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Optimizing Economic Performance via MES: A Strategic Decision-Making Framework for Apparel Manufacturing

Hariom Kumar Singh [1], Santi Novani [2]

Abstract:

In the dynamic landscape of the apparel manufacturing industry, timely and accurate decision-making is critical to operational success. However, the absence of a real-time monitoring system on the production floor has led to dependency on manual reporting, resulting in data delays, inconsistencies, and even manipulation. These challenges severely limit transparency, responsiveness, and overall efficiency. This thesis addresses this business-critical issue by proposing the implementation of a Manufacturing Execution System (MES) to digitally transform production monitoring and reporting processes. Utilizing the Soft Systems Methodology (SSM), this study explores multiple stakeholder perspectives including production teams, supervisors, and management to define root causes and identify feasible solutions. The research incorporates qualitative insights through interviews and surveys, coupled with best practice analysis to design a context-specific MES framework. The outcome aims to enhance real-time data visibility, streamline workflows, and support data-driven decision-making, ultimately contributing to increased productivity and trust across operational levels.

Keywords: *Manufacturing Execution System, MES, Apparel Industry, Digital Transformation, Real-time Data, Decision-Making, Soft Systems Methodology, Operational Efficiency, Industry 4.0*

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1. Introduction

The apparel manufacturing industry operates in an increasingly fast-paced and competitive environment, where operational agility and timely decision-making are critical to survival. Yet, many garment factories—especially in Southeast Asia—continue to rely heavily on manual processes for production monitoring and reporting (Mohon & Chatterjee, 2018; Silva & Kumari, 2021). These outdated practices often lead to human errors, data delays, and manipulation, which hinder productivity and quality assurance (Tayur & Ganesh, 2020; Shrouf & Miragliotta, 2015). As global demand for efficiency rises, such inefficiencies pose serious threats

[1]*Institut Teknologi Bandung, Indonesia. 29123751@mahasiswa.itb.ac.id*
[2]*Institut Teknologi Bandung, Indonesia.*

to competitiveness, customer satisfaction, and resource optimization (Eisenhardt, 1989; Stevenson, 2020).

At PT. Anggun Kreasi Garmen, for instance, production floor decisions are still based on manually compiled reports from various departments. These reports are not only time-consuming but also prone to inaccuracies due to intentional manipulation or communication gaps (Silva & Kumari, 2021; Mohamed & Alraddadi, 2024). As a result, management often makes critical decisions with incomplete or outdated data, affecting lead times, production planning, and resource allocation (Mohon & Chatterjee, 2018; Gunasekaran et al., 2016). This mirrors the broader issues in similar mid-sized manufacturers, where fragmented information flow limits strategic responsiveness (Elliott, 2013; Rahamaddulla et al., 2021).

Digital transformation has emerged as a potential solution to these issues. Tools like Manufacturing Execution Systems (MES) offer real-time data visibility, streamline workflows, and enable faster and more informed decisions (Costa et al., 2024; Qiu et al., 2020). In the context of the apparel sector, MES adoption has shown to improve transparency, production tracking, and overall efficiency (Ko et al., 2022; Sengupta et al., 2021). Despite these benefits, MES implementation remains limited among SMEs due to cost, customization challenges, and lack of integration with legacy systems (Pfeifer, 2021; Tata Technologies, 2019; Frost & Sullivan, 2021).

Research on MES in the garment industry has mainly focused on large-scale implementations, with little attention paid to mid-sized firms in developing markets (Park & Lee, 2019; Nurdiyanto & Kindiasari, 2024). Moreover, existing studies often overlook human and organizational dynamics that influence the adoption process. This creates a research gap concerning how MES can be successfully contextualized and implemented in people-centric, resource-constrained environments (Presley, 2002; Shojaeinasab et al., 2022). Addressing this requires a methodological approach that not only considers technical aspects but also engages stakeholders in identifying operational pain points and opportunities.

To bridge this gap, this study employs Soft Systems Methodology (SSM), a qualitative, participatory approach ideal for diagnosing complex, ill-structured problems in socio-technical systems (Checkland & Poulter, 2006; Tako & Kotiadis, 2019). SSM has been successfully applied in similar organizational contexts, such as the sugar industry and public universities, to uncover systemic issues and co-create feasible interventions (Gerwel Proches & Bodhanya, 2015; Md Saad et al., 2012). By integrating stakeholder perspectives from production workers to top management, the approach supports holistic problem-solving and system redesign (Kotiadis, 2007; Davenport, 2013).

The novelty of this research lies in combining SSM with MES design for a real-world case in the Indonesian apparel sector. While MES is a widely recognized solution, its contextualization using participatory systems thinking has not been deeply explored in the domain of labor-intensive manufacturing (Mohamed & Alraddadi, 2024; Shojaeinasab et al., 2022). This study also incorporates regional insights into SME readiness and transformation challenges, providing new empirical evidence from Southeast Asia (Rahamaddulla et al., 2021; Frost & Sullivan, 2021). Additionally, it contributes to the literature on agile manufacturing and the role of information systems in operational strategy (Gunasekaran et al., 2016; Shrouf & Miragliotta, 2015).

The objective of this thesis is to propose a stakeholder-informed MES implementation framework for PT. Anggun Kreasi Garmen. The research seeks to (1) identify the root causes of data-related challenges, (2) evaluate the feasibility of MES adoption using SSM, and (3) design a practical and scalable digital roadmap that supports strategic decision-making and productivity (Costa et al., 2024; Elliott, 2013). In doing so, the study aims to support the company's long-term digital transformation goals and offer a replicable model for similar mid-sized manufacturers navigating the shift to Industry 4.0 (Ko et al., 2022; Pfeifer, 2021).

