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Modeling Business Processes in Food Enterprises According to Business Process Model Notation 2.0

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Abstract

This paper models and analyzes business processes in the food manufacturing industry using (Business Process Model and Notation) BPMN 2.0 to improve operational efficiency and minimize waste. We examine the packaging, storage and distribution processes and identify time losses and bottlenecks in the warehouse area. The study evaluates the impact of shuttle systems on productivity and proposes improvements based on Value Stream Mapping (VSM) analysis of BPMN 2.0 models. The findings aim to strengthen decision-making and contribute to operational excellence in the food manufacturing sector.

Key words: Food production, BPMN, business processes

JEL Code: M11, L66.

1. Introduction

The global food production industry has faced escalating challenges in recent years, compelling businesses to re-evaluate their operational efficiency and effectiveness. The increasing complexity of supply chains, volatility in consumer demands, and the impacts of climate change necessitate food production enterprises adopt modernized processes. Efficient business processes are crucial for enhancing product quality and safety, alongside ensuring sustainability and waste reduction, playing a critical role in addressing the sector's multifaceted issues. These processes act as a framework for continuous improvement, allowing companies to maintain competitive advantage and adapt to evolving market conditions.

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In today's rapidly evolving food industry, effective business process management is vital for achieving operational efficiency, product quality, and customer satisfaction. The inherent complexity of food production—spanning from raw material procurement to final product delivery—demands structured process modeling. Business Process Model and Notation (BPMN) 2.0 has emerged as a leading standard in business process modeling, facilitating communication among stakeholders and deepening process understanding. This study aims to examine the importance of modeling business processes using BPMN 2.0 within a food production company. The food industry faces unique challenges, including stringent regulatory requirements, diverse consumer expectations, and sustainability initiatives. BPMN 2.0 empowers companies to visualize their processes, identify inefficiencies, and implement improvements aligned with industry's best practices.

From the sourcing of raw materials to the delivery of finished products, processes in the food industry form the cornerstone of operational efficiency and sustainability. Each process encompasses critical activities such as sourcing, processing, quality control, and distribution. The effective management of these processes is vital for ensuring compliance with safety and regulatory standards, which are crucial for consumer trust and market competitiveness. The integration of efficient business processes enables food production companies to meet safety and quality standards and satisfy consumer demands, thereby contributing to increased operational efficiency. For instance, lean manufacturing techniques focus on waste reduction and production flow optimization, which is particularly critical for the food industry given its perishable raw materials. By adopting lean principles, food manufacturers can achieve significant improvements in time, cost, and quality, ultimately enhancing overall business performance.

This study emphasizes the importance of modeling business processes in food production enterprises according to the BPMN 2.0 standard. The main objectives of this research are; to identify and analyze time losses and bottlenecks within the warehouse and logistics operations of the facility based on the BPMN 2.0 process models; to evaluate the potential effects of shuttle systems and other optimization strategies on enhancing productivity and reducing space constraints in the warehouse area; to apply VSM to the modeled processes to thoroughly analyze the current state, identify waste, and pinpoint opportunities for lean improvements; and to propose concrete improvement suggestions aimed at increasing operational efficiency, minimizing waste, and strengthening decision-making mechanisms in the food production sector, specifically addressing storage capacity and logistical flow.

The first section is the literature review. The second and third sections are methodology and findings. The last section concludes.

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2. Literature Review

In today's dynamic and competitive business environment, organizations increasingly recognize the need to understand, model, and continuously improve their internal processes. Particularly in production-based sectors such as food manufacturing, where quality, traceability, and efficiency are vital, the ability to visualize and optimize operational workflows becomes a key source of competitive advantage. To that end, BPMN 2.0 has emerged as a widely adopted standard for modeling business processes. Its graphical representation provides a shared language for stakeholders from different departments—technical, operational, and managerial—fostering better communication and alignment across the organization (Dumas et al., 2018).

