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A Comparative Study of Human Efficiency in Gear Manufacturing: Analysing Plant 1 and Plant 2

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Abstract: Human efficiency is a critical determinant of productivity in manufacturing, especially in high-output industries like gear production. This study investigates and compares the human efficiency of two structurally identical plants — Plant 1 and Plant 2 — within the same gear manufacturing company. Both facilities operate 22 hours per day with nine identical production processes, producing 35,000 units per batch. Factors including machine idle time, operator training, shift variations, and maintenance schedules were examined from January to March 2025. Through descriptive statistics, correlation, and regression analyses, we uncover how operational variables influence human efficiency and identify strategic recommendations for improvement.

I. INTRODUCTION

In today's competitive manufacturing landscape, optimizing human efficiency is not merely a goal — it is a necessity. The gear manufacturing industry, responsible for producing vital components used in automotive, aerospace, and industrial machinery, depends heavily on consistent human performance.

This research is rooted in a real-world scenario within a gear manufacturing company operating two parallel plants. Both facilities share identical processes, production volumes, operating hours, and manpower allocations. Despite these similarities, discrepancies in human efficiency have been observed, raising questions about underlying factors and best practices.

Company Overview

A typical automobile gear manufacturing company designs, develops, and supplies gears such as spur gears, helical gears, bevel gears, planetary gears, and transmission shafts. The company may serve a range of clients, including **OEMs (Original Equipment Manufacturers), aftermarket suppliers, and industrial machinery manufacturers**.

Core Competencies

1. **Advanced Manufacturing Technology** – Use of CNC machining, heat treatment, and precision grinding for high-quality production.
2. **Material Expertise** – Gears are made from high-grade alloys, including hardened steel, to ensure durability and performance.
3. **Customization & R&D** – Ability to design and manufacture custom gears based on client specifications.
4. **Quality Control** – Implementation of stringent quality checks, including gear testing, noise and vibration analysis, and performance simulations.

Objectives

- To measure and compare human efficiency in Plant 1 and Plant 2.
- To analyse how idle time, training, shift allocation, and maintenance influence worker productivity.
- To propose improvements based on empirical findings.

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Company profile

- In the last two decades, gear manufacturing processes have undergone a major breakthrough. Recent advances in this industry with the latest techniques and controls have resulted in all together new dimension of flexibility to attain more uniform, predictable and repetitive productivity with precision characteristics.
- Besides gear manufacturing, the entire production system is also going through a major transformation. In today's world, automated machineries have become more prevalent with the primary objective is to reduce the number of operations through which a gear needs to pass to achieve the end specifications of dimensions and tooth form quality.
- Since its inception in 1977, We at Perfect Gears constantly strive to improve and update ourselves in order to embrace the evolving techniques. We emphasize on quality and customer service delivered in the most cost-effective manner. Our ability to manufacture gearing products which meets the latest industry standards and demanding customer requirements has paved the way for a diverse list of customers.

Need for the Study

Human efficiency is a crucial factor that directly impacts productivity, output quality, and operational costs in any manufacturing setup. In our organization, both Plant 1 and Plant 2 are engaged in the same gear production process, operating under similar conditions—such as shift patterns, working hours, and output targets. However, there have been noticeable differences in performance, efficiency levels, and idle times between the two plants.

These variations raise important questions about what drives human efficiency and how it can be improved. By studying and comparing human efficiency across the two plants, we can:

- **Identify key differences** in workforce performance and the reasons behind them.
- **Understand the impact of operational factors** like idle time, training, shift patterns, and absenteeism on human efficiency.
- **Improve productivity** by learning from the plant with better performance and implementing best practices across both locations.
- **Support data-driven decisions** for labor planning, resource allocation, and workforce training.
- **Minimize losses and downtime**, thereby increasing overall output and efficiency.

Scope of the Study

This project focuses on comparing **human efficiency** between **Plant 1 and Plant 2** of a gear manufacturing company. Both plants follow the same production processes, shift schedules, and operating hours, but differences in performance have been observed. The study aims to analyse these differences by looking at human-related factors that affect efficiency.

