JTE HCMUTE
ISSN: 2615-9740

JOURNAL OF TECHNICAL EDUCATION SCIENCE
Ho Chi Minh City University of Technology and Education
Website: https://jte.edu.vn
Email: jte@hcmute.edu.vn

Continuous Improvement of Productivity and Quality with Applying Lean Six Sigma: A case study

Minh Tai Le*, Hoang Khang Lu, Kieu Thuy Hang Nguyen
Ho Chi Minh City University of Technology and Education, Vietnam

*Corresponding author. Email: tailm@hcmute.edu.vn

ARTICLE INFO

Received:	03/05/2024
Revised:	04/06/2024
Accepted:	02/07/2024
Published:	28/08/2024

KEYWORDS

Industrial Engineering;

Lean;

Lean Six Sigma;

Improvement;

Wood Company.

ABSTRACT

Any business that wants to compete may need to constantly raise both its output and quality. An effective and popular approach to achieving continuous improvement is known as Lean Six Sigma. This paper demonstrates a successful implementation through a case study in wood manufacturing. The enhancement greatly benefited from the optimization of the production process. The seven quality control tools were integrated into specific systematic steps of the PDCA cycle and DMAIC process, along with lean technology. As a result, this led to an increase in product quality and a decrease in manufacturing errors. Customer satisfaction and market competitiveness have risen as a result. A wood production line's productivity and quality were both improved, and this case study demonstrates the positive effects. It could be considered for implementation in various production or assembly lines in other fields such as electronic, clothing and furniture assembly lines.

Doi: https://doi.org/10.54644/jte.2024.1586

1. Introduction

Lean Manufacturing was first used to describe Toyota's car-making process and has its roots in Japan. It is considered a pivotal moment in the transition from traditional manufacturing thinking to lean thinking [1]. These are 6 advantages of lean manufacturing: less process waste, reduced production time, less rework, cost savings, reduced inventory. Eliminating all types of waste inside the firm is the main goal of implementing a lean manufacturing system. A lean system comprises two fundamental pillars: the first being "jidoka" and the second being "just-in-time". A lean manufacturing system's main objective is to produce high-quality goods as quickly and inexpensively as possible [2].

In their study, Rahman et al. [3] demonstrated that the Kanban system can be used to implement lean production with minimal inventory and reduced costs. The author of this research also implemented the Kanban system and found that it led to a reduction in operating costs, waste, scrap, and loss, while also allowing for more flexible workstations and better control of production warehouses.

Another study by Anil S. Badiger et al. [4] explored ways to improve device performance through the implementation of Kaizen and poka-yoke. This study's objective was to improve productivity and overall performance, and its findings revealed that OEE rose from 49.9% to 74.68%. This rise in OEE led to better resource utilization, higher availability, higher product quality, and stronger employee trust in their work.

Some time ago, professionals who had been utilizing Six Sigma and Lean Manufacturing merged these approaches, giving rise to what is known as Lean Six Sigma (LSS). A lean culture forms the perfect basis for the swift and effective incorporation of the Six Sigma quality practices. Moreover, Six Sigma metrics guide the implementation of Lean Manufacturing practices when they are most suitable. Additionally, the methods and processes of Six Sigma should be employed to minimize defects in processes, which is often a critical prerequisite for the success of a lean production project [5]. Lean Six Sigma, which focuses on continuously improving processes, gained prominence in the 1980s as Toyota emerged to dominate the US car market. They achieved this by producing cars that were not only less expensive but also of higher quality than American manufacturers [6]. It can be applied to enhance the quality management of equipment maintenance. This approach tackles deficiencies and inefficiencies within the equipment maintenance process, leading to increased efficiency and improved equipment maintenance quality [7].

Another, Lean Six Sigma focuses on delivering customer satisfaction by providing high-quality products, on-time delivery, balanced work processes, eliminating waste, efficient work performance, and easy observation and management. It's quickly becoming a key driver for many technology-driven, project-driven organizations. Various approaches to Six Sigma have been adopted to increase the overall performance of different business areas. Those efforts all contribute to improve the efficiency and maximizing the value of the Six Sigma method. Six Sigma principles and implementations are more likely to succeed by continually improving organizational culture [8].

In today's competitive landscape, wood manufacturers face mounting pressure to embrace new manufacturing practices and management strategies. This shift is driven by the need to reduce production costs, streamline delivery times, and improve overall product quality to remain competitive in an increasingly globalized market [9]. Within the wood products industry, the pursuit of continuous improvement underscores an ongoing commitment to enhancing both quality and productivity [10]-[11]. Over the past decade, Lean Six Sigma (LSS) has found adoption in numerous companies as they restructure their manufacturing processes. LSS revolves around monitoring production yields, reducing costs, and shortening cycle times [12]. J. Guerrero et al. [13] applied LSS implementation in a small furniture company, revealing potential benefits, including a 25% reduction in defects, a 13% decrease in waste, and a 14% increase in sales productivity in the first year.

