Sigma level choice examination in executing incline Lean Six Sigma (LSS) within the material and item material industry

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ABSTRACT

Many manufacturing industries in the world use the Lean Six Sigma (LSS) approach in analyzing and improving waste activities and reducing production defects. The Textile and Product Textile (TPT) industry can also be easily implemented because this industry is a labor-intensive industry. However, in its development, no one has analyzed the sigma level in the TPT industry by reviewing studies. The sigma level obtained from various sources and various types of TPT industries cannot yet be concluded about the sigma level value for each type of industry. This research points to look at writing articles related to LSS, particularly within the TPT industry. This inquire about employments the clustering strategy, specifically a refinement research strategy taken within the TPT industry within the writing review. This ask around found dispersions of 55 articles that were effectively studied inside the composing with the Six Sigma technique being the preeminent broadly utilized and more explore objects based on the tall quality of 41 articles. Gathering by industry section is the piece of clothing industry with 14 articles that reinforce the LSS. In the interim, based on nation groupings, the biggest number is Indonesia with 19 articles. It is trusted that this inquire about commitment can ended up a reference for anybody who will utilize LSS within the fabricating industry.

1. Introduction

Currently, the industrial sector's contribution to development in several countries relies heavily on the manufacturing industry. The manufacturing industrial sector plays an important role in contributing to the country's income to develop more advanced (Kurnia, Setiawan, et al., 2022). The manufacturing industrial sector promises high productivity results compared to other sectors. The manufacturing industry absorbs a lot of labor, especially the Textile and Product Textile (TPT) industries, which can create added value for the country (Hutama, 2022). So this added value can trigger competition between companies regarding productivity and quality which must be improved (Haviana & Hernadewita, 2019), including in the TPT industry which requires all activities to have benefits for the company (Chitichotpanya et al., 2022). Even though each activity has a different value, especially operational costs, every company must still think about increasing its profits by eliminating waste and reducing defects (Santos et al., 2019).

Every manufacturing industry must have a strategy specifically for improvement to increase customer satisfaction and meet customer demands (N. M. Ahmed et al., 2015; Kurnia et al., 2023). Every company needs to implement an improvement approach that can increase productivity and

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quality so that operational costs can be reduced (Putri & Primananda, 2021). This improvement strategy also applies to the TPT industry, where to improve the performance of the industry and its workers, waste analysis must be carried out and reduce dominant defects that occur in each production process flow (Pereiraa et al., 2019).

Lean Manufacturing (LM) could be a strategy that centers on diminishing squander in all viewpoints of a company's generation exercises may be a procedure that centers on diminishing misuse in all points of a company's era works out (Siregar et al., 2018), by using a repair tool called VSM (Maria et al., 2019; Zahrotun & Taufiq, 2018). The Lean approach can be combined with Six Sigma to reduce defects and determine the sigma level (Kurnia & Hardi Purba, 2021). The Lean approach still includes LM, namely by doing things better using fewer resources, including energy, equipment, time, and space, which can provide benefits for the company (Engelseth & Gundersen, 2018). The Lean method can also be applied to reduce waste in every TPT production process (Mothilal & Prakash, 2019).

One sustainable strategy that can be used by various industries to improve performance and reduce waste is called LM (Jaqin et al., 2023; Kaneku-Orbegozo et al., 2019), the LM method can also be applied in the health industry (Sukma et al., 2022). Apart from that, this method can provide effective results to optimize production costs efficiently and effectively (Zulkarnaen et al., 2023), and increase productivity by eliminating waste (Prayugo & Zhong, 2021).

The method that can be applied to the TPT industry is the Six Sigma method where the sigma level can be determined for each product. This method also aims to improve quality and minimize defects (Hayajneh et al., 2020). Within the piece of clothing industry, this strategy can improve item quality within the form of men's formal coats by analyzing absconds within the overwhelming parts (Sjarifudin et al., 2022). The Six Sigma strategy can be connected to the material industry by optimizing quality control, minimizing the number of absconds, and guaranteeing wrapped up products meet quality guidelines (Shafira & Mansur, 2018).

The Six Sigma strategy can be connected with the Define-Measure-Improve-Analyze-Control (DMAIC) approach which incorporates the estimation arrange in decreasing item absconds (Zaman & Zerin, 2017), and can moreover increment the number of conveyances to clients (Hamdi et al., 2015).

