

Optimization of Pc500 Unit Rolling to Eliminate Double Cost at PT Antareja Mahada Makmur Jobsite Mifa Bersaudara

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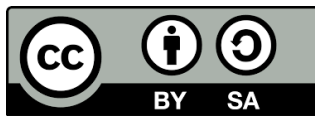
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ABSTRACT

Uneven operating hours among rented excavators can result in standby charges despite adequate overall equipment utilization, thereby increasing operational costs in mining activities. This study aimed to identify the causes of hour meter imbalances and evaluate an equipment rotation mechanism for eleven PC500 excavators at PT Antareja Mahada Makmur, Mifa Bersaudara Jobsite, under a contractual minimum requirement of 398 operating hours per unit per month. A Quality Control Circle (QCC) approach incorporating the Plan–Do–Check–Act (PDCA) cycle was employed. Operational records from January to May 2026 were used to establish baseline conditions, while corrective measures were implemented and evaluated during June and July 2026. A fishbone diagram analysis identified insufficient supervisory monitoring and the absence of standardized guidelines for equipment rotation and activity allocation as the primary contributing factors. The interventions included routine operational briefings, systematic hour meter monitoring, an activity monitoring dashboard, and a rotation priority matrix developed using existing resources. Excess standby costs decreased from a peak of USD 6,528 in March to USD 145 in June and were eliminated entirely in July, when average operating hours reached 481 per unit. These findings demonstrated that prioritizing underutilized excavators could effectively minimize additional charges resulting from uneven equipment utilization. The interventions required no additional expenditure and were subsequently formalized through a standard operating procedure (SOP). The study concluded that an operating-hour-based equipment rotation strategy improved operational cost control and resource utilization, although a longer observation period is necessary to evaluate its long-term sustainability.



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INTRODUCTION

The availability and utilization of heavy equipment supporting production operations are key factors influencing operational cost efficiency in the mining industry (Jafari et al., 2026; Pavlidakis et al., 2024; Pervukhin & Tang, 2024; Waqar et al., 2024). Suboptimal management of heavy equipment operating hours, as recorded by hour meters (HM), can reduce productivity and increase operational costs due to equipment remaining on standby

(idle) or being operated beyond actual operational requirements (Castañón et al., 2024; Prabowo et al., 2023; Rivai & Octova, 2021; Semarajaya et al., 2021).

Under heavy equipment rental contracts in the mining industry, a minimum number of monthly operating hours is generally established as the basis for billing. If a unit's actual operating hours fall below the contractual minimum, the company may still incur standby charges corresponding to the shortfall. Conversely, when one unit exceeds the minimum operating hours while other units remain below the required threshold, the company may incur overlapping rental and standby charges, resulting in additional operational expenses commonly referred to as double costs (Lusitania & Razak, 2025; Sidinra et al., 2022).

At PT Antareja Mahada Makmur (AMM), Mifa Bersaudara Jobsite, eleven PC500 excavators are deployed for loading and production-support activities, with a contractual minimum requirement of 398 operating hours per unit per month. To identify and classify the primary sources of operational costs, a stratification analysis was conducted by categorizing the cost contributions of different equipment types according to their operational activities during the January–May 2026 period, as presented in Table 1.

Table 1. Stratification of Operational Costs by Activity and Unit Type (January–May 2026)

Activity	Unit Type	Cost Contribution
Hauling	MB4845	38%
Hauling	CAT777	19%
Loading & Support	PC500	13%
Road Maintenance	GD705	10%
Loading	CAT395	9%
Support	PC210	6%
Hauling	HD785	4%
Road Maintenance	SV526D	1%
Support	Tower Lamp	1%

Based on this stratification analysis, the PC500 excavators were identified as the third-largest contributors to operational costs (13%), following the MB4845 (38%) and CAT777 (19%) haulage units. The MB4845 and CAT777 units were excluded from the improvement initiative because they are directly involved in production-related hauling activities, with operating hours primarily determined by production demands (Liu et al., 2022; Prasetyo et al., 2024), thereby limiting opportunities for further optimization. In contrast, the PC500 excavators, which perform loading and production-support activities, offer greater potential for optimizing hour meter (HM) utilization through effective demand planning and operational scheduling (Hazrathosseini & Moradi Afrapoli, 2024; Liu et al., 2022). Therefore, the PC500 excavators were selected as the primary focus of the improvement initiative in this study.

