JAFM: Journal of Accounting and Finance Management
E-ISSN: 2721-3013
P-ISSN: 2721-3005
https://dinastires.org/JAFM dinasti.info@gmail.com +62 811 7404 455
DOI: https://doi.org/10.38035/jafm.v7i2

Improving Meal Break Efficiency Using Six Sigma to Minimize Operational Delay: A Case Study of the Mining Sector in Indonesia

M. Daffa Arafi[1], Yuliani Dwi Lestari[2]
[1]Institut Teknologi Bandung, Bandung, West Java, Indonesia, daffamarafi@gmail.com
[2]Institut Teknologi Bandung, Bandung, West Java, Indonesia, yuliani.dwi@sbm-itb.ac.id

Corresponding Author: daffamarafi@gmail.com[1]

Abstract: Operational efficiency in mining operations is strongly influenced by effective working time utilization, particularly in shift based systems where equipment productivity directly affects production performance. One significant source of inefficiency is Internal Operational Delay (IOD), especially delays caused by meal break execution. This study investigates the impact of meal break implementation on operational delays and proposes an improvement strategy to enhance efficiency in mining operations in Indonesia. The research applies the Six Sigma DMAIC (Define Measure Analyze Improve Control) methodology to identify, measure, and improve inefficiencies related to meal break activities. Statistical process control using Individuals Moving Range (XmR) charts was employed to assess process variability and stability. Root causes were analyzed using Pareto analysis, Fishbone Diagram, Root Cause Validation, and Cause Prioritization Matrix. The findings reveal that simultaneous meal breaks create a "wave effect," causing multiple units to become idle simultaneously and reducing equipment utilization. Process-related issues were identified as the most dominant and controllable factors. The proposed improvement is a staggered meal break system, which maintains operational continuity and reduces idle time. The study concludes that optimizing meal break execution can significantly reduce IOD and improve Primary Working Time (PWT), contributing to more stable and efficient mining operations.

Keywords: Operational Efficiency, Internal Delay, Mining Operations, Staggered Meal Break, Time Utilization

INTRODUCTION

Mining operations are highly dependent on operational efficiency, particularly in large scale, shift based environments where equipment utilization directly influences production performance. In open pit mining activities, the continuity of loading, hauling, and dumping processes must be maintained consistently to achieve production targets and optimize equipment productivity. Any interruption in operational flow, even within short durations, can reduce equipment utilization and negatively affect overall production outcomes. Therefore, effective management of working time has become a critical aspect of operational performance in the mining industry.

One of the key indicators used to measure operational productivity is Primary Working Time (PWT), which reflects the actual productive time equipment spends performing core mining activities within a given operational period. A decrease in PWT generally indicates the presence of operational inefficiencies or delays that interrupt production continuity. Among various contributors to reduced PWT, Internal Operational Delay (IOD) has emerged as one of the most significant and controllable sources of production loss. Unlike external disturbances such as weather conditions or geological uncertainty, IOD originates from internal operational activities and procedural inefficiencies that occur during daily mining operations.

Previous operational observations and production reports indicate that a considerable portion of IOD originates from routine and planned operational activities. Although these activities are formally integrated into operational schedules, their implementation in practice often generates additional non productive time. One recurring operational pattern identified in mining activities is the execution of meal breaks during shift operations. Meal breaks are essential to support worker welfare and comply with labor regulations. However, their implementation may unintentionally disrupt operational continuity when not properly coordinated.

In many mining operations, meal breaks are conducted simultaneously across fleets and operational units. This practice frequently creates a temporary concentration of idle equipment, commonly referred to as a “wave effect,” where multiple hauling and loading units become inactive at the same time. As a result, operational flow is interrupted, equipment utilization decreases, and additional delays occur during the transition back to active production after the break period. Although each delay may appear relatively minor on an individual basis, the cumulative effect across multiple units and shifts contributes significantly to production losses and inconsistent PWT performance.

The issue becomes increasingly important in modern mining environments where operational targets are closely tied to fleet productivity and cycle time consistency. Even small inefficiencies in shift execution can generate measurable impacts on production achievement, equipment availability, and overall operational cost efficiency. Therefore, identifying operational practices that create avoidable delays is necessary to improve productivity without requiring substantial capital investment.

