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Application of Overall Labor Effectiveness (OLE) and Root Cause Analysis for Workforce Performance Improvement

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Abstract

This study evaluates workforce performance using the Overall Labor Effectiveness (OLE) index in the cleaning workshop of an investment casting factory over a one-year period. OLE was calculated monthly across availability, performance, and quality components and compared against global benchmarks. The annual average OLE of 81.44% fell below the benchmark of 85%, with Quality identified as the primary limiting factor. Root Cause Analysis (RCA) using the 5 Whys technique revealed two systemic issues: a misaligned incentive system that prioritized production volume over quality, and inadequate production planning leading to end-of-period overworking. Redesigning the incentive system and adopting risk-based production planning are proposed as primary improvement interventions.

Keywords: Overall labor effectiveness, Operator performance, Root cause analysis, 5 whys, Performance improvement, Investment casting.

1 | Introduction

In today's highly competitive manufacturing environment, organizations are required to effectively utilize technology, production equipment, and human resources to enhance productivity, improve quality, and increase operational flexibility.

Despite significant advancements that have been made in automation, digitalization, and intelligent systems, human resources remain one of the most critical factors influencing organizational performance. Employees' knowledge, skills, experience, and decision-making abilities play a decisive role in the effective utilization of equipment, execution of processes, and achievement of organizational objectives [1]. Therefore, enhancing workforce performance and establishing effective performance evaluation mechanisms have become critical concerns in operations management and productivity improvement [2].

Since the early twentieth century, with the emergence of Scientific Management proposed by Frederick Winslow Taylor, efforts to standardize work and measure labor productivity began [3]. Subsequently, the

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development of Key Performance Indicators (KPIs) enabled organizations to quantitatively evaluate their performance, identify weaknesses, and strengthen data-driven decision-making [4]. Among operational indicators used in manufacturing, Overall Equipment Effectiveness (OEE) is one of the most widely applied metrics, originally developed within the framework of Total Productive Maintenance (TPM). This indicator consists of three components—availability, performance, and quality—and serves as an effective tool for identifying losses and evaluating equipment efficiency [5].

Despite its widespread application across industries, OEE primarily focuses on equipment and machinery and does not directly assess workforce performance. Meanwhile, in many manufacturing environments, a substantial portion of variations in productivity, quality, and overall performance can be attributed to human factors, which also influence the successful implementation of Total Quality Management (TQM) [6]. Consequently, in recent years, Overall Labor Effectiveness (OLE) has been introduced as a complementary indicator to OEE.

By preserving the conceptual structure of OEE, OLE evaluates workforce performance through three dimensions: labor availability, labor performance, and quality of outputs associated with labor activities. Since its introduction, OLE has been applied across various industries and manufacturing environments [7], and some extensions and complementary performance evaluation approaches have been developed based on this framework [8].

In addition to providing a comprehensive picture of workforce effectiveness, OLE can serve as a valuable basis for identifying sources of loss, evaluating the effectiveness of corrective actions, and improving organizational productivity.

Studies have shown that implementing OLE can enhance employees' awareness of the importance of production activities and increase transparency in reward systems, ultimately contributing to improved financial performance [9]. Therefore, the application of this indicator has gained growing importance in manufacturing environments. Case studies have demonstrated that combining OLE with methods such as the Analytic Hierarchy Process (AHP), Root Cause Analysis (RCA), and process improvement approaches such as Six Sigma can facilitate a deeper understanding of current conditions and the identification of factors affecting performance. For example, Maharani et al., in a case study conducted in the musical instrument manufacturing industry, employed OLE together with AHP and RCA and identified quality as the most significant constraint on performance [10]. Other studies have similarly shown that integrating OLE with various analytical tools can reveal a significant relationship between product quality and workforce performance, providing a foundation for operational improvement initiatives [11].

Despite the growing importance of OLE, a review of previous studies indicates that most existing research has focused on the conceptual development of the indicator or on cross-sectional evaluations. Longitudinal studies, particularly those incorporating RCA of performance-related factors in complex industries such as investment casting, appear to be limited. Furthermore, empirical evidence regarding the practical use of OLE as a tool for identifying operational issues and formulating improvement actions in real production environments is still scarce [9–11].