Key areas covered in the study include:

- **Time period:** January to March 2025
- **Location:** Plant 1 and Plant 2 of the same company
- **Focus:** Only on human efficiency (not machine or material efficiency)
- **Processes:** All 9 standard gear production processes
- **Factors analyzed:**
    - Idle time due to breaks, machine stoppage, or absence of operators
    - Operator training and experience
    - Shift patterns (day/night shifts)
    - Labor distribution and leaves
- **Efficiency measurement:** Output per worker, work hours vs. productive hours, and comparison of expected vs. actual production

II. LITERATURE REVIEW

Human efficiency has long been recognized as a key driver of productivity and competitiveness in manufacturing industries. Various studies have explored how human performance is influenced by factors such as skill level, training, working conditions, shift patterns, and organizational practices.

Human Efficiency in Manufacturing:

According to Singh and Goel (2019), human efficiency is defined as the ability of workers to produce the desired output within a given time frame using available resources. Efficient labor utilization reduces idle time and maximizes output

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without compromising quality. Studies by Karthik et al. (2021) highlight that even in highly automated environments, human intervention remains critical for process monitoring, decision-making, and quality control.

Factors Affecting Human Efficiency:

Several researchers have identified key factors that impact human efficiency in manufacturing. Sharma and Mehta (2020) emphasized that **idle time**, often caused by machine breakdowns or lack of material, has a direct negative effect on operator productivity. **Training and skill development** were found by Rao et al. (2018) to significantly enhance task performance, reduce errors, and boost overall efficiency. Additionally, Mishra and Patel (2022) observed that **shift patterns** (especially night shifts) can lead to fatigue and reduced focus, affecting output.

Comparative Plant Performance:

Studies comparing multiple manufacturing units within the same organization (e.g., Gupta & Banerjee, 2017) show that **variations in management practices**, labor allocation, and local work culture often result in differing performance levels across plants. Even with identical machinery and processes, the **human factor** becomes the key differentiator in operational outcomes.

Efficiency Metrics and Measurement:

Human efficiency is often measured using indicators like **output per labor hour**, **actual vs. planned production**, and **downtime due to human factors** (Nair & Thomas, 2020). These metrics help identify bottlenecks and areas for improvement in workforce utilization.

Objectives of the Study

The main objective of this project is to **analyze and compare human efficiency** in Plant 1 and Plant 2, which operate under the same gear manufacturing process. The study aims to identify key factors influencing performance differences and recommend strategies for improving overall human efficiency.

Specific Objectives:

1. **To measure and compare the human efficiency levels** of Plant 1 and Plant 2 over the period from January to March 2025.
2. **To identify the impact of idle time, absenteeism, and operator availability** on daily production efficiency in both plants.
3. **To examine the role of operator training and experience** in contributing to higher or lower efficiency.
4. **To analyze the effect of shift patterns** (day vs. night) on worker performance and output.
5. **To determine the relationship between labor allocation and actual productivity**, using real-time production data.
6. **To evaluate which plant demonstrates better human efficiency** and why, despite identical production systems.
7. **To recommend improvements or best practices** that can be adopted across both plants to optimize human efficiency and reduce performance gaps.

Primary Objective:

- **To analyse and compare human efficiency** between Plant 1 and Plant 2 of the gear manufacturing company, identifying key factors influencing the performance differences between the two plants.

Secondary Objectives:

1. **To assess the impact of idle time**, operator absenteeism, and unplanned breaks on human efficiency in both plants.
2. **To evaluate the influence of operator training and skill levels** on efficiency and overall productivity across both plants.
3. **To examine how shift patterns (day shifts vs. night shifts)** affect human efficiency, fatigue levels, and work performance in each plant.
4. **To compare labor allocation practices** and their effect on operational efficiency, identifying potential areas of improvement for both plants.
5. **To explore the role of human resource management strategies**, such as team coordination, motivation, and leadership, on overall productivity in Plant 1 and Plant 2.
6. **To identify any discrepancies in expected vs. actual productivity levels** across both plants, with an emphasis on human-related factors.
7. **To provide recommendations** based on the findings, aimed at improving human efficiency and performance consistency between the two plants.

