Design of a Lean Capacity Optimization Strategety for Machines Under No Mixing Policies

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Abstract

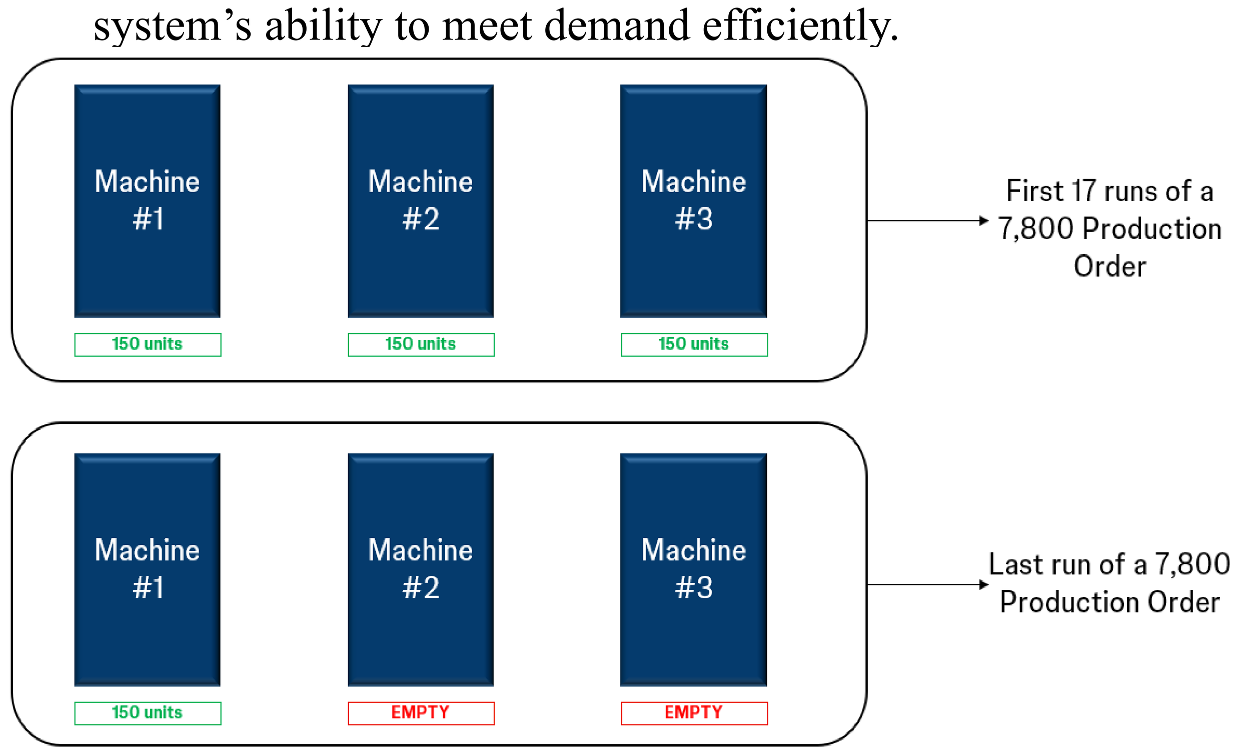
Manufacturing systems with fixed batch sizes and strict no-mixing requirements often lose capacity due to misalignment with machine cycle output. This study analyzes a three-machine system where idle cycles reduce utilization and increase lead times. Using DMAIC, traceability was identified as the root cause, and a traceability-based feeding system was implemented. The solution, incorporating uniquely identified trays, improved documentation, and 5S practices, eliminates idle cycles without changing batch sizes or adding equipment, thus unlocking hidden capacity.

Introduction

Manufacturing systems that operate under strict batching and traceability requirements often face significant challenges in aligning production capacity with fluctuating demand. This investigation focuses on solving a common but underexplored manufacturing problem: how rigid batching and sequencing rules can lead to persistent capacity loss, underutilized assets, longer lead times, and increased risk to on-time delivery performance. The challenge involves a manufacturing company that is in need of maximizing machine capacity due to increase demand. The company currently has 3 identical machines for production, and the current batching system inhibits it to utilize its entire capacity. This investigation strives to unlock that capacity without breaking the strict batching rules.

Problem

The manufacturing company examined in this research operates three machines, that operate 150 units each for a total of 450 units per production cycle (see below). Each production cycle must be dedicated to a single production order of a fixed quantity of 7,800 units per production order. Due to this every 17 production cycles, two of the three machines remain idle for an entire cycle, resulting in the loss of two machine cycles of available capacity. This systematic underutilization of assets leads to increased average lead times and elevated work-in-process (WIP), which currently translates to 57,000 units of backorder for the company. Although demand is rising, capital expansion is not yet justified, and strict batching and traceability requirements prevent operational flexibility, limiting the system's ability to meet demand efficiently.