A few approaches are as a rule connected by the TPT industry for enhancement, counting the Kaizen approach. This approach prioritizes assessment, planning, and taking remedial activity. Each enhancement procedure to kill exercises that don't have included esteem employments the Container Do Check Activity (PDCA), Statistical Process Control (SPC), 5S, and other approaches. This approach has been made by numerous distributers in different diaries, counting the Lean Six Sigma (LSS) approach.

This LSS approach is a combination of Lean methods with Six Sigma which functions to reduce costs, improve quality, and encourage continuous improvement. All of this aims to achieve higher levels of customer satisfaction and profitability. The LSS approach is more broadly connected to the fabricating industry to overcome squander and imperfection issues within the fabricating industry including the TPT industry. The method stages within the TPT mechanical division start with the planning of normal filaments and fake strands planning for making yarn (Turning Plants). Then the next process is making woven fabric or clothing materials (Weaving and Knitting), and the last is making textile materials that are used as garment materials or accessories.

This phenomenon has been experienced by the textile industry and researchers have had difficulty finding bibliography as a reference in determining standards. The application of LSS in the textile industry did not find a sigma level in each textile industry, and little is still known about the scope of application of Six Sigma in the textile industry. All textile industries each release their own research results, there is no reference for other research to use as a guide. Therefore, this research emerged with the motivation that each textile segment, including spinning, weaving, knitting and garments, must have a sigma level reference.

This new research approach not only examines literature reviews but also determines sigma reference levels for several products produced by the textile industry. This is different from other research which only determines the sigma level for one product. This research summarizes all research results by reviewing the sigma level of each product so that it can be used as a reference for the sigma level of each TPT product. Another novelty is that this research will become a guide for other research in terms of sigma level references in each textile industry sector. The analysis is very detailed starting from the type of paper, type of repair, and methods used in the corrective action

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process. This research aims to detect systematic observations of literature related to LSS in all TPT sectors and draw sigma level conclusions in each TPT sector.

2. Methods

This inquire about incorporates expressive investigate utilizing auxiliary information, to be specific by collecting articles related to the utilize of the LSS approach within the TPT industry division. The articles that will be collected are constrained to the a long time 2015 to 2025 so the articles found are the most recent. Looks can be carried out on well-known distribution databases on Google Researcher, Elsevier, and Research Gate, and Science Direct. Revelation of TPT articles using keywords, specifically LSS, within the TPT industry. The inquire about stages are separated into 3 stages, the inquire about steps can be seen in Fig. 1.

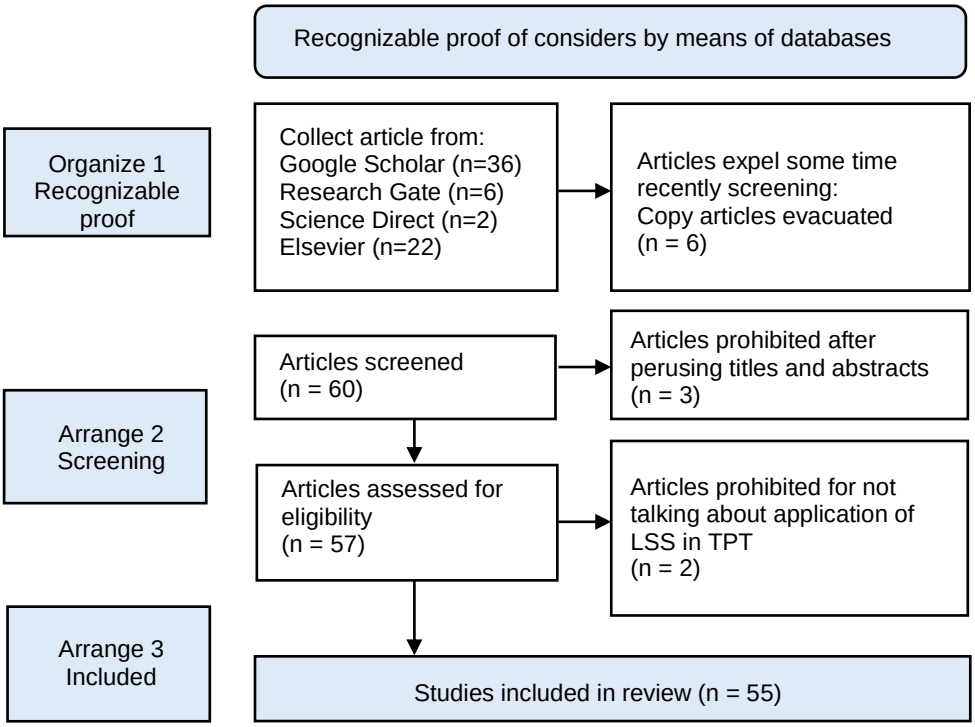

Fig. 1 Study framework.

