Management Studies and Entrepreneurship Journal
Vol 7(6) 2026: 1451-1458

Implementation Of Lean Manufacturing Using The Value Stream Mapping Method In The Production Department (A Study At PT XYZ)

Penerapan Lean Manufacturing Menggunakan Metode Value Stream Mapping Pada Departemen Produksi (Studi Pada PT XYZ)

Alvin Maulana[1], Intan Widuri Sakti[2]
Widyatama University, Indonesia[1,2]
alvin.maulana@widyatama.ac.id[1], intan.sakti@widyatama.ac.id[2]

**Coresponding Author*

ABSTRACT
This study investigates the application of lean manufacturing and value stream mapping (VSM) to improve the production flow of T4427B catalyst at PT XYZ, a chemical manufacturing company. The study addresses prolonged processing times and increasing demand by integrating VSM with the Define–Measure–Analyze–Design–Verify (DMADV) framework. Data were obtained through direct observation, structured interviews, production log sheets, standard operating procedures, and internal process documentation. The current-state assessment covered 13 production stages and identified an aggregate cycle time of 177.1 h per batch, compared with an internal target of 78 h. Six processes were selected for redesign without purchasing new equipment: premixing, filtration to unload precipitated cake, reslurry, mulling, extrusion, and screening. The future-state design combines method redesign, overlapping preparation activities, condition-based washing, and parallel use of installed equipment. The combined time of the six priority processes is projected to decrease from 73.1 to 34.8 h, representing a 52.4% reduction. At the total-line level, cycle time is projected to decline to approximately 138.8 h, or 21.6%. Direct utility savings are estimated at approximately USD 128–129 per batch, mainly from reduced demineralized-water, steam, and electricity consumption during filtration. The findings demonstrate that VSM and DMADV can provide a practical, low-capital pathway for improving batch chemical manufacturing, although the proposed future state requires multi-batch verification of process time, product quality, safety, equipment reliability, and resource consumption before standardization.
***Keywords**: Lean manufacturing; value stream mapping; DMADV; catalyst production; waste reduction; process efficiency.*

ABSTRAK
Penelitian ini mengkaji penerapan *lean manufacturing* dan *value stream mapping* (VSM) untuk memperbaiki alur produksi katalis T4427B di PT XYZ, sebuah perusahaan manufaktur bahan kimia. Studi ini mengatasi masalah waktu pemrosesan yang lama dan permintaan yang meningkat dengan mengintegrasikan VSM ke dalam kerangka kerja *Define–Measure–Analyze–Design–Verify* (DMADV). Data diperoleh melalui observasi langsung, wawancara terstruktur, lembar catatan produksi, prosedur operasi standar, dan dokumentasi proses internal. Penilaian kondisi saat ini mencakup 13 tahap produksi dan mengidentifikasi total waktu siklus sebesar 177,1 jam per *batch*, dibandingkan dengan target internal sebesar 78 jam. Enam proses dipilih untuk dirancang ulang tanpa pembelian peralatan baru: *premixing*, *filtration to unload PPT cake*, *reslurry*, *mulling*, ekstrusi, dan *screening*. Desain kondisi masa depan menggabungkan perancangan ulang metode, tumpang tindih aktivitas persiapan, pencucian berbasis kondisi, dan penggunaan peralatan terpasang secara paralel. Total waktu untuk keenam proses prioritas tersebut diproyeksikan turun dari 73,1 jam menjadi 34,8 jam, yang mencerminkan penurunan sebesar 52,4%. Pada tingkat lini produksi secara keseluruhan, waktu siklus diproyeksikan turun menjadi sekitar 138,8 jam, atau sebesar 21,6%. Penghematan biaya utilitas langsung diperkirakan sekitar USD 128–129 per *batch*, terutama berasal dari pengurangan konsumsi air demineralisasi, *steam*, dan listrik selama tahap filtrasi. Temuan ini menunjukkan bahwa VSM dan DMADV dapat memberikan solusi praktis dengan kebutuhan modal rendah untuk meningkatkan efisiensi manufaktur bahan kimia sistem *batch*, meskipun desain kondisi masa depan yang diusulkan memerlukan verifikasi lintas *batch* terkait waktu proses,

kualitas produk, keselamatan, keandalan peralatan, dan konsumsi sumber daya sebelum dilakukan standardisasi.
Kata kunci: *Lean manufacturing, value stream mapping,* DMADV, produksi katalis, pengurangan *waste,* efisiensi proses.