This study focuses on analyzing meal break execution as one of the contributors to Internal Operational Delay in mining operations. The research is conducted within the context of Indonesian mining operations, where shift based activities and large equipment fleets require continuous operational coordination. Rather than eliminating meal breaks, this study emphasizes improving how meal breaks are managed and integrated into operational workflows to minimize unnecessary idle time while maintaining worker welfare and operational stability.

To address this issue systematically, the study adopts the Six Sigma DMAIC (Define Measure Analyze Improve Control) methodology. The DMAIC framework provides a structured approach to identify operational problems, measure process performance, analyze root causes, develop improvement strategies, and establish control mechanisms to sustain operational improvements. In the measurement stage, operational performance is evaluated using Primary Working Time (PWT) and Internal Operational Delay (IOD) data supported by statistical process control analysis. Root causes of delay are further analyzed using Pareto analysis, Fishbone Diagram, and Cause Prioritization Matrix to determine the most significant and controllable factors contributing to operational inefficiencies.

Based on the analysis, the study proposes a staggered meal break system as a potential improvement strategy. Instead of implementing simultaneous meal breaks across operational units, staggered scheduling distributes break periods sequentially to maintain partial operational continuity during shift transitions. This approach is expected to reduce idle time concentration, improve equipment utilization, and stabilize Primary Working Time performance throughout operational shifts.

The contribution of this study lies in providing a practical and data-driven operational improvement approach for mining operations. In addition, the research highlights the importance of focusing on controllable operational processes as a strategic entry point for improving production efficiency in complex industrial environments. The findings are expected to provide useful insights not only for mining operations, but also for other industries that rely heavily on shift-based operations and equipment productivity.

METHOD

This study applies a case study based applied research design using a mixed-method approach that combines qualitative and quantitative analysis to investigate operational delays associated with meal break execution in mining operations. The research focuses on identifying the causes of Internal Operational Delay (IOD) during shift operations and developing improvement strategies to enhance Primary Working Time (PWT) and operational efficiency. The mixed-method approach was selected because operational delay issues involve both measurable productivity impacts and behavioral or procedural factors related to workforce coordination and operational discipline.

The research adopts the Six Sigma DMAIC (Define Measure Analyze Improve Control) framework as the primary methodology for problem solving and process improvement. Six Sigma is widely recognized as a structured methodology for reducing process variability and improving operational performance in industrial environments (George, 2002). The DMAIC framework provides a systematic process to define operational problems, measure process performance, analyze root causes, implement improvements, and establish control mechanisms to sustain operational gains.

The study began with a problem identification stage through field observations, operational discussions, and reviews of production data and operational logs. Preliminary findings indicated that meal break execution contributed significantly to Internal Operational Delay (IOD), particularly due to simultaneous break implementation across fleets that created temporary operational stoppages or "wave effects." To prioritize operational issues systematically, a Cause Prioritization Matrix (Impact × Effort) was applied. This approach evaluates operational problems based on their potential impact on productivity and the feasibility of implementation improvement efforts (Bicheno & Holweg, 2009).

The qualitative component of the research involved semi structured interviews with operational stakeholders, including field supervisors, shift leaders, dispatch personnel, and equipment operators. Semi structured interviews were selected because they provide flexibility to explore operational issues while maintaining alignment with research objectives. The interviews focused on operational experiences related to meal break execution, operational coordination, equipment restart processes, and perceived sources of delay.

The quantitative component utilized operational logs, Fleet Management System (FMS) data, and time motion observations to measure break duration, equipment idle time, and Primary Working Time (PWT). Operational records were analyzed to identify patterns of Internal Operational Delay (IOD) before, during, and after meal break periods. Direct observations were also conducted to validate the consistency between operational records and actual field conditions.

To evaluate process stability and operational variability, the study employed Statistical Process Control (SPC) using an Individuals Moving Range (XmR) control chart based on National Institute of Standards and Technology (NIST) methodology. The XmR chart was selected because operational delay data were collected sequentially over time and involved individual observations rather than subgroup measurements. This method enabled the identification of abnormal operational variations and inconsistencies in meal break execution.