BPMN 2.0 facilitates the clear depiction of the sequence of activities, decision points, parallel processes, and data flows, making it a valuable tool not only for documentation but also for process analysis and reengineering. Several authors argue that BPMN can be particularly effective when combined with lean thinking methodologies. Lean management, which originated from the Toyota Production System (Ohno, 1988), focuses on the elimination of waste (muda), continuous improvement (kaizen), and maximizing customer value. The synergy between BPMN and lean tools such as VSM, 5S, and Standard Work allows for both high-level strategic analysis and detailed operational diagnostics (Rother & Shook, 2003; Netland, 2016).

According to Çörekçioğlu (2006), process modeling plays a central role in business process management, as it enables organizations to move from intuition-based decisions toward evidence-based improvements. By making processes explicit, BPMN models help identify unnecessary steps, reduce variability, and serve as a foundation for performance measurement. When organizations attempt to adopt lean practices without a clear process map, they risk addressing symptoms rather than root causes. BPMN can thus be instrumental in identifying the real sources of inefficiency and enabling more targeted interventions.

Several empirical studies have validated the effectiveness of BPMN in real-world industrial settings. Laguna and Marklund (2013) demonstrated how BPMN could be used to model production workflows in discrete manufacturing and batch processing environments. By using swim lanes and events, organizations can map the responsibilities of different actors and the flow of materials and information. This capability is particularly relevant in food production, where compliance with food safety regulations (such as HACCP) often requires detailed documentation of each production step. BPMN models also help highlight process interdependence and enable organizations to simulate the impact of potential changes, such as automation or layout redesign.

In a similar vein, Rozinat and van der Aalst (2008) discuss the integration of process mining techniques with BPMN modeling. Process mining involves extracting knowledge from event logs generated by information systems and mapping actual processes based on real performance data. When combined with BPMN diagrams, it becomes possible not only to model the intended process flow but also to compare it against the actual execution and identify deviations. This approach is particularly valuable in continuous improvement efforts, where empirical data can guide decisions on where to focus kaizen initiatives.

The lean approach, especially when applied with BPMN, often utilizes Value Stream Mapping to capture end-to-end process flows, including process time, waiting time, and inventory levels. However, VSM's static nature and lack of standard notation sometimes limit its applicability across complex or cross-functional processes. BPMN, on the other hand, offers a more dynamic and standardized modeling approach that can be further enriched with performance data (del-Río-Ortega et al., 2010). As a result, organizations are increasingly using BPMN as the core modeling language while incorporating lean metrics such as take time, cycle time, and Overall Equipment Effectiveness (OEE) into the logic process.

In the context of warehouse and distribution processes—key components of supply chains, BPMN has also been employed to model and assess material handling, picking systems, and order fulfillment strategies. For example, process inefficiencies caused by manual shuttle systems or suboptimal storage layouts can be visualized and quantified using BPMN. The ability to explicitly model wait times, transport loops, and decision logic allows analysts to simulate alternatives and predict the time savings associated with improvements (Beverungen et al., 2021). This is particularly relevant for operations characterized by high volume and variability, such as those found in the food industry.

Additionally, scholars like Seethamraju and Marjanovic (2009) have pointed out the benefits of BPMN in ERP (Enterprise Resource Planning) implementation projects. BPMN enables organizations to map their "as-is" processes before system deployment and design "to-be" models aligned with best practices and system functionalities. When aligned with lean principles, these models can help organizations avoid the common pitfall of simply automating inefficient processes.

It is important to note, however, that while BPMN provides a powerful descriptive and diagnostic framework, it does not prescribe improvements by itself. Thus, its effectiveness largely depends on how well it is integrated into a broader continuous improvement system that includes lean thinking, performance metrics, employee involvement, and strategic alignment (Harmon, 2019).