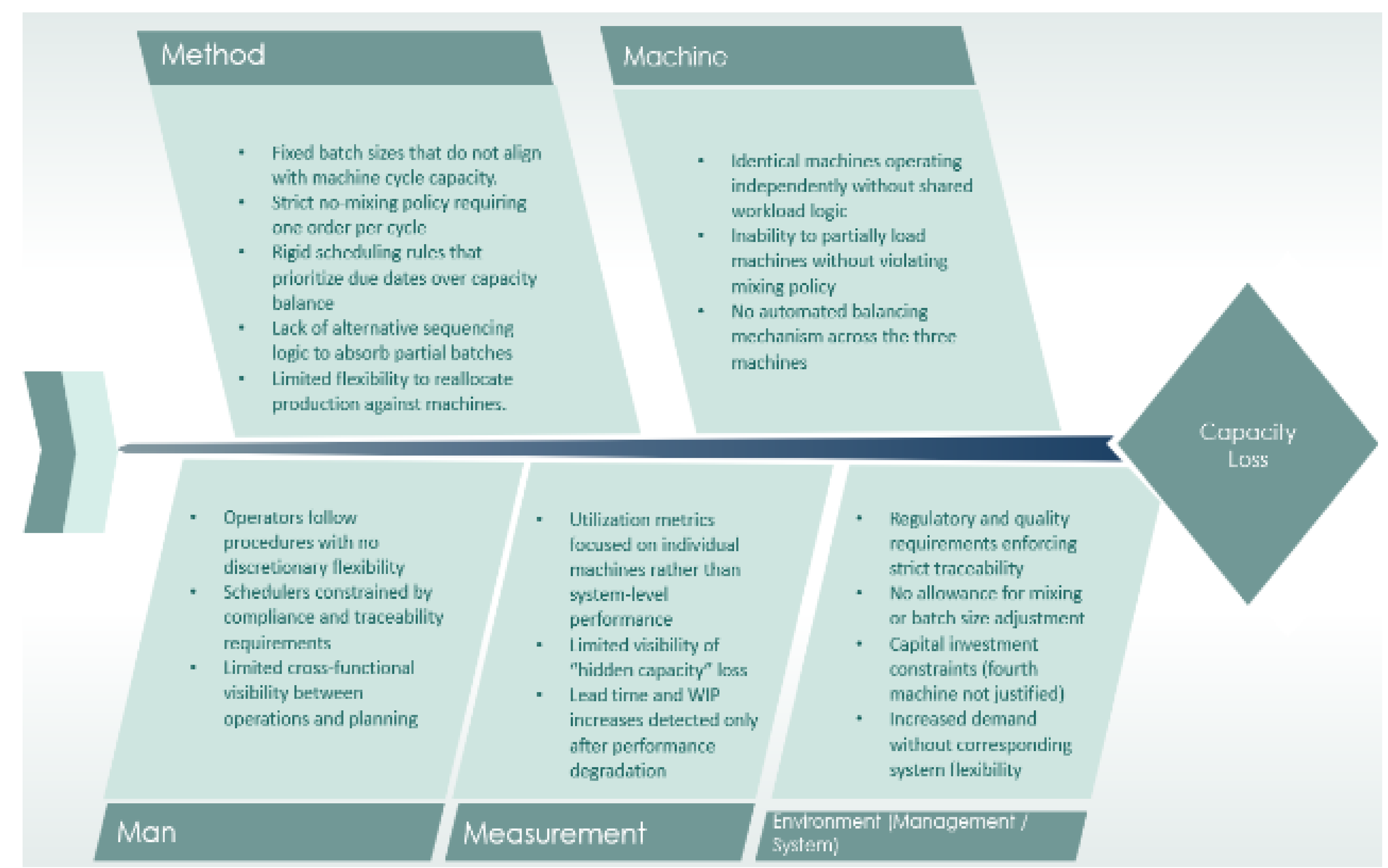
Methodology

This study applies DMAIC to reduce capacity loss from idle machine cycles in systems with fixed batch sizes and strict no-mixing policies. The approach is data driven and ensures sustainable process improvement in regulated environments. Lean principles, Good Documentation Practices (GDP), and 5s are integrated to maintain compliance, improve traceability, reduce downtime, and enhance overall productivity.