Accordingly, the present study aims to evaluate workforce performance using the OLE indicator in the cleaning workshop of an investment casting factory. In this study, employee performance data were collected over a one-year period, and the OLE indicator was calculated on a monthly basis. Subsequently, trends in the indicator were analyzed, and factors contributing to performance deterioration were identified through RCA. Finally, based on the findings, a set of improvement recommendations was proposed to enhance workforce effectiveness and increase productivity.

2 | Research Methodology

This study is applied in purpose and descriptive–analytical in nature, relying on quantitative data. The descriptive component focuses on documenting the actual workforce performance over a one-year period, whereas the analytical component aims to identify performance trends, deviations from expected levels, and their root causes.

2.1 | Case Study

The case study was conducted in the cleaning workshop of an investment casting company. This workshop was selected as a suitable environment for evaluating OLE due to its considerable dependence on workforce skills, availability, and productivity compared with more automated manufacturing processes.

The workshop consists of deburring, milling, and welding units and operates with approximately 40 employees working in a single shift. Furthermore, owing to the production of a wide variety of parts and the execution of numerous finishing operations, workforce performance plays a critical role in achieving production targets, maintaining product quality, and meeting production schedules.

2.2 | Data Collection

Data were collected monthly over a one-year period. The collected data included operational indicators such as production efficiency, the number of produced parts, scrap and rework rates, and operators' working time records.

2.3 | Overall Labor Effectiveness Calculation Model

OLE is calculated as the product of three main components: Availability, Performance, and Quality, as shown in *Eq. (1)*.

$$\text{OLE} = \text{Availabiility} * \text{Performance} * \text{Quality}. \tag{1}$$

I. Availability: Availability represents the ratio of productive working time to the total available working time of the workforce and is calculated using *Eq. (2)*.

$$\text{Availability} = \frac{\text{Productive Time}}{\text{Total Available Working Time}}. \tag{2}$$

II. Performance: Performance represents the ratio of the actual production rate to the ideal production rate, taking into account speed losses such as minor stoppages and reduced operating speed, and is calculated using *Eq. (3)*.

$$\text{Performance} = \frac{\text{Actual Production Rate}}{\text{Ideal Production Rate}}. \tag{3}$$

III. Quality: Quality represents the ratio of accepted products to the total number of products processed by the operator, taking into account scrap and rework that occur due to the operator, and is calculated using *Eq. (4)*.

$$\text{Quality} = \frac{\text{Accepted Products}}{\text{Total Number Of Products}}. \tag{4}$$

3.4 | Data Analysis Procedure

In this study, the three components of the OLE index — availability, performance, and quality — were calculated monthly over a one-year period using real operational data collected from the workshop, and the overall OLE index was derived and compared against benchmarks.

In the first stage, the monthly values of each component and the overall OLE index were examined to identify performance trends and critical points of underperformance. In the second stage, each component was individually analyzed and compared against its benchmark to determine the degree of deviation and characterize the nature of underperformance — whether isolated or persistent.

In the third stage, the three components were compared to identify the primary limiting factor — the component exhibiting the largest and most persistent gap from its benchmark. The 5 Whys technique was then applied to extract the root causes of performance deterioration, and based on the findings, improvement recommendations were proposed to enhance workforce performance.

3 | Results and Discussion

3.1 | Overall Labor Effectiveness Analysis

Table 1 presents the monthly OLE components and overall index values. Benchmarks were set at 90%, 95%, and 99.99% for Availability, Performance, and Quality respectively, resulting in an OLE benchmark of approximately 85%.

Table 1. Monthly ole components and overall index.