In summary, the literature supports the use of BPMN 2.0 as a foundational tool for business process modeling, especially when deployed alongside lean methodologies. In production environments such as food manufacturing, BPMN enables the visualization of complex workflows, the identification of bottlenecks, and the simulation of improvement scenarios. When combined with lean tools like VSM, kaizen, and takt-based scheduling, BPMN modeling not only supports the

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diagnosis of operational problems but also contributes to sustainable performance improvement and waste reduction.

3. Methodology

In this research, we adopt a qualitative and analytical research methodology to model, analyze, and improve key operational processes in a food production enterprise using BPMN 2.0 and Lean Management tools. The methodology is structured in three main stages: (1) process mapping and data collection, (2) process modeling and analysis, and (3) evaluation and improvement proposals based on lean principles.

3.1. Research Design

The research follows a case study approach focused on a specific food production company operating in Azerbaijan. The selected case allows for an in-depth investigation of real-life process complexities, inefficiencies, and improvement opportunities. A single-case, embedded design was chosen due to the availability of detailed process data and the organization's openness to engage in modeling and evaluation.

3.2. Data Collection

Primary data was collected through site visits, direct observation, semi-structured interviews with key stakeholders (e.g., production supervisors, warehouse personnel, and quality control managers), and document analysis (e.g., production logs, inventory records, layout diagrams). Observational studies focused particularly on the post-packaging storage and distribution stages, where time losses and inefficiencies were frequently reported. All data were recorded, categorized, and coded to identify key processes and performance challenges.

3.3. BPMN Process Modeling

The core operational processes—such as packaging completion, internal transport, storage (including shuttle-based systems), and shipment preparation—were modeled using BPMN 2.0. The BPMN standard was chosen due to its ability to represent detailed workflows and integrate both human and automated activities. Modeling was performed using standard BPMN tools such as Camunda Modeler and Bizagi Modeler. Each process model included events, tasks, gateways, and sequence flows that reflected the actual execution in the factory. Swim lanes were used to indicate the responsibilities of different departments or actors.

The modeling process followed the guidelines proposed by Dumas et al. (2018) and adhered to best practices in clarity, completeness, and semantic correctness. Iterative feedback from company personnel ensured the accuracy of the models and helped validate real-time reflections of operations.

3.4. Lean Analysis and VSM Integration

Following BPMN modeling, the processes were further analyzed using lean tools, most notably, VSM. VSM allowed the identification of non-value-adding activities, excessive waiting times, and transport inefficiencies. Attention was paid to shuttle movements, manual transfers, and delays in shelf placement after packaging.

Cycle times, lead times, and batch sizes were recorded and included in both the BPMN and VSM models. Observed inefficiencies such as idle time during shuttle transit or mismatched storage logic were highlighted as potential kaizen targets. Additionally, process metrics such as Process Cycle Efficiency (PCE), take time, and the 7 wastes (muda) framework were applied to assess performance gaps.

3.5. Improvement Design and Evaluation

Based on the lean analysis, alternative scenarios were designed using the "to-be" process modeling approach. These included layout adjustments, standardized shelf placement protocols, and redesign of transport logic. The proposed improvements were visualized using BPMN 2.0 to simulate potential gains in efficiency, responsiveness, and flow continuity.

Stakeholder workshops were conducted to evaluate the feasibility and expected impact of proposed changes. A qualitative impact matrix was developed to prioritize improvements based on ease of implementation, expected cost, and contribution to operational excellence (OpEx). Where available, historical KPI data (e.g., delay times, output rates) was used to benchmark potential improvements.

4. Findings

4.1. Analysis of Current Situation (AS-IS) and Identification of Problems

The products leaving the packaging line are transported to the warehouse entrance with the help of conveyor belts. This process involves receiving and recording the products in accordance with the warehouse layout. After the products leaving the packaging line are transported to the warehouse entrance, operators stack them neatly on pallets. This is a critical stage before the products are moved to the shelves and is important for both order and safety. The palletizing stage lays the foundation for the other steps of the warehouse process to proceed smoothly. Organized and safe placement of products on pallets increases efficiency in both the racking and order picking stages (Figure 1).