2. Theoretical Background

Strategic Decision-Making
Strategic decision-making in a dynamic environment demands more than intuition—it requires timely data visibility, reliable information, and the evaluation of appropriate alternatives to align strategy with operations. Organizations that succeed in high-velocity industries rely on rapid access to operational data to foster informed decision-making (Eisenhardt, 1989; Davenport, 2013). This underscores the importance of Manufacturing Execution Systems (MES), which provide real-time data visibility and operational transparency, enabling managers to make timely and accurate decisions (Costa et al., 2024; Qiu et al., 2020).

Soft System Methodology
Soft Systems Methodology (SSM) is a thinking process developed to address real-world, messy problems characterized by human-centered conflicts and ambiguous goals. It is especially effective in situations involving multiple stakeholders and differing perspectives (Checkland & Poulter, 2006; Kotiadis, 2007). SSM enables collaborative engagement to explore systemic issues and identify shared solutions (Md Saad et al., 2012; Tako & Kotiadis, 2019).

Manufacturing Execution System (MES)
MES is an integrated software solution designed to monitor, control, and optimize manufacturing operations. Serving as a bridge between ERP systems and the production floor, MES supports digital transformation in manufacturing by

enhancing real-time data visibility and process control (Ko et al., 2022; Shojaeinasab et al., 2022). Its key functionalities include work-in-progress (WIP) tracking, machine and labor monitoring, quality assurance, production scheduling, and efficiency management (Qiu et al., 2020; Mohamed & Alraddadi, 2024).

In apparel manufacturing, where processes are interdependent, time-sensitive, and labor-intensive, MES helps overcome issues related to manual reporting and fragmented visibility (Park & Lee, 2019; Sengupta et al., 2021). Implementing MES in garment factories has shown significant improvements in delivery performance, quality control, and decision-making speed (Silva & Kumari, 2021; Nurdiyanto & Kindiasari, 2024).

MES supports strategic decision-making by providing real-time operational data, enhancing quality control and enabling transparency across production stages (Gunasekaran et al., 2016; Pfeifer, 2021). It eliminates the reliance on manual or paper-based reporting, improving traceability and accuracy in a high-paced manufacturing environment (Elliott, 2013; Ko et al., 2022).

Production Floor Challenges in Apparel Manufacturing

Apparel manufacturing is process-sensitive and heavily dependent on manual coordination, from cutting and sewing to finishing and packaging. This dependency leads to inefficiencies, especially when data visibility is limited due to manual systems (Mohamed & Alraddadi, 2024; Stevenson, 2020). Production floor managers often struggle with delayed decision-making and inaccurate reporting.

Manual Data Entry Issue

Manual data entry through spreadsheets or handwritten logs is prone to manipulation, delays, and human error (Mohon & Chatterjee, 2018). Such errors result in inaccurate reporting of downtimes and production figures, which can hinder production planning and delivery schedules (Silva & Kumari, 2021; Tayur & Ganesh, 2020).

Lack of Real-Time Performance Metrics

Without real-time performance metrics, managers rely on end-of-shift data, which is often too late for corrective action (Tayur & Ganesh, 2020). Only a small percentage of factories in Southeast Asia have tools for real-time monitoring, which limits their responsiveness to production issues (Frost & Sullivan, 2021).

MES vs Manual Reporting

Comparative studies show that MES implementation significantly enhances factory performance. In one case, MES-enabled factories achieved improved on-time delivery and reduced downtime discrepancies (Silva & Kumari, 2021). These

improvements result from real-time data collection and analysis, allowing supervisors to address production bottlenecks effectively (Ko et al., 2022).

Industry 4.0 and Digital Transformation
Industry 4.0 represents a new wave of interconnected, data-driven manufacturing powered by IoT, CPS, and real-time analytics (Shrouf & Miragliotta, 2015). More than automation, it focuses on how data flows through systems and informs autonomous decision-making (Davenport, 2013; Gunasekaran et al., 2016).

Readiness of Small & Medium Enterprises (SMEs) for Digitalization
Digital transformation offers significant benefits to SMEs, including enhanced data visibility and traceability. However, budget constraints, limited infrastructure, and digital literacy remain key challenges (Rahamaddulla et al., 2021; Pfeifer, 2021). Many SMEs still operate with legacy systems and lack full digital integration (Frost & Sullivan, 2021).

Critical Success Factors for MES Implementation
Successful MES implementation depends on technical compatibility, organizational commitment, and human factors (Shojaeinasab et al., 2022; Ko et al., 2022). MES must integrate with existing ERP systems to avoid redundancy and inefficiencies (Qiu et al., 2020; ARC Advisory Group, 2020).

Organizational and Human Factors
Top management involvement and stakeholder participation are essential for MES project success (Boston Consulting Group, 2021). Employee resistance due to fear or lack of training is a common barrier (Tata Technologies, 2019). Addressing this requires early user involvement, adequate training, and change management strategies (Checkland & Poulter, 2006; Tako & Kotiadis, 2019).

Conceptual Framework
Conceptual Framework emphasizes in the themes explored in theoretical review. The study addresses the issue of manual reporting, lacking of available real-time data, delay in strategic decision making at PT. Anggun Kreasi Garmen. It illustrates the relationship between current messy problem and solution associated with it of effective implementation of Manufacturing Execution System (MES).

The framework highlights manual reporting, lacking real-time matrix, and inconsistent reporting as the part of input of the problem. Operational inefficient and delayed strategic decision reflects the main root of the problem in this case study. Enabling factors includes integration with existing ERP, organizational leadership and governance, and adoption and training to the respective stakeholders during this implementation. Outcome enables the accurate and faster reporting, visibility of real-time data, improving strategic decision making, and improved operational efficiencies.