Month	Availability	Performance	Quality	OLE
1	93%	97%	96%	86.60%
2	94%	98%	97%	89.36%
3	96%	96%	94%	86.63%
4	94%	93%	96%	83.92%
5	97%	95%	95%	87.54%
6	79%	88%	96%	66.74%
7	90%	97%	94%	82.06%
8	97%	94%	93%	84.80%
9	91%	92%	95%	79.53%
10	93%	96%	91%	81.24%
11	93%	94%	92%	80.43%
12	80%	95%	90%	68.40%
Avg	91.42%	94.58%	94.08%	81.44%
Benchmark	90%	95%	99.99%	85%

As illustrated in *Fig. 1*, the monthly OLE values exhibit considerable variation throughout the year, with the overall average (81.44%) falling below its benchmark of 85%. The most significant declines occurred in months 6 and 12, where OLE dropped to 66.74% and 68.40%, respectively, primarily due to sharp reductions in Availability. In addition, a secondary downward trend is observed in the Quality component from month 10 onward, which coincided with the continued decrease in OLE. These combined effects contributed to sustained OLE values below the benchmark during the final quarter of the year.

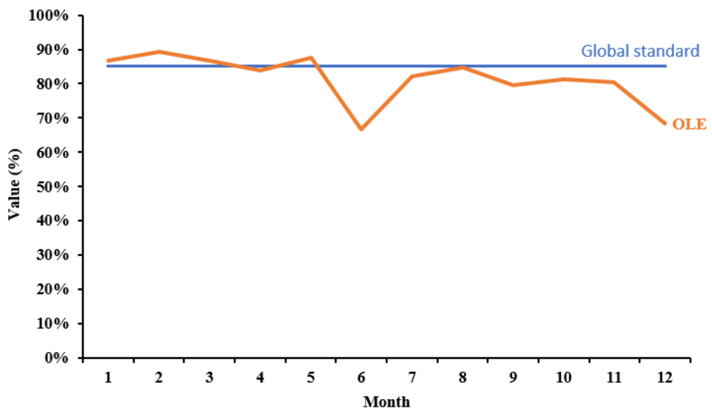

Fig. 1. Monthly OLE trend over the one-year study period.

3.2 | Component Analysis

Availability: As presented in *Fig. 2*, the Availability component exhibited an annual average of 91.42%, exceeding the benchmark of 90%. However, this figure conceals two critical episodes of severe underperformance. In month 6, Availability dropped sharply to 79%, representing an 11-percentage-point deviation below the benchmark, which directly caused OLE to collapse to its lowest recorded value of 66.74%. A similar pattern was observed in month 12, where Availability declined to 80%, again falling 10 percentage points below the benchmark and resulting in an OLE of 68.40%. Outside of these two critical months, Availability remained consistently above the benchmark, ranging between 90% and 97%. This pattern suggests that while workforce attendance and productive time were satisfactory throughout most of the year, two isolated but severe disruptions had a disproportionate impact on the annual OLE index.

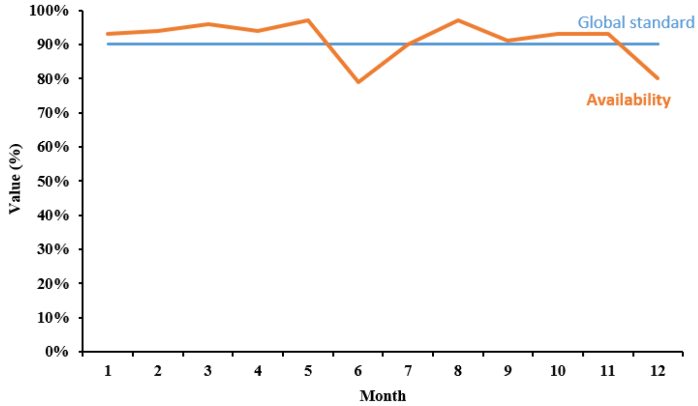

Fig. 2. Monthly availability trend over the one-year study period.

Performance: As presented in *Fig. 3*, the Performance component recorded an annual average of 94.58%, slightly below the benchmark of 95%. Unlike Availability, Performance did not exhibit isolated critical drops but instead showed a distributed pattern of moderate underperformance across multiple months. The lowest value was recorded in month 6 at 88%, coinciding with the sharp Availability decline, suggesting that reduced workforce presence negatively affected productivity rates. Outside of month 6, Performance ranged between 92% and 98%, remaining close to but frequently falling short of the benchmark. Notably, months 2 and 7 recorded the highest values of 98% and 97% respectively, indicating that when attendance was adequate, operators demonstrated strong productivity. The persistent but moderate gap between actual Performance and benchmark suggests systemic inefficiencies in workflow or workload distribution rather than isolated disruptions.