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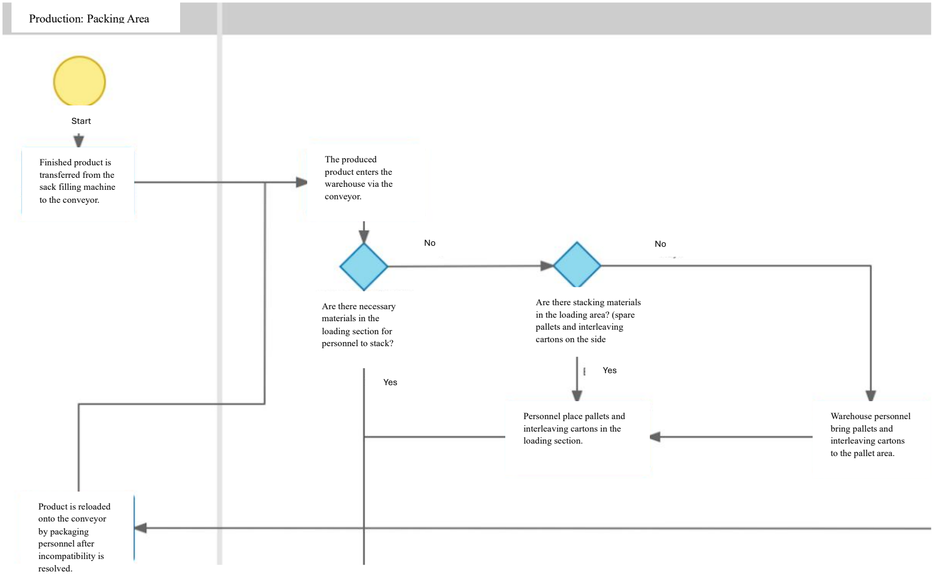
Figure 1. Packaged Goods Entering the Warehouse