The operational data analysis revealed that, during February–March 2026, the actual standby costs associated with the PC500 excavators consistently exceeded the expected standby costs. Furthermore, during April–May 2026, although the average operating hours per

unit had reached or exceeded the contractual minimum of 398 hours, standby charges continued to occur. These findings indicated an uneven distribution of operating hours among the excavators, resulting in recurring excess costs (Rahimdel et al., 2026). The highest recorded excess cost reached USD 6,528 in March 2026, representing approximately 3.9% of the total standby costs.

Previous studies have demonstrated that consistent hour meter monitoring significantly influences heavy equipment productivity and operational cost efficiency (Limbong et al., 2026; Semarajaya et al., 2021). Similarly, improvements in the effective utilization of loading and excavation equipment have been shown to substantially reduce operational cost losses (Lusitania & Razak, 2025; Prabowo et al., 2023; Rivai & Octova, 2021). Furthermore, the continuous improvement approach based on the Plan–Do–Check–Act (PDCA) cycle has been widely adopted as a systematic framework for identifying root causes, developing corrective actions, and implementing measurable operational improvements within a Quality Control Circle (QCC) (Cuya-Acuña et al., 2025; Fernandes et al., 2022; Gaspersz, 2011; Ishikawa, 1985; Isniah et al., 2020; Nguyen et al., 2023).

In response to these operational challenges, the SRT500 Team developed a data-driven PC500 excavator rotation and control mechanism based on individual unit operating hours (Bisschoff & Grobbelaar, 2022; Zhang et al., 2023) to eliminate overlapping rental and standby charges (double costs) resulting from uneven equipment utilization. This study aimed to identify the root causes of operating-hour imbalances among PC500 excavators, design and implement corrective measures without incurring additional costs, and evaluate their effectiveness in reducing excess standby charges and achieving a more balanced distribution of operating hours across units during June–July 2026

METHOD

This study employed a Quality Control Circle (QCC) approach based on the Plan–Do–Check–Act (PDCA) cycle, comprising seven stages. The research began with problem identification using operational data from January to May 2026, followed by the design and implementation of corrective measures from June to July 2026. Evaluation and standardization were conducted in August 2026. The research stages are summarized in Table 2.

Table 2. Stages of the PDCA-Based Research Method

No.	Stage (PDCA)	Activity	Output
1	Plan (Step 1–4)	Problem identification & stratification, determination of theme and title, analysis of impact on stakeholders, and setting of targets (SMART).	Ratified theme, title, and SMART target
2	Plan (Step 2–3)	Review of the problem object, cause-and-effect (fishbone) analysis, determination of dominant root causes, formulation of alternative solutions, and selection of the best solution along with its risk analysis.	Dominant root causes and selected solutions
3	Do (Step 4–5)	Preparation of the improvement plan (What-How-Why-Where-Who-When-	Improvement solutions

No.	Stage (PDCA)	Activity	Output
		How Much), preparation of team competencies and resources, and implementation of the improvement solutions.	implemented during the June–July 2026 period
4	Check (Step 6)	Evaluation of improvement results based on standby cost and HM data, verification of financial performance, and analysis of target achievement based on the QCDSM aspects.	Comparison of conditions before and after improvement
5	Action (Step 7)	Preparation of a proposed new standard in the form of a Standard Operating Procedure (SOP) for HM Unit Controlling.	New SOP ratified (AMM-MIFA-SOP-ENG-33)

The improvement target was established using the SMART framework, aiming to eliminate double costs associated with PC500 excavator standby charges and excess operating hours. The target was to reduce these costs to zero through an equipment rotation and control mechanism based on operational requirements and individual unit hour meter (HM) utilization. This initiative was aligned with the dispatch key performance indicators (KPIs) and mining profit margin objectives, with implementation scheduled for June–July 2026.

