Analysis of Lean Manufacturing and Agile Manufacturing Implementation to Reduce Waste and Improve Productivity in Crankshaft Repair Production (Case Study: Intidaya Dinamika Sejati LTD– Jember)

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Abstract

This study aims to analyze the implementation of Lean Manufacturing and Agile Manufacturing in reducing waste and increasing productivity in the crankshaft repair production process at Intidaya Dinamika Sejati LTD– Jember. Value Stream Mapping (VSM) and Process Activity Mapping (PAM) methods are used to identify non-value-added activities. Root Cause Analysis, and Fishbone Diagram are employed as supporting tools to analyze the main causes of waste. Agile Manufacturing is examined through the aspect of production flexibility. The results show that the dominant waste involves waiting time. After the implementation of improvements, there was an increase in production efficiency, and an improvement in process lead time. The integration of Lean and Agile Manufacturing has proven effective in enhancing the company's operational performance.

Keywords*: agile, lean, productivity, vsm, waste*

1. Introduction

PT. Intidaya Dinamika Sejati, within its production department under the automotive division, faces challenges in the crankshaft repair process due to the presence of non-value-added (NVA) activities or waste. These wastes lead to increased consumption of resources, energy, labor, and time, resulting in inefficient production processes. To address this issue, the company implements Lean Manufacturing using the Value Stream Mapping (VSM) approach to identify waste and improve production efficiency [1]. The Lean Manufacturing tool used in this study to minimize waste is Value Stream Mapping (VSM) [2]. VSM is a visual method for mapping a product's production flow, including the flow of materials and information at each workstation. The reason for choosing VSM is that it can illustrate all value-added and non-value-added activities from raw material to finished product. Moreover, VSM serves as a starting point for companies to identify various types of waste and their root causes.

Meanwhile, Agile Manufacturing focuses on the flexibility of the production system in responding to changes in customer demand and product variations [3]. The combination of these two approaches is expected to improve productivity and optimize resource utilization at Intidaya Dinamika Sejati LTD, particularly in the crankshaft repair process, which is characterized by high levels of variation and complexity. The competitive nature of the engine component repair industry requires companies to enhance both efficiency and production flexibility. Intidaya Dinamika Sejati LTD, is dealing with waste issues in the crankshaft repair process, including waiting time, product defects, and inefficient transportation. Lean Manufacturing is applied to identify and reduce waste, while Agile Manufacturing plays a role in increasing the process's flexibility in adapting to changing customer demands [4].

2. Research Methods

Lean manufacturing is a business philosophy that emphasizes efficiency in the use of resources, including time, across various company activities. This approach focuses on identifying and eliminating non-value-adding activities in the production process within the manufacturing sector, service operations, and supply chain management, with the primary goal of increasing value for the customer. The method used in this study is a case study on the crankshaft production line. Data were collected through observation, interviews, and documentation.