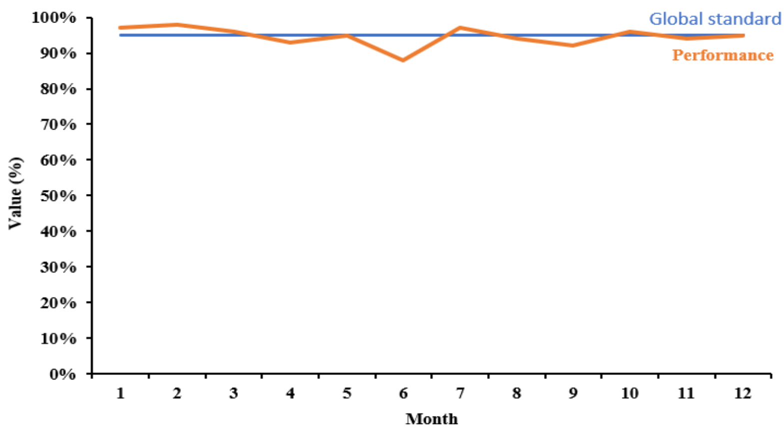

Fig. 3. Monthly performance trend over the one-year study period.

Quality: As presented in *Fig. 4*, the Quality component recorded an annual average of 94.08%, substantially below the benchmark of 99.99%, making it the most persistently underperforming component. Unlike Availability, which exceeded its benchmark on average, and Performance, which remained close to its target, Quality consistently fell short of the benchmark in every single month without exception. The lowest value was recorded in month 12 at 90%, coinciding with the sharp Availability decline, suggesting that reduced workforce presence also negatively affected output quality. Outside of the final quarter, Quality ranged between 94% and 97%, remaining relatively stable but persistently below benchmark. Notably, months 1 and 2 recorded the highest Quality values of 96% and 97% respectively, indicating that when attendance and performance were strongest, operators demonstrated better workmanship. The consistent and widening gap between actual Quality and benchmark, particularly the progressive decline from month 10 onward, suggests systemic issues in operator skill, workmanship standards, or process control rather than isolated incidents.

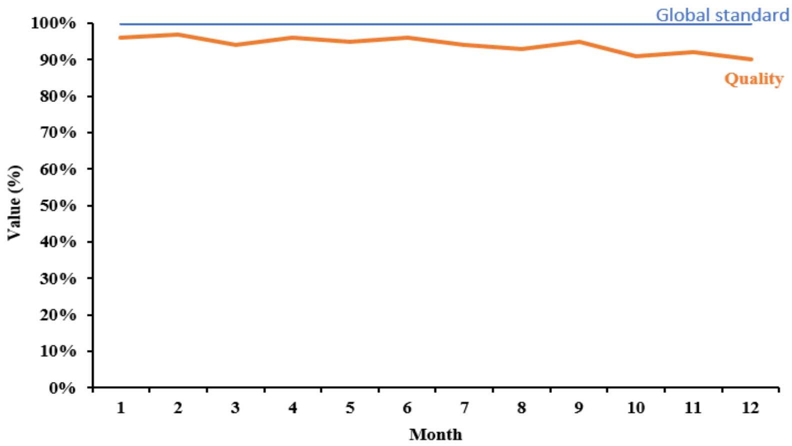

Fig. 4. Monthly quality trend over the one-year study period.

3.3 | Limiting Factor Identification

Among the three OLE components, Quality was identified as the primary limiting factor, consistently falling below its benchmark of 99.99% in every month with an annual average of 94.08%. While Availability and Performance remained close to their respective benchmarks on average, all three components exhibited a simultaneous declining trend from month 10 onward, suggesting a common underlying cause requiring further investigation.