Root Cause Analysis

Root cause analysis was conducted using a cause-and-effect (fishbone) diagram, examined from the Man, Method, and Environment factors, as shown in Figure 1. The review of the problem object showed that supervisors had not been consistently monitoring PC500 HM and activity (Man); there was no reference for rolling units or for determining PC500 activity based on HM achievement (Method); and the demand for and placement of PC500 units as loading or support units changed according to operational and pit conditions (Environment).

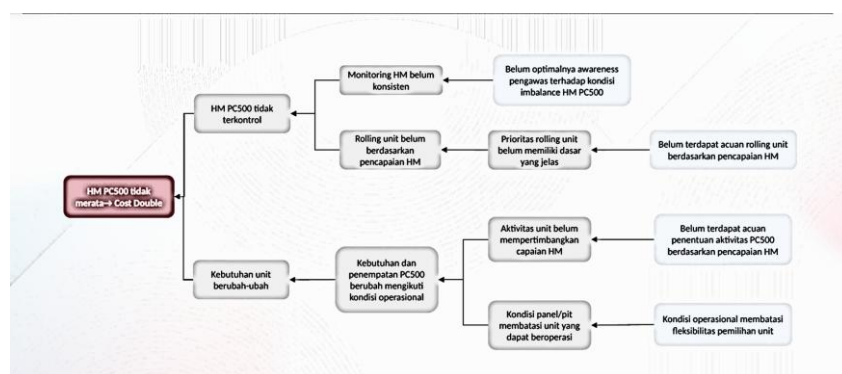


Figure 1. Cause-and-Effect (Fishbone) Diagram of PC500 HM Imbalance

Based on validation of actual field conditions, four dominant root causes were established, namely: (1) supervisors' awareness of the PC500 HM imbalance condition was not yet optimal; (2) there was no reference for rolling units based on HM achievement; (3) there

was no reference for determining PC500 activity based on HM achievement; and (4) operational conditions limiting the flexibility of unit selection due to limited panel/pit conditions.

Determination and Risk Analysis of Solutions

For the first three root causes, five alternative solutions were formulated and then evaluated based on effectiveness, cost, and ease of application (Table 3). All five solutions were determined to be effective, cost-free (IDR 0), and easy to implement, and were therefore selected for implementation. The fourth root cause, namely limited operational/pit conditions, was not implemented because the proposed solution in the form of a unit-allocation plan was considered difficult to apply consistently due to dynamic changes in field and weather conditions in each panel.

Table 3. Determination of the Best Solutions Based on Effectiveness, Cost, and Ease-of-Application Analysis

Root Cause	Selected Solution	Analysis	Remarks
Supervisors' awareness of HM imbalance not yet optimal	Routine briefing and discussion on PC500 HM achievement every shift; socialization of the impact of HM imbalance on cost	Effective; IDR 0; Easy	Implemented
No reference yet for rolling units based on HM achievement	Creating a PC500 HM monitoring format as the basis for rolling units	Effective; IDR 0; Easy	Implemented
No reference yet for determining PC500 activity based on HM	Creating a unit activity monitoring dashboard and a loading/support activity priority matrix based on HM	Effective; IDR 0; Easy	Implemented
Operational conditions limiting the flexibility of unit selection	Creating a unit allocation plan based on operational needs and area conditions	Effective; IDR 0; Difficult to apply consistently	Not implemented

Risk analysis of the five selected solutions was carried out based on four criteria (effectivity, effortness, time, and cost) using a 1–3 scale, and all solutions obtained a total score of 11–12 out of a maximum of 12, and were therefore accepted for implementation in the improvement plan.

Implementation Plan and Preparation

The improvement action plan was drawn up using the What-How-Why-Where-Who-When-How Much format, with GL Dispatch and GL Manpower Equipment (MPE) as the main implementers, during Weeks 1 and 2 of June 2026, with an implementation cost of IDR 0 for all solutions. Preparation of the team's competencies included understanding of shift schedules and unit assignment (Dispatch Operation), data analysis and dispatch system skills (Dispatch Analyst), and cross-functional communication with the MPE team (coordination soft skills). The resources prepared included personnel (GL Dispatch & GL Manpower), infrastructure (laptop/PC, Microsoft Excel, and the SPIPP/Web SS6 system), the implementation environment (the PC500 operational area and briefing room), and monitoring data in the form of PC500 HM, activity, and status data.