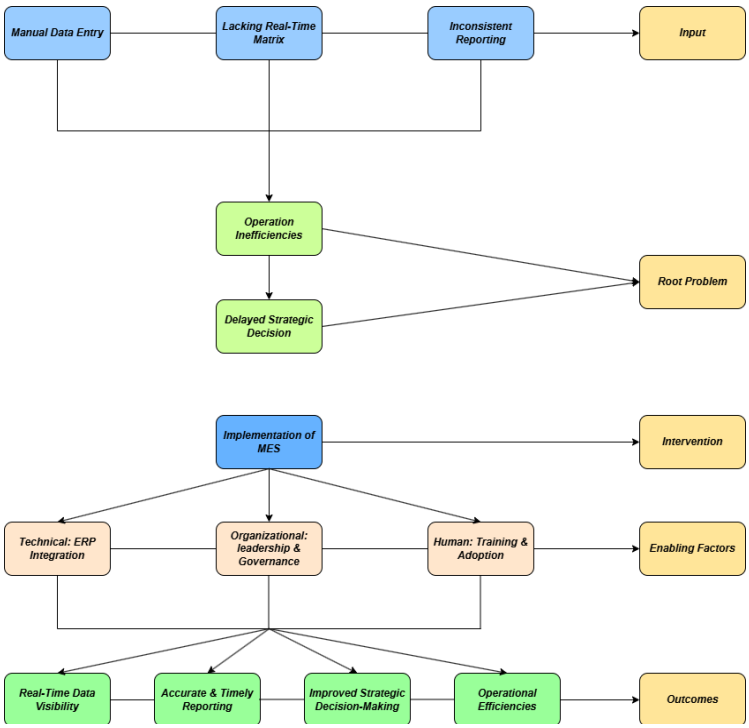

Figure 1. Conceptual Framework

3. Methodology

Soft System Methodology (SSM) is a methodology, specifically used for solving human-centric, ill-structured, messy and diverse opinion and observation of the individuals and the group. This method has been chosen to dug deep in the understanding of research questions with help of Soft System Methodology (SSM) to provide a holistic understanding of research questions.

Question 1 (Q1) it will explore the bottleneck in current practice such as human centric approaches, manual reporting, missing real-time visibility about production operations and how it is affecting current decision-making. Question 2 (Q2) will emphasize on implementation of Manufacturing Execution System (MES) to improve overall real-time data visibility, precise and accurate report, production operation visibility, transparency of data, and it's effectiveness in strategic decision-making. Question 3 (Q3) will explore the possible enables that are important in order to consider the implementation of a Manufacturing Execution system. It is vital to take the enables in consideration to ensure successful implementation of Manufacturing Execution System at PT. Anggun Kreasi Garmen.

4. Empirical Findings/Result

Soft System Methodology (SSM) Analysis
In this section, we will apply the Sofy System Methodology (SSM) at PT. Anggun Kreasi Garmen, utilizing multiple perspective and assumptions of the stakeholders. It will be consist of seven steps of Soft System methodology (SSM).

Stage One: Addressing Problematic Situation
Through out the data collection, the data was collected through interviews, focused group discussion and surveys. Several key issues were highlighted and given specific attention to address. Referring to discussion with stakeholders we agree that there are multiple hurdle on production floors operations digitalization which is leading to inefficiency to multiple processes and operations.

Although, the reason and root cause of each issues can be bifurcated in multiple bucket but the root analysis suggest due to lack of availability of the data on real-time construct unavoidable issue at production floor.

In current era of digitalization where companies invest heavily in digitaization, it is vital for the factories in South East Asia also catchup with the market trend including PT. Anggun Kreasi Garmen. The buyer also prefers wo work with the factories having digital infrastructure in place to have better negotiation for sourcing it's product.

There have been formal suggestions from the buyers to the factories to invest in data visibility and other machinery component to reduce a complete reliance on human-centric Standard Operating Procedures (SOPs).

Given these scenarios, it become important for the manufactures to come forward towards in catching the race of digitalization and industry 4.0. While there remarks are making valid points, but in complete digitalization in apparel manufacturing depends on the cooperations from multiple stakeholders such as buyer, manufacturer/factories (PT. Anggun Kreasi Garmen).

Apparel manufacturing is very versatile and dynamic business where the material requirements and the methos of producing the garments changes for each and every styles, it makes difficulty for the manufactures also to integrate it system with raw material supplier as there are hundreds of materials used in order to produce a ferment and raw material suppliers might also vary depending on the type of material and competence of the supplier to produce such raw materials.

However, having Manufacturing Execution System (MES) in place, it does not reduce and hurdle we have due to lack of integration with supplier system to

manufactures, but it provides and consolidate view about the operations and its governance within the factory.

While there are few Manufacturing Execution System (MES) in the market and their subject to integration might vary on the Enterprise Resource Planning (ERP) system that they are using. Having said that and highlighted earlier in enabler aspect (Figure: II.6), it is vital foe the manufactures also to select right Manufacturing Execution System (MES) to keep up to its expectancy and being used in a positive growth of the organization. Few on the main aspects and expectations from Manufacturing Execution System (MES) is mentioned as below:

a. Ability to Automatically plan the fabric roll for cutting process: Each and every fabric roll received from the supplier might vary in it's length. It is important that a Manufacturing Execution System (MES) identify right fabric rolls to be load for cutting in order to achieve highest output and less wastage of the raw materials.
b. Availability of cutting room solution and ability to understand bundling aspects: The cutting room solution is the concept that only applies in cutting process in apparel manufacturing. The moment fabric are cut, they are not accounted in the form of garments/finished goods but they are accounted in the form of panels which later in subsequent processes takes the form of garment which finally results in a finished goods garment. Management expectation for Manufacturing Execution System is to understand the bundling concept and should have a smooth transfer to subsequent process with output accountability.
c. Production Process Output and Integration with output: In Apparel there are multiple process involved to produce the finished good product, a sample example for expressing the process would be: Cutting, Sewing, Finishing, Packing.
   The output of these process should be integrated with Enterprise Resource Planning (ERP), eliminating the need of accounting production output in Enterprise Resource Planning (ERP) again. Results in reducing workload on the teams while giving a holistic view about production status in real-time.
d. Provision of Quality Inspection: The Manufacturing Execution System (MES) should facilitate the quality related operation on the production floor such as endline QC, inline QC, QC repots, and unexpected quality check on buyer request.
e. Production Planning: The Manufacturing Execution System (MES) should facilitate the production planning module to ensure planned and actual productivity of the style or the goods produced in the process and with overall output post all the production processes.
f. Line Planning: Most of the manufacturing institutions manages the skill matrix of the operators, the Manufacturing Execution System (MES) should be able to plan the line-wise planning for each operator level bringing the use

of machine learning and artificial intelligence to ensure utilization of right person for the right process in right production line.

g. Machine Maintenance: The Manufacturing Execution System (MES) should have the module to maintain required operations for machine downtime, assigning mechanics, and issue resolution end to end. It also involves the stockpiling of machines and spare parts by mechanic department.

h. Time & Action Calendar: Integrated time and action calendar to keep track of production operations and their delay, if any.

Stage Two: Rich Picture of Production Process at PT. Anggun Kreasi Garmen

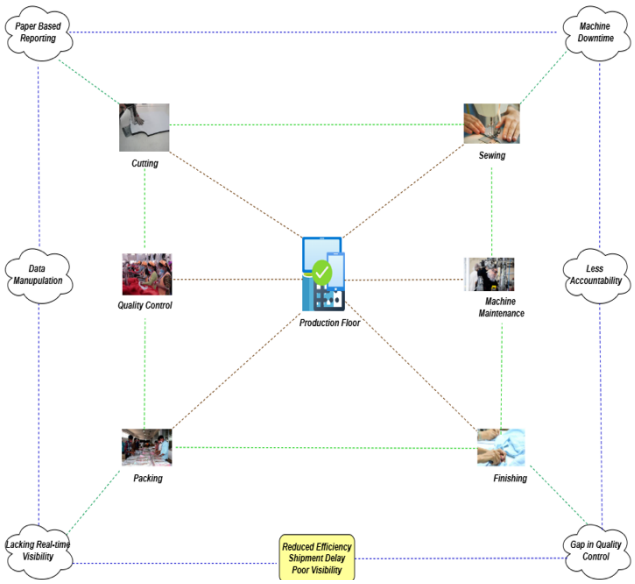

Figure 2. Rich Picture of Production at PT. Anggun Kreasi Garmen
Source: Author (2025)

To better understand and communicate the messy problem on the production floor, a Rich Picture was created to reflect the real conditions at PT. Anggun Kreasi Garmen. This visual map helps highlight the complex web of issues that affect day-to-day operations, especially in the absence of digital tools for reporting and monitoring.

At the center of the picture is the Production Floor, which serves as the operational heart of the factory. Surrounding it are key processes like Cutting, Sewing, Finishing, and Packing, along with support functions such as Quality Control and Machine Maintenance. Each of these areas connects to common challenges observed in the field.

Some of the core issues include:

a. Paper-Based Reporting, which makes it hard to maintain consistent records and causes delays in tracking progress.
b. Data Manipulation, where manual entries can be changed or adjusted, often without any clear trail or accountability.
c. Lack of Real-time Visibility, meaning managers and staff can't see what's happening on the floor at any given moment, making fast decisions difficult.
d. Machine Downtime, which often catches teams off guard due to the absence of a proactive maintenance system.
e. Less Accountability, since there's no digital audit trail to track who did what and when.
f. Gaps in Quality Control, with manual checks that vary in consistency and sometimes miss defects altogether.

The Rich Picture doesn't just highlight technical or process-related issues, it also reflects how these problems are interconnected. For example, when reporting is slow or unclear, it affects production planning, quality, and even employee performance. When quality checks fail or machines break down unexpectedly, it slows everything else down.

Reduced Efficiency, Shipment Delays, and Poor Visibility. These are not just outcomes, they're daily realities faced by people working on the floor.

This Rich Picture acts as a bridge between what's really happening and the structured problem-solving process that follows. It helps everyone, management, supervisors, and staff, to see the full picture, not just their part of it. It also sets the stage for the next parts of the analysis, including CATWOE, conceptual modelling, and exploring practical improvements.

Root Cause Analysis

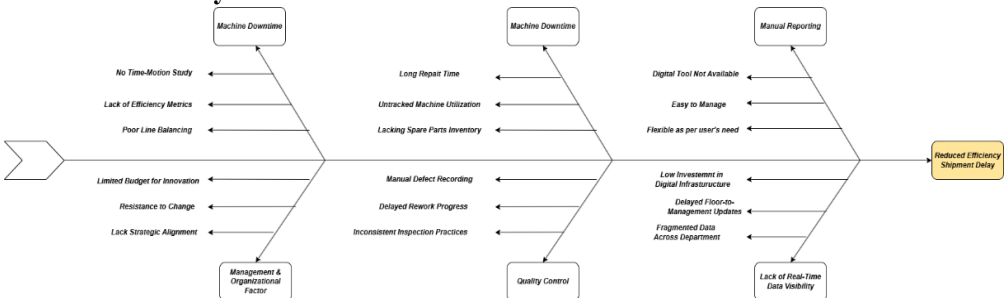

Figure 3. Fishbone Diagram
Source: Author (2025)

To explore the underlying causes of the production inefficiencies at PT. Anggun Kreasi Garmen, a Fishbone (Ishikawa) diagram was developed. This tool helps visually break down the multiple contributing factors behind the key problem identified in the research: Reduced Efficiency, Shipment Delays, and Poor Visibility.