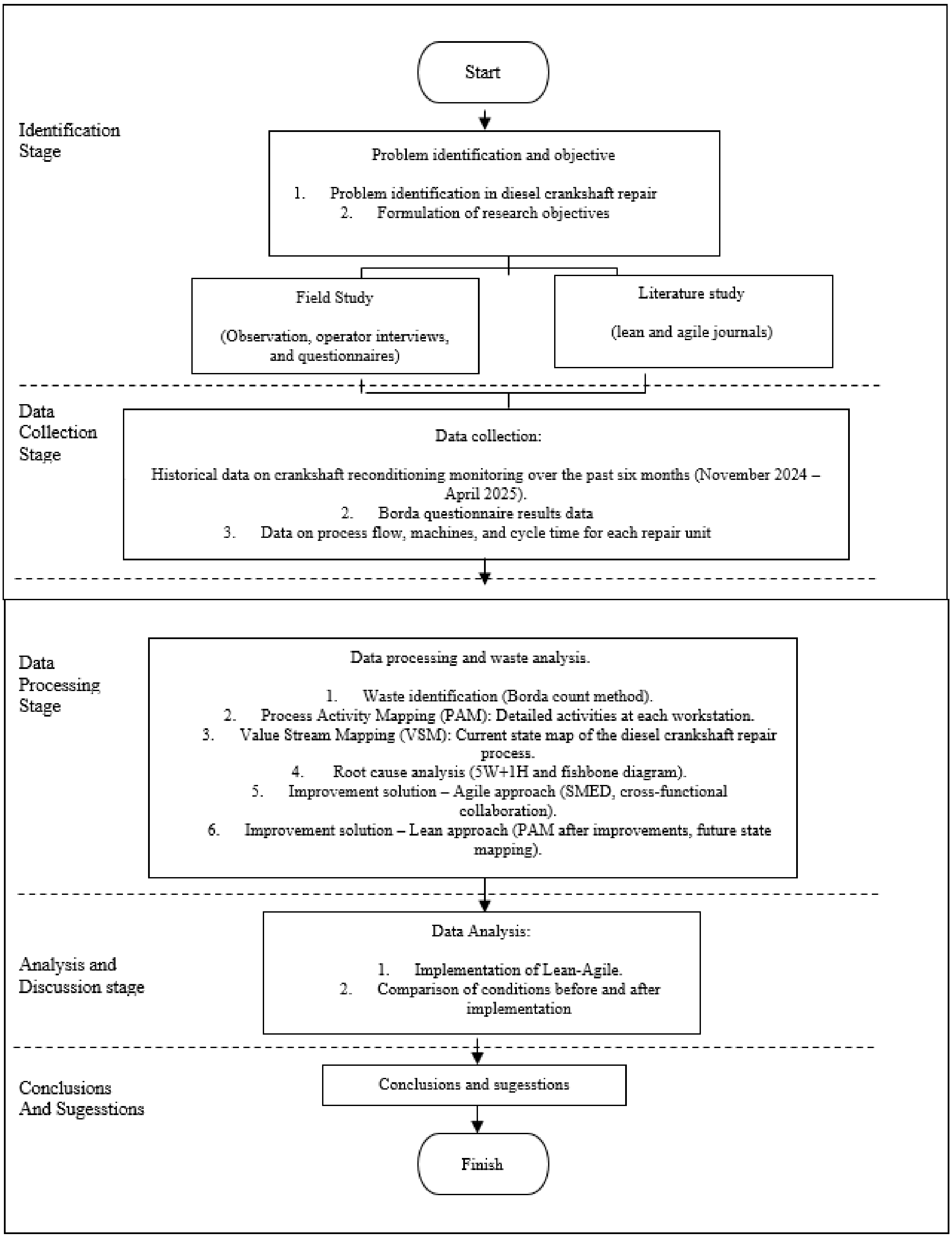

Figure 1. Flowchart of Research Methodology

Intidaya Dinamika Sejati LTD is a company engaged in the repair and reconditioning of engine components, including crankshafts. Its repair process still faces several challenges, such as long waiting times, low production process efficiency, and waste that impacts production flexibility. Therefore, it is necessary to conduct an analysis of the implementation of Lean Manufacturing and Agile Manufacturing in order to identify the root causes of waste and to design more effective improvement strategies. This study has a distinctive contribution compared to previous research because it combines Lean Manufacturing and Agile Manufacturing methods to simultaneously reduce waste, improve productivity, and enhance flexibility in the crankshaft repair production process. While previous studies have predominantly focused on improving efficiency in mass production, this study also emphasizes adaptation to changing customer demands and product variations, which is crucial in the repair of machine components with high complexity.

This data collection employed a qualitative approach by conducting interviews with machine operators, supervisors, and the head of production manager, focusing on the crankshaft repair production in the automotive division of the production department at Intidaya Dinamika Sejati LTD. Based on the collected data, the crankshaft is the engine component with the highest repair quantity in the automotive division of Intidaya Dinamika Sejati LTD. This chapter analyzes the results of the implementation of lean manufacturing and agile manufacturing in the crankshaft repair production at Intidaya Dinamika Sejati LTD. This section presents the conclusions drawn from the research findings and provides suggestions for improvement and future work.