During the Analyze phase, several analytical tools were applied to identify and validate root causes of operational delays. Pareto analysis was used to determine the most significant contributors to Internal Operational Delay (IOD), while Fishbone Diagram analysis categorized contributing factors into people, process, machine, material, and environment dimensions. Root Cause Validation and Cause Prioritization Matrix analysis were then conducted to determine which operational factors provided the highest improvement potential with relatively feasible implementation effort.

Based on the analytical findings, the Improve phase proposed the implementation of a staggered meal break system. Unlike simultaneous meal break execution, staggered scheduling distributes break periods sequentially among operational units to maintain partial operational continuity during break windows. The proposed improvement strategy was evaluated qualitatively and operationally to assess its feasibility and potential impact on reducing idle time and improving Primary Working Time (PWT).

Finally, the Control phase focused on developing mechanisms to sustain operational improvements through monitoring systems, Standard Operating Procedures (SOPs), and Key Performance Indicators (KPIs). Suggested KPIs include average delay duration per meal break period, percentage of equipment idle time during shifts, and monthly PWT performance trends. Continuous monitoring and operational feedback are essential to ensure that process improvements remain effective and sustainable within mining operations

RESULTS AND DISCUSSION

Define Phase

The Define phase was conducted to clarify the operational problem related to meal break execution and to establish the improvement scope within PT XYZ's mining operations. Operational observations and dispatch records indicated that meal breaks, although formally planned within shift schedules, frequently generated additional unplanned idle time that reduced Primary Working Time (PWT) and disrupted production continuity.

From an operational perspective, meal-break execution was identified as a suitable improvement target for three main reasons. First, meal breaks occur consistently during every shift, making the delay pattern recurring and measurable. Second, the operational impact extends beyond the break duration itself because additional recovery time is required to restore stable fleet flow after breaks. Third, compared with other operational delays such as weather disruptions or major equipment failures, meal break execution is relatively controllable and can be improved through operational coordination and scheduling adjustments.

A preliminary review of Internal Operational Delay (IOD) records further confirmed that meal break related delays represented one of the largest contributors to operational losses during the observation period. This finding supported the selection of meal break execution as the primary improvement focus within the DMAIC framework.

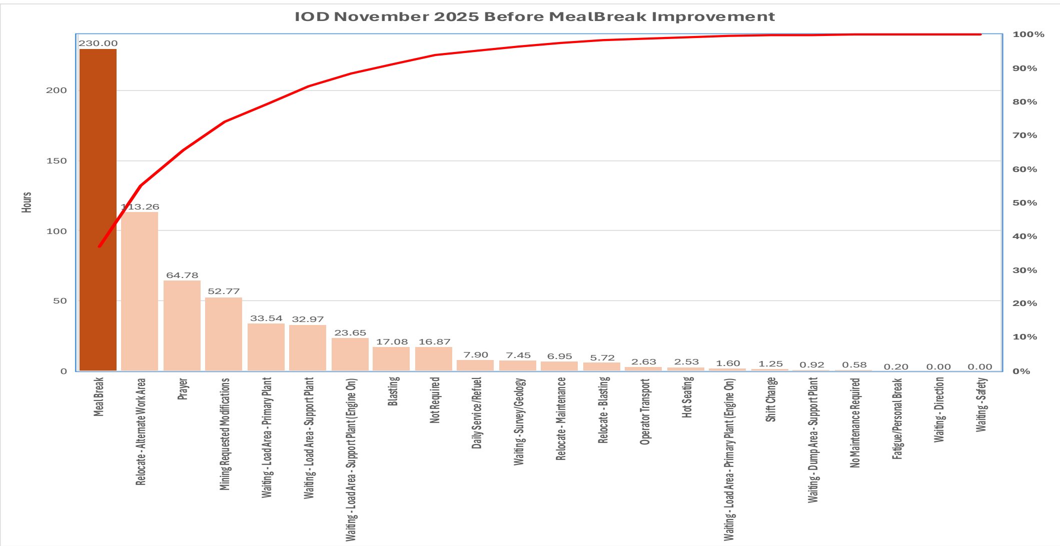

Figure 1. Pareto Chart of Current Operational Delays (Before Improvement)

The project objective was therefore established as reducing break related delays through a staggered meal break system to improve fleet utilization and stabilize operational flow without compromising worker welfare or labor compliance.