Based on Fig. 1, this inquire about framework livelihoods three research stages. The essential step is recognizing distinctive articles collected from different distributer databases and after that cross-checking the articles to maintain a strategic distance from duplicate articles with the same subject. The moment step is to channel articles from a few articles to guarantee that nothing is out of the LSS subject within the TPT industry. The third step is to assess a few articles to examine how particularly the application of LSS is within the TPT fabricating industry.

3. Results and Discussion

This section discusses the results and discussions that have been obtained from data collection and processing during the research.

Article Analysis Result

After several articles have been collected, the next step is to analyze several articles within a parameter. Several articles have been collected according to the theme, namely LSS in the TPT manufacturing industry. Several textile sectors in the world are divided into Spinning, Weaving, Knitting and Garments (Kurnia, Tumanggor, et al., 2021). The results of the analysis of several articles can be seen in Table 1.

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Table 1 Existing literature review of the LSS in TPT industries

No	Article Identity	Sector	Research Object	Result
1	(Kurnia, Jaqin, & Purba, 2022b)	Knitting	Quality	Increase sigma-level 3.70 to 3.96
2	(Kurnia, Jaqin, & Manurung, 2022)	Weaving	Waste	3.87
3	(Kurnia, Jaqin, et al., 2021)	Knitting	Quality	3.96
4	(Kurniawan & Prestianto, 2020)	Garment	Waste	4.14
5	(Dey et al., 2020)	Garment	Waste	3.12
6	(Khan et al., 2020)	Weaving	Quality	2.91
7	(Fithri, 2019)	Weaving	Quality	5.07
8	(Henny et al., 2019)	Spinning	Quality	4.00
9	(Purnama et al., 2018)	Garment	Quality	Increase sigma-level 3.61 to 3.86
10	(Shafira & Mansur, 2018)	Weaving	Productivity	3.32
11	(Sjarifudin et al., 2022)	Garment	Quality	Increase sigma-level 3.57 to 3.78
12	(Syafwiratama et al., 2017)	Spinning	Quality	Increase sigma-level 2.20 to 3.10
13	(Adikorley et al., 2017)	Spinning	Waste	Increase sigma-level 3.74 to 4.32
14	(Zaman & Zerin, 2017)	Garment	Quality	2.80
15	(Pratiwi et al., 2016)	Weaving	Quality	3.57
16	(Alkatiri et al., 2015)	Weaving	Waste	4.09

Table 2 Normal sigma level based on case ponder

No	Sector	Product	Process	Average Sigma Level Based on Case Study	References
1	Spinning	Yarn	Spinning	4.00	(Manan et al., 2018)
		Fiber	Cutting	2.65	(Kurniawan & Prestianto, 2020)
2	Weaving	Dim textures	Weaving	3.57	(Hanbay et al., 2016)
		Color textures	Assessment	5.00	(Achmad, 2012)
		Tape	Weaving	3.87	(Kurnia, Jaqin, & Manurung, 2022)
3	Sewing	Socks	Sewing	3.83	(Kurnia, Jaqin, et al., 2021)
4	Garment	Child dress	Wrapping up	4.14	(Tannady et al., 2019)
		Formal jacket's	Wrapping up	3.68	(Sjarifudin et al., 2022)
		Shirts	Sewing	2.84	(Simanová et al., 2019)
		Clothing	Sewing	2.75	(Tjandra et al., 2018)
		Sacks	Sewing	3.73	(Yadav et al., 2020)
		Pants	Sewing	3.12	(Christoper & Suliantoro, 2015)

Based on Table 1, each division of the TPT industry has contrasts in terms of sigma level enhancement comes about. The Six Sigma strategy has come about in expanded sigma levels after

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enhancements have been made. It can be concluded that executing LSS can decrease generation absconds and increment the sigma level (Prahara & Nawangpalupi, 2021). A summary of sigma levels in several sectors of the TPT industry can be seen in Table 2.