Table 1

DMAIC Approach

DMAIC phase	Objective	Key activities	Tools and data sources	Outputs
Define	Define problem, scope, and constraints	Problem definition, stakeholder identification	Process documentation, stakeholder input	Defined scope, problem statement
Measure	Establish baseline performance	Data collection on utilization and idle cycles	Production records, system logs, observations	Baseline utilization metrics
Analyze	Identify root causes of idle cycles	Interaction analysis, root cause identification	Fishbone diagram, 5M framework	Prioritized root causes
Improve	Reduce idle cycles and improve utilization	Solution development, lean integration, pilot testing	Lean tools, GDP, performance comparison	Reduced idle cycles, improved utilization
Control	Sustain improvements	Procedure updates, KPI monitoring, training, hypercare	SOPs, visual controls (forms).	Sustained performance and final evaluation

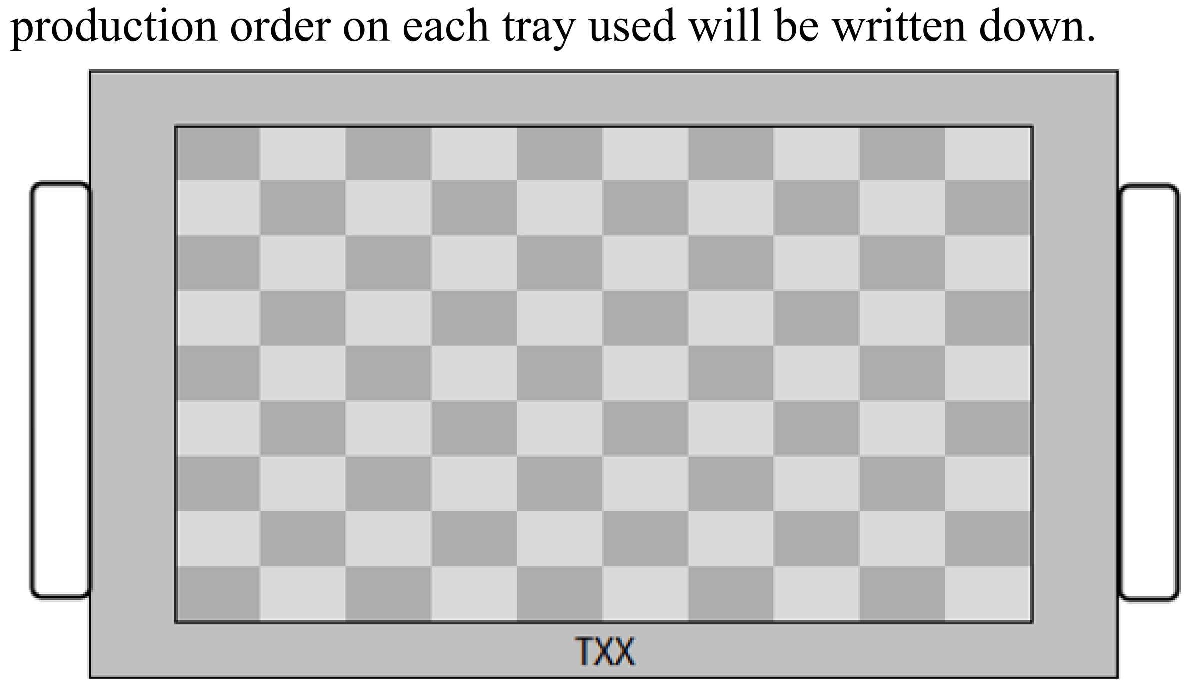


Results and Discussions