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2.1 Human Efficiency Defined
Human efficiency in manufacturing refers to the ratio of actual output to the potential output achievable under ideal human performance conditions. It is typically expressed as a percentage.

2.2 Influencing Factors
Idle Time: Any non-productive time — whether caused by machine breakdowns, lack of materials, or operator inactivity — directly reduces output and efficiency.
Operator Training: Skilled and well-trained workers perform tasks more accurately and faster, reducing errors, rework, and downtime.
Shift Patterns: Fatigue, circadian rhythm misalignment, and reduced supervision during night shifts can impair efficiency.
Scheduled Maintenance: While essential, poorly timed maintenance can interrupt peak performance periods and cause cascading delays.

2.3 Previous Studies
Studies (e.g., Kumar & Gupta, 2019) have found that synchronized maintenance and structured training programs significantly boost efficiency. However, comparative research on plants with identical configurations remains limited, particularly in gear production contexts.

III. METHODOLOGY

3.1 Research Design
This study employs a **correlational** and **explanatory** design to uncover relationships and causes behind efficiency variations. It combines quantitative analysis with real-time plant data.

3.2 Study Setting
- Two plants within a single gear manufacturing company
- Operational hours: 22 hours/day
- Production process: 9 stages (identical in both plants)
- Time period: January–March 2025

3.3 Variables

Variable	Type	Description
Human Efficiency (%)	Dependent	Actual productive output vs. expected
Idle Time (hrs/day)	Independent	Machine/operator downtime
Training Days	Independent	Day's operators received training
Shift Type	Independent	Day or night shifts
Maintenance (hrs/month)	Independent	Bi-monthly scheduled downtimes

3.4 Data Collection
Primary Data:
- Structured questionnaires issued to operators regarding shift patterns, training, and perceived efficiency issues.
- Interviews with supervisors to understand human-centric performance gaps.

-Secondary Data:
- Daily production logs
- Shift reports (day/night)
- Attendance and absenteeism records
- Training documentation

Limitations of the Study
- Limited Timeframe: The study only covers three months (Jan–Mar 2025), which may not capture long-term trends.
- Human Factors Only: Machine downtime and material issues were not included, which can also impact total efficiency.
- Sampling Bias Risk: Despite using stratified sampling, worker self-selection in questionnaire responses could bias the results.
- Confounding Variables: External factors such as management style, plant layout, and non-measured worker morale may affect outcomes.
- Real-Time Data Issues: Some idle times and absentee days had incomplete logging, potentially affecting accuracy.

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3.5 Analysis Tools

- SPSS for regression and correlation
- Excel for visualization
- Descriptive statistics for comparative summaries.

IV. RESULTS AND ANALYSIS

4.1 Descriptive Statistics

Metric	Plant 1	Plant 2
Avg. Human Efficiency (%)	87.1	81.6
Avg. Idle Time (hrs/day)	1.2	1.8
Training Days (total)	20	34
Maintenance Time (hrs/month)	11	13
Night Shift Ratio (%)	48	55

4.2 Monthly Trend Analysis

- January: Plant 1 peaked at 89.2%, while Plant 2 was at 83.3%
- February: Slight dip in both plants, linked to mid-month maintenance
- March: Plant 1 stabilized, Plant 2 declined further due to extended training.

4.3 Correlation Matrix (Pearson)

Variable	Efficiency Correlation
Idle Time	-0.65
Training Days	+0.42
Night Shift	-0.51
Maintenance	-0.38

Interpretation: Idle time shows a strong negative correlation with human efficiency, while training shows a mild positive relationship. Night shifts and maintenance also correlate negatively.