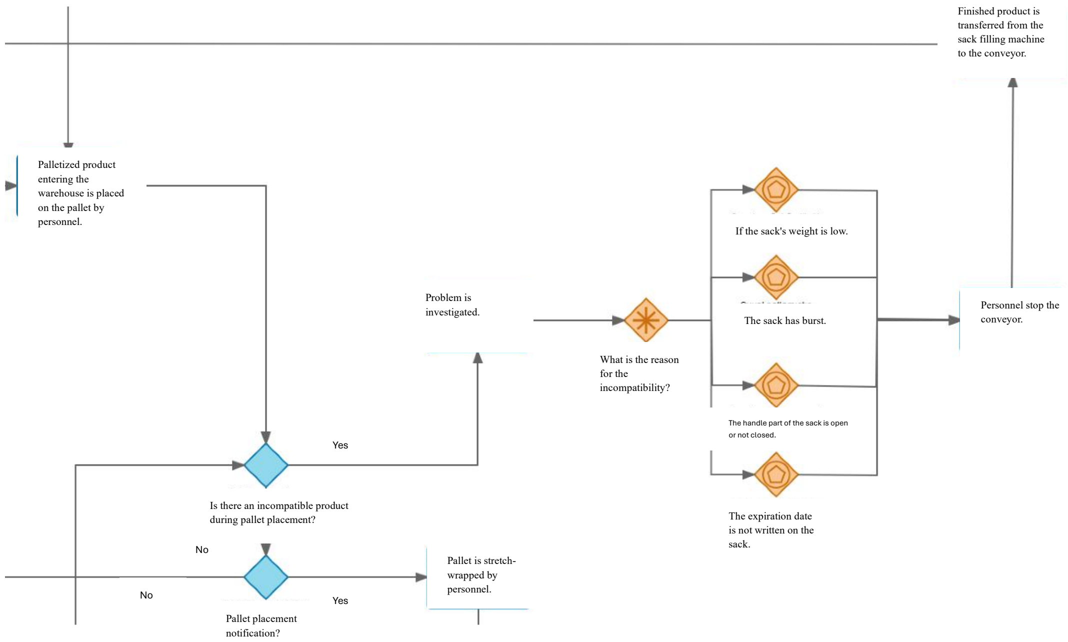


Source: Authors' calculations

Figure 2 shows during the stacking process, products are carefully stacked to ensure stability, adhering to each pallet's maximum load capacity**.** Potential issues during palletization can interrupt the process; the operator quickly analyzes the problem (e.g., checking for damaged products or stacking errors). If necessary, the conveyor belt is stopped to halt product movement. The operator then corrects and rearranges the problematic product. Once the issue is resolved, the process is restarted, and the conveyor resumes operation.

Pallets placed in the designated empty spaces within the warehouse are subsequently moved by a warehouse employee using a forklift to be stored on racks. This is a critical step for organized product storage and ensuring easy accessibility during order picking. However, technical or operational issues can arise during this process, causing disruptions and decreasing overall warehouse efficiency. Figure 3 shows during the stacking process, products are carefully stacked to ensure stability, adhering to each pallet's maximum load capacity**.** Potential issues during palletization can interrupt the process; the operator quickly analyzes the problem (e.g., checking for damaged products or stacking errors). If necessary, the conveyor belt is stopped to halt product movement. The operator then corrects and rearranges the problematic product. Once the issue is resolved, the process is restarted, and the conveyor resumes operation.

Figure 2. Warehouse Process of Packaged Product



Source: Authors' calculations

Figure 4 shows potential problems during pallet handling:

- **Broken Pallets:** A common issue during shuttle system operations is pallet breakage, often due to uneven weight distribution or overloading. This can lead to fallen and scattered products, shuttle system stoppage, and significant occupational safety risks, including potential injuries to employees during cleanup.
- **Shuttle System Sensor Issues:** Sensor malfunctions in the shuttle system can disrupt the automated placement process by failing to detect pallets. Such malfunctions necessitate manual intervention, causing delays and increasing the workload and physical strain on employees.