Measure Phase

The measure phase aimed to quantify the operational impact of meal break execution on Primary Working Time (PWT). Operational data were collected from Fleet Management System (FMS) records and daily operational logs during the observation period. Statistical Process Control (SPC) analysis using an Individuals Moving Range (XmR) chart based on the NIST methodology was employed to evaluate process stability.

The analysis produced an average PWT of 14.26 hours with an Upper Control Limit (UCL) of 21.66 hours and a Lower Control Limit (LCL) of 6.86 hours. Several observations fell below the lower control limit, indicating the presence of special cause variation and confirming that the operational process was statistically unstable.

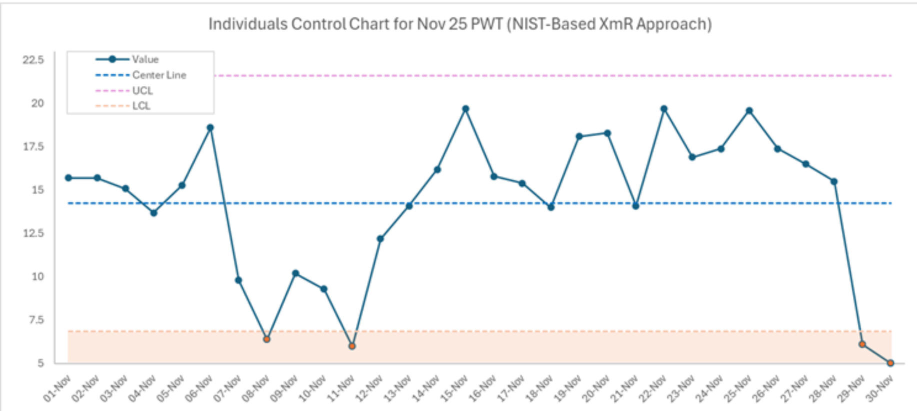

Figure 2. Individuals Control Chart (XmR) for PWT

The control chart also revealed substantial day to day variation in operational performance. Although the average PWT remained relatively close to production expectations, the instability indicated that operational delays were not consistently controlled. These findings demonstrated a measurable opportunity to recover lost productive time through operational improvement initiatives.

Table 1. Statistical Summary of PWT Control Chart

Indicator	Value
Average PWT	14.26 hours
Average Moving Range	2.78
Estimated Standard Deviation	2.46
Upper Control Limit (UCL)	21.66
Lower Control Limit (LCL)	6.86

Analyze Phase

Fishbone Analysis

Following the measurement stage, root cause analysis was conducted to identify the operational factors contributing to meal break related delays. A Fishbone Diagram (Ishikawa Diagram) was developed to categorize contributing factors into people, process, machine, material, and environment dimensions.