1. Introduction

Manufacturing organizations operate under increasing pressure to improve responsiveness, cost efficiency, quality, and resource productivity. In batch chemical manufacturing, these objectives are difficult to achieve because material transformation depends on sequential chemical, thermal, separation, and forming operations. Long processing times, uneven equipment capacities, waiting for laboratory decisions, repeated material handling, and large sub-batches can extend production lead time even when individual operations appear technically necessary. Lean manufacturing provides a system-level approach for distinguishing customer-value-adding work from necessary but non-value-adding activities and avoidable waste (Womack & Jones, 2020; Liker, 2021).

Value stream mapping is particularly suitable for this setting because it integrates material flow, information flow, process data, and time into a single visual model. Unlike isolated machine-efficiency studies, VSM evaluates the complete product flow and reveals how local capacity, batch size, scheduling, and process dependencies interact. When integrated with DMADV, VSM can be used not only to diagnose the current state but also to design and verify an improved operating system (Rother & Shook, 2019; Montgomery, 2020).

PT XYZ produces T4427B catalyst for petrochemical and fertilizer-industry applications. Demand increased from 15,860 kg in 2023 to 234,146 kg in 2025, while the 2026 forecast reached 315,781 kg. Management therefore sought a higher effective production capacity without immediately increasing capital expenditure. The current production line consists of metal dissolution, premixing, precipitation, filtration, drying, reslurry, a second filtration and drying sequence, mulling, extrusion, pellet drying, and screening. Preliminary data showed that the total cycle time substantially exceeded the internal target.

This study aims to: (1) map value-added and non-value-added activities in T4427B production; (2) identify capacity constraints and dominant time losses; (3) design an attainable future-state process using existing assets; and (4) formulate verification criteria for time, quality, safety, and utility savings. The study contributes an application of lean VSM and DMADV in a batch catalyst-manufacturing environment, where physical process requirements must be distinguished carefully from operational waste.

2. Literature Review

2.1 Lean Manufacturing and Value Stream Mapping

Lean manufacturing defines value from the customer’s perspective and seeks to improve flow by reducing overproduction, waiting, unnecessary transportation, over-processing, inventory, motion, defects, and underutilized human capability. Lean should be treated as a management system rather than a set of isolated tools because sustainable improvement requires standard work, problem solving, employee involvement, and continuous learning (Liker, 2021; Antony et al., 2023).

VSM visualizes supplier and customer relationships, production control, information transmission, material movement, process boxes, inventories, and a time line. Its core measures include cycle time, lead time, takt time, value-added time, and process cycle efficiency. The current-state map makes waste visible; the future-state map converts the diagnosis into a coordinated operating design (Rother & Shook, 2019).

2.2 DMADV and the Theory of Constraints

DMADV structures process redesign into five phases: Define identifies customer and business requirements; Measure establishes the baseline; Analyze identifies waste, constraints, and design drivers; Design develops the improved process; and Verify tests whether the design meets critical requirements. The Theory of Constraints complements VSM by emphasizing that system throughput is governed by the effective capacity of the current constraint, rather than by the utilization of every resource (Goldratt, 2020).

3. Research Methods (Metode Penelitian)

The study used a descriptive case-study design with quantitative process-time analysis. The unit of analysis was the T4427B production value stream in the Production Department of PT XYZ. Primary data were obtained through direct observation and structured interviews with operators and supervisors. Secondary data included production log sheets, work instructions, standard operating procedures, equipment information, production records, and internal utility-cost data.