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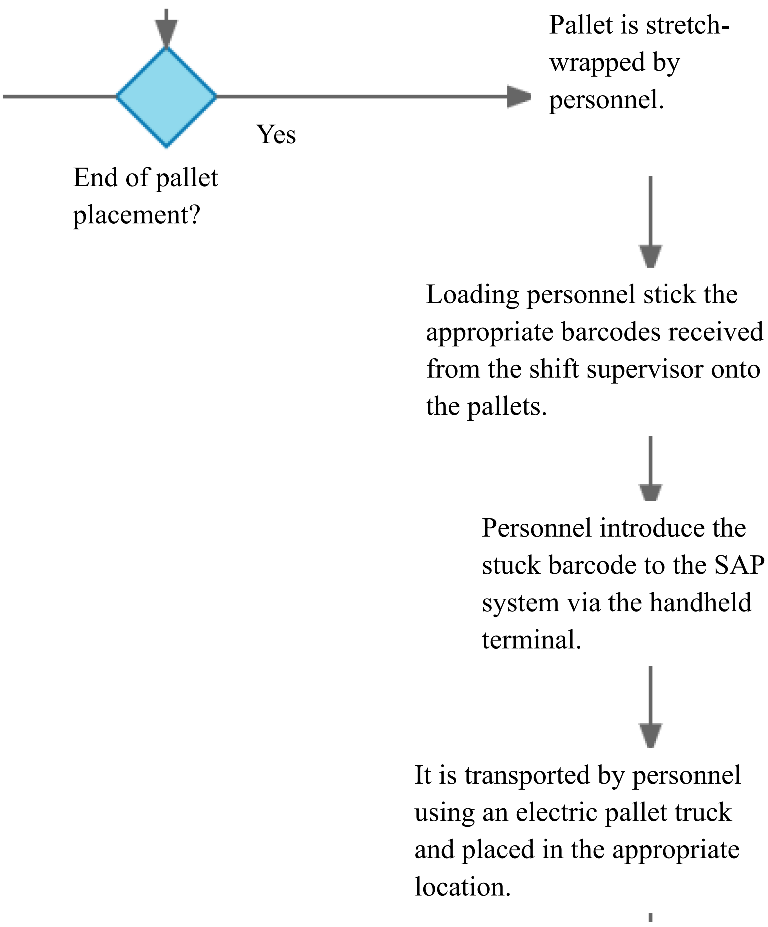
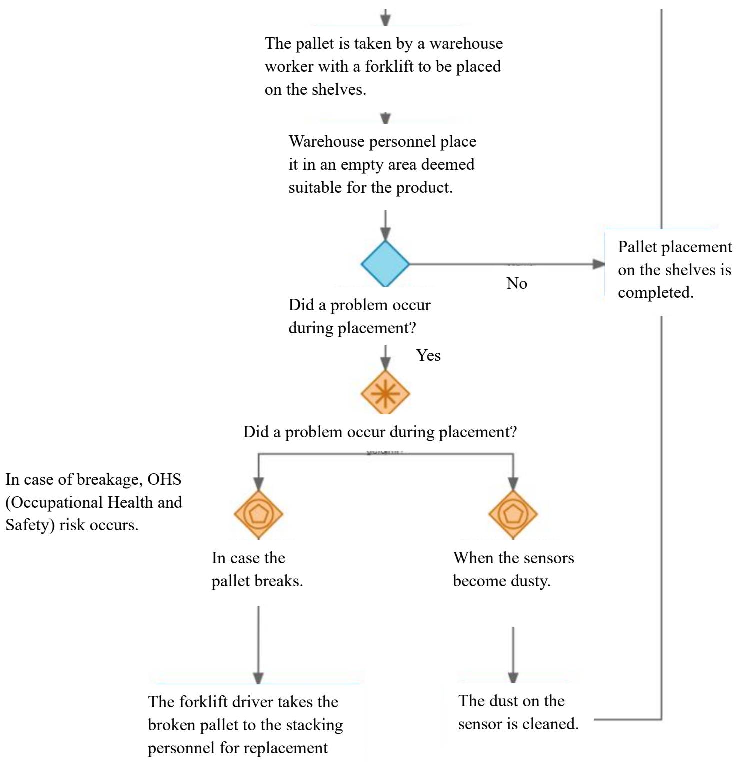
Figure 3. Post-Packaging Stretching and Barcoding Process