Figure 2. Implementation of Routine Briefings and Discussions on PC500 HM Achievement

In addition to routine briefings, the team also carried out a socialization session on the impact of HM imbalance on overcost for all relevant supervisors and operators (Figure 3), as part of the solution to increase supervisors' awareness of the PC500 HM imbalance condition.



Figure 3. Socialization of the Impact of HM Imbalance on PC500 Overcost

Design of the Monitoring System and Rolling-Unit Prioritization

As a reference for rolling units, the team developed a PC500 HM monitoring format containing month-to-date (MTD) HM achievement, deviation from the minimum hours (398 hours), remaining working days, average daily HM over the past week, and projected remaining unit usage, as shown in Figure 4. This format is used as the basis for determining rolling-unit priority, in which the unit with the largest HM deviation (furthest from 398 hours) is prioritized to be operated (running), while units that have approached or exceeded the minimum HM are directed to standby or general/rehandling duties as needed.

Unit	Unit	HM MTD	Jam Minimum	Dev HM	Sisa Hari	Average HM Daily 1 Minggu Terakhir	Sisa Penggunaan (Hari)	Note
1	E517PPA	88,7	398	309,3	19	14,1	22,0	Prior Running CG
2	E5511	125,2	398	272,8	19	14,1	19,4	Prior Running CG
3	E5512	133,2	398	264,8	19	14,1	18,8	Prior Running CG
4	E5506	138	398	260	19	14,1	18,5	Prior Running CG
5	E5507	141,4	398	256,6	19	14,1	18,3	Prior Running CG
6	E5530	146,4	398	251,6	19	14,1	17,9	Prior Running CG
7	E5509	163,1	398	234,9	19	14,1	16,7	General/Rehandling jika dibutuhkan
8	E5510	163,3	398	234,7	19	14,1	16,7	General/Rehandling jika dibutuhkan
9	E5508	204,3	398	193,7	19	14,1	13,8	Jika tidak urgent, diutamakan standby
10	E518PPA	212,2	398	185,8	19	14,1	13,2	Jika tidak urgent, diutamakan standby
11	E5529	216	398	182	19	14,1	12,9	Jika tidak urgent, diutamakan standby

Figure 4. PC500 Rolling-Unit Priority Matrix Based on HM Achievement

To facilitate daily monitoring of unit activity, HM and unit activity data are integrated into a monitoring dashboard based on the company's internal application (Figure 5), so that the

dispatch and MPE teams can monitor the status, location, and activity of each PC500 unit in real time without having to conduct manual field checks.