3.1 DMADV Procedure

Table 3. 1 Value Stream Mapping DMADV Procedure

Phase	Main Activities	Outputs
Define	Establish the business problem, internal process-time target, product family, and improvement scope.	Problem statement, scope, Pareto priorities.
Measure	Record process steps, cycle time, supporting activities, equipment, labor, and available time; classify VA, NNVA, and NVA.	Process activity map and current-state VSM.
Analyze	Compare process time with targets; assess exit time, bottleneck candidates, capacity imbalance, and waste.	Root causes and improvement priorities.
Design	Redesign work sequence, externalize preparation, adopt condition-based washing, and use available parallel equipment.	Future-state VSM and projected performance.
Verify	Conduct repeated production trials and evaluate time, quality, safety, reliability, and utilities.	Validated standard work or corrective redesign.

Available production time was calculated as 30 days per month × 3 shifts per day × 7 effective hours per shift, producing 630 h per month. Customer demand of 216 t per month generated a takt time of 2.92 h/t. With a nominal batch size of 1.8 t, the equivalent takt time was approximately 5.26 h per batch. Process cycle efficiency was evaluated using the ratio of value-added time to total lead time. Improvement was calculated as the difference between current- and future-state process time divided by current-state time.

4. Results and Discussions

4.1 Current-State Value Stream

The current-state VSM contained 13 primary operations and 13 equipment groups. Production planning centrally transmitted instructions to the process areas, while quality control was involved at raw-material receipt, intermediate decisions, and finished-product release. The information architecture was predominantly schedule-driven; explicit pull signals, FIFO limits, or supermarket controls were not evident. This arrangement may create work-in-process when upstream batches are released without full consideration of downstream capacity.

Table 4. 1 Cycle Time Process

Process	Current Time (h)	Percentage of Total (%)
Metal Dissolving Cu	30.5	17.2
Mulling	22.5	12.7
Drying PPT Cake	22	12.4
Metal Dissolving Zn	20	11.3
Drying Pellet	17	9.6
Screening	12.3	6.9
Extrusion	11.5	6.5
Filtration to Unload PPT	11	6.2
Reslurry	8.5	4.8
Drying RS Cake	7.5	4.2
Premixing	7.3	4.1
Filtration to Unload RS	3.8	2.1
Precipitation	3.3	1.8
Total	**177.1**	**100**

The total cycle time was 177.1 h per batch, exceeding the aggregate internal target of 78 h by 99.1 h. The five longest processes accounted for approximately 63.3% of total cycle time. Nevrtheless, process duration alone was not sufficient to identify the system constraint. Metal Dissolving Cu required 30.5 h but produced the equivalent of four required dissolution batches, resulting in an exit interval of approximately 7.6 h. Metal Dissolving Zn produced two required batches in 20 h, resulting in a 10 h exit interval. By contrast, Mulling and Drying PPT Cake each produced one batch in 22.5 and 22 h, respectively, making them stronger capacity-constraint candidates.

Process-activity analysis also distinguished long technical operations from removable or reducible time. Premixing contained preparation, volume checks, valve operations, laboratory analysis, and pH verification. Filtration to unload PPT was dominated by normal washing and path changes between filtration, washing, backwashing, compression, and unloading. Reslurry included repeated preparation and material handling. Mulling required nine sub-batches due to limited machine capacity. Extrusion processed the same sub-batches sequentially with periodic die changes, and Screening processed the final material using one vibrating screen.

4.2 Priority Selection and Waste Analysis

Six processes were selected for intervention: Premixing, Filtration to Unload PPT, Reslurry, Mulling, Extrusion, and Screening. The selection did not simply follow the longest-time ranking. It combined time impact, waste opportunity, technical feasibility, management judgment, and the requirement that the first improvement stage should avoid the purchase of new machinery. Metal dissolution and drying were retained as subsequent improvement opportunities because their durations are more strongly governed by reaction kinetics, heat and mass transfer, and product-quality requirements.