3.4 | Root Causes Identification

The 5 Whys technique was applied to the two most critical performance issues identified in this study: (1) the persistent underperformance of the Quality component throughout the year, and (2) the simultaneous deterioration of all three OLE components during the last quarter of the study period. *Table 2* presents the RCA for the persistent Quality underperformance.

Table 2. Root cause analysis of persistent quality underperformance.

Level	Why	Answer
Why 1	Why did the quality component remain consistently low throughout the year?	Operators did not receive regular feedback regarding quality performance
Why 2	Why did operators not receive quality feedback?	The performance evaluation and incentive system was primarily based on Performance
Why 3	Why was the performance evaluation system based mainly on only productivity?	Managers mainly emphasized production output rather than quality performance
Why 4	Why did managers emphasize production output rather than quality?	Managers had limited awareness of quality-related costs, and the incentive system for both managers and operators was only linked to Performance
Why 5	Why was the incentive system mainly linked to Performance?	The organization lacked a comprehensive performance management system founded on systems thinking principles

Table 3. Root cause analysis of the simultaneous deterioration of all three OLE components during the final.

Level	Why	Answer
Why 1	Why did all three OLE components decline simultaneously from month 10 onward?	Daily working hours increased significantly, from 8 hours in month 9 to 11 hours in month 10 and 12 hours in months 11 and 12
Why 2	Why were working hours extended so drastically?	The factory was under pressure to complete and deliver all overdue orders before the end of the financial year
Why 3	Why were there overdue orders that required emergency production planning?	A large number of orders had accumulated beyond their scheduled delivery dates
Why 4	Why had orders accumulated beyond their scheduled delivery dates?	Several unforeseen events disrupted normal production activities, preventing the factory from meeting the planned production schedule
Why 5	Why was the factory unable to respond effectively to production disruptions?	The organization lacked a risk-based production planning approach

3.4 | Suggestions for Improvement

Based on the root causes identified through the 5 Whys analysis, two primary areas require corrective intervention: The incentive and feedback system, and production planning practices.

Incentive system redesign: The current incentive structure, which is based solely on production volume and Performance, was identified as the primary driver of Quality underperformance. It is recommended that the organization redesign its compensation and incentive system to incorporate both Performance and Quality as equally weighted evaluation criteria. A formal feedback cycle should be established in which quality defects are tracked at the operator level and communicated systematically to both workers and their direct supervisors. Underperformance in either component should carry clear and predefined consequences for operators and related managers alike, while exceeding targets in both dimensions should be rewarded. This dual-component incentive structure will align individual behavioral incentives with organizational quality and productivity objectives.

Furthermore, improving middle management competence in systems thinking and operational risk awareness is essential. This can be achieved through targeted training programs — either internal or external — as well as performance monitoring, and where necessary, personnel replacement or recruitment of qualified candidates.

Risk-based production planning: The simultaneous deterioration of all three OLE components in the final quarter was directly attributable to the absence of risk-based thinking in production planning, which resulted in a substantial increase in daily working hours due to the accumulation of overdue orders. It is recommended that the organization adopt a risk-based production planning approach that explicitly accounts for environmental uncertainties, including recurring challenges such as industrial power outages and other external disruptions that reduce available working hours. Contingency plans should be developed and integrated into the planning process at the beginning of each production period. Employees responsible for production planning should receive dedicated training in risk identification, scenario planning, and early warning systems to prevent the recurrence of end-of-period overloading and its cascading effects on workforce effectiveness.

4 | Conclusion

This study evaluated workforce performance using the OLE index in the cleaning workshop of an investment casting factory over a one-year period. Monthly data were collected and analyzed across three components and compared against global benchmarks.

The results revealed that the annual average OLE of 81.44% fell below the benchmark, indicating overall underperformance in workforce effectiveness. Availability exceeded its benchmark on average but experienced two severe isolated drops in months 6 and 12, directly causing the most critical OLE collapses of the year. Performance remained close to but slightly below its benchmark throughout the year. Quality was identified as the primary limiting factor, consistently falling below its benchmark in every single month, with a progressive deteriorating trend from month 10 onward.