The use of Lean Six Sigma tools and techniques led to significant improvements in productivity and product quality at a furniture manufacturing company, based on the methodology's accomplishments and efficacy [14]. Leading B2B supplier of premium wooden furniture, the company's headquarters are situated on a 30-hectare campus in Binh Duong, Vietnam. The company boasts an indoor manufacturing area of over 10 hectares, complete with a swimming pool, kindergarten, and after-school center for its employees' families. With over 750 skilled employees and over 28 years of experience, the company distributes over 120 containers of premium furniture per month to over 20 countries worldwide, with the US, Japan, and Korea being their main markets. The author of this report optimized multiple areas of the company's production process by implementing Lean Six Sigma concepts. The main goals were to lower production costs, raise output productivity, and enhance product quality. A strong basis is established for the development and broader adoption of these methods in the furniture production industry, as well as their potential expansion into other related industries, by utilizing the extensive techniques and tools of Lean Six Sigma, as described in this article.

2. Literature review and methods

2.1. Lean six sigma

Lean Six Sigma is a management methodology that combines Lean and Six Sigma, emerging as a highly effective approach to improving processes and reducing costs in manufacturing companies. This study integrates the seven quality control tools into the PDCA cycle and DMAIC process to optimize the production process [15]-[16]. Lean approach focuses on minimizing waste and lead time, optimizing production flow, and increasing productivity, all of which are highly desirable outcomes for manufacturers. Companies can use Lean technologies to detect and reduce waste in their manufacturing processes, resulting in considerable cost savings and increased efficiency. Six Sigma, on the other hand, is a fantastic technique for increasing product quality and minimizing defects. Six Sigma assists businesses in eliminating defects and lowering repair costs, resulting in higher customer satisfaction and revenues. However, implementing Lean Six Sigma methods in a business is not easy, and quick success is not assured. It takes a clear commitment from senior leadership to make decisions based on a long-term perspective, even if it means sacrificing short-term financial goals.

2.2. Six Sigma DMAIC methodology

To attain the maximum level of Six Sigma, 3.4 faults per million, Motorola created a five-stage process known as the 'DMAIC Model'. The five steps are described below: define the problem or opportunity for improvement; measure process performance and identify the key inputs; analyze the

JTE
HCMUTE
ISSN: 2615-9740

JOURNAL OF TECHNICAL EDUCATION SCIENCE
Ho Chi Minh City University of Technology and Education
Website: https://jte.edu.vn
Email: jte@hcmute.edu.vn

data to determine the root cause of the defects (in this step, fishbone diagram, 5-WHYS, ...); improve the process by eliminating defects using kanban cards, check sheets, etc.; control the new process and continuously monitor performance.

3. Results and Discussion

3.1. Productivity Improvement

The Dayna chair product line has 8 continuous packaging stages that are carried out on 2 conveyor belts arranged at right angles to each other as shown in Figure 1.