		SMALL DIGGER ACTIVITY REPORT AMM - MFA											
Rabu, 24 Agustus 2024												Shift Malam 05:00	
No	HE-001	HE-002	HE-003	ACTIVITY								PROBLEM	REMARK
				19:00	20:00	21:00	22:00	23:00	00:00	01:00	02:00		
KEMASUKAN PUMP-10M5 & KEMASUKAN POSSIBLE 10M													
1	E200MFA	PT SELATAN	Abukha	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	RIZA MANAPAT	clearing BM 1 Abukha
2	E200MFA	PT SELATAN	Abukha	Slaying	Slaying	Slaying	Slaying	Slaying	Slaying	Slaying	Slaying	SARU ANWAR	
3	E200MFA	PT SELATAN	Mitigi	Slaying	Slaying	Slaying	Slaying	Slaying	Slaying	Slaying	Slaying	SARU ANWAR	
4	E200MFA												
5	E200MFA												
6	E003												
7	E200MFA												
8	E004												
9	E200MFA												
10	E005												
11	E005	PT SELATAN	PT Selatan	Penghap Tunggai	Penghap Tunggai	Penghap Tunggai	Penghap Tunggai	Penghap Tunggai	Penghap Tunggai	Penghap Tunggai	Penghap Tunggai	SARU ANWAR	
12	E009	PT BARAT	QPO Barat	Leading Soil	Leading Soil	Leading Soil	Leading Soil	Leading Soil	Leading Soil	Leading Soil	Leading Soil	WIRATNO	
13	E200MFA												
14	E004	PT SELATAN	Mitigi	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	WIRATNO FARI	clearing
15	E200MFA	PT SELATAN	Saren B Utara	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	YUSRI SULITON A	pendaftaran parit di atas
16	E200MFA												
17	E200MFA	PT UTARA	Saren B Utara	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	Pembuat Paritan	YUSRI SULITON A	kuran kan handling di 2000
18	E200MFA												
19	E200MFA												
20	E006	PT SELATAN	Mitigi	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	Clearing BM	WIRATNO FARI	clearing
21	E006	PT SELATAN	Abukha	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	RIZA MANAPAT	leading cool
22	E007	PT SELATAN	Abukha	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	RIZA MANAPAT	leading cool
23	E008	PT SELATAN	Mitigi	Clearing BM dan Root Saffty	Clearing BM dan Root Saffty	Clearing BM dan Root Saffty	Clearing BM dan Root Saffty	Clearing BM dan Root Saffty	Clearing BM dan Root Saffty	Clearing BM dan Root Saffty	Clearing BM dan Root Saffty	WIRATNO FARI	general purpose digger
24	E009	PT UTARA	Saren B Utara	Coltoid BM	Coltoid BM	Coltoid BM	Coltoid BM	Coltoid BM	Coltoid BM	Coltoid BM	Coltoid BM	YUSRI SULITON A	cekak kaku hura di 900 utara
25	E009	PT UTARA	Saren B Utara	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	WIRATNO FARI	leading cool
26	E009	PT UTARA	Saren B Utara	Cool Dettling	Breakdown	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	WIRATNO SAPUTRA	Cool Problem
27	E007	PT SELATAN	Saren B Selatan	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	WIRATNO FARI	leading cool
28	E009MFA	PT UTARA	Saren B Utara	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	WIRATNO FARI	leading cool
29	E009MFA												
30	E009	PT SELATAN	Abukha	OB Removal	OB Removal	OB Removal	OB Removal	OB Removal	OB Removal	OB Removal	OB Removal	RIZA MANAPAT	leading di by Sery Abukha
31	E009	PT SELATAN	Abukha	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	Cool Dettling	WIRATNO FARI	Cool Problem

Figure 5. PC500 Unit Activity Monitoring Dashboard

RESULTS AND DISCUSSION

Evaluation of the improvement's success was carried out by comparing the trend of standby overcost and average PC500 HM in the period before improvement (January–May 2026) and after improvement (June–July 2026), as shown in Figure 6.

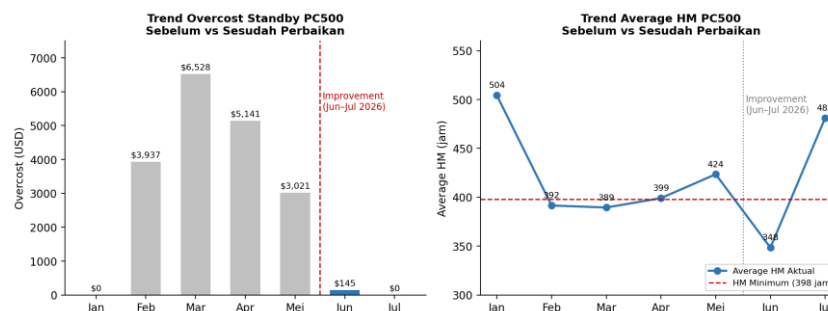


Figure 6. Trend of Standby Overcost and Average PC500 HM Before and After Improvement

Before the improvement, PC500 standby overcost fluctuated and reached a peak value of USD 6,528 in March 2026, with an average HM that was unstable relative to the 398-hour minimum threshold. After the improvement was implemented in June 2026, the deviation between actual and expected standby cost was successfully suppressed to only USD 145, and in July 2026, overcost reached USD 0, with an average PC500 HM of 481 hours, well above the 398-hour minimum threshold. This shows that the distribution of HM across PC500 units has become more even and controlled through the data-driven rolling-unit mechanism.