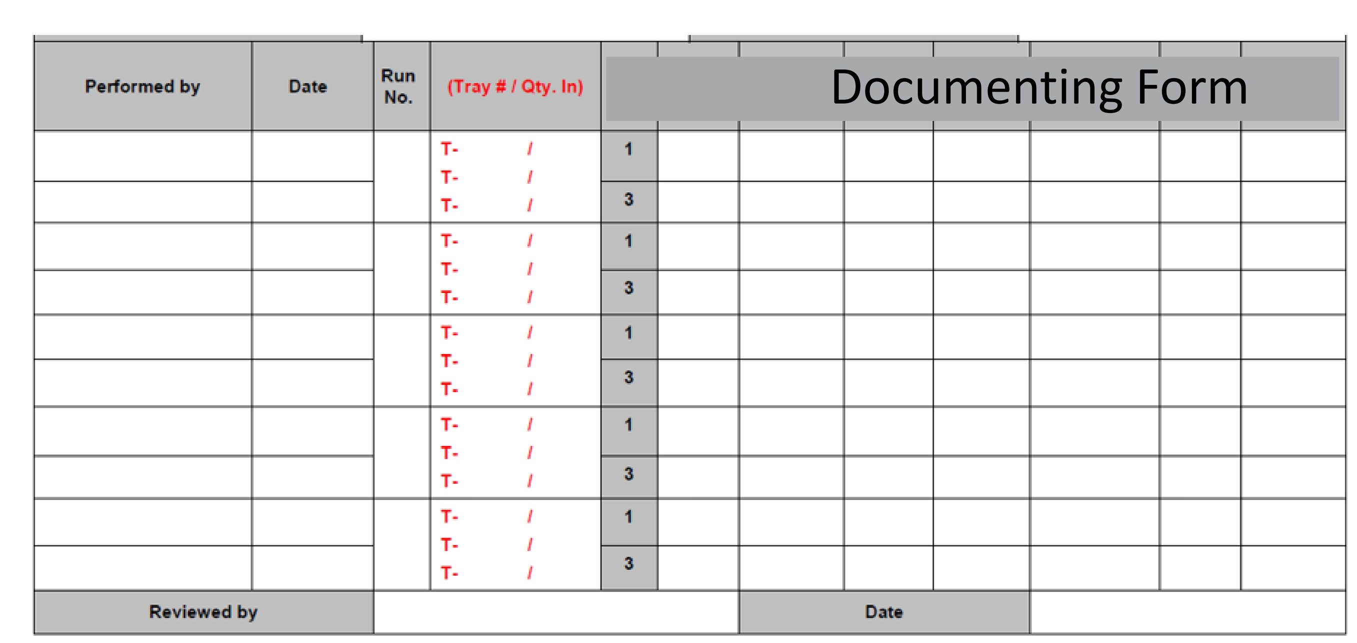
Given that the last run of a production order has an unused capacity of 300 units, and each cycle has a calculated duration of 48.4 minutes, and the company operates at a 8 hour 5 days a week schedule (2,080 hours), it can be calculated that the yearly loss of capacity (1) given this inefficiency is 43,000 units (2). This represents 75.4% of the current back order for the company.

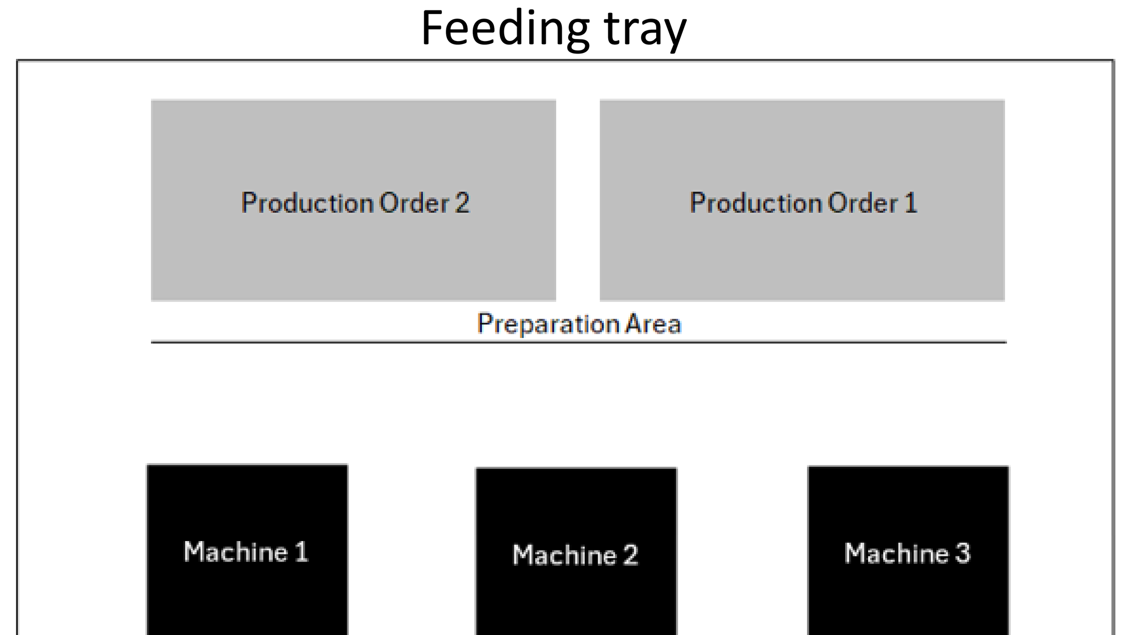
$$x=\frac{(\text{PO capacity loss})(\text{yearly labor (hrs)})}{\text{cycle time (min)}} \quad (1) \qquad x=\frac{(300)(2{,}800)}{(48.4)}=43{,}000\text{ units} \quad (2)$$

Based on the information gathered , the solution identified as part of this research project is that on each feeding tray used a unique engraving will be added in each tray to match and document the production order. All runs will have to document a form where the production order on each tray used will be written down.

