on an Indian production company in Patiala, Punjab reported reduction in WIP (work in progress) inventory by 89.47 percent, finished goods inventory by 17.85 percent, product lead time by 83.14 percent, processing time by 12.62 percent, manpower required by 30 percent and output per operator was increased by 42.46 percent (Singh, B, et al., 2010). Similarly, many sectors have used lean techniques, some real-life examples have shown that it can improve the operational performance and reduce cost. The following seven real examples are presented as the findings (ASME, 2022):

- A cable manufacturing company wanted to reduce set up time as well as shorten lead time. Their lean manufacturing team did it by streamlining the machine setup and change over requirements by implementing scheduling system to enhance just in time and upstream balance production parts by using downstream manufacturing and assembly. This result help company to reduce machine setup from 5 hour per machine to 35 minutes, adding additional 5 hour up time per machine per day. Focus [SMED Technique]
- South Dakota truck body manufacturing company for service and industrial market, to keep demand with the market, they established lean 101 training program for their managers, supervisor, key operators. They also established Kanban system to support just in time for manufacturing and to reduce inventory levels. Lean helped in over all production. Their productivity increase by 5 percent and company revenues improved by 20 percent. Focus [Lean training including Kanban]
- A printing company had issue with late orders and long lead times. Their inventory was piled up over 10 percent of the finished product. They implement a lean technique which was using value stream mapping to identify waste so that it can be reduced or remove from the workflow. They also implement the 5S visual workplace and used cellular manufacturing systems. This helped to increase on-time delivery to 95 percent with short lead times and improved inventory management. Focus [Inventory reduction]
- An automotive parts manufacturing company was losing efficiency on shift change task. They were having issue with three shift changes per day averaged 30 minutes on each change. They consulted lean expert who worked with the organization to overcome with downtime. The change resulted 1.5 hours of added production time and increase revenue by more than 1 million dollars annually. Focus [SMED Technique]
- A warehouse was used by a manufacturing company for immense volume of raw materials. Including material handlers, delivering parts to assembly line when needed, the operational cost was high. When management team decided to eliminate warehouse without affecting production run time, lean team worked with manufacturer suppliers and design the Kanban system for just in time manufacturing process. They also trained the team on workflow process and 5S workplace organization. This helped company to eliminate the warehouse and helped material handler to move and trained into higher skill positions. Focus [Warehouse Management]
- A manufacturing company was having issue to keep up with an increase order demand. They realized that pre-order production time was taking long, and they have lot of non-value-added administrative task which ultimately causing delays in order processing tasks. Management team used lean method to tackle this issue by including 5S and Kanban pull system. Lean system helped company to increase capacity by 20 percent and it boost the onetime delivery to 95 percent with less administrative steps. Focus [Pull System]
- A Nevada-based manufacturing company MicroMetl produces heating and air conditioning equipment. They wanted to increase efficiency and maintain high quality product for customer and its consistency. The company noticed that the one-part assembly travels almost 1.5 miles in a plant during assembly process. With the lean implementation, company used cellular manufacturing process and travel time was reduced within

the area of 100 feet. This helped company to reduce indirect labor costs by 21 percent and increased market share as well as retain 25 positions. Focus [Travel Time]

Additionally, there were many more industries than these seven company examples that follow similar implementation journey that are not presented on this paper. Many are using lean manufacturing techniques to improve manufacturing process, eliminating, and reducing nonvalue added activities along with uplifting their business. Understanding customers value and customer needs and delivering the customer on time every time with a quality work and products comes from Lean methods.

Energy industries transformation into Lean manufacturing can improve performance

Apart from manufacturing sectors, lean techniques and its tools are spreading widely into other sectors. Among others, one sectors is Oil and Gas industries and its products are most useful in day-to-day human life. Few known industries are Exxon Mobil and Chevron (Global EEE, n.d.). Now, the questions arise how oil and gas industries or similar energy sector can improve the performance in such filed by using lean techniques? The following activities will be able to achieve by implementing lean into energy industries (oil and gas) field (Newton, 2020):