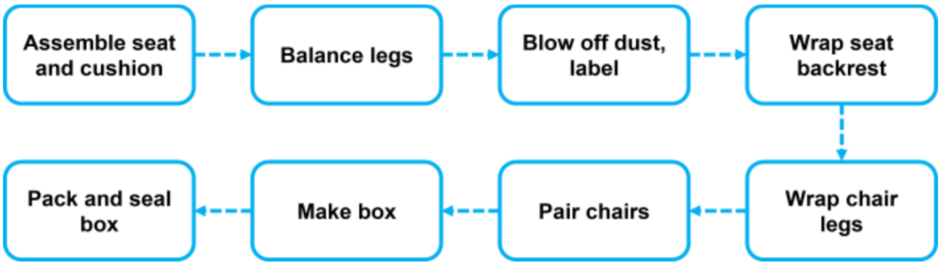

Figure 1. *Dayna Side Chair packaging process*

Table 1. *Cycle time of each step before improvement*

Step/Time (s)	Assemble seat and cushion	Balance legs	Blow off dust, label	Wrap seat backrest	Wrap chair legs	Pair chairs	Make box	Pack and seal box
T01	31.72	51.31	10.34	56.74	92.2	26.21	46.23	78.67
T02	27.37	54.07	12.78	52.53	100.49	30.18	62.67	67.05
T03	30	46.78	11.36	47.61	105.73	36.89	50.56	77.34
T04	27.38	54.11	12.05	52.66	92.12	37.56	41.12	54.06
T05	27.65	41.59	10.11	64.3	96.86	35.12	46.35	54.48
T06	29.09	38.33	13.89	63.4	90.28	27.31	44.93	62.67
T07	32.21	48.12	11.54	50.12	110.41	28.47	55.01	56.12
T08	38.29	49.13	10.15	57.25	89.25	28.32	49.45	62.78
T09	37.02	44.86	11.4	49.15	90.86	30.15	48.89	61.45
T10	32.7	41.67	9.86	48.53	97.89	27.25	47.71	65.34
Average Time	31	47	11	54	97	31	49	64
Take-time	57	57	57	57	57	57	57	57
Tmax	97	97	97	97	97	97	97	97

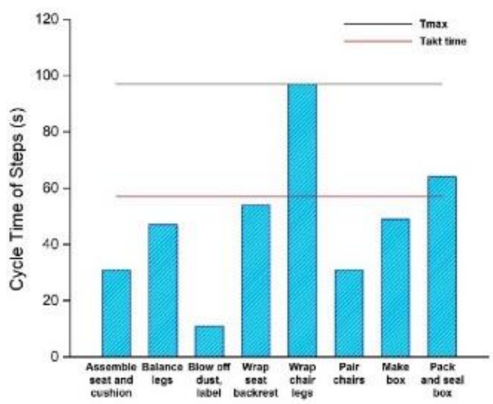

Figure 2. *The Cycle Time chart for each stage before improvement*

$$Takt\ time = \frac{Working\ time\ 1\ day}{Request\ a\ day\ order} = \frac{11400}{200} = 57\ \ (second)$$

The author identified five areas for improvement based on data and observations: establishing a support device for the foam-cutting process, arranging material shelves and work tables during the packaging stage, removing the bottleneck of the bottle necktie during the leg wrapping operation, and ensuring consistent operation and material positioning during the box wrapping process as shown in Figure 2.

3.1.1. Remove the bottleneck of bottle necktie removal in the leg wrapping process

Table 2. *Status before and after improvement of the leg wrapping process.*

BEFORE		AFTER	
Issue	**Image**	**Result**	**Image**
The finished products remain stagnant on the conveyor, causing it to stop for troubleshooting.		The number of finished products has decreased.	
Workers have to run around to perform tasks and often experience shoulder fatigue by the end of their shift.		Workers no longer need to run to perform tasks, resulting in faster and more comfortable operations.	
The coordination between two workers is ineffective.		Workers perform tasks more accurately and do not waste materials.	
Workers doing other people's tasks lead to uneven work performance.		Everyone has improved their work performance.	

Before the change, the author watched and documented the ineffective packaging procedure in the inefficient area. There were excessively many pointless steps and inefficient movements, which at this point created a bottleneck. After identifying the reasons and non-value-added operations, the author offered and implemented remedies to eliminate them, improving process efficiency and avoiding wasteful resource waste.

Table 3. *The result after improving the leg wrapping process.*

Content	Before	After	Effective
Cycle time (s)	97	47	Reduced 51.55%
WIP	6	1	Reduced 83.33%

3.1.2. Standardize the operation and material placement position at the box wrapping process

The workers' packaging procedure includes a number of wasteful steps. Furthermore, material positioning is inefficient, wasting time and reducing packaging output. The author observed and altered the operation, redefining the location of materials to make it more sensible. The results indicated that the packing process's cycle time fell from 64 seconds to 48 seconds (a 25% reduction), and it was less than the Takt time.

3.1.3. Design a support device for the foam-cutting method

Foam is one of the necessary materials in the packaging process, used for packing tables, chairs, sofas, etc. The process of preparing foam specifications is an important and necessary step in the packaging process. However, the current situation shows that this process requires two people to work together, the speed of producing foam sheets according to demand is not fast, and the workers can easily get tired when performing a large amount of work.