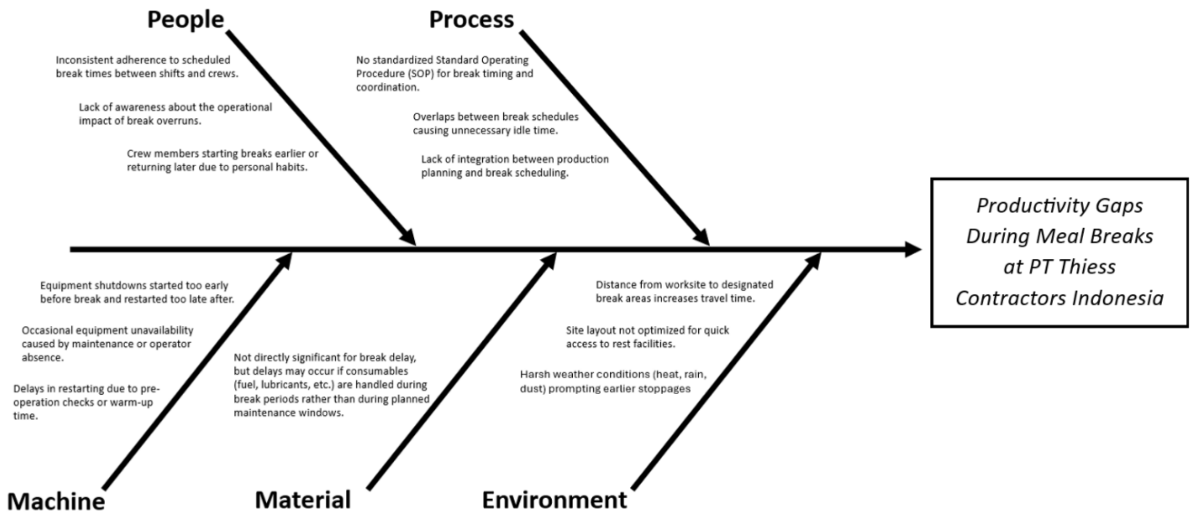

Figure 3. Fishbone Diagram of Meal Break Delay Factors

The analysis identified process related factors as the dominant contributors to operational inefficiency. The most critical issue was the implementation of simultaneous meal breaks across operational fleets, which created a “wave effect” where multiple units became idle simultaneously. This condition reduced fleet availability and generated concentrated idle time during break periods.

People related factors also contributed significantly to delay accumulation. Field observations showed inconsistent adherence to break schedules, including early break initiation and delayed return to operation. In addition, limited awareness regarding the cumulative impact of small operational delays increased variability in operational performance.

Machine related factors included early equipment shutdown before break periods and inconsistent restart procedures after breaks. Although these factors did not independently create delays, they intensified the operational consequences of simultaneous break execution.

Environmental and support related factors, such as long travel distances to rest areas and overlapping refueling activities during break windows, were also identified as secondary contributors to operational inefficiency.

Root Cause Validation and Prioritization Analysis

To ensure that improvement efforts focused on operationally significant factors, root causes identified through fishbone analysis were validated using operational records, field observations, and stakeholder interviews. A Cause Prioritization Matrix (Impact × Effort) was then applied to evaluate each factor based on its operational impact and implementation feasibility.

Table 2. Cause Prioritization Matrix (Impact x Effort)

Root Cause	Category	Impact	Effort	Priority
Meal break execution (simultaneous breaks / wave effect)	Process	High	Low	High Priority (Quick Win)
Relocation & alignment work area delays	Process	High	High	Medium Priority
Waiting time due to process coordination (e.g., blasting, instruction, standby)	Process	High	High	Medium Priority
Equipment restart delays (warm-up, readiness checks)	Machine	Medium	Medium	Medium Priority
Operator-related variability (timing discipline, responsiveness)	People	Medium–High	Medium	Medium Priority
Support process delays (fueling, minor servicing during operation)	Material	Low–Medium	Medium	Low–Medium Priority

Travel distance to crib / rest area	Environment	Medium	High	Low Priority
Weather-related disruptions	Environment	Low–Medium	High	Low Priority

The analysis identified simultaneous meal-break execution as the highest priority improvement opportunity because it generated substantial operational impact while requiring relatively low implementation effort. This finding validated the selection of staggered meal break scheduling as the primary improvement strategy.

Pareto Analysis of Internal Operational Delay (IOD)

Pareto analysis was conducted to evaluate the contribution of meal-break delays to total Internal Operational Delay (IOD) before and after implementation of the staggered meal break system. Before improvement, meal break related delays reached 230.00 hours and contributed significantly to the total IOD of 622.65 hours (Figure 1). During the same operational period, recorded Primary Working Time (PWT) was 1,236.92 hours.