RCA using the 5 Whys technique revealed two underlying systemic issues. First, the organization's incentive system, which was based solely on production volume, created a behavioral misalignment in which operators prioritized quantity over quality, with no feedback mechanism or consequences for poor workmanship. Second, the absence of risk-based thinking in production planning led to the accumulation of overdue orders, forcing a significant increase in daily working hours from 8 to 12 hours during the final quarter, resulting in operator fatigue and simultaneous deterioration across all three OLE components.

Based on these findings, two primary improvement interventions are recommended. The incentive system should be redesigned to incorporate both Quality and Performance as equally weighted criteria, supported by a formal feedback cycle and clear consequences for underperformance at both operator and managerial levels.

Additionally, the organization should adopt risk-based production planning practices that account for environmental uncertainties, including recurring external disruptions, and develop contingency plans to prevent end-of-period workload accumulation.

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Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to the confidentiality of workforce performance records and organizational policies, the raw dataset is not publicly accessible.

References

[1] Natsir, I., Ode, H., Irfana, T. B., Pulungan, D. R., & Sihite, M. (2024). An analysis of the role of human resource management in enhancing organizational efficiency and effectiveness. *International Journal of Economics (IJEC)*, *3*(2), 1089–1097. https://doi.org/10.55299/ijec.v3i2.1097

[2] Neumann, W. P., Winkelhaus, S., Grosse, E. H., & Glock, C. H. (2021). Industry 4.0 and the human factor--a systems framework and analysis methodology for successful development. *International Journal of Production Economics*, *233*, 107992. https://doi.org/10.1016/j.ijpe.2020.107992

[3] Taylor, F. W. (1911). *The principles of scientific management*. NuVision Publications, LLC. https://strategy.sjsu.edu/www.stable/pdf/Taylor,%20F.%20W.%20(1911).%20New%20York,%20Harper%20&%20Brothers.pdf

[4] Parmenter, D. (2010). *Key performance indicators (KPI): Developing, implementing, and using winning KPIs*. John Wiley & Sons. https://kpiacademy.uk/wp-content/uploads/2022/04/Key-Performance-Indicators-KPI-Developing-Implementing-and-Using-Winning-KPIs-David-Parmenter-z-lib.org_.pdf

[5] Nakajima, S. (1988). *Introduction to TPM: Total productive maintenance*. Productivity Press, Inc. https://openlibrary.org/books/OL2064937M/Introduction_to_TPM

[6] Bowen, D. E., & Lawler III, E. E. (1992). Total quality-oriented human resources management. *Organizational Dynamics*, *20*(4), 29–41. https://doi.org/10.1016/0090-2616(92)90073-V

[7] Deepak, V., Bhaskar, S., & Balaji, M. (2021). Enhancing overall labour effectiveness of CSD warehouse by adopting lean tools in construction equipment manufacturing process. *Industrial Engineering Journal*, *14*(1), 40–48. https://iejournal.in/assets/pdf/1) IEJ Jan 2021-40-48.pdf

[8] Braglia, M., Castellano, D., Frosolini, M., Gallo, M., & Marrazzini, L. (2021). Revised overall labour effectiveness. *International Journal of Productivity and Performance Management*, *70*(6), 1317–1335. https://doi.org/10.1108/IJPPM-08-2019-0368

[9] Brabec, Z., & Jáčová, H. (2022). Overall labor effectiveness as a tool for measuring performance in a given company. *ACC Journal*, *28*(2), 7–18. https://doi.org/10.15240/tul/004/2022-2-001

[10] Maharani, A. T. P., Sugarindra, M., & Antyolin, A. V. (2024). Overall labor effectiveness (OLE) method for analyzing employee performance in the musical instrument industry. *Journal of Industrial Engineering and Halal Industries*, *5*(2), 32–40. https://doi.org/10.14421/jiehis.4968

[11] Nurprihatin, F., Ayu, Y. N., Rembulan, G. D., Andry, J. F., & Lestari, T. E. (2023). Minimizing product defects based on labor performance using linear regression and six sigma approach. *Management and Production Engineering Review*, 88–98. https://doi.org/10.24425/mper.2023.146026