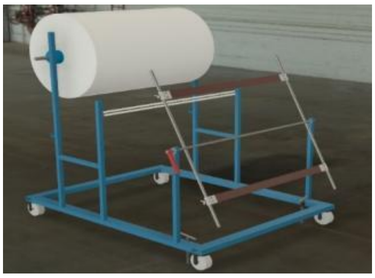

Figure 3. *Design ideas of cutting tool for foam*

Figure 4. *The worker is implementing a new the foam-cutting method*

From those identified issues, the author proposed a new foam cutting plan that involves using a cutting tool for foam. This tool has a simple structure and is made from readily available materials from the company (Figure 3).To assure the tool's safety and stability during use, the author calculated and evaluated its durability with Inventor simulation software. The tool was then manufactured and directly integrated into the production process (Figure 4). After a period of implementation, the author obtained the following results:

Table 4. *Results of implementing a new the foam-cutting method*

Content	Before	After	Effective
Workers	2	1	Reduced 50%
Time (s) of cutting 100 foarms (1050*1000)	80	50	Reduced 37.35%
Tolerance (mm)	±8	±6	Reduced 28.57%

3.1.4. Set up and arrange material shelves, and work tables at the packaging stage

The author applied the 5S method to organize and arrange tools and materials on shelves and workstations in a visual manner, following the principles of easy retrieval, minimal movement, and straightforward management. This facilitated the packaging process, and eliminated waste and inefficiency during operations. The author proposed and implemented a labeling system for material shelves to improve worker awareness and facilitate management (Figure 5).

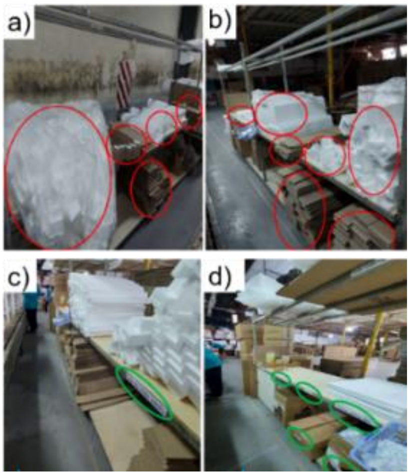

Figure 5. *Packaging material shelf before (a, b) and after (c, d) improvement.*

3.1.5. Design the layout for placing finished products, defective products, quality inspection, and repair of defective products

Because the packaging area was not clearly divided into zones for outgoing products, finished goods placement, and material storage, products were spilling into walkways and other areas, making it difficult to supply packaging materials, equipment, and raw materials, resulting in delays and hampered access (Figure 6).

JOURNAL OF TECHNICAL EDUCATION SCIENCE
Ho Chi Minh City University of Technology and Education
Website: https://jte.edu.vn
Email: jte@hcmute.edu.vn

Figure 6. *Packaging area before improvement*

The author planned and implemented a packaging area layout to clearly designate the location of finished items, work-in-progress, defective products, and products in need of repair.

Table 5. *Standard lines and colors in the packing area*

Line	Color	Image	Mean
Solid line	Yellow		Transport, workspaces,..
	Green		Finished products
	Red		Defective products
Dashed line	Green		Non-Finished products
	Red		Repair of defective products.

The layout is planned on the FIFO principle, with elements that impact each other located close together. Products that are close to delivery will be placed outside for ease of transportation and time savings.

Figure 7. *Packaging area before improvement*

3.1.6. Effective

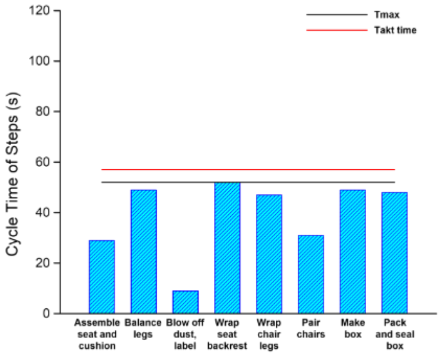

Figure 8. *The Cycle Time chart for each stage after improvement*

After applying lean methods and tools to improve the process, the author measured the results of the stages again (Figure 8). Table 6 shows the parameters before and after the improvement recorded by the author.

Table 6. *Summary of parameters before and after improvement*

Content	Before	After	Effective
Cycle time (s)	97	47	Reduced 51.55%
WIP	6	1	Reduced 83.33%
The area occupies the material (m^2)	12	4.3	Reduced 64.17%
Material delivery time (s)	300	60	Reduced 80%
Tool search time (s)	180	10	Reduced 94.44%
Number of product boxes placed in the packing area	110	120	Increased 8.33%
Packaging delivery time for packing (s)	1,800	900	Reduced 50%
Area of finished product placement (m^2)	182.75	192.50	Increased 5.06%
Area of package placement.	20.55	12.16	Reduced 40.82%
Productivity (Product/person/work session).	17	33	Increased 94.12%

3.2. Quality Improvement

3.2.1. Define

The author proceeded to use the Dayna Side Chair product line to increase product quality. This is because this chair line is mass-produced and has a high rate of product problems.

3.2.2. Measure

Sampling principles: Systematic random sampling method.