The analysis categorizes causes into six main branches: Manual Reporting, Lack of Real-Time Data Visibility, Machine Downtime, Quality Control Issues, Industrial Engineering Gaps, and Management & Organizational Factors. Each category represents a cluster of issues that collectively create bottlenecks and performance gaps on the production floor.
For example:

a. Manual Reporting includes the ongoing reliance on paper or Excel-based processes, lack of digital tools, and the flexibility these manual systems offer, which ironically reinforces resistance to change.
b. Real-Time Data Gaps highlight how fragmented systems, the absence of MES or ERP integration, and insufficient investment in infrastructure limit management's ability to make fast, informed decisions.
c. Machine Downtime covers the lack of preventive maintenance, untracked machine usage, and long repair lead times, all of which disrupt the smooth flow of production.
d. Quality Control Issues point to inconsistencies in manual inspection, delayed defect detection, and the absence of automated quality alerts.
e. Industrial Engineering Gaps reflect the absence of structured time-motion studies, poor line balancing, and a lack of productivity metrics or efficiency tracking.
f. Management & Organizational Factors, the newly added category, acknowledges that beyond technical and operational issues, cultural resistance, unclear digital strategies, limited innovation budgets, and poor cross-department communication all play critical roles in why systemic improvements are difficult to achieve.

This structured analysis provides a comprehensive view of the root causes that need to be addressed, reinforcing the idea that solving the production challenges is not only about adopting new technology but also about aligning people, processes, systems, and leadership. The Fishbone diagram thus serves as a roadmap for identifying targeted interventions that the proposed MES implementation could address.

Stage Three: Root Definition Using CATWOE

Upon a comprehensive analysis of current manual system at PT. Anggun Kreasi Garmen management, and stakeholders acknowledges the shortcoming with current system. The report developed using Soft System Methodology (SSM) provides a clear picture and understanding about the issues and relevant solution on current

system to reduce ongoing issue with right and recommended solutions. Using the CATWOE framework (Customers, Actors, Transformation, Worldview, Owners, Environmental Constraints), this analysis identifies the key players, processes, and challenges involved in shifting from manual to digital reporting systems through Manufacturing Execution System (MES) implementation.

CATWOE Analysis

Table 1. CATWOE Analysis

Element	Description	PT. Anggun Kreasi Garmen Scenario
Customers	Who benefits from the system	Factory management, production planners, and external buyers
Actors	Individuals or groups involved in the system	Floor operators, supervisors, industrial engineering (IE) team, quality control staff, and mechanics
Transformation Process	How inputs are turned into outputs	Shifting from manual reporting to a Manufacturing Execution System (MES) that enables real-time tracking and supports better decision-making
Worldview	The broader social, economic, or organizational context	Having accurate, real-time data is crucial for maintaining efficiency and staying competitive
Owner	Who is accountable for the system	Senior management, including the CEO, Head of Production, and Head of Finance
Environmental Constraints	Limitations the system must operate within	Budget restrictions, IT infrastructure, workforce preparedness, and production time pressures

Customers: The primary users benefiting from the system are factory management, production planners, production supervisors, quality control team, and industrial engineers who rely on the timely and accurate data available on real-time data for faster and accurate strategic decision-making.

Actors: The main involved actors are the production staff, quality control staff, Information technology, and the factory management for governance and direction for the implementation of Manufacturing Execution System (MES).

Transformation Process: This process shift the work from manual reporting, human centric data collection, dependent on the teams for delayed report to a real-time readily data available for faster decision-making process. Manufacturing Execution System's (MES) scope covers way beyond this as it integrates the factory with industry 4.0 and also enhances factory efficiency and buyer visibility.

Worldview: The core belief of today's world is fast moving apparel manufacturing company. It is versatile in nature and having Manufacturinfg Execution System (MES) in place will enable the managers to take faster and accurate decision-making. It will also be crucial for maintaining efficiency and keeping the factory competitive locally and internationally in the market.

Owner: The system is overseen by the management and the leaders of the company sich as Chief Executive Office, Factory Manager, Chief Finance Officer who are responsible for making decision, allocation budget and resources for the project allocation.

Environmental Constraints: The system must operate within given circumstances and budget allocation for management. The system should align with the existing Enterprise Resource Planning (ERP). It should be well within considering the environmental aspects to ensure the implementation of the Manufacturing Execution System (MES) for a long period of time.

Root Definition

A well-designed and digitalized system owned by senior management and operated by multiple departments such as production planners, quality control, industrial engineers, mechanics making it an overall packaged solution for digitalization and real-time data visibility. An implementation of Manufacturing Execution System bring the visibility and accountability to the team down-the-line. It also provides an edge over it's competitor to compete in the market, enabling the company for better negotiation with buyer and suppliers, making Manufacturing Execution System (MES) and bridge for win-win solution for all the stakeholders involved.

Stage Four : Conceptual Model to Integrate System to Improve Efficiency

Purpose of Conceptual Model

The purpose of conceptual model is the define and outline the processes within PT. Anggun Kreasi Garmen to achieve the transformation mentioned in stage 3. Identifies required steps and move in from ill-structures manual work to a data-drive Manufacturing Execution System (MES) enabled accurate, faster, and strategic decision-making in real-time.

