ICASET
International Conference on Academic Studies in Science, Engineering, and Technology
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OPTIMIZATION OF PRODUCTION PROCESSES BY DEFINING PRIORITIES WITH ANALYTIC HIERARCHY PROCESS (AHP)

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INTRODUCTION

This paper explores the application of the Analytic Hierarchy Process (AHP) as a systematic methodology for optimizing manufacturing processes by defining strategic priorities. The research focuses on addressing the challenge of efficient allocation of limited resources in modern manufacturing environments, where multi-criteria decision-making is becoming increasingly complex.

The case study demonstrates how the AHP methodology provides a transparent and demonstrable approach to decision-making, enabling better resource management and reducing subjectivity in the decision-making process. Sensitivity analysis confirms the robustness of the results and their applicability in real production conditions.

METHOD

In this phase, pairwise comparisons of all elements in the hierarchy are conducted. For each criterion and sub-criterion, the team conducts structured comparison sessions using the standard AHP scale of 1-9. The process includes:

- Individual assessments by each team member
- Group discussions to reach consensus
- Documenting the reasoning behind each assessment
- Checking the consistency of each comparison matrix

Step 3: Calculation and analysis

Using specialized software or matrix calculations, weight coefficients are determined for each element in the hierarchy. Calculations include:

- Eigenvectors to determine relative weights
- Consistency index to validate the assessments
- Aggregation of results to obtain global priorities
- Sensitivity analysis to test the robustness of the results

Step 4: Interpretation and implementation

The final results are interpreted in the context of the production objectives and constraints. The model generates:

- A ranked list of alternatives according to their priority
- A detailed analysis of the impact of each criterion
- Recommendations for action with a time frame
- Metrics to monitor implementation

Defining the strategic goal:

- Clear formulation: “Optimize the manufacturing processes in the factory”
- Specifying the scope: all major product lines
- Time horizon: improvements within the next 12 months

RESULTS AND DISCUSSION

Alternatives:
A1: Process automation
A2: Implementation of Lean methods
A3: Advanced data analysis
A4: Training and staff development

Matrix for comparison of main criteria and Weight calculation:

	c1	c2	c3	c4	WEIGHT
c1	1	2	3	4	2.083
c2	1/2	1	2	2	3.833
c3	1/3	1/2	2	3	6.5
c4	1/4	1/3	1/2	1	10

Normalized matrix:

	c1	c2	c3	c4	WEIGHT
c1	0.480	0.522	0.462	0.400	0.466
c2	0.240	0.261	0.308	0.300	0.277
c3	0.160	0.130	0.154	0.200	0.161
c4	0.120	0.087	0.077	0.100	0.096

Comparison of alternatives for each criterion "Cost" (C1):

	A1	A2	A3	A4	WEIGHT
A1	1	1/3	1/2	2	0.160
A2	3	1	2	4	0.467
A3	2	1/2	1	3	0.277
A4	1/2	1/4	1/3	1	0.096

Consistency check:

- λ max = 4.045
- CI = (4.045 - 4) / 3 = 0.015
- CR = 0.015 / 0.90 = 0.017 (< 0.10 → ACCEPTABLE)

Local priorities by criterion:

	C1 (0.466)	C2 (0.277)	C3 (0.161)	C4 (0.096)	Calculation of global priorities
A1	0.160	0.350	0.200	0.100	0.215
A2	0.467	0.250	0.400	0.300	0.372
A3	0.277	0.300	0.250	0.450	0.285
A4	0.096	0.100	0.150	0.150	0.128

(C1) to 0.60 Alternative	New global priorities	(C2) to 0.40 Alternative	New global priorities
A1	0.180	A1	0.240
A2	0.420	A2	0.340
A3	0.280	A3	0.310
A4	0.120	A4	0.110

CONCLUSION

The analysis using the Analytic Hierarchy Process highlights several important findings for strategic decision-making in manufacturing. Lean methods emerge as the top strategy due to their excellent cost-benefit ratio, allowing significant improvements with minimal investment by focusing on waste reduction and process enhancement.

Advanced data analytics is recognized as a strategic long-term investment that, despite requiring higher initial costs, can provide deep insights and predictive capabilities, fostering sustainable competitive advantages as organizations grow.

Although automation has high upfront costs, it remains relevant for specific uses and gradual modernization plans, necessitating careful investment assessment. Meanwhile, training programs, while secondary to other optimization strategies, play a supportive role in enhancing the effectiveness of broader initiatives

The research results indicate that the implementation of Lean methods receives the highest priority (0.372), followed by advanced data analysis (0.285), automation (0.215) and training programs (0.128). These findings reveal the importance of balancing short-term operational improvements with long-term strategic investments.

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