Table 7. *Statistical table of frequency of defects*

No.	Defect	Quantity	Rate (%)	Accumulation (%)
1	Dent	36	20.81	20.81
2	Touch up	32	18.50	39.31
3	Gap	30	17.34	56.65
4	Dust	22	12.72	69.36
5	Wrinkled	15	8.67	78.03
6	Crack	12	6.94	84.97
7	Sagging	10	5.78	90.75
8	Rough	7	4.05	94.80
9	Scabrous	6	3.47	98.27
10	Dappled	3	1.73	100
	TỔNG	**173**	100	

Table 8. *Batches check of Dayna Side Chairs*

Batches	Quantity
B1	200

JTE HCMUTE
ISSN: 2615-9740
JOURNAL OF TECHNICAL EDUCATION SCIENCE
Ho Chi Minh City University of Technology and Education
Website: https://jte.edu.vn
Email: jte@hcmute.edu.vn

B2	150
B3	150
B4	200
B5	150
Average	**170**

The current Sigma level of the Dayna Side Chair product line:

$$DPMO = \frac{Total\ number\ of\ defects\ in\ sample * 1{,}000{,}000}{sample\ size\ units * \ number\ of\ defect\ opportunities\ per\ unit\ in\ the\ sample}$$

$$= \frac{173 * 1{,}000{,}000}{170 * 10} = 101{,}764$$

With DPMO = 101,764, referring to the appendix table for Sigma levels, the current Sigma level for Dayna Side Chair is obtained as: 2.75.

According to the Pareto chart, the amount of dents, touch-ups, and gaps accounts for the vast majority of all product faults. As a result, the author concentrated on identifying and implementing practical ways to restrict these flaws, ultimately improving product quality and optimizing the manufacturing process.

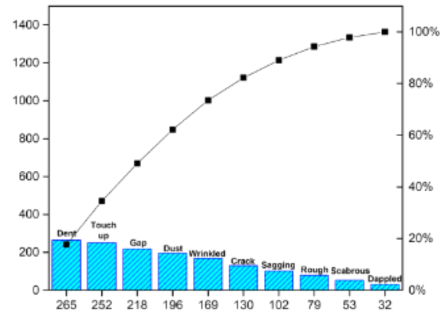

Figure 9. *The Pareto chart shows the order of commonly occurring defects.*

3.2.3. Analyze

Using a fishbone diagram, the author analyzed the root causes of defects, such as dents, touch-ups, and gaps.

Poorly managed sanding is one of the primary sources of dents, as Figure 10 illustrates. Furthermore, because the wood production business is known for producing a lot of dust, improper handling of dust particles during production can lead to dust collection over dents, making it challenging to sand before painting.

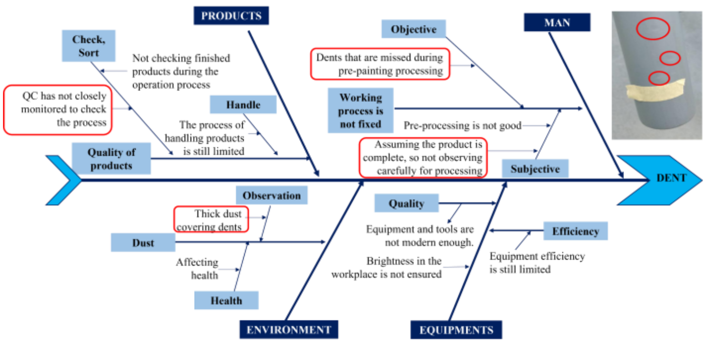

Figure 10. *The fishbone diagram of Dent*

In Figure 11, the author analyzed and listed possible causes of the issue of touch up, and then pinpointed the root cause using the 5-WHYS method. The primary cause of this error is due to painters not following the established painting process as specified on the sample card. The problem arises from the lack of clear guidelines for placing the paint sample card in a visible location for the painter to observe and properly follow the standardized painting procedures.

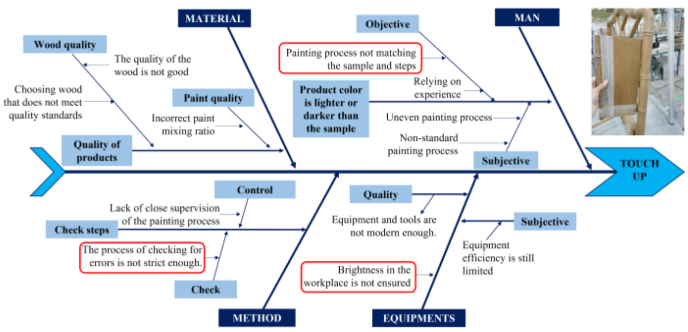

Figure 11. *The fishbone diagram of Touch up*

Gap faults are widespread in items with several joints or complex components. These elements frequently result in a certain level of looseness. Figure 12 shows the fundamental causes of this problem. The author observes that, while gap errors are typically apparent and correctable during the sanding process, insufficient lighting and light source angles have resulted in certain gaps being undetected during the mistake correction procedure.