3. Results and Discussion

3.1 Results Implementation of lean-agile

This method illustrates the physical and informational flow, focusing on the crankshaft repair production in the automotive division of the production department at Intidaya Dinamika Sejati LTD. The duration required for each activity, the distance traveled, and the level of inventory at each stage of production. The identification of activities becomes easier due to their classification into four categories: inspection, delay, transportation, and storage [5].

Table 1. Process Activity Mapping Crankshaft Diesel

No.	Process	Activity	Activity					Time	Machine/ tools	Operator	VA/NVA /NNVA
			O	T	I	S	D				
1	Preparation	measurement and inspection of crankshaft damage			V			15 minute	micrometer, cylinder bore gauge, vernier caliper	1	VA
		down payment			V				computer	1	
		creating a work order (SPK)			V				computer	1	
		transferring the crankshaft to the unloading area		V				2 minute	hand pallet	1	NVA
2.	Unloading	crankshaft held in queue waiting for its turn				V	V	60 minute	hand pallet		NVA
		transferring the crankshaft to the slep grinding station		V				2 minute		1	NVA
3.	Slep grinding	crankshaft slep grinding process	v					60 minute	2 machine cyl grinding krukas-italy	2	VA
		re-setup and size calibration for each crankshaft repair unit					v	15 minute	machine cyl grinding, micrometer, vernier caliper		NNVA

No.	Process	Activity	Activity					Time	Machine/ tools	Operator	VA/NVA /NNVA
			O	T	I	S	D				
		transferring the crankshaft to the lathe machine		v				1 minute	hand pallet	1	NVA
4	Lathe	crankshaft turning (lathe) process	v					60 minute	2 machine Horizontal Lathe Conventional	2	VA
		re-setup and size calibration for each crankshaft repair unit					v	15 minute	Machine Horizontal Lathe Conventional , micrometer, vernier caliper		NNVA
		transferring the crankshaft to the welding station		v				8 minute	Hand pallet	1	NVA
5	Welding	welding process for cracked crankshafts	v					30 minute	2 welding S.M.A.W redbow	2	VA
		welding wire installation and welding machine setup					v	5 minute	welding S.M.A.W redbow	2	NNVA
		transferring the crankshaft to quality control		V				5 minute	Hand pallet	1	NVA
6	Quality control Preparation	accuracy check, re-measurement, and precise adjustment	V					15 minute	vernier caliper, micrometer, dan dial Gauge	2	VA
		measurement and inspection of crankshaft damage		V				5 minute	Hand pallet	1	NVA
		14% of crankshafts that fail qc are reworked					V	60 minute	Machine bubut/cyl grinding/las S.M.A.W redbow	1	NVA

Root Cause Analysis (RCA) is a problem-solving method aimed at identifying the root causes of a problem or event and addressing the contributing factors responsible for the issue. RCA is used to uncover the underlying causes of a problem and determine the primary root cause [6].

Based on the observations and collected data, it was found that the most significant types of waste are waiting time The waiting time waste occurs due to queues at the unloading area before entering the production line, as well as the transfer of each crankshaft unit between the lathe machine, grinding machine, and quality control process. This is caused by the limited machine capacity and suboptimal coordination between processes.

The cause-and-effect diagram (also known as the Ishikawa or fishbone diagram) is a graphical representation that shows the relationship between causes and effects [8]. In the context of statistical process control, this diagram is used to identify causal factors that affect the quality characteristics of a process.