Table 4. Analysis of Target Achievement Based on the QCDSM Aspects

Aspect (QCDSM)	Achievement After Improvement
Quality	The distribution of PC500 HM across units became more controlled through data-driven monitoring.
Cost	PC500 standby cost was successfully suppressed to USD 145 in June 2026 and USD 0 in July 2026, down from a previous peak overcost of USD 6,528.
Delivery	Monitoring of PC500 HM distribution became more effective, targeted, and could be tracked in real time via the dashboard.
Safety	Reduced potential operational risk arising from the use of PC500 units with excessive HM without adequate maintenance scheduling.
Morale	Increased supervisors' awareness and involvement in PC500 HM control through routine briefings and socialization.

In terms of cost, all improvement solutions were implemented at no additional cost (IDR 0/USD 0), as they made use of already-available resources, namely dispatch and MPE personnel, computer devices, the Microsoft Excel application, and internal information systems (SPIPP/Web SS6). The cost efficiency achieved came purely from the reduction in standby overcost resulting from more even HM distribution, from USD 6,528 at its peak to USD 145 in June and USD 0 in July 2026, equivalent to up to a 100% reduction in overcost in the final evaluation month.

In operational terms, the availability of the HM monitoring format and unit activity dashboard made it easier for the dispatch team to objectively determine rolling-unit priority based on data, replacing what had previously been a reactive and undocumented determination process. The rolling-unit priority matrix (Figure 4) enables the team to consistently direct units with the largest HM deviation to be prioritized for operation, so that operating hours across units can be evenly distributed before approaching the end of the monthly contract period.

As a follow-up to the success of this improvement, PT AMM Jobsite Mifa Bersaudara ratified a Standard Operating Procedure (SOP) for HM Unit Controlling (Doc. No. AMM-MIFA-SOP-ENG-33; PT Antareja Mahada Makmur, 2026), which governs the purpose, scope, definitions, and procedures for HM monitoring, identification of HM imbalance, determination of rolling priority, implementation, and evaluation of rolling-unit results, as shown in Figure 7. This standard serves as the official reference for all similar units within PT AMM Jobsite Mifa Bersaudara to prevent the recurrence of double cost conditions caused by HM imbalance.

CONCLUSION

The implementation of a data-driven PC500 excavator rotation and control mechanism based on hour meter (HM) utilization, supported by routine briefings and training sessions, a standardized HM monitoring system, an equipment activity dashboard, and a unit rotation priority matrix, effectively eliminated double costs at PT Antareja Mahada Makmur (AMM), Mifa Bersaudara Jobsite. Excess standby costs, which had previously reached USD 6,528 per month, decreased to USD 145 in June 2026 and were completely eliminated in July 2026. During this period, the average operating hours of PC500 excavators exceeded the contractual

minimum requirement of 398 hours per unit per month.

All corrective measures were implemented without additional expenditure by utilizing existing resources, personnel, and information systems within the dispatch and Mining Production Engineering (MPE) departments. In addition to reducing operational costs, these improvements enhanced supervisors' awareness of equipment operating-hour management and supported the company's mining profit margin objectives in alignment with dispatch key performance indicators (KPIs).

The findings suggest that the HM-based equipment rotation and control mechanism could be extended to other production-support equipment operating under similar minimum-hour rental agreements. Future research should investigate the integration of an automated early-warning system into the monitoring dashboard and examine how working-area and mining pit conditions influence equipment rotation flexibility. Further evaluation over an extended operational period is also recommended to assess the long-term effectiveness and sustainability of the standardized HM-based equipment control procedure.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest, whether personal, commercial, or financial, that could have influenced the conduct or the results of this research.

AUTHOR CONTRIBUTIONS

B.M.A.S. Anaconda Bangkara and Nimas Aryany Pratiwi contributed to the conceptualization, theoretical development, literature synthesis, and analytical interpretation of the study. Both authors participated in drafting, reviewing, and revising the manuscript, approved the final version for publication, and agreed to be accountable for the integrity and accuracy of the work.

GENERATIVE AI STATEMENT

In preparing this article, the authors used generative artificial intelligence (AI) as a tool to assist with language refinement, structuring of the text, and grammar correction. The use of AI was limited in scope and remained under the authors' supervision. All data, analysis, interpretation, and scientific content in this article have been checked and verified by the authors. The authors bear full responsibility for the accuracy, originality, and final content of the manuscript.

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