Conceptual Model Activities

a. Collect real-time production data
   This activity focuses on collecting the real-time production, quality, mechanical data on production floor from cutting, sewing, finishing & packing, including quality defects, passed, and rejected garments. Without continuous data collection, it is impossible generate real-time data which contributes to dynamic decision making.
b. Automate data entry and reporting
   Currently, there is an extensive use of manual data entry through help of

Excel, pen-paper, and other available tools. Systemized data entry will enable the availability of real-time reports and less reliant on teams to provide the data. Manufacturing Execution System (MES) reduces the risk of inconsistency or manipulation, and provides a clear picture about production status to the management and other involved stakeholders.

c. Enable performance monitoring (KPIs, dashboards)
With continues data flowing into the system, it provides the management and managers to analyze the KPIs on real-time to identify the bottleneck in the process such as defects rate, efficiency, and machine utilization.

d. Integrate quality control and defect tracking
Quality control related activity such as inline inspection and end line inspection are being performed manually currently and it is inconsistent. By integrating the quality control module directly in Manufacturing Execution System (MES) will capture the quality defects, flags issue promptly, and support in better root cause analysis.

e. Incorporate machine maintenance scheduling
Machine breakdowns causes unplanned production downtime, disrupts overall production schedule, and results in efficiency loss. By directly integrating machine maintain ace with Manufacturing Execution System (MES), will provide concise data about machine's health, scheduled machine maintenance, reduces sudden failure and overall equipment effectiveness.

f. Provide data-driven decision support
One of the main features of Manufacturing Execution System (MES) is to provide the real time, accurate, consistent, and concise data which helps the managers to avoid instinct based decision-making, and allow them to make data-driven decision-making that ensures better decision-making.

g. Facilitate communication across departments
Many current issue arises due to poor communication between the department regards to planning, production output, quality inspection and machine downtime. Having a Manufacturing Execution System in place shares the same data which can be utilized to avoid misleading communication gap, and improves the communication between the departments for real-time communication and decision-making.

h. Regularly review and refine system outputs
No system works perfectly from the start. This activity focuses on continuous monitoring of the system, gathering user feedback, identifying bottleneck and weaknesses. This ensures the Manufacturing Execution System (MES) meets factory's challenging needs.

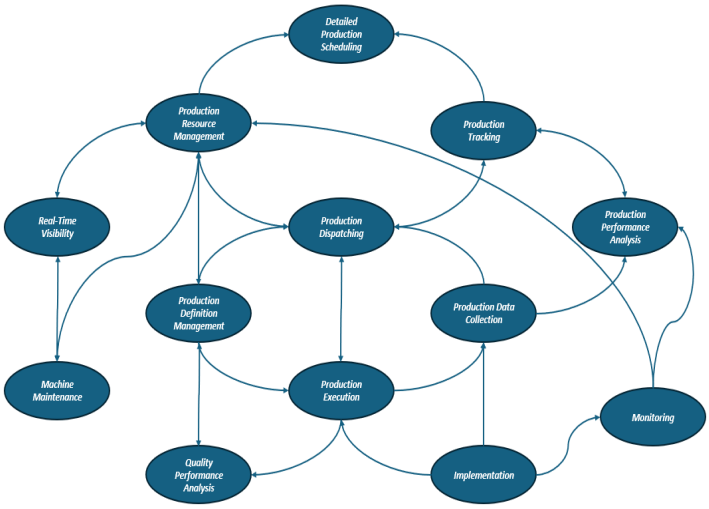

Figure 4. Conceptual model
Source: Author (2025)

This conceptual model visualizes and transformed the digital improvement is needed at PT. Anggun Kreasi Garmen from manual reporting and managing operation to a data-driven digitalize solution. It does not addresses the current operational challenges but provides a structured framework form improvement.

Anticipated Outcomes

a. Improvement in production efficiency and lead time reduction
b. Increase accuracy and trust in production and quality data
c. Enhances decision-making speed and quality
d. Reducing manual wok for the staff, allowing them to focus on other higher priority commitments
e. Improved cross-departmental communication and visibility
f. Strengthening operational foundation

Stage Five : Comparing the Conceptual Model with the Real-World

At this point of research, our focus shifts to comparing the conceptual model developed earlier to comparing that with real-world situation at PT. Anggun Kreasi Garmen. It is important to analyze that as it compares the ideal state of the attributes, current situation at PT. Anggun Kreasi Garmen, and what PT. Anggun Kreasi Garmen can do to improve ongoing manual recording data and shifts to a full digitalized smart production floor.

While PT. Anggun Kreasi Garmen have the stock IT Infrastructure, applications, and system in place to serve multiple aspects of digitalization within the organization, few of them are such as Enterprise Resource Planning (ERP), Power BI, automated

application to server it's purpose, SQL Server Reporting Services. However, these applications are mainly for other purposes leaving a blank spot on production floor for digitalization. Operations of production floor is still being managed manually currently.

Table 2. Comparison of Models with Reality

Proposed MES Activity	Ideal State	Current Situation	What the Company Can Do
Real-Time Production Data Capture	Live data is automatically collected from machines and operators, flowing into dashboards and management tools.	ERP system and reports exist, but production-floor data is gathered manually; there's a time lag between operations and reporting.	Install MES terminals or IoT sensors to capture real-time data and feed it directly into dashboards, improving visibility and decision-making.
Automated Reporting & Dashboards	Automated, live reports show production progress, KPIs, and bottlenecks.	Power BI and SSRS provide useful reports, but they rely on delayed or manual inputs from the shop floor, limiting their real-time usefulness.	Connect MES to the existing BI environment to generate real-time dashboards that combine production, quality, and planning data.
Quality Control Integration	Quality checks are seamlessly integrated into the MES, tracking defects and issues as they happen.	Quality inspections happen, but data is collected manually and not always linked to other systems or analyzed in real time.	Integrate MES quality modules so quality checks flow automatically into the system, enabling immediate corrective actions.
Preventive Maintenance Scheduling	Machines are monitored for performance and health, and maintenance is scheduled proactively.	Maintenance activities are mostly reactive, based on breakdowns; ERP tracks some maintenance records but without predictive tools.	Add MES maintenance features or link MES with ERP maintenance data to develop preventive maintenance plans.
Cross-Departmental Coordination	MES acts as a central hub connecting production, planning, maintenance, and	Departments operate with limited cross-visibility; communication is often manual, creating gaps.	Use MES to create a unified data and communication platform so all departments work from the same real-