- **Reducing Equipment repair times:** In oil and gas industry preventative maintenance is critical and needs to be in top of it. Due to having large and heavy equipment, removing even few components can have costly downtime and delays in the operation process. In this case many leading companies are using data analytics tools to find abnormal operation. This type of tools will help to eliminate expensive repairs ahead of time. Often, when parts are sent back to vendor or mechanic for repair which can delay the fixing process in such cases lean principles uses can shorten the repair times. Similarly, as example, during an internal investigation found out that each service center maintained a different technical documents library. Such document's locations do not have appropriate resources for each task, which delayed the completion time. Lean principles can be used to standardize the documents on all locations.
- **Lowering error rates:** Using lean principles can help companies to reduce error rate associated with crucial projects. For example, When Hess lunched work on its Tubular bells deep water development in Gulf of Mexico, work was performed within the lean method. That leads into fast sanction of first oil in three years. Before drilling a hole, a field investigation and development is needed. During that phase, just planning takes more time than execution which results better drilling and well placements, this helps workers time to focus on actual work other than spent time on resolving preventable mistakes.
- **Enhancing Competitive Advantages:** Industries not being innovative and failing to remove ineffective processes or weakness could easily lead into loss rather than profitability. Hungarian oil and gas company (MOL) group involved lean facilitators to improve financial performance and company culture. The main objective of the group was to reduce waste that was observed in three hours of work. During three hours of work, only 15 minutes of work was value added activities. Once, the lean principles were implemented, with the help of data analytics result it clearly show that it worked. The MOL group team gave effort to control and improve internal processes, later analyzing data to see the effects. Lean application is not a quick approach to find a faster resolution on a problem, nor it is free from difficulties but at the end it will pay off the hard work. MOL spent 5 years on financial struggling phase and after lean implementation business had a record-breaking year.
- **Raising Environmental Consciousness:** Many consumers are aware of today's actions effect on the planet future health, some are stating that oil and gas industries should do more to reduce adverse effects on the earth. Many companies have committed to make a drastic change. As an example, BP is focus on low carbon energy while scaling back its oil and gas activities. This challenge is arising globally for different oil and gas companies. For example, European Union (EU) has a methane strategy to reduce emission related with human activities. At some point, EU will address the regulations to cut methane level related with supply chains used by other countries. However, former government decision maker moved to roll back emission limits but as the current decision maker took over the office in 2021, based on analyst he was pressured by environmental groups to regulate emission. As the emission control plan is not still clear out and we cannot

say it won't happen. It's better to focus on continuous improvement at oil and gas industries sectors as well cause if new requirements will take place than with lean methodology it is achievable.

Furthermore, Lean manufacturing application are also used in electrical industries. Mainly in cable manufacturing, electrical accessories, Allied and Power industries (Add Value, n.d.). As the electricity demand is increasing day by day. It would be interesting to see how power sector are satisfying with customer demands. In this modern technology era, with phones, TVs and lot of advance electronic gadgets consumers want these accessories to run continuously and without electricity its impossible to use. Customer demand is highly deviating into quality power, cost effective and excellent customer service in electricity sectors. Implementing lean into electrical power field will help to improved customer satisfaction. A case study was performed on an Indian company Discom 1 which is an electrical service provider in Western Indian. They have about 451,200 industrial customers along with domestic, agriculture, poultry, hospital, etc. Their service center received the flow of 700 customer for daily services. Services like changing meter, testing, new connections and so on. Their consumers expressed unsatisfaction about the time taken for new electricity connection and long wait time for new customers. The organization decided to implement Lean study on time taken for new connection. Based on company data, average time for new connection wait time (NCWT) was 24 hr, company plan was to bring it down to 12 hr and consider defect if the time goes over 12 hr. After implementing lean principles, NCWT was reduced from 24 hr to 11.28 h, it was reduced by 53 percent. This result lead into great customer satisfaction (Sony, 2019).

Lean principles are begun to widely be understood method into manufacturing and energy sectors. Let's assume not all sectors are implementing lean into their business model but it is the time to think about it and start making a lean production market model to support the business plan. It really does not matter what business you are running but ultimate goal for any business is to satisfy customer needs alongside its net profit margins. Lean principles are not going into effect right away, the movement you implement. If manufacturing sectors can take profitability from it, then energy sectors can as well. As explained above cases and examples related with energy industry, lean requires proper planning, commitment, and structured approach to take the business where you want.

Rolls Royce urges to use lean manufacturing techniques in manufacturing industries.