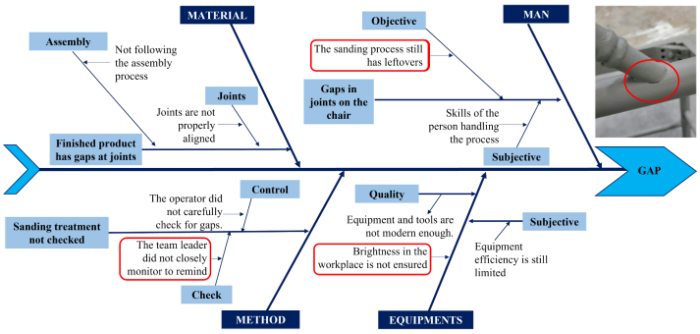

Figure 12. *The fishbone diagram of Gap*

3.2.4. Improve

3.2.4.1. Improving the process of sanding before painting.

Therefore, the author has changed the procedure so that each worker will perform operations on a specific position of the chair instead of three people processing on the same chair to create a production flow and implementing better defect control measures (Figure 13).

Figure 13. *The process of sanding after improvement*

3.2.4.2. Upgrading the inspection procedure of the QC department.

The author observed that several factors contributed to the inadequate defect checks by the QC team during the sanding process throughout the observation and cause analysis phase. The author used visual representations of the flaws to enhance the QC team's defect control skills.

Figure 14. *Table of defects in hard-to-see locations*

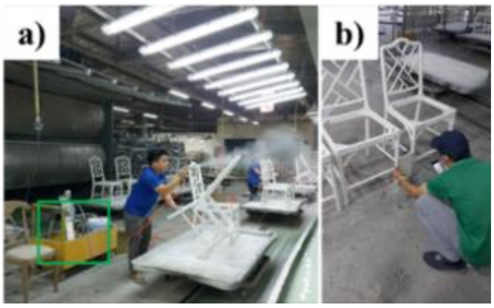

Figure 15. *Painted area after improvement*

3.2.4.3. Improved process of paint steps and color cards.

Currently, the team has identified an issue that the painting workers have not followed the paint color card or have lost the paint color card. After improvement, the color card is placed next to the painting operator near the paint tank (Figure 15.a). In addition, the paint quality control team (Figure 15.b) will be appointed to inspect the color at each painting stage to detect defects and prevent them.

3.2.4.4. Improving the angle and light quality of the lamp.

After conducting observations in the paint area, the author observed that the lighting system in the area was installed to shine straight down from top to bottom and the brightness was not guaranteed. The author proposed a plan to change the arrangement of tilted lighting to help paint workers observe the product more easily, as they can clearly see product angles.

BEFORE **AFTER**

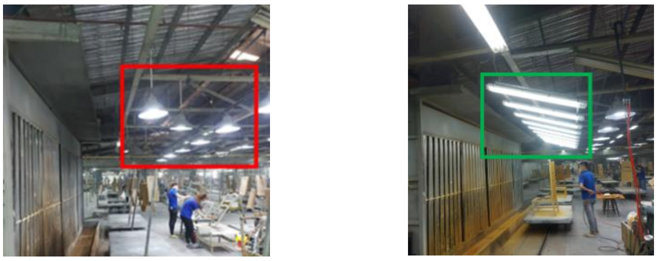

Figure 16. *Painted area lights before and after improvement*

3.2.4.5. Result

The after Sigma level of the Dayna Side Chair product line:

$$DPMO = \frac{Total\ number\ of\ defects\ in\ sample * 1000000}{sample\ size\ units * \ number\ of\ defect\ opportunities\ per\ unit\ in\ the\ sample}$$

$$= \frac{112 * 1000000}{170 * 10} = 65{,}882$$

With DPMO = 65,882, referring to the appendix table for Sigma levels, the current Sigma level for Dayna Side Chair is obtained as: 3.0.