Proposed MES Activity	Ideal State	Current Situation	What the Company Can Do
	quality teams with real-time shared data.		time information.
Continuous Improvement & Monitoring	MES provides reliable data to support regular reviews, performance monitoring, and improvement initiatives.	Improvement efforts rely on delayed or manually compiled reports; real-time insights are lacking.	Use MES to generate live performance reports and trend analyses that fuel structured, data-driven improvement cycles.
Structured Change Implementation & Tracking	Changes are introduced systematically, with clear monitoring and evaluation of their effectiveness.	Process changes are often informal and lack structured follow-up; it's hard to assess whether they deliver the intended benefits.	Develop formal change management processes within the MES environment, allowing for controlled implementation, tracking, and adjustment.

Business Solution

Stage Six : Solution Analysis – Recommended Strategic Move

Soft System methodology has helped in identifying the ill-structured problem within PT. Anggun Kreasi Garmen. Reference from stage 5, the recommendations here are focused on real-time data visibility, operational efficiency, ease for managers to take accurate and data-driven decisions, production planning, line balancing and machine breakdown, quality control, all these aspects to take place to provide the data in a digital manner in real-time.

Recommended Strategic Move

Introduce Manufacturing Execution System (MES) as a Focused, Purposeful-Built Solution.

Rather than spreading multiple tools and applications, company should focus on implementing a single purposeful-built Manufacturing Execution System (MES). This will bridge gap between management and operation on the production floor, allowing rea-time data visibility and better decision-making.

Bring real-time Production Tracking

By setting up production floor spots, and tablets, the team can start collecting live data of machines, operator progress, and work-in-progress counts. This shifts the

company from replying on manual data to system-driven data to respond faster on strategic-moves.

Integrate Quality Control Directly into The System
Right now, quality checks are recorded manually, often on paper pr spreadsheet, and do not connects to the border data flows. By embedding quality module directly into Manufacturing Execution System (MES), company can track the defects in real-time, trigger alerts when needed, and closes the loop between quality and corrective actions.

Setup preventive maintenance Schedule
Rather than writing machine breakdown, Manufacturing Execution System (MES) can predict the maintenance needed based on performance data. This shifts company toward proactive care, cutting unplanned machine downtime, and keep production running smoothly without any unexpected intervention.

Strengthen Cross-Department Communication and Visibility
Manufacturing Execution System (MES) acts as a sharing hub for all the departments across the company. Reduces misunderstanding and communication between the departments by providing up to date information. Reducing communication gap, and support smoother coordination between the departments.

Build a Culture of Continuous Improvement
With MES generating detailed performance reports and trend analyses, management can establish regular review cycles. This means the company can identify patterns, spot opportunities for optimization, and make improvements.

Support the People Side with Change Management
Rolling out MES isn't just a technology project, it's a change journey. The company should invest in thorough, hands-on training for supervisors, operators, and planners, making sure everyone feels confident using the new system. Creating "change champions" inside the organization can help drive smoother adoption.

Stage Seven: Implementation Approach

a. **Start small**: Pilot the system in one department or line, work out the kinks, and build internal experience.
b. **Scale up**: Once the team is confident, expand MES to other areas, adjusting based on early lessons.
c. **Integrate carefully**: Make sure MES connects smoothly to the ERP and reporting systems, so data flows seamlessly.
d. **Keep refining:** Use the insights MES provides to continuously improve workflows, address issues, and strengthen teamwork.

Monitoring and Evaluation
This stage focuses on how PT. Anggun Kreasi Garmen will monitor, evaluate, and continuously improve the MES implementation after rollout. The goal is to ensure the system delivers on its promise of improving real-time visibility, production efficiency, and operational control, while also creating space for ongoing refinement based on real-world performance.

Setting Key Performance Indicators (KPIs)
Production Efficiency: Units produced per hour, downtime reduction.
Data Accuracy: Error rates between recorded and actual production data.
Lead Time: Reduction in time from order to shipment.
Quality Performance: Number of defects caught at each stage, rework rates.
Employee Adoption: System usage rates, feedback from operators and supervisors.
Machine Downtime: Machine downtime matrix from all over the production floor.

Roles & Responsibilities
Production Managers: Track day-to-day MES performance, report issues.
IT Team: Maintain system integrity, ensure data flows smoothly into ERP/reporting tools.
Senior Leadership: Review quarterly KPI summaries and set improvement goals.
Operators and Supervisors: Provide feedback on usability, suggest process refinements.

Continuous Improvement Plan
a. Run monthly review sessions to address operational issues.
b. Hold quarterly performance reviews with senior management.
c. Collect regular user feedback to identify pain points and opportunities for further automation or integration.
d. Revisit and adjust KPIs every six months to ensure they remain relevant as the company's capabilities grow.

Anticipated Challenges
There may be an initial learning curve among staff - Addressed through structured training and mentoring.
Some legacy processes may resist integration - Handled by phasing in changes gradually.
System bugs or gaps may arise - Managed through a formal issue-tracking and resolution process, led by the IT team.

5. Discussion

The conceptual model developed in this study proposes a practical roadmap for PT. Anggun Kreasi Garmen to transition from a manually-driven production environment to a digitally-enabled manufacturing floor through the implementation

of a Manufacturing Execution System (MES). This transformation is not only technically necessary but strategically critical for improving real-time visibility, efficiency, and decision-making.