Based on Table 2, it can be concluded that each TPT sector has obtained a sigma-level reference. This Sigma-level reference in each sector of the TPT industry can be used as an illustration of Six Sigma research by other researchers or business actors on TPT products and processes. This reference can make it easier for other researchers in comparative studies if the research results are too far from the results of other studies.

Article Classification

Gathering a few articles from the investigation comes about, a add up to of 55 articles have been collected. Based on the classification of a few articles that center on the year, mechanical division, distributer, nation, strategy, question, and sort of investigate that has been carried out. The nitty gritty comes about can be seen in Fig. 2.

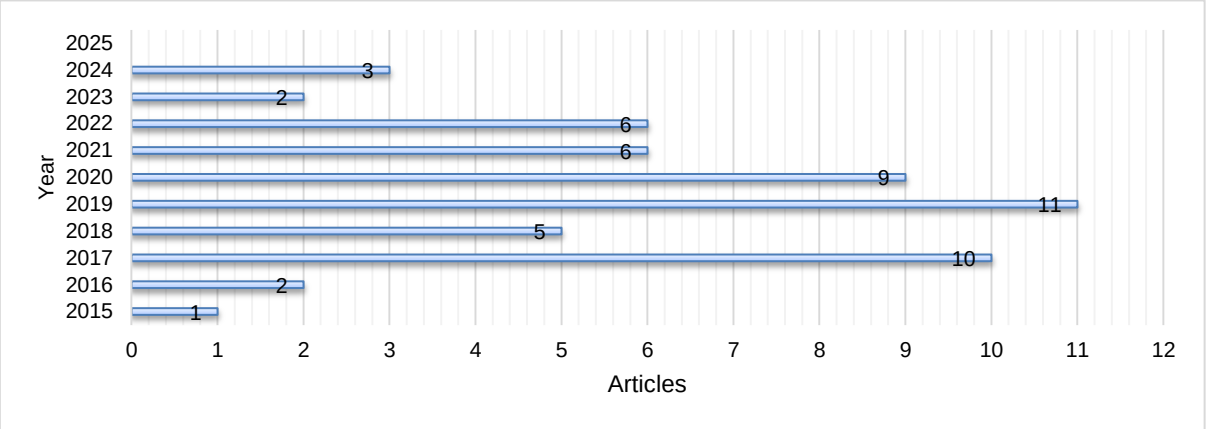

Fig. 2 Year of publication.

Based on Fig. 2, it shows that the collection of article publications is limited from 2015-2025. The most dominant year of publication on the LSS theme in the TPT industry was 2019 with 11 articles or 20%. Likely, this year many researchers from business actors in the TPT sector will conduct research to improve waste, non-value-added activities, and decreased productivity. Meanwhile, a grouping of several articles that focus on the segmentation of the TPT industry can be seen in Fig. 3.

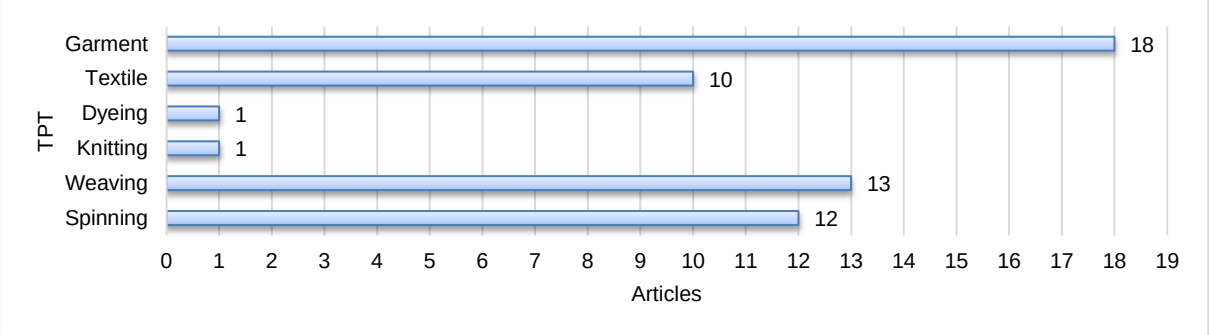

Fig. 3 Focus of sector.

Based on Fig. 3 which centers on industrial fragment division, it is found that the TPT fragment is the first overpowering in terms of the foremost vital number of distributed articles, to be particular inside the article of clothing portion with 18 articles or 33%. The piece of clothing industry fragment is the first curiously put for explore by various investigators since the division may be a uncommonly complex issue. The recognizable confirmation of many articles that center on the country where the ask almost was conducted can be seen in Fig. 4.