Source: Authors' calculations

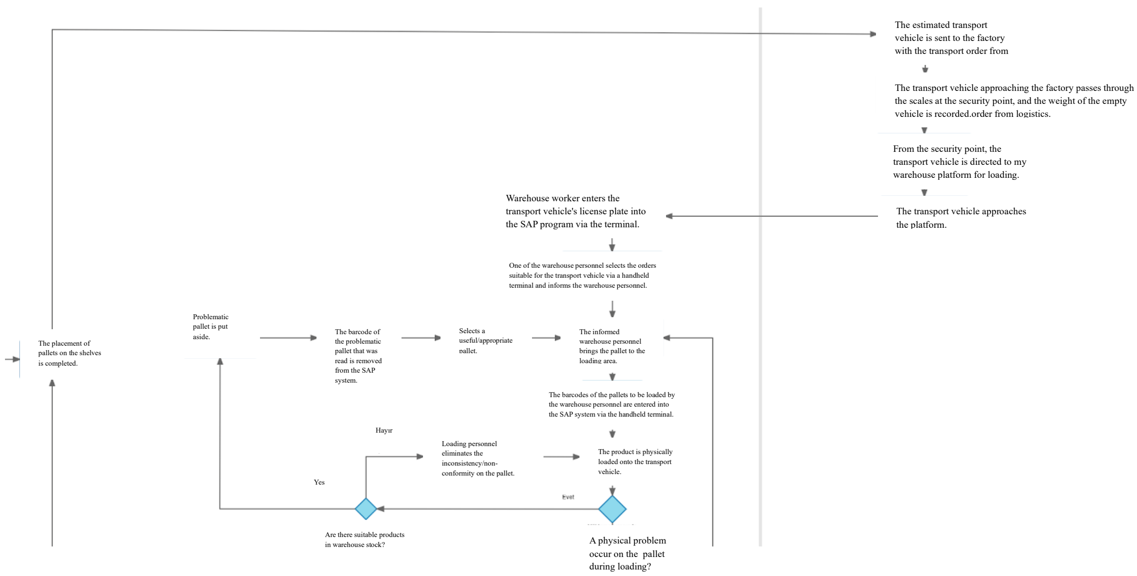
During order picking, the shuttle system faces difficulties in accurately transporting products from racks due to sensor issues or corrosion and rust on rack rails. Critically, rust particles falling onto pallets contaminate products, leading to damage for customers. Furthermore, failure to adhere to FIFO (First-In, First-Out) principles results in the accumulation of older products in the warehouse. Additionally, pallet breakages disrupt the picking process and pose safety risks. It's been observed that shuttle system sensor malfunctions cause an average daily delay of one hour, and rust-induced quality issues have led to a ten percent increase in product returns. Pallet breakages have also created unsafe working conditions, endangering employees (Figure 5).

Graph 4. Process of Placing Pallets on Shelves



Source: Authors' calculations

Figure 5. Order Picking Process from Shelves



Source: Authors' calculations

4.2. VSM Analysis Based on Modeling Results

This section presents the detailed findings of the observed processes from packaging to customer delivery. The entire process is divided into the following key steps:

- Warehouse Inbound
- Palletization
- Placement onto Racks
- Order Picking from Racks
- Product Loading onto Transport Vehicle
- Warehouse Outbound

For each step, detailed information is provided, including Batch Size (BS), Number of People (P), Cycle Time (CT), Total Time (TT*)* (including both value-added and non-value-added operations throughout the process), and Value-Added Time (VAT).

The factory operated 21 hours daily across 3 shifts for 7 days, achieving a production rate of 6 tons per hour, equivalent to 6 pallets. During this period, observations indicated a target production of 882 pallets. However, initial checks at Warehouse Inbound revealed 71 pallets were unsuitable, resulting in a 92% performance rate, indicating no significant bottlenecks at this stage.
Detailed Process Performance:

- **Warehouse Inbound:**

BS: 1, CT: 25 seconds, VAT: 25 seconds. Operates at 92% efficiency with no apparent bottlenecks.

- **Palletization:**

BS: 40, CT: 10.5 minutes, TT: 18.2 minutes, VAT: 10 minutes. Out of 811 pallets entering this stage, 64 were found unsuitable, leading to a 92.11% success rate. The total time (TT) indicates that the handling process significantly contributes to overall time.

- **Placement onto Racks:**

BS: 40, CT: 5.1 minutes, VAT: 5 minutes, TT: 45.1 minutes. A significant 119 out of 747 pallets were deemed unsuitable, resulting in an 84.08% success rate. This highlights a critical need for improvement, as non-conformities cause delays and reduce overall efficiency. The long Total Time (TT) compared to VAT suggests considerable non-value-added activities.

- **Order Picking from Racks:**

BS: 10, CT: 5.6 minutes, TT: 25.3 minutes, VAT: 5.2 minutes. Out of a target of 628 pallets, 89 were unsuitable, leaving only 317 pallets picked correctly. This results in an 86% performance rate. Inefficiencies at this stage significantly impact timely and complete order fulfillment, negatively affecting customer satisfaction and overall warehouse operations. The long Total Time (TT) points to extended transportation durations.

