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"Optimizing Machine Selection and Cost of Quality: A Comprehensive Approach for Enhanced Industrial Efficiency and Economic Growth"

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Abstract: In today's modern industrial economy, selecting suitable machinery and efficiently managing quality costs are critical for achieving sustainable growth and competitiveness. This research paper presents a comprehensive approach to optimizing machine selection and cost of quality (COQ) within industrial operations. The study commences by delineating the criteria for machine selection and determining their respective weights using the Analytic Hierarchy Process (AHP). Subsequently, the VIKOR method is applied to select the most suitable machine based on the established criteria and weights. Moreover, the paper explores the concept of COQ, underscoring its importance as a performance measurement tool for organizations. The research investigates various strategies for minimizing quality-related expenses and maximizing benefits, including defect prevention, quality assurance, and continuous improvement initiatives. A case study analysis, focusing on the selection between mechanical cutting CNC machines and laser cutting CNC machines, provides practical insights into the implementation of the proposed methodologies. Real data analysis of cost and quality metrics, coupled with formula-based calculations, offers valuable insights into the decision-making process. The research underscores the significance of market analysis and leveraging modern technology trends to inform machine selection decisions. Overall, the findings contribute to enhancing industrial efficiency and promoting economic growth by facilitating informed decision-making in machine selection and COQ management.
Keywords: Machine Selection, Cost of Quality, Analytic Hierarchy Process, VIKOR Method, Industrial Efficiency, Economic Growth.

I. INTRODUCTION

In the ever-evolving industrial landscape of today, the meticulous selection of machinery stands as a cornerstone for fostering productivity, efficiency, and profitability within organizations. Concurrently, the proficient management of quality costs emerges as an indispensable facet, pivotal in ensuring the delivery of products or services of unparalleled excellence while optimizing resource utilization. This introductory section serves as a gateway to the exploration of the profound significance of both machine selection and cost of quality optimization within the realm of industrial operations, delineating the overarching objectives and scope of the ensuing research endeavor.

A. *Significance of Machine Selection*

The selection of appropriate machinery holds paramount importance in modern industrial settings, serving as a catalyst for driving operational efficacy and achieving strategic objectives. A carefully chosen set of machines can significantly impact production processes, influencing factors such as throughput, product quality, and resource utilization efficiency. By investing in state-of-the-art machinery tailored to specific operational requirements, organizations can unlock new avenues for innovation, streamline production workflows, and gain a competitive edge in the marketplace. Furthermore, the selection of machinery aligns closely with overarching business goals, playing a pivotal role in shaping organizational performance and profitability.

B. *Essentiality of Cost of Quality Optimization*

Effective management of quality costs is imperative for organizations striving to uphold standards of excellence while navigating the intricacies of resource allocation. The concept of cost of quality (COQ) encompasses both the expenditures incurred to ensure product or service quality and the costs stemming from failures and defects. By meticulously managing these costs, organizations can mitigate risks, enhance operational efficiency, and safeguard their reputation in the market. Moreover, optimizing the cost of quality allows organizations to channel resources towards value-adding activities, fostering sustainable growth and profitability in the long run.

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C. Objectives of the Research

Against this backdrop, the primary objectives of the research are twofold:
To explore the multifaceted dimensions of machine selection and delineate effective strategies for optimizing this critical process.
To delve into the intricacies of cost of quality optimization, examining various methodologies and approaches aimed at minimizing quality-related expenses and maximizing benefits within industrial operations.

D. Scope of the Research

The research encompasses a comprehensive analysis of machine selection and cost of quality optimization within industrial contexts. It delves into various methodologies, frameworks, and best practices employed by organizations to navigate these complex domains effectively. Additionally, the research incorporates real-world case studies and practical insights to provide a holistic understanding of the challenges and opportunities inherent in machine selection and COQ optimization. Furthermore, the scope extends to exploring emerging trends and technologies that are reshaping the industrial landscape, offering valuable insights into future directions and opportunities for innovation.

II. METHODOLOGY

The methodology section serves as a blueprint for the systematic approach adopted in the research, delineating the step-by-step process employed to address the objectives outlined in the study. This section details the methodologies utilized for criteria determination, criteria weighting using the Analytic Hierarchy Process (AHP) method, machine selection through the VIKOR method, and strategies for optimizing the cost of quality (COQ). Each methodological choice is accompanied by a rationale, elucidating the reasoning behind its selection, and the procedures for data collection and analysis are outlined to ensure transparency and reproducibility.

A. Criteria Determination

The first step in the methodology involves determining the criteria for machine selection and COQ optimization. This process entails identifying key factors and attributes that are essential for evaluating machines and managing quality costs effectively within industrial operations. Criteria may include performance specifications, reliability, maintenance requirements, cost considerations, and compliance with regulatory standards. The selection of criteria is informed by a thorough review of existing literature, consultation with domain experts, and consideration of organizational objectives and stakeholder requirements.

B. Criteria Weighting using AHP

Once the criteria are identified, the next step involves assigning weights to each criterion to reflect its relative importance in the decision-making process. The Analytic Hierarchy Process (AHP) method is employed for this purpose, providing a structured framework for pairwise comparisons and hierarchical decision-making. Stakeholders are engaged in the weighting process, offering their expert judgments and preferences to establish the relative significance of each criterion. Through a series of pairwise comparisons and mathematical calculations, priority weights are assigned to the criteria, reflecting their overall importance in the decision-making process.