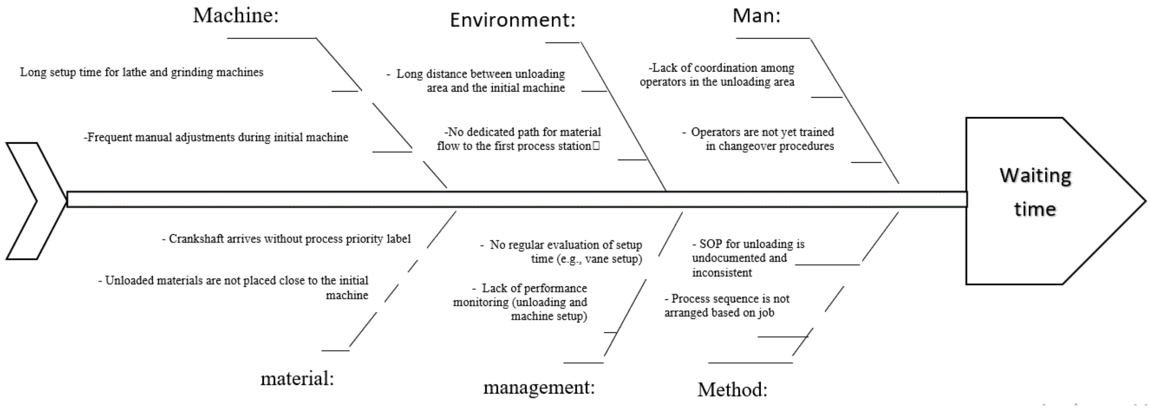

Figure 2. Fishbone Diagram

The 5W+1H method is an analytical technique used to identify preventive actions for root causes. This approach involves six key questions: What, Who, Where, When, Why, and How [9].

Table 2. Method 5W+1H

Questions	Description	Answer
What	what is the problem?	the high number of excessive waiting time.
Who	who is involved or affected?	operator, teknisi qc, manajer produksi, dan pelanggan.
When	when does this problem occur?	during the production process over the past six months, and waiting time at the unloading process due to queues before entering the production line.
Where	where does this problem occur?	at the welding workstation, and partly at the lathe and grinding stations.
Why	why does this problem occur?	because the company has not fully implemented a lean approach in managing the production flow.
How	how does this problem occur?	because there is no standardized visual system or scheduling between workstations.

Agile Manufacturing is a production system that can quickly adapt to market changes, allowing flexible transitions between product models or lines, particularly to meet consumer demands [10]. At this stage, brainstorming and identification are carried out on the processes that have the potential to be converted into external activities [11]. Initially, all machine setup activities were internal activities [12]. Converting internal activities into external ones means shifting certain internal activities that can be performed outside of machine downtime.

Final score for overproduction = (1×6) + (1×5) + (1×3) = 14. After calculating the final score, the weight of each type of waste is determined by dividing the final score of each waste by the total final score of all types of waste: Weight of overproduction = 14/104 = 0.13

Once the weight values of each type of waste are calculated, the type of waste with the highest weight can be identified. The type of waste with the highest weight is considered the most frequent. Based on the results of the calculation and questionnaire distribution, it is found that the most frequent types of waste are waiting with a weight of 0.20**.**

Table 3. Borda Count Questionnaire Calculation

Waste	Ranking									Final Score	Weight
	1	2	3	4	5	6	7	8	9		
Overproduction			1	1		1				14	0,13
Delay/waiting	1	1	1							21	0,20
Transportation				1	1	1				12	0,11
Inventory			1		1		1			12	0,11
Unnecassary motion					1	1		1		8	0,07

Defect	1	1		1						20	0,19
Not utiliting employees							1	1	1	3	0,02
Exces Process			1				1	1		9	0,08
Overprocessing					1			1	1	5	0,04
M	8	7	6	5	4	3	2	1	0	104	

From the current state map of the diesel engine crankshaft repair process (without rework), it can be observed that the total value-added (VA**)** time in the production process is 180 minutes (3 hours), the total non-value-added (NVA) time is 83 minutes (1.38 hours), and the total necessary non-value-added (NNVA) time is 35 minutes (0.58 hours). All activities require a total lead time of 298 minutes (4.9 hours**)** to complete the crankshaft repair for diesel engines.

The non-value-added activity, namely the waiting time in queue to enter the production line, is considered work-in-process (WIP) and classified as a form of time waste that slows down the production process. In the crankshaft repair process, significant waiting occurs during unloading and transitions between process stations. Therefore, efforts must be made to minimize waiting time waste in order to improve productivity.