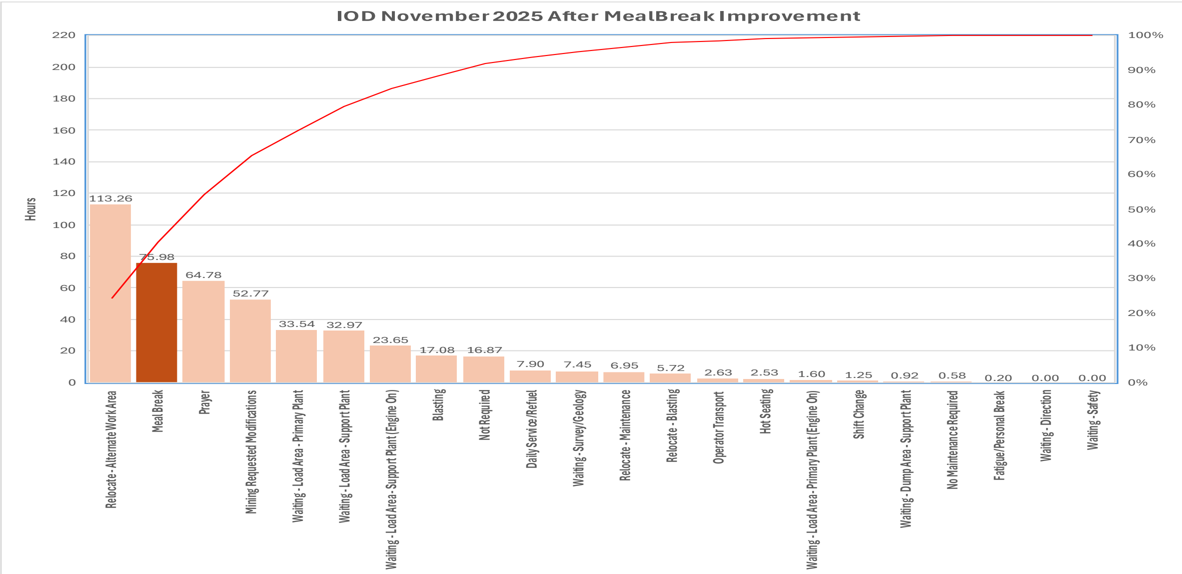

Figure 4. Pareto After Staggered Meal Break

Table 3. Total Hours Before and After Staggered Meal Break

Reason	Before (Hours)	After (Hours)
External Op Delay (EOD)	184.63	184.63
Internal Op Delay (IOD)	622.65	468.63
Non-Rostered Time (NRT)	427.78	427.78
Planned Maintenance (PMD)	135.67	135.67
Primary Working Time (PWT)	1236.92	1390.93
Secondary Working Time (SWT)	36.03	36.03
Unplanned Maintenance (UMD)	116.32	116.32
Grand Total	**2760**	**2760**

Following implementation of the staggered meal break system, meal break delay decreased substantially to 75.98 hours, while total IOD decreased to 468.63 hours. Simultaneously, PWT increased to 1,390.93 hours. The reduction of approximately 154 hours in IOD closely matched the increase in PWT, indicating that recovered delay time was effectively converted into productive working time.

These findings demonstrate that meal break execution represented a controllable operational loss category and that structured scheduling improvements could generate measurable operational benefits without requiring significant capital investment.

Imrpove Phase

Based on the analytical findings, the primary improvement strategy implemented in this study was the development of a staggered meal break system supported by a standardized Standard Operating Procedure (SOP). Unlike the previous simultaneous break system, staggered scheduling distributed meal breaks sequentially across operators and excavator units to maintain partial operational continuity during break periods.

	Shift												Utilization
Excavator Name	07	08	09	10	11	12	13	14	15	16	17	18	(Hours)
Excavator 01	Asferry	Asferry	Asferry	Asferry	Asferry	Asferry	Rest	Asferry	Asferry	Asferry	Asferry	Asferry	11
Excavator 02	Darmaji	Darmaji	Darmaji	Darmaji	Darmaji	Darmaji	Rest	Darmaji	Darmaji	Darmaji	Darmaji	Darmaji	11
Excavator 02	Sinaga	Sinaga	Sinaga	Sinaga	Sinaga	Sinaga	Rest	Sinaga	Sinaga	Sinaga	Sinaga	Sinaga	11
												Total Hours	33

Operator Name	Working Hours	Rest Hours
Asferry	11	1
Darmaji	11	1
Sinaga	11	1

Figure 5. Before Improvement: Simultaneous Meal Break System

Under the previous system, all excavator operators entered break periods simultaneously, resulting in: (1) Temporary production stoppage; (2) Increased truck queuing; (3) Reduced excavator utilization; (4) Extended operational recovery time