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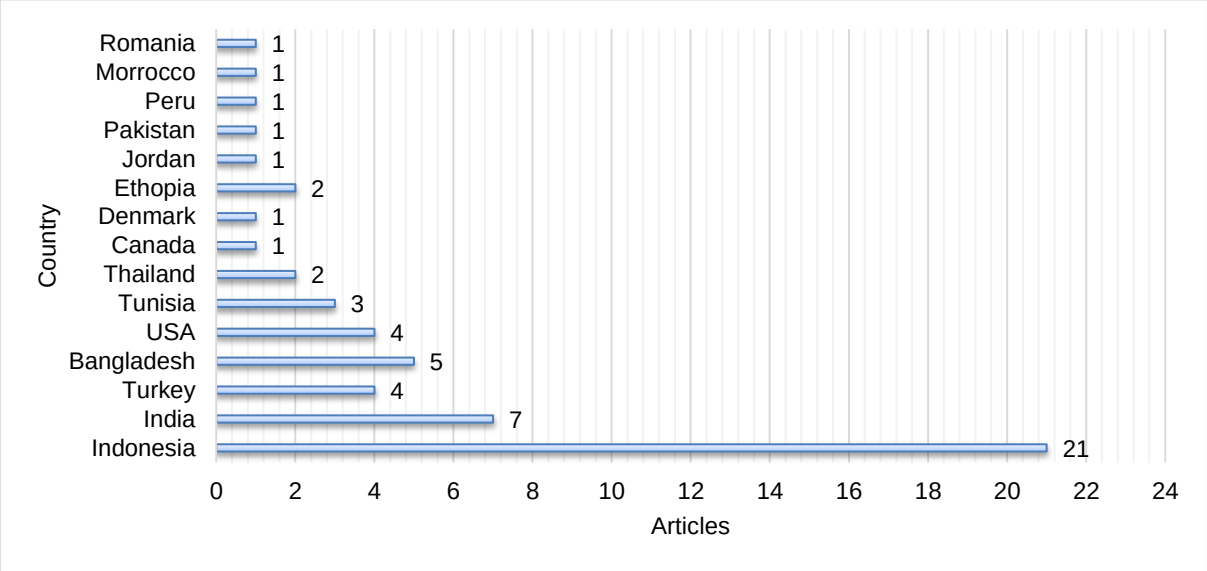

Fig. 4 Focus of country.

Based on Fig. 4, approximately the number of transportation equipment inspections centered on the first largest inspection country is Indonesia with 21 articles or 38%. This shows that Indonesia has many textile industry facilities, so many analysts conduct research related to LSS in the textile industry in Indonesia. The textile industry in Indonesia absorbs a lot of labor so it is often called a labor-intensive industry. However, the supply of materials still depends on supplies from foreign countries or imports, such as cotton raw materials and machine spare parts, so that Indonesia still finds it difficult to develop in the textile industry compared to other countries and this will only last until there is certainty or policy from the government.The comes about of the analysis of a few articles centering on research objects can be seen in Fig. 5.

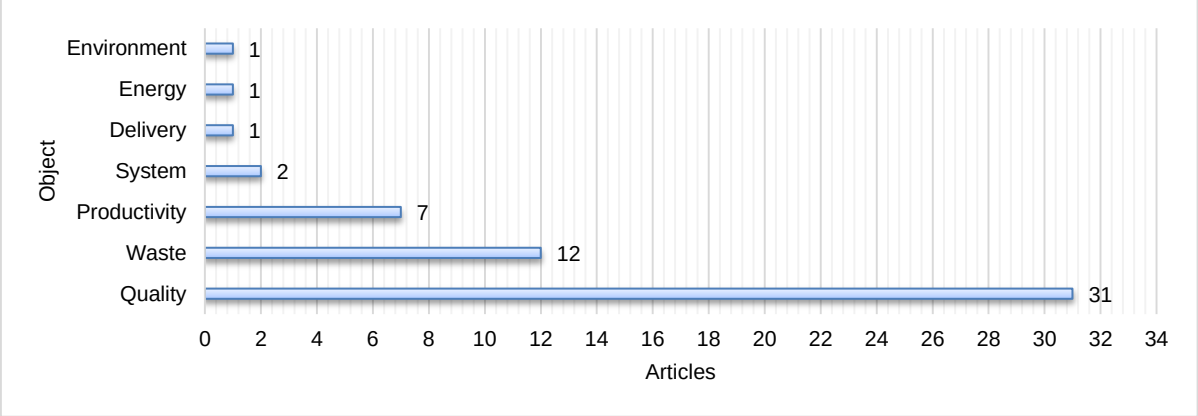

Fig. 5 Object of research.