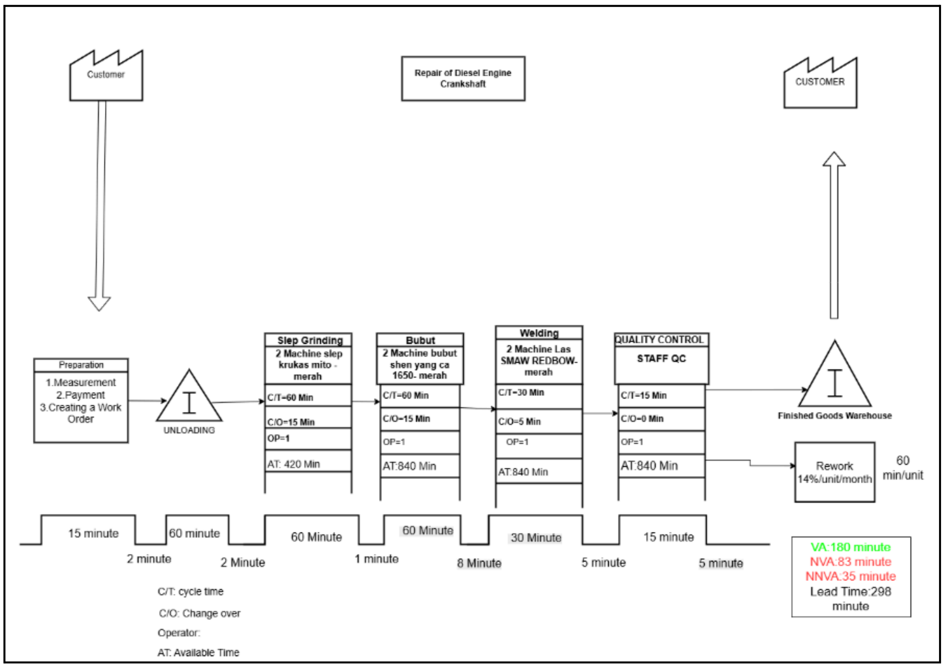

Figure 3. ***Current State Mapping Crankshaft*** **Diesel Cars**

As with the diesel crankshaft process, non-value-added activities, particularly waiting in queue for production, are classified as WIP, which constitutes a time waste that slows down the overall production flow. The crankshaft repair process involves delays at unloading and during transfer between workstations. Thus, minimizing waiting time waste is essential to increase productivity.

The percentage comparison diagram of each activity categorized as VA, NVA, and NNVA is presented as follows:

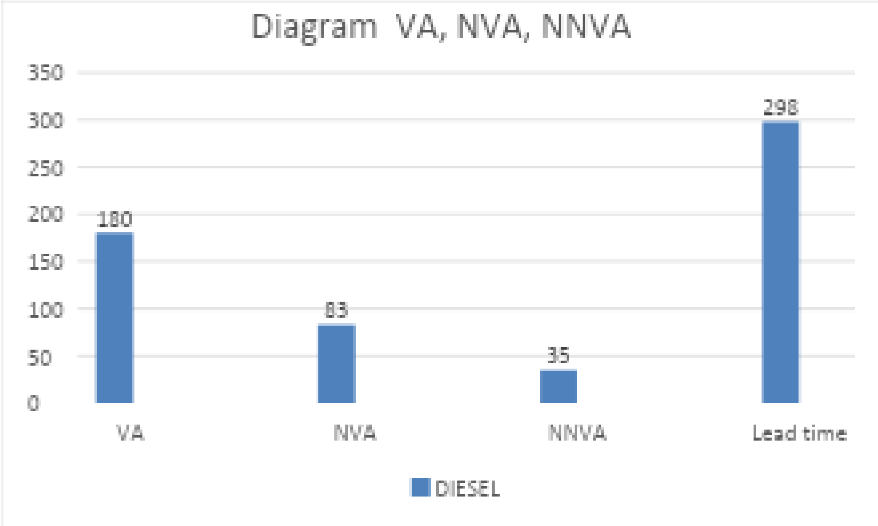

Figure 4. Comparison Diagram VA, NVA, NNVA

Improvements made include eliminating changeover time activities at the spot grinding and spot turning (lathe) processes. The improvement involves removing non-value-added activities at specific process stations**.**