	Shift												Utilization
Excavator Name	07	08	09	10	11	12	13	14	15	16	17	18	(Hours)
Excavator 01	Asferry	Asferry	Asferry	Asferry	Asferry	Asferry	Rest	Asferry	Asferry	Asferry	Asferry	Asferry	11
Excavator 02	Darmaji	Darmaji	Darmaji	Darmaji	Darmaji	Darmaji	Rest	Darmaji	Darmaji	Darmaji	Darmaji	Darmaji	11
Excavator 02	Sinaga	Sinaga	Sinaga	Sinaga	Sinaga	Sinaga	Rest	Sinaga	Sinaga	Sinaga	Sinaga	Sinaga	11
												Total Hours	33

Operator Name	Working Hours	Rest Hours
Asferry	11	1
Darmaji	11	1
Sinaga	11	1

Figure 6. After Improvement: Simultaneous Meal Break System

After implementation, at least part of the excavator fleet remained operational throughout the shift. This reduced operational stoppages, minimized post break idle clustering, and improved production stability. Excavator utilization increased from approximately 11 productive hours per shift to nearly 12 productive hours per shift.

A financial feasibility assessment was also conducted to evaluate the economic impact of the proposed improvement. The analysis indicated that the operational gains generated through increased PWT were sufficient to offset the additional personnel and operational costs associated with staggered scheduling.

Description	UoM	Option I 3 Fleet
9350	Unit	1
9250	Unit	2
9350	Bcm/hr	1,212
9250	Bcm/hr	704
Capacity	Bcm/hr	2,620
Staggered Mealbreak Fleet	Fleet	3
Staggered Mealbreak Capacity	Bcm/day	2,400
Stripping Ratio	Bcm/T	8.9
Opportunity OB Production	Bcm	72,000
Opportunity Coal Production	Tonnes	8,048
Waste Distance	km	2.0
Coal Distance	km	5.4

Description	Option I 3 Fleet
Additional Personnel	9
Digger	1
Truck	5
Dozer	1
Grader	2

Description	Rate	Option I 3 Fleet
Main Contract	$	$ 223,171
Waste Removal	2.50	$ 180,000
Waste U/Ohaul	0.38	$ 26,885
Coal Getting	1.27	$ 10,222
Coal Overhaul	0.14	$ 6,064
Rise and Fall	%	$ 81,922
R&F Waste Removal	37%	$ 66,318
R&F Other	36%	$ 15,604
Earned Revenue		$ 305,093
Direct Cost	$	$ 213,052
Waste Removal	0.38	$ 27,360
Haul Waste	0.36	$ 51,390
Drill & Blast	0.41	$ 29,520
Coal Getting	0.43	$ 3,461
Haul Coal Pit to ICF	0.15	$ 6,497
Coal Rehandle	0.03	$ 241
Pit Support	0.54	$ 42,223
Fuel & backcharges	0.52	$ 40,659
Additional Operator	1,300	$ 11,700
G&A	6.28%	$ 19,160
Total Cost		$ 232,212
Profit		$ 72,881
PoR		23.9%

Figure 7. Financial Impact of Staggered Meal Break Implementation

The financial analysis demonstrated that operational improvements achieved through staggered meal break implementation generated positive returns while maintaining acceptable operational profitability margins.

Control Phase

The Control phase focused on sustaining the operational improvements achieved through the staggered meal break system. To prevent operational performance from reverting to previous conditions, a structured control framework was established consisting of standardization, monitoring, accountability, and continuous feedback mechanisms.

The staggered meal break workflow was formalized into a Standard Operating Procedure (SOP) that defined sequencing rules, dispatch responsibilities, supervisor control mechanisms, and deviation reporting procedures.

Table 4. Total Hours Before and After Staggered Meal Break

KPI	Definition	Frequency
Meal Break Delay Duration	Difference between planned and actual break duration	Daily
PWT During Break Window	Effective productive time during break period	Daily
Meal Break Related IOD	Delay caused by meal break execution	Weekly
Excavator Utilization	Productive operating hours per shift	Weekly

Clear accountability structures were also defined. Dispatchers were responsible for managing sequencing compliance, supervisors monitored operational discipline, and operational management reviewed performance trends regularly.