Table 4. 2 Value Stream Mapping, Current vs Future

Priority Process	Current (h)	Future (h)	Reduction (h)	Reduction (%)	Primary Design Logic
Premixing	7.3	4.5	2.8	38.4	Externalize preparation and overlap compatible activities.
Filtration to Unload PPT	11	5.3	5.7	51.8	Condition-based washing and standardized path changes.
Reslurry	8.5	4.5	4	47.1	Prepare water, heat, and material handling in parallel.
Mulling	22.5	7.5	15	66.7	Use three available mix mullers in parallel.
Extrusion	11.5	6.8	4.7	40.9	Use two extruders with balanced sub-batch allocation.
Screening	12.3	6.2	6.1	49.6	Use two vibrating screens in parallel.
Total	**73.1**	**34.8**	**38.3**	**52.4**	Integrated method and capacity redesign.

4.3 Future-State Design

4.3.1 Premixing

Premixing was redesigned by moving transfer preparation, line checks, valve readiness, and demineralized-water preparation outside the critical path where technically and safely feasible. The new sequence synchronizes Cu and Zn solution availability and coordinates sampling with laboratory capacity. The proposed time decreases from 7.3 to 4.5 h. The design does not eliminate agitation, composition analysis, temperature control, or pH verification; instead, it reduces waiting and serial preparation. This distinction is essential because activities required for process safety and product conformance remain necessary non-value-added work until a more robust control method is validated.

4.3.2 Filtration to Unload PPT

The filtration redesign focuses on the 6.5 h normal-washing activity, which was the largest component of the original 11 h process. Rather than terminating washing only after a fixed duration, the future-state concept applies measurable completion criteria, such as filtrate conductivity, impurity concentration, cumulative wash volume, flow behavior, and pressure response. Standardized valve positions and prepared unloading resources further reduce transition time. The projected duration is 5.3 h. Because under-washing may transfer contamination risk downstream, implementation must confirm cake impurity, moisture, unloadability, drying demand, and subsequent reslurry performance.

4.3.3 Reslurry

Reslurry is reduced from 8.5 to 4.5 h by overlapping tank preparation, initial demineralized-water charging, heating, cake handling, and loading readiness. Material movements from tray to drum and loading point do not transform the product and should therefore be minimized through fixed routes, pre-positioned containers, and clear operator assignments. Agitation remains governed by slurry homogeneity and impurity-removal requirements. The design consequently compresses elapsed time without treating technically necessary mixing as removable waste.

4.3.4 Mulling

Mulling provides the largest improvement opportunity. One upstream batch is divided into nine smaller mulling sub-batches. Sequential use of one mix muller required 22.5 h, while three available units reduce the theoretical elapsed time to 7.5 h. This change elevates effective capacity without new capital equipment. The redesign requires standardized material weighing, PEG-solution concentration, water adjustment, mixing time, blade condition, staggered start times, traceability by sub-batch, and product-homogeneity testing. Without these controls, parallel processing could reduce time while increasing variation or operator overload.

4.3.5 Extrusion

Two extruders are assigned in parallel to reduce extrusion time from 11.5 to 6.8 h. The proposed time is deliberately higher than the ideal half-time of 5.75 h because preparation, die changes, loading imbalance, operator movement, and equipment differences cannot be eliminated completely. Verification must compare output rate, pellet dimensions, surface condition, blockage frequency, die-change time, and rework between the two machines. Capacity must also be synchronized with Mulling and Drying Pellet to prevent the bottleneck from shifting into an uncontrolled queue.

4.3.6 Screening

Two vibrating screens reduce the projected screening time from 12.3 to approximately 6.2 h, close to the theoretical division of demand across two equivalent units. The design requires standardized mesh size, vibration settings, feed rate, screen integrity checks, and balanced material distribution. Faster screening is acceptable only if the proportion of on-size product, undersize, oversize, and rework remains at least equal to the baseline. Packaging, weighing, labeling, and final quality release must be prepared to absorb the faster output; otherwise, waiting merely moves to the final stage.

4.4 Overall Performance and Economic Implications

The combined time of the six redesigned processes decreases from 73.1 to 34.8 h, releasing 38.3 h or 52.4% within the selected improvement scope. Assuming the seven unchanged processes remain constant and all reductions affect the critical path, total cycle time is projected to decline from 177.1 to approximately 138.8 h, equivalent to a 21.6% line-level reduction. The remaining 60.8 h gap to the 78 h aggregate target demonstrates that the proposed future state is an intermediate, achievable condition rather than a final lean state. Subsequent work should address Metal Dissolving Cu and Zn, Drying PPT Cake, Drying RS Cake, and Drying Pellet through controlled technical studies.