Rolls Royce develop and deliver complex power and propulsion solution for safety critical applications in the air, sea and on land. Their business division are civil aerospace, defense, power system, electric and hybrid electric. The company have customers in over 150 countries and operate in more than 50 countries worldwide (Rolls Royce, n.d.). The company headquarters is at United Kingdom with 41,400 employees worldwide. The company products and technologies include manufacturing and developing engines, submarine, nuclear power plant, SMR (Small modular reactors) and new electrical power solutions. The company electrical power solutions market its products with the MTU brand. The MTU business operations location are across the US, Asia, Europe, Middle East, and Africa (Global Data, 2024). Rolls Royce is known for most powerful brand in the world and always have been associated with building and providing quality products to the customers. The company adoption of lean management lead into the success over the years.

Rolls Royce has implemented different lean techniques into its manufacturing process. They use lean process to simplify its inbound flow to take out unnecessary process. In 2016, company removed 90% of the steps for sourcing and rewrote the documents in a more intuitive format to focus on core products. They also outsource sub-systems components to make simpler production chain (UK Essays, 2018). As a corporate business, company follows same process in every location. Let's review what are the different process and tools they recommend using lean manufacturing in industries globally.

Rolls Royce also uses value stream mapping process to eliminate waste. This is a one of the tools that is widely use in various industries to investigate waste. The idea of using this tool is to enable continuous improvement within the organization. Why use this tool? (RR, 2019):

- It creates a standard on which to document the whole process. This will lead into thinking "total cost" for entire process.
- Understand how the operations is really working now and how was it design to operate. The main thing is to visualize the actual system and plan to optimize process for future vision.

- Value stream mapping expose the waste and it allows everyone to see the improvement opportunities. This mapping will show both value-added and non-value-added activities like, changeovers, bottleneck, underutilized tolls, equipment as well as manpower and duplicated process.
- This will help to synchronize production and manufacturing style to meet customers' demand.
- This also provides a progress vision on journey which will help to remind exactly what was achieved.

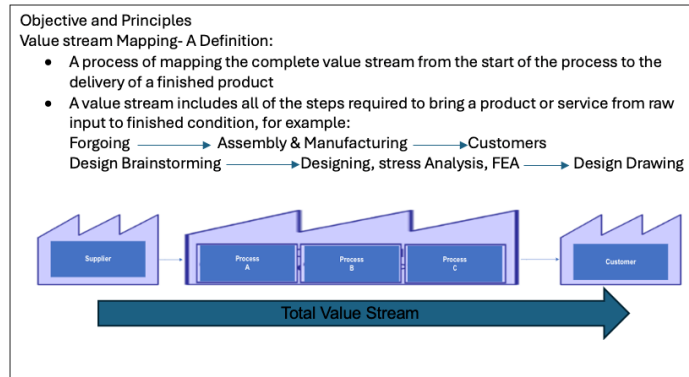


Figure 2. Value Stream Mapping definition as per Rolls Royce

As shown in Figure 2, VSM (Value Stream Mapping) will helps to see big picture as it consists of entire process. This tool will give visibility to investigate each step in a process including supplier, internal plant process and customers. It will help to see the connection between information, material flow and vice versa. Especially this tool will help to represent waste in a process or system, along with opportunities to reduce or eliminate waste for future and lead into continuous improvement for a business.

Rolls Royce also has created a process for VCC (Value chain competitiveness) (RR, 2019), to improve workstation and Process Design to Minimize Waste. The Scope of this process is to use of an appropriate analysis tools to identify waste, uses of different guidelines to banish waste from operating processes, design the work cell or workstation guidelines for safety, productivity, and quality. Based on the RR training module to implement this process knowledge of Lean principles, factory design and layout, error prevention, material storage and performance management are requisite. Industries using these techniques will help to on followings sides as shown in Figure 3,