This study demonstrate that operational inefficiencies caused by meal break execution can be significantly reduced through structured scheduling control and operational discipline. The findings also emphasize that practical process improvements targeting controllable operational factors can generate substantial productivity gains in mining operations without requiring major infrastructure or technological investment.

CONCLUSION

study investigated the impact of meal break execution on operational efficiency in mining operations at PT XYZ using the Six Sigma DMAIC (Define Measure Analyze Improve Control) framework. The findings demonstrate that although meal breaks are mandatory and operationally planned, their simultaneous execution generated additional unplanned idle time that significantly reduced Primary Working Time (PWT) and disrupted production continuity.

The Define and Measure phases confirmed that meal break related delays represented a recurring and measurable contributor to Internal Operational Delay (IOD). Statistical analysis using the XmR control chart further indicated that the operational process was unstable, with several observations falling outside control limits due to special-cause variation associated with operational delays.

In the Analyze phase, root cause analysis revealed that the dominant contributors to delay were process and people related factors, particularly simultaneous meal-break scheduling, lack of coordination between dispatch and operations, and inconsistent adherence to break timing. Pareto analysis further validated that meal break execution represented one of the largest and most controllable sources of operational loss.

To address these issues, the Improve phase introduced a staggered meal-break scheduling system that redistributed break timing across operational units while maintaining compliance with labor and safety requirements. The implementation significantly reduced meal break related delay, decreased total Internal Operational Delay (IOD), and increased Primary Working Time (PWT). Operational improvements were also supported by positive financial outcomes, indicating that the proposed solution is economically feasible without requiring major capital investment.

Finally, the Control phase established sustainability mechanisms through Standard Operating Procedures (SOPs), KPI monitoring, dispatch accountability, and continuous operational evaluation to maintain long term performance consistency.

REFERENCES

Alomar, I., & Nikita, D. (2025). Predictive maintenance and spare-parts optimization using hybrid forecasting models to reduce equipment downtime. Applied Sciences, 15(2), 945.

Atakhanova, Z., & Azhibay, S. (2023). Labor productivity in mining under resource depletion and economic pressure: Evidence from Kazakhstan. Resources Policy, 85, 103987.

Bicheno, J., & Holweg, M. (2009). The lean toolbox: The essential guide to lean transformation (4th ed.). Picsie Books.

Coutinho, H. L., Pereira, B. I., Pinto, R. J. L., Lima, H. M., & Costa, L. V. (2024). Application of Lean Six Sigma to improve productivity of truck–excavator fleets in mining operations. International Forum on Clean Energy (IFC) 2024 Proceedings.

Fursule, N. V., Bansod, S. V., & Fursule, S. N. (2012). Understanding the Benefits and Limitations of Six Sigma Methodology. International Journal of Scientific and Research Publications, 2(1).

George, M. L. (2002). Lean Six Sigma: Combining Six Sigma quality with Lean production speed. McGraw-Hill.

Heizer, J., & Render, B. (2011). Short-Term Scheduling. . In Principles of Operations Management.

Heizer, J., Render, B., & Munson, C. (2017). Operations management : sustainability and supply chain management. Pearson Education Limited.

Montgomery, D. C. (2009). Introduction to Statistical Quality Control (6th ed). Arizona State University.

Pathan, S. M., Pathan, A. G., & Memon, M. S. (2024). Analysis of operational delays in dumper cycles of open-pit mining operations. IEOM Society International Conference Proceedings.

Powell, T., & Bonnici, T. S. (2015). Pareto Analysis.

Pyzdek, T. (2003). The Six Sigma handbook: A complete guide for green belts, black belts, and managers at all levels. McGraw-Hill.

Vallejo, A. A. D., Acosta, F. J. G., Ibanez, C. R., & Rojas, V. S. A. (2023). Continuous improvement model under the Lean Six Sigma and KPIs approach to reduce unproductive times in the loading and hauling stage in surface mining. 2023 Congreso Internacional de Innovación y Tendencias En Ingeniería (CONIITI), 1–6.