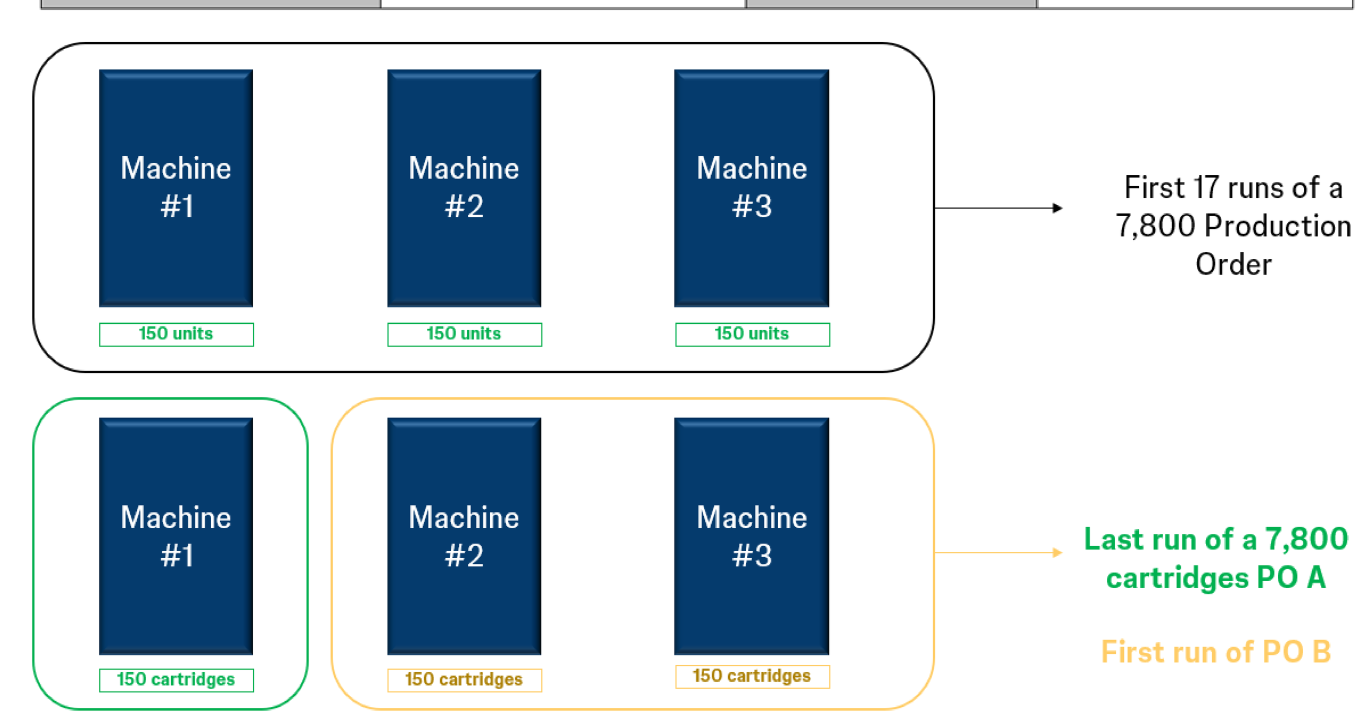


Feeding tray





5s



Conclusions

This study examines capacity loss in a manufacturing system with fixed batch sizes and strict no-mixing policies. Misalignment between order quantity and machine capacity caused recurring idle cycles and a 300-unit loss per order.

Using DMAIC, limited traceability was identified as the root cause. A traceability-based system was implemented using uniquely identified trays, improved documentation, and 5S practices, enabling full machine utilization without changing batch sizes or adding equipment.

Results show that significant hidden capacity can be recovered through process and traceability improvements, with applicability to similar constrained manufacturing systems.

Future Work

Future work will focus on extending this traceability-based feeding system to other production areas were batching rules limit machine utilization. Additional efforts will include validating the solution across different product families, integrating the system with tracking tools for real-time monitoring, and quantifying long-term impacts on lead time, WIP, and service level. Further research will evaluate scalability in higher-volume operations, assess operator adoption and standardization through training programs, and explore opportunities to combine this approach with advanced scheduling models. These efforts aim to strengthen the robustness, adaptability, and broader applicability of the solution in constrained manufacturing environments.

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