- **Product Loading onto Transport Vehicle:**

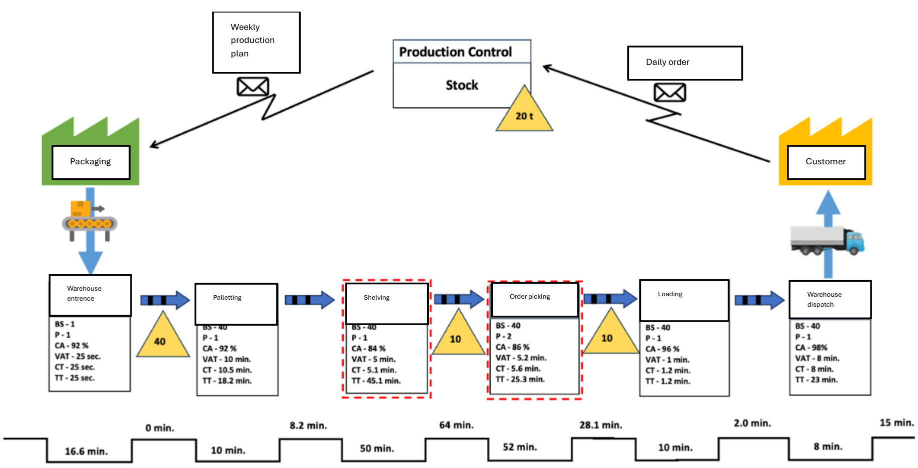
BS: 40, CT: 1.2 minutes, VAT: 1 minute, TT: 1.2 minutes. 304 out of 317 pallets were successfully loaded, achieving a 96% success rate, demonstrating high operational efficiency with no significant bottlenecks.

- **Warehouse Outbound:**

BS: 40, CT: 8 minutes, TT: 23 minutes, VAT: 8 minutes. 304 out of 317 pallets were successfully loaded, yielding a 96% success rate, indicating efficient process execution.

Analyzing the stages from warehouse inbound to product loading onto the vehicle, significant variations in efficiency and success rates were observed. While initial stages like warehouse inbound and final loading show high efficiency, the palletization, placement onto racks, and order picking from racks reveal notable bottlenecks and non-conformities. Specifically, the low success rates of 84.08% for rack placement and 86% for order picking underscore significant issues that lead to delays and reduced overall system performance. For a selected batch of 10 pallets, the expected completion time was 146.6 minutes. However, due to various problems and bottlenecks encountered throughout the process, the actual completion time extended to **263.3 minutes**. This substantial deviation highlights significant efficiency losses and a clear need for process optimization to minimize time wastage and enhance overall productivity (Figure 6).

Figure 6. Steps from Packaging to Customer Delivery



Source: Authors' calculations

Note: The figure, titled "Steps from Packaging to Customer Delivery," is a Value Stream Map visualization. It includes the timeline showing the high proportion of

Total Time (TT) (263.3 minutes) that is composed of non-value-added activities, in contrast to the Value-Added Time (VAT) (146.6 minutes), visually representing the bottlenecks identified in the Placement onto Racks and Order Picking stages.

5. Conclusion

VSM enabled the visualization of bottlenecks and time losses in the process. In particular, the solution of the problems identified related to the placement on and collection time from the shelf was identified as an important opportunity area to reduce the total time from 263.3 minutes to 146.6 minutes. With these improvements, both time savings will be achieved, and customer satisfaction will be increased.

In the light of the analysis and the bottlenecks observed throughout the process, the Kobetsu Kaizen approach was adopted for improvement suggestions. This method suggests forming a team to develop specific solutions to problems and carrying out focused improvement efforts. Suggested improvements include standardized shelf placement protocols and a redesign of shuttle logic to prioritize FIFO, reduce the impact of sensor issues, and minimize non-conformities, following the Kobetsu Kaizen team's recommendations.

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