Table 4. SMED Change Over Time Spot Grinding

No.	Actvity	Time	Element		Man
			Internal	External	
1.	Turn off the machine and secure the work area	*2*	*V*		Operator
2.	Remove the old crankshaft fixture	*3*	*V*		Operator
3.	Retrieve and prepare the new crankshaft fixture	*2*	*V*		Asisten /helper
4.	Install the new fixture and adjust its position	*3*	*V*		Operator
5.	Calibrate the position and ensure grinding alignment	*2*	*V*		Operator
6.	Check the availability of coolant and lubricant	*1*	*V*		Operator
7.	Perform an initial trial run	*2*		*V*	Operator
	Total time (minute)	15	13	2	

Table 5. SMED Change Over Time Spot Bubut

No.	Activity	Time	Element		Man
			Internal	External	
1.	Turn off the machine and secure the work area	2	V		Operator
2.	Remove the old crankshaft fixture	2	V		Operator
3.	Retrieve and prepare the new crankshaft fixture	1	V		Asisten /helper
4.	Install the new fixture and adjust its position	2	V		Operator
5.	Calibrate the position and ensure grinding alignment	5	V		Operator
6.	Check the availability of coolant and lubricant	1	V		Operator
7.	Perform an initial trial run	2		V	Operator
	Total time(minute)	15	13	2	

Note: Activities that can be eliminated and improved

From the changeover time table at the spot grinding and spot turning (lathe) stations (totaling 15 minutes), the following internal activities can be converted into external ones in the context of implementing SMED (Single Minute Exchange of Dies): Removing the old crankshaft fixture can be performed while the machine is still running on the previous unit (parallel preparation). Retrieving and preparing the new crankshaft fixture can be eliminated by assigning a helper/assistant to prepare it in advance, before the machine stops. Checking the availability of coolant and lubricant can be eliminated by implementing a daily machine cleanliness and readiness checklist.

3.2 Discussion Comparison of conditions before and after implementation

The implementation of Lean-Agile successfully increased productivity:

1. For diesel crankshaft repairs, the lead time was reduced from 298 minutes (4.9 hours) to 248 minutes (4.1 hours).
2. This improvement was achieved by reducing waiting time in the unloading process from 60 minutes to 15 minutes.

Table 6. Impact of Implementation Lean-Agile

Parameter	Before implementation	After implementation	Improvment	Reason
Productivity				
Lead time (diesel)	298 minute	248 minute	50 minute	reduction time NVA and NNVA
Waste				
Waiting time	60 minute	15 minute	45 minute	rescheduling with two shifts and a visual kanban system
Change over time slep grinding	15 minute	12 minute	3 minute	implementation SMED
Change over time bubut	15 minute	13 minute	2 minute	implementation SMED

Contribution of lean manufacturing focused on identifying waste through VSM (Value Stream Mapping), RCA (root cause analysis), 5w+1h, pareto diagram, and fishbone diagram, particularly for eliminating waiting time and defects. Contribution of Agile manufacturing centered on the implementation of SMED to reduce changeover time in the grinding and turning processes from 15 minutes to 12–13 minutes, priority-based scheduling in the unloading area to reduce queue time from 60 minutes to 15 minutes,

4. Conclusion

The crankshaft repair process at PT. Intidaya dinamika sejati has experienced waste, primarily in two categories waiting time, caused by queues during the unloading process and suboptimal machine changeover time. By applying the lean manufacturing method, particularly value stream mapping (VSM) and process activity mapping, the production process was classified into value-added (VA), non-value-added (NVA), and necessary but non-value-added (NNVA) activities. For diesel crankshaft, the lead time was 298 minutes, consisting of 180 minutes va, 83 minutes nva, and 35 minutes nnva. By integrating the principles of lean manufacturing (process efficiency and waste reduction) and agile manufacturing (flexibility in demand and change), a combined strategy was achieved. From the lean side focus on eliminating key wastes and mapping the process using vsm. from the agile side: emphasis on flexibility as reinforcement (e.g., smed and cross-functional teams) to enhance responsiveness to product variation and market demand, which cannot be fully addressed by lean principles alone.

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