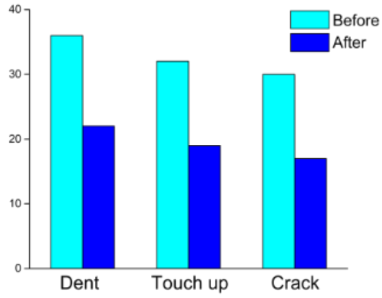

Figure 17. *Number of defects before and after improvement*

3.2.5. Control

The author randomly chose 20 chairs from each production batch and did continuous measurements 15 times to ensure product quality after improvement. Conclusion: It is evident that the frequency of defects is within control limits (Figure 18), and there are no unstable situations.

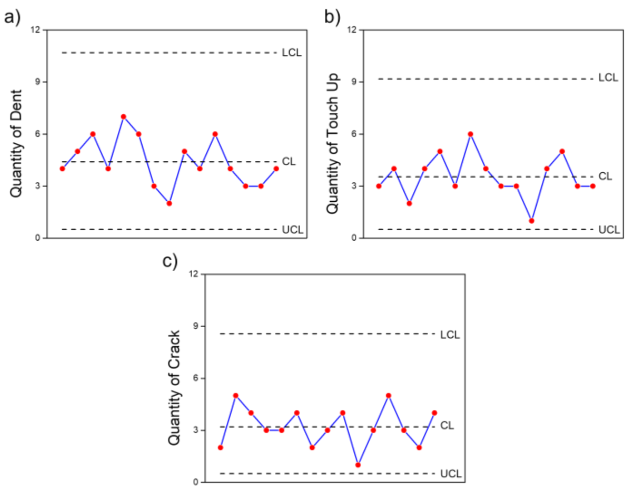

Figure 18. *Control chart of defects before improvement*

3.2.6. Economic efficiency

Table 9. *Cost savings after improvement.*

Cost	Before	After
Average loss per order	$20.76	$12.86
Average loss per month (estimated for 60 orders)	20.76 * 60 = $1245.6	12.86 * 60 = $771.6
Average loss per year	1245.6 * 12 = $14947.2	771.6 * 12 = $9259.2
Savings	14947.2 - 9259.2 = $5,688	

After improving product quality, the result shows a saving of over $5,688 per year that would have been paid for poor quality costs.

4. Conclusions

4.1. Productivity Improvement

This study demonstrates that implementing Lean Six Sigma can significantly enhance productivity and quality in wood manufacturing. Future research could explore the application of these methodologies in other manufacturing sectors. This study showed increased productivity by removing the bottleneck of the bottle necktie during the leg wrapping operation. The packing should be done in one continuous motion to ensure consistent operation and material positioning during the box wrapping process. The results showed that the cycle time for the packing process decreased from 64 seconds to 48 seconds, which is a 25% reduction. The new cycle time is now less than the takt time. To improve efficiency, we need to develop a support device for the foam-cutting process, increase productivity, and reduce the time spent on delivering foam during the packing process. Additionally, we should organize material shelves and work tables during the packaging stage to raise worker awareness and streamline management. It's also important to create a layout for storing finished and defective products, inspecting quality, and repairing defects, with the goal of optimizing the layout to minimize unnecessary movements.

4.2. Quality improvement

Furthermore, research brings increases in quality: Significant drop rates are shown below: The dent decreased by 38.89%, the touch-up by 40.63%, and the gap by 43.33%. The sigma level increased by 0.25 points on the sigma scale, from 2.75 to 3.0; the quality control chart findings reveal errors within the higher and lower control limits, showing the success of the improvements; saved over $5,688 per year on low-quality costs.

Acknowledgments

The author appreciates the support from the Ho Chi Minh City University of Technology and Education, Vietnam.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

[1] M. Andrew, “A lean route to manufacturing survival,” *Assembly Automation*, vol. 26, no. 4, pp. 265– 272, Oct. 2006, doi: 10.1108/01445150610705155.
[2] P. Dennis, Lean production simplified, New York: Productivity Press, 2007.
[3] A. Rahman, M. Sharif, and M. Esa, “Lean Manufacturing Case Study with Kanban System Implementation,” *International Conference on Economics and Business Research*, vol.7, pp. 174-180, Dec. 2013.
[4] A. Badiger, R. Gandhinathan, N. Gaitonde, and S. Jangaler, “Implementation of Kaizen and Poka-yoke to Enhance Overall Equipment Performance - A Case Study,” *Manufacturing and Industrial Engineering*, vol. 1, no. 4, pp. 24-29, 2007, doi: 10.1016/S2212-5671(13)00232-3.