One of the key drivers for the conceptual model is the need to replace manual reporting with real-time data acquisition. Research by Mohon and Chatterjee (2018) highlights the risks associated with manual data entry in apparel production, including inaccuracy, delays, and manipulation. This inefficiency impacts production planning and performance. Integrating MES allows for accurate, live tracking of processes such as cutting, sewing, and packing, which supports rapid decision-making and reduces dependency on delayed spreadsheet-based updates (Costa et al., 2024).

Moreover, the integration of quality control and defect tracking directly within MES resolves existing inconsistencies and allows for early detection of defects. Park and Lee (2019) demonstrated that MES implementation in a Korean garment firm significantly improved inter-departmental visibility and reduced production cycle time. Similarly, Sengupta, Roy, and Kapoor (2021) found that MES adoption improved compliance and delivery performance in Indian textile firms. These findings validate the anticipated outcomes of the proposed system, such as improved quality control and streamlined production flow.

In the context of decision-making, MES provides the infrastructure for data-driven strategies, especially in dynamic, high-velocity environments. As Eisenhardt (1989) argued, strategic agility depends on access to accurate and timely information. With MES dashboards and KPI monitoring in place, managers can shift from instinct-based decisions to informed, analytical responses (Gunasekaran et al., 2016). MES also improves transparency, providing stakeholders with a single source of truth (Shojaeinasab et al., 2022), which reduces operational silos and supports better cross-functional collaboration (Qiu, Wang, & Chen, 2020).

The application of Soft Systems Methodology (SSM) was essential in designing the conceptual model, as it accommodates the complexity of human factors, stakeholder perspectives, and conflicting interests. SSM enabled the research team to analyze ill-structured problems on the production floor, a key limitation of traditional system engineering approaches (Checkland & Poulter, 2006). As demonstrated by Gerwel Proches and Bodhanya (2015), SSM is particularly effective in capturing the social and systemic dimensions of operational change, making it ideal for transformation projects in labor-intensive industries like apparel manufacturing.

The comparison of the conceptual model with the current state at PT. Anggun Kreasi Garmen revealed gaps in digital infrastructure. Although the company has implemented systems like ERP, Power BI, and SQL Reporting Services, these tools

are disconnected from real-time floor operations. This aligns with observations by Tayur and Ganesh (2020), who found that many Southeast Asian garment factories still rely on legacy systems with minimal production-floor integration. MES implementation would bridge this gap by enabling automated reporting and seamless integration with existing ERP and analytics platforms (Ko, Lee, & Cho, 2022).

The readiness of SMEs for digital transformation is a critical concern. Frost & Sullivan (2021) and Rahamaddulla et al. (2021) noted that budget limitations, infrastructure gaps, and low digital literacy are common barriers for small manufacturers. PT. Anggun Kreasi Garmen reflects this reality. However, Pfeifer (2021) emphasized that with structured planning and stepwise implementation, SMEs can successfully integrate MES by starting small and scaling up. This is further supported by the implementation approach in Stage Seven of this study.

Moreover, digital transformation is not just about technology—it is a cultural shift. Tata Technologies (2019) found that 50% of MES implementation delays were due to insufficient training and end-user resistance. Hence, the success of MES at PT. Anggun Kreasi Garmen will heavily rely on proactive change management, including training, user involvement, and the identification of internal "change champions" to foster digital confidence (Md Saad et al., 2012; Tako & Kotiadis, 2019).

In the broader context of Industry 4.0, MES acts as a foundational technology enabling intelligent, interconnected production systems (Shrouf & Miragliotta, 2015). MES facilitates predictive maintenance, as shown in the conceptual model, reducing unplanned downtime—a common issue in apparel production (Mohamed & Alraddadi, 2024). Davenport (2013) emphasized that process innovation, supported by IT, is vital for sustainable competitive advantage. By implementing MES, PT. Anggun Kreasi Garmen not only enhances operational control but positions itself strategically within the global apparel supply chain.

Lastly, continuous monitoring and performance evaluation are central to the success of the MES journey. By setting and tracking KPIs such as production efficiency, data accuracy, and defect rates, the company can move toward structured continuous improvement cycles (Stevenson, 2020). As Elliott (2013) argued, long-term MES success depends on systematic evaluation, integration, and iteration—principles embedded in this research's conceptual and implementation approach.

6. Conclusions

This study has taken a deep dive into the operational challenges faced by PT. Anggun Kreasi Garmen, particularly zooming in on the heart of its production floor. Throughout the research process, it became clear that the company has been struggling with several overlapping issues, from manual processes slowing down

operations and delayed approvals, to poor real-time data access, scattered quality control efforts, frequent machine downtime, and limited visibility across departments. While systems like ERP, SSRS, and Power BI have already been implemented, they haven't fully bridged the gap between day-to-day production activities and management-level oversight, leaving critical blind spots in performance monitoring and decision-making.

One of the biggest insights that emerged is that the absence of a Manufacturing Execution System (MES) is at the core of these challenges. Without MES, the company remains heavily reliant on human effort and manual tracking, which opens the door to inefficiencies, miscommunications, and missed opportunities for improvement. What's particularly important here is that the solution isn't about replacing everything or launching an overwhelming digital transformation all at once. Instead, it's about introducing smart, targeted systems that connect what's already in place, ensuring that production-floor data, machine performance, quality checks, and operational insights flow smoothly and in real time to the people who need them most.

Overall, this research concludes that PT. Anggun Kreasi Garmen has both the need and the opportunity to transform its production operations, making them faster, smarter, and more reliable. By focusing on digital integration, better data capture, and more seamless collaboration across teams, the company can strengthen its performance, boost product quality, and improve customer satisfaction, all while building a more resilient, future-ready organization.

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