Direct utility savings are concentrated in Premixing, Filtration to Unload PPT, and Reslurry. The thesis data indicate approximately USD 2, USD 120, and USD 6 per batch, respectively. The component total is USD 128 per batch, while the summarized estimate is approximately USD 129 because of source-value rounding. With the 2026 forecast of 315,781 kg and a nominal batch size of 1,800 kg, production demand equals 175.4 batches and should be planned as 176 full batches if the complete forecast must be met. Annual direct savings would therefore be approximately USD 22,700 at USD 129 per batch. Capacity release, overtime avoidance, and deferred investment may generate additional value, but these should not be reported as realized savings until supported by operational and financial data.

4.5 Verification Plan

The future state remains a design hypothesis until verified under normal production conditions. At least three representative batches should be observed using the same start-and-finish definitions applied in the baseline. Each trial should record process time, waiting, downtime, labor allocation, equipment used, output, first-pass yield, rework, quality results, utility consumption, safety deviations, and downstream effects. Results should include the mean, minimum, maximum, and variation across batches.

A design should be classified as verified only when time improvement, product quality, process safety, equipment reliability, and utility performance are achieved simultaneously. If the target time is met but quality or safety deteriorates, the design should be rejected or adjusted. Once verified, the improved method should be incorporated into standard operating procedures, standard work, operator training, visual performance management, and periodic audits. The verified future state then becomes the new current state for the next improvement cycle.

5. Conclusion

This study shows that integrating lean manufacturing, VSM, and DMADV provides a structured approach to improving a complex batch catalyst-production line. The current state required 177.1 h per batch, substantially exceeding the internal aggregate target. The redesign prioritized six processes that could be improved through method changes and better use of existing assets. Premixing, Filtration to Unload PPT, and Reslurry were redesigned through activity overlap, standardized preparation, and condition-based control. Mulling, Extrusion, and Screening were redesigned using parallel equipment already available in the plant.

The six priority processes are projected to decline from 73.1 to 34.8 h, a 52.4% reduction, while total-line cycle time may decline by approximately 21.6% to 138.8 h. Direct utility savings are estimated at approximately USD 128–129 per batch. The findings also show that local speed improvement must be evaluated at value-stream level because the constraint may shift to drying operations. The proposed future state should therefore be treated as an intermediate design and verified through repeated production trials before standardization.

Managerially, the study demonstrates that substantial improvement can be achieved before major capital investment by combining standard work, cross-functional coordination, condition-based process control, and disciplined use of installed parallel capacity. Future research should incorporate work-in-process measurements, equipment uptime and OEE, process variability, quality capability, and simulation of overlapping batches to establish a more complete capacity model.

References

Antony, J., Sony, M., & Gutierrez, L. (2023). Deconstructing the eight wastes of lean in the digital era: A systematic review and research agenda. International Journal of Production Research.

Bicheno, J., & Holweg, M. (2016). The Lean Toolbox: A Handbook for Lean Transformation. Picsie Books.

Goldratt, E. M. (2020). The Goal: A Process of Ongoing Improvement. North River Press.

Heizer, J., Render, B., & Munson, C. (2023). Operations Management: Sustainability and Supply Chain Management. Pearson.

Liker, J. K. (2021). The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer. McGraw-Hill.
Montgomery, D. C. (2020). Introduction to Statistical Quality Control. Wiley.
Rother, M., & Shook, J. (2019). Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda. Lean Enterprise Institute.
Slack, N., & Brandon-Jones, A. (2022). Operations Management. Pearson.
Tortorella, G. L., Vergara, A. M., & Garza-Reyes, J. A. (2022). Lean 4.0 implementation framework for smart operations. International Journal of Production Economics.
Womack, J. P., & Jones, D. T. (2020). Lean Thinking: Banish Waste and Create Wealth in Your Corporation. Simon & Schuster.