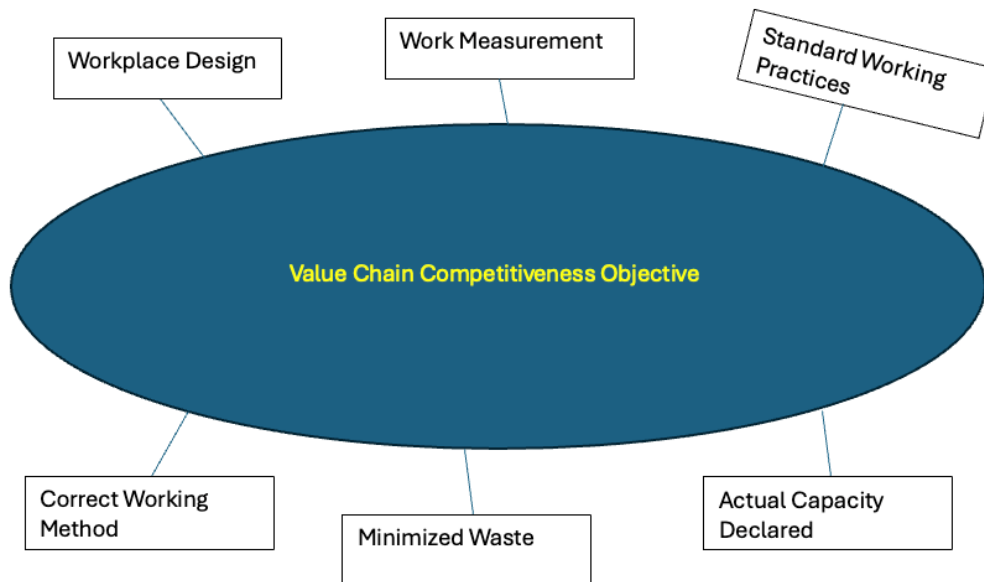


Figure 3. VCC process objective to improve workstation and minimize waste of process design.

As explained in Figure 3, VCC process main objectives and principles outline are as follows:

- For workplace design, suitable analysis to be performed for establishment of current or proposed operating process.
- For work measurement, eliminates wasteful activities wherever is possible.
- For standard working practices, maximize ability to restructure practices.
- For correct working method, make work environment safe, comfortable, and systematically efficient.
- For minimizing waste, uses of error prevention methods to remove possible cause of defects.
- For actual capacity declared, implement of visual management to instant expose of non-conformance.

4. Conclusion and Discussion

Lean manufacturing process has a lot of benefits and can be applied in every industry. The method cannot only be in manufacturing or energy sectors, it can be applied in any business-like banking, educational, constructions, software's development, retail, healthcare, logistics and distribution and so on (Lopes, 2023). Lean industries sectors can have benefits from various important ways, there is no right or wrong method to improve your organization or operations. It all depends on what and how you want to focus on your business. Does customer values important to your business? Where you want to take your business? At the end, it all depends on your business goals and plans. Absolutely, there are many applications of lean methodology, as all the different studies performed earlier, the use of lean application has an advantage and has helped many industries. The main goal of lean method is to reduce waste to an absolute minimum.

In essence, application of lean manufacturing in energy sectors has been widely used. Its benefits lead various energy industries into cost reduction techniques in manufacturing process. To implement lean into business, that authority always belongs to stake holders or decision makers. Many big corporations are using lean methodology in their manufacturing process and doing lot of trainings programs to support other industry to achieve same results as they did. Lean implementation is a long process and results takes time, only applying lean techniques will not give you success right away. The progress takes time and adjustment will require within your company so, to get full benefit from it, change mindset and proper planning for these effects is needed. One question is, are you ready to implement lean principles if you have not done yet, one thing to keep in mind is, implementing lean and its principle to your business is the commitment.