[5] M. Gunasegeran, K. Venkatachalapathy, and K. Pajaniradja, "Impact on integration of Lean Manufacturing and Six Sigma in various applications - a review," *IOSR Journal of Mechanical and Civil Engineering*, vol. 450, no. 1, pp. 98-101, 2013, doi: 10.9790/1684-06198101.
[6] D. Allen and P. Laure, "Exploiting Lean Six-Sigma Quality Tools to Improve Test and Other Processes," *Conference: Autotestcon*, 2006, doi: 10.1109/AUTEST.2006.283716.
[7] X. Wang, Y. Wang, and D. Xu, "Lean six sigma implementation in equipment maintenance process," *Conference: Quality, Reliability, Risk, Maintenance, and Safety Engineering (ICQR2MSE)*, 2012, doi: 10.1109/ICQR2MSE.2012.6246481.
[8] A. Rahman, C. Shaju, K. Sarkar, Z. Hashem, K. Hasan, R. Mandal, and U. Islam, "A Case Study of Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) Methodology in Garment Sector," *Independent Journal of Management & Production*, vol. 8, no. 4, pp. 1309-1323, Dec. 2017, doi: 10.14807/ijmp.v8i4.650.
[9] J. Czabke, E. Hansen, and T. Doolen, "A multisite field study of lean thinking in U.S. and German secondary wood products manufacturers," *Forest Products Journal*, vol. 58, no. 9, pp. 77-85, 2008.
[10] A. Pirraglia, D. Saloni, and H. Dyk, "Status of lean manufacturing implementation on secondary wood industries," *BioResources*, vol. 4, no. 4, pp. 1341–1358, 2009.
[11] A. Susanty, B. Tjahjono, and E. Sulistyani, "An investigation into circular economy practices in the traditional wooden furniture industry," *Prod. Plan. Control*, vol. 31, pp. 1–13, 2020, doi: 10.1080/09537287.2019.1707322.
[12] N. Anderson and J. Kovach, "Reducing welding defects in turnaround projects: A Lean Six Sigma case study," *Quality Engineering*, vol. 26, no. 2, pp. 168–181, 2014.
[13] J. Guerrero, S. Leavengood and H. G. Pulido, "Applying Lean Six Sigma in the Wood Furniture Industry: A Case Study in a Small Company," *Quality Management Journal*, vol. 24, no. 3, pp. 6-19, 2017, doi: 10.1080/10686967.2017.11918515.
[14] D. Seth and Gupta, "Application of value stream mapping for lean operations and cycle time reduction: An Indian case study," *Production Planning & Control*, vol. 16, no. 1, pp. 44–59, Jan. 2005, doi: 10.1080/09537280512331325281.
[15] R. Evans, "Quality and Performance Excellence," *Quality Management Journal*, vol. 22, no. 4, pp. 6-17, 2015.
[16] Ishikawa and Kaoru, "Guide to Quality Control," Tokyo, Japan: Asian Productivity Organization, 2011.

Le Minh Tai received his B.Sc. degree in Mechanical Engineering from Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam in 2008. He received M.Sc. degree in Mechanical Engineering from HCMUTE in 2011. From 2008 up till 2012, he worked as a lecturer at the Vietnam-Germeny training center of HCMUTE. He received his PhD in Mechanical Engineering from the National Kaohsiung University of Applied Sciences, Taiwan (R.O.C.) in 2015. His interests include mechanics of materials, nanocomposites, optimal design, manufacturing systems, industrial management, production engineering and data envelopment analysis. Email: tailm@hcmute.edu.vn.
ORCID: https://orcid.org/0000-0003-0546-3656

Lu Hoang Khang received his B.Sc. degree in Industrial Engineering from Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam in 2022. From 2021 to 2023, he worked at a wood company focusing on enhancing productivity and product quality. Since 2023, he has been employed at SEHC as an industrial engineer specializing in LOB, cycle time and takt time improvement. Additionally, he is involved in enhancing and designing tools for automation to support operator tasks, ensuring ergonomic considerations, and increasing productivity. Email: khanglh66@gmail.com.
ORCID: https://orcid.org/0009-0009-9015-0734

Nguyen Kieu Thuy Hang received her B.Sc. degree in English language teaching (Technical English) from Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam in 2018. She received M.Sc. degree in Industrial system Engineering from Ho Chi Minh City University of Technology (HCMUT), Vietnam in 2023. Between 2017 and 2022, she worked at several foreign enterprises. The most recent was change management at Jabil company, an American multinational manufacturing company involved in the design, engineering, and manufacturing of electronic circuit board assemblies and systems. She has been an Industrial Systems Engineering visiting lecturer at HCMUTE since 2023. Her areas of interest are Logistics and supply chain management, production management, quality management, optimal design, manufacturing systems and service quality. Email: hangnkth@gmail.com .
ORCID: https://orcid.org/0009-0006-1117-3523