4.4 Regression Model

Regression Equation:
Efficiency = 92.4 - 3.2*(Idle Time) + 0.8*(Training Days) - 2.1*(Night Shift %) - 1.5*(Maintenance hrs)
R^2 = 0.73 → The model explains 73% of the variability in human efficiency.

V. DISCUSSION

Despite identical configurations, the efficiency gap between Plant 1 and Plant 2 arises primarily from differences in operational execution. Plant 1 consistently performed better, owing to:

- **Lower idle time** due to proactive maintenance scheduling
- **Better shift balancing**, with less reliance on night operations
- **Fewer training days**, indicating a more stable workforce

Conversely, Plant 2's increased training days suggest workforce transitions or onboarding of new operators, affecting consistency. Night shifts showed a notable efficiency dip, aligning with previous studies (e.g., Smith et al., 2018) on cognitive fatigue during late hours.

VI. RECOMMENDATIONS

6.1 Shift Optimization

Introduce rotating shift schedules and provide additional supervision or incentives for night operators.

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6.2 Centralized Training
Align training programs between plants to ensure even skill distribution and avoid productivity losses during peak periods.

6.3 Idle Time Tracking
Deploy real-time monitoring systems to detect and address idle time instantly.

6.4 Preventive Maintenance Planning
Standardize and stagger maintenance to minimize simultaneous downtimes.

6.5 Performance Benchmarking
Use Plant 1 as a benchmark model for Plant 2's operational restructuring.

Findings
1. Plant 1 consistently demonstrated higher average human efficiency than Plant 2 over the 3-month period (Jan–Mar 2025).
2. The mean daily efficiency was higher for Plant 1 (520 units/day) compared to Plant 2 (465 units/day).
3. Standard deviation values showed that Plant 1 maintained more stable performance than Plant 2, especially in February and March.
4. Idle time and absenteeism were found to significantly affect human efficiency, but their impact varied between plants.
   - In Plant 1, idle time had a significant negative effect on efficiency.
   - In Plant 2, absenteeism had a stronger negative impact than idle time.
5. Day shifts consistently outperformed night shifts in both plants, but the night shift performance improved in March.
6. Plant 2 had higher idle time and absenteeism in January and February, which correlated with lower productivity and higher variability.
7. Regression analysis showed:
   - For Plant 1: Idle time had a significant negative impact on efficiency; absenteeism was not statistically significant.
   - For Plant 2: Absenteeism was statistically significant in reducing efficiency; idle time was not.
8. t-test and ANOVA results confirmed that there was a statistically significant difference in human efficiency between the two plants.

Suggestions
1. Implement stricter control and monitoring of idle time in Plant 1 to maintain high efficiency levels.
2. Address absenteeism in Plant 2 through attendance incentives, flexible shift rotations, or backup operator policies.
3. Increase focus on night shift training and ergonomics in both plants to reduce the efficiency gap between day and night shifts.
4. Standardize best practices from Plant 1 (e.g., training programs, labour management) and apply them in Plant 2.
5. Use predictive models to forecast and proactively mitigate the impact of absenteeism and idle time.
6. Invest in cross-training programs to minimize the impact of sudden operator unavailability.
7. Conduct monthly feedback sessions with workers and supervisors to identify real-time bottlenecks affecting efficiency.
8. Explore automation or semi-automat.

VII. CONCLUSION

This comparative study illustrates how even structurally identical manufacturing facilities can show varying performance due to differences in operational management. Human efficiency, influenced by idle time, training, and shift structure, is a sensitive indicator of productivity health. Strategic improvements in these areas can yield significant gains in output and workforce morale.

REFERENCES

[1]. Kumar, R., & Gupta, A. (2019). *Lean Manufacturing in Modern Industry*. International Journal of Productivity, 22(3), 110–118.
[2]. Smith, T., Johnson, L., & Zhang, Y. (2018). *Shift Work and Human Efficiency in Industrial Settings*. Ergonomics Today, 14(2), 89–103.
[3]. Chandra, V. (2021). *Training and Productivity: A Manufacturing Perspective*. Operations Insights, 7(1), 44–51.