References

- ASQ., What is lean? Lean manufacturing & lean enterprise | ASQ. 2019. Asq.org. <https://asq.org/quality-resources/lean>
- Benefits of Lean Manufacturing | Why Implement Lean? (n.d.). Lean Manufacturing Tools. <https://leanmanufacturingtools.org/63/benefits-of-lean-manufacturing/>
- Crawford, M., 7 Examples of Lean Manufacturing in Action - ASME. Wwww.asme.org. 2020. <https://www.asme.org/topics-resources/content/7-examples-of-lean-manufacturing-in-action>
- Cunningham, J., The Eight Wastes of Lean. Lean Enterprise Institute. 2020. <https://www.lean.org/the-lean-post/articles/the-eight-wastes-of-lean/>
- How to Improve Workstation and Process Design to Minimise Waste Value Chain Competitiveness (VCC). (2019). <https://www.rolls-royce.com/~media/Files/R/Rolls-Royce/documents/sustainability/value-chain-competitiveness/16-vcc-how-to-improve-workstation-and-process-design-to-minimise-waste.pdf>
- Lean Energy Management In Manufacturing., Manufacturing.net. <https://www.manufacturing.net/industry40/article/13057239/lean-energy-management-in-manufacturing>
- Lean Manufacturing in Electrical Industry | Lean Training in Electrical Industry. (n.d.). Wwww.avci-Lean.com. Retrieved April 8, 2024, from <https://www.avci-lean.com/lean-manufacturing-electrical.html>
- Lean Manufacturing Process & Principles | Oil & Gas Industry. (n.d.). Wwww.globaleee.com. <https://www.globaleee.com/global-news/-history/lean-manufacturing-oil-gas-industry.html>
- Lopes, J. (2023, August 9). Lean Principles: What They Are & How to Implement. Pipefy. 2023. <https://www.pipefy.com/blog/lean-principles/#:~:text=The%20lean%20management%20model%20uses>
- MELTON, T., The benefits of lean manufacturing: What lean thinking has to offer the process industries Chemical Engineering Research & Design, 83(A6), 662–673, 2005. <https://doi.org/10.1205/cherd.04351>
- Newton, E, How Do Lean Principles Improve Oil and Gas Performance? Lean Manufacturing Junction. 2020. <https://lean-manufacturing-junction.com/2020/12/how-do-lean-principles-improve-oil-and-gas-performance/>

- R.R., B., O.V., D., & I.S., A, Features of Lean Manufacturing in the Energy Sector. *International Journal of Engineering Research and Technology*, 13(11), 3530. 2020. <https://doi.org/10.37624/ijert/13.11.2020.3530-3536>
- Rolls-Royce. , Products & Services. 2018.Rolls-Royce.com. <https://www.rolls-royce.com/products-and-services.aspx>
- Sciortino, M., & Watson, S, The Importance of Energy Efficiency in Lean Manufacturing: Declaring Energy the Ninth Waste. 2009. https://www.aceee.org/files/proceedings/2009/data/papers/3_6.pdf
- Shield Square Captcha. *Www.globaldata.com*. [https://www.globaldata.com/company-profile/rolls-royce-holdings-plc/\(n.d.\)](https://www.globaldata.com/company-profile/rolls-royce-holdings-plc/(n.d.)).
- Singh, B., Garg, S. K., Sharma, S. K., & Grewal, C., Lean implementation and its benefits to production industry. *International Journal of Lean Six Sigma*, 1(2), 157–168, 2010. <https://doi.org/10.1108/20401461011049520>
- Sony, M. , Lean Six Sigma in the power sector: frog into prince. [Lean Six Sigma in the power sector] *Benchmarking*, 26(2), 356-370. 2019. <https://doi.org/10.1108/BIJ-10-2017-0276>
- Supply Chain Planning and Management at Rolls Royce. (n.d.). *Us.ukessays.com*. Retrieved April 8, 2024, from <https://us.ukessays.com/essays/business/supply-chain-planning-and-management-at-rolls-royce.php?vref=1>
- US EPA, O. , Lean & Energy Toolkit: Chapter 3. 2016. *Www.epa.gov*. <https://www.epa.gov/sustainability/lean-energy-toolkit-chapter-3>
- Womack, J., Jones, D. and Roos, D., *The Machine That Changed the World: The Story of Lean Production, Toyota's Secret Weapon in the Global Car Wars That Is Now Revolutionizing World Industry*. Free Press, New York., 1990.

Biographies

Prabhakar Uprety is a graduate student of Professional Science master's in engineering management (PSME) at Minnesota State University, Mankato. He also earned bachelor's degree in mechanical engineering from same university. He is working as a Quality Engineer at Rolls Royce Power System. He is also a professional ASQ member and working towards to be a Certified Quality Engineer through ASQ. He has experience on different disciplines of quality like root cause analysis, analytical skills, FMEA, PFMEA, continuous improvement, failure analysis and quality training.

Dr. Pawan Bhandari is an Assistant Professor at Minnesota State University, Mankato. He received a PhD in Technology Management from Indiana State university, USA. He has earned Master and bachelor's in manufacturing engineering technology from Minnesota State University, Mankato. He has over 10 years of work experience. He has worked as Principal health system engineer at Mayo Clinic before working as faculty at MNSU. He also certified Quality improvement Associate and certified Six Sigma Blackbelt from ASQ. His research interest is in Quality Systems, Six Sigma and Lean Manufacturing.