Based on Fig. 5, appears that the LSS method research protest within the TPT industry is more overwhelming within the quality angle with 31 articles or 56%. Usually since the Six Sigma strategy may be a strategy at the Sigma level in lessening surrenders within the generation handle. In terms of actualizing this strategy, is simple to do in terms of decreasing production defects (Tjandra et al., 2018). The results of the analysis of several articles that focus on research types can be seen in Fig. 6.

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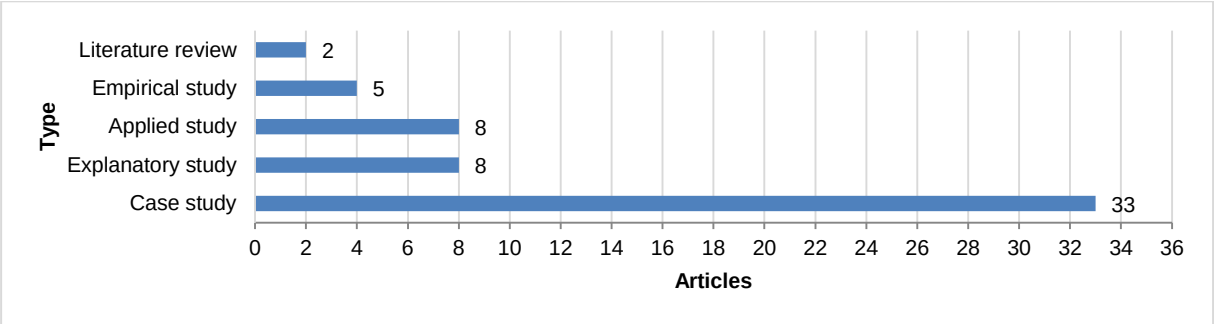

Fig. 6 Type of research.

Based on Fig. 6, shows up that the comes almost of the examination of some articles that center on the sort of inquire about are more centered on case considers, 33 articles equal 57%. This demonstrates that with this sort of case ponder, the article is more centered and looks for remedial arrangements to generation imperfection issues. This sort of case think about centers more on applying the LSS approach through coordinate perception within the field by collecting information, handling information, and taking remedial activity.

The type of research that is a literature review is a method of studying scientific works produced by means of identification, implicit, conceptual and orderly. The scientific works obtained come from a collection of previous scientific works produced from previous research (Kurnia, Irwati, et al., 2023). The type of empirical study research is the collection and analysis of primary data based on direct observation or experience based on the author's experience. This research has obtained primary data or direct observation in the field, so this research is called descriptive research (Boon Sin et al., 2015). The type of applied research is research that aims to find solutions to problems in industry and organizations as a continuation to obtain research models that are innovative and the discovery of new technologies (Abdullah et al., 2023). Explanatory research type aims to find why an event occurs causal relationship of the problem that has occurred. This research is more concentrated in determining the cause of a problem that arises by testing the hypothesis (Wiyatno et al., 2024). The Case Study research type is a qualitative descriptive research used to understand a problem by using a case that occurs in an organization, so that it can produce the right solution in handling the problem (Zulkarnaen et al., 2023).

Article Focus Summary

The comes approximately of this ask almost have recognized 50 articles related to the application of LSS inside the TPT industry gotten from conveyed journals. The assurance get ready for a number of articles is outstandingly clear, centering on the application of LSS within the TPT industry. The gathering of many chosen articles will be summarized and analyzed based on the fabric industry portion, checking Turning, Weaving, and Weaving. Within the cruel time, the piece of clothing division is assembled based on the additional items utilized .

This LSS approach includes the basic concept of Kaizen in terms of improving problems in the manufacturing industry. The improvement parameters are based on the Lean method to analyze waste in non-value-added activities. Apart from that, it also analyzes non-value-added processing time waste using the Value Stream Mapping (VSM) method (Carvalho et al., 2019). Meanwhile, to apply the sigma level, the DMAIC approach can be used, meaning that the DMAIC approach is a stage of the improvement process where each stage uses an improvement tool (M. S. Khan et al., 2020). Then, the Total Quality Management (TQM) approach is all forms of total quality improvement which also calculates the percentage of production defects (Hardono et al., 2023).

The comes about of this inquire about relate to the overwhelming writing audit of a few articles that apply the LSS approach to the TPT industry utilizing the DMAIC approach. The DMAIC approach capacities to decide the sigma level and decrease generation abandons (Kurnia, Jaqin, & Purba, 2022b). The demonstrate found in this ask around is that there were 18 articles equal 36% that utilized the DMAIC approach in coherent work.

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Benefits Implementation of LSS

LSS is a combination of LM and Six Sigma, which means it has a double meaning, each of which aims to reduce non-value-added activities. The Lean method more often uses the VSM method to map all activities in each section. VSM is a system that can eliminate all types of waste. The advantages of the Lean method can increase production while making the process more effective (Zulkarnaen et al., 2023). Meanwhile, by implementing Six Sigma, companies will be able to reduce production defects and increase sigma levels.

LSS is presently one of the foremost sought-after quality change approaches by organizations in many businesses. This is often since this approach can give benefits in terms of trade decision-making. All choices are made based on existing marvel information, successful compared to choices that as it were depend on hypothesis. Separated from that, the advantage of LSS is that it can spare time in getting fast arrangements and can diminish operational costs. Fetched investment funds in diminishing generation squander, and picking up benefits for the company so that the company can still work (Raja Sreedharan & Raju, 2016). The general description of the LSS in the TPT Industry in its application that has been collected can be seen in Table 3.

Table 3 Existing rundown of LSS within the TPT industry

No	Parameters	Authors	Amount of Articles
1	LM defects	(Adikorley et al., 2017) (Mohan Prasad et al., 2020) (Palange & Dhatrak, 2021) (Kaswan & Rathi, 2020) (Nørup et al., 2019) (Mothilal & Prakash, 2019) (Roesmasari et al., 2018) (Kaswan & Rathi, 2019) (Raj & Handayati, 2024) (Limonur Rahman Lingkon et al., 2024)	10
2	LM processing time	(Dinulescu, Ruxandra Dima, 2019) (Martinez-Condor et al., 2020) (Bharath et al., 2017) (Bustommy et al., 2021)(Elboq et al., 2023)	5
3	DMAIC Six Sigma	(Kurnia, Jaqin, & Purba, 2022b) (Kurnia, Jaqin, et al., 2021) (Kurnia, Jaqin, & Manurung, 2022) (Karabulut & Yildiz Kumru, 2019) (Kumar et al., 2020) (Vermaelen & Kovach, 2021) (Dey et al., 2020) (Khan et al., 2020) (Hayajneh et al., 2020) (Purnama et al., 2018) (Nurprihatin et al., 2017) (Syafwiratama et al., 2017) (Zaman & Zerin, 2017) (Suwanich & Chutima, 2017) (Pratiwi et al., 2016) (Alkatiri et al., 2015) (Mukhopadhyay, 2015) (Kurnia, Jaqin, & Purba, 2022a) (Kurnianingtias et al., 2024) (Dagne, 2023)	20
4	DMAIC Kaizen	(Amira & Nejib, 2021) (Sukwadi et al., 2021) (Sakti et al., 2021) (Ahmmed & Ayele, 2020) (F. Ahmed, 2019) (Sjarifudin et al., 2022) (Sjarifudin & Kurnia, 2022)	7
5	Kaizen Six Sigma	(Putri & Primananda, 2021) (Fithri, 2019) (Shafira & Mansur, 2018) (Henny et al., 2019) (Bhargava, 2019) (Kurniawan & Prestianto, 2020) (Kurnia, Jaqin, & Purba, 2022c)	7
6	TQM	(Abbes et al., 2018) (Lajoie et al., 2019) (Uluskan et al., 2018) (Bakar et al., 2017) (Sihombing & Sumartini, 2017) (Maralcan & Ilhan, 2017) (Uluskan et al., 2017)	7
		Total of Articles	56

Based on Table 3, the resume of the collection of articles on LSS in the TPT industry shows that there have been 50 articles that have been effectively researched in writing with the Six Sigma technique as the most widely used and most widely researched object based on the quality of 41 articles. While the collection based on the purpose of the research is to reduce waste in the TPT industry, there are 14 articles that strengthen LSS.

The Gap Analysis of Review on LSS and Future Research Suggestions

The analysis gaps in article studies that use the LSS approach are very diverse. These gaps have been grouped according to the TPT industry sector. In the interim, the comes about of the

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investigation of a few articles that prioritize the LSS approach that has been connected so faraway transcendently utilize the Six Sigma strategy compared to the LM strategy.

The comes about of the examination with respect to the hole between mechanical divisions between the sewing segment and the article of clothing segment appear that the LSS strategy is more overwhelmingly connected within the article of clothing division compared to the weaving division. Usually since the number of piece of clothing industries is more prominent than the weaving segment. The number of distributions within the weaving area is still exceptionally little since there are few sewing production lines. This gives an opportunity for other analysts to conduct investigate within the sewing division so that the publication can give edification for other analysts.

The measures of this ask almost are based on different composing considers inside the TPT portion by making sigma-level references from diverse divisions such as turning, weaving, sewing, and articles of clothing. It is trusted that the commitment of this ask approximately can be utilized as a reference for the sigma level of the TPT segment. So that investigators or exchange on-screen characters can compare the comes almost with past explore. This explore joins a body of data on operations ask almost and examination which joins examine and examination related to the application of LSS inside the TPT segment .

It is trusted that this investigate will proceed to be carried out with more challenging topics related to Industry 4.0 within the fabricating industry within the same segment, specifically the TPT industry. The government has begun to encourage the implementation of Industry 4.0 in various sectors so that it can compete with other countries (Alcácer & Cruz-Machado, 2019). The sectors that have started implementing Industry 4.0 are the automotive, food, chemical, household needs, and the TPT industries. In future research, the TPT industry implementing Industry 4.0 can make decisions faster, more reliably, and more satisfactorily with diverse data collection. The relationship between the LSS approach and the Industry 4.0 approach can be seen in Fig. 7.

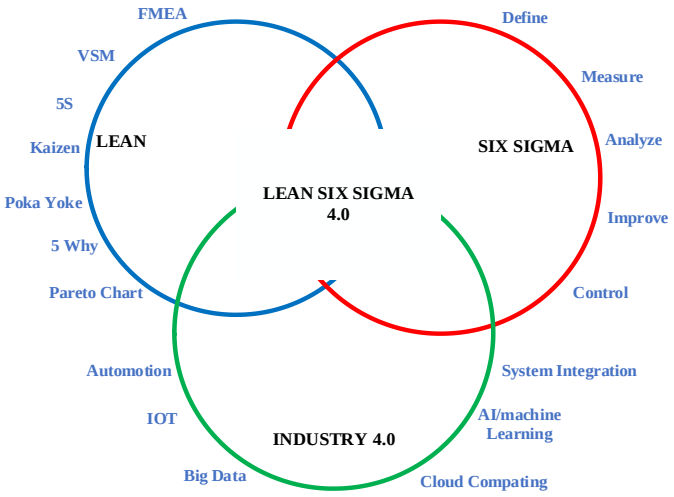

Fig. 7 Future research framework.

4. Conclusion

The LSS approach in the TPT industry is a combination of lean and six sigma methods, where the LSS approach seeks to improve employee performance in the productivity and efficiency process, in addition the company can also eliminate wasteful activities that are not valuable and reduce products. Therefore, the implementation of LSS in the TPT industry is very important in realizing a company that has high productivity and gets profits according to the company's targets. A literature survey of articles related to the application of LSS within the TPT industry in article distributions brought about in 50 articles. This research too found a classification of a few articles that centered on the year of distribution, specifically 2019, totaling 11 articles. In the interim, the center on mechanical division is the article of clothing industry with 15 articles. In the interim, the analysis of articles that centered on most nations was Indonesia with 19 articles. At that point the crevice examination centered on the investigate goals, finding quality destinations totaling 41 articles. This inquire about come about that the type of inquire about that's most broadly utilized is the case think about sort where each company

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employments this approach to settle its issues. In the mean time, with respect to sigma-level references for a few TPT items that have been considered based on the comes about of case considers, they can be utilized as a direct in assist investigate.

The hypothetical suggestions of the comes about of this research can be utilized as a reference for those who are inquisitive about inquiring about the same or comparative issues. In the mean time, the viable suggestions of the comes about of this investigate can make it less demanding for trade performing artists to supply an diagram and data with respect to the LSS strategy connected to the TPT industry.

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