C. Machine Selection using VIKOR Method

With the criteria and their respective weights established, the VIKOR method is employed to select the most suitable machine from the available alternatives. VIKOR is a multi-criteria decision-making technique that balances the need for maximizing benefits while minimizing regrets. The method considers both the best and worst outcomes for each alternative and identifies the compromise solution that offers the best overall performance. By incorporating the weighted criteria and performance evaluations of each machine, the VIKOR method facilitates informed decision-making, ensuring that the selected machine aligns with organizational objectives and stakeholder preferences.

D. Strategies for Cost of Quality Optimization

In parallel with machine selection, strategies for optimizing the cost of quality are explored. This involves identifying areas for improvement, implementing preventive measures, and investing in quality assurance activities to minimize quality-related expenses and maximize benefits. Strategies may include defect prevention, quality control processes, continuous improvement initiatives, and cost-benefit analysis. Data collection methods such as surveys, interviews, and historical data analysis are employed to assess the current state of quality costs and identify opportunities for optimization.

III. PROCEDURAL STEPS FOR COQ STUDY

For conducting cost of quality (COQ) study in an organization one must take the following steps: (8)

1) Choose an area of activity for study.
2) Form a team under a senior manager from the chosen area of activity.
3) Prepare a cost model to be used for this study.
4) Conduct a seminar or workshop for briefing the team members.
5) Guide the team member to record cost data on a given cost sheet.
6) Process the collected data for reporting purposes.
7) Take action after analysis of obtained data and implement the remedial recommendations.
8) The COQ study may be an annual study which is general in nature for the whole company or a targeted study for a specific area of activity. Generally, it is with stipulated dates and time for completion and implementation of recommendations.

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IV. ANALYTICAL HIERARCHY PROCESS

In AHP method solve technical structural critical problem. And justify it is for concerned decision making of the problem. In this process methodology used for deciding features of machine after choose a machine by previous technique. Here discussed about CNC cutting machine on based of cost, quality, productivity and quantity analysis.

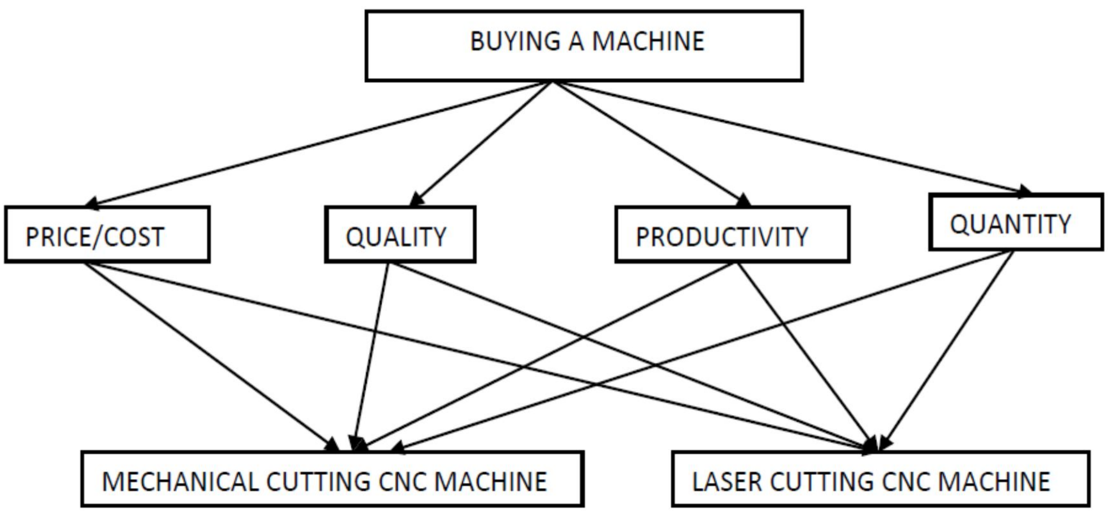

Fig.1. AHP Figure of both Machines

First collect data according to importance of this parameter. This parameter will compare to its equal importance with comparison to other and somewhere moderate, strong, very strong, extremely strong and intermediate values lie. That decides by purchasing machine customer.

After collecting this data use to following these steps:

1) Prepare comparison matrix by using authentically collected data.
2) Prepare normalized matrix with pair-wise by dividing unique cell data by sum of this column. Then after the criteria value is calculating by summation of each row data.
3) Prepare a matrix on based on weighted value for normalized matrix. Unique value of cell in pair-wise matrix is multiply with sequence of column for cross functioning.
4) Find consistency index.
5) Find consistency ratio.

If the consistency ratio is below 0.10, then we confirm to take decision.

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V. VIKOR METHODOLOGY

The MCDM technique is extremely well-liked method generally apply for determining the best result amongst numerous alternatives having several attributes. A MCDM problem can be represented by a decision matrix as follows [42]:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ A_m \end{array} \begin{bmatrix} \underline{Cx_1} & \underline{Cx_2} & . & . & . & . & \underline{Cx_n} \\ x_{11} & x_{12} & . & . & . & . & x_{1n} \\ x_{21} & x_{22} & . & . & . & . & x_{2n} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ x_{m1} & x_{m2} & . & . & . & . & x_{mn} \end{bmatrix} \quad (1)$$

Here, A_i represents ith alternative, $i = 1, 2, ..., m$; Cx_j represents the jth criterion, $j = 1, 2, ..., n$; and x_{ij} is the individual performance of an alternative. The measures for evaluating the top result to an MCDM problem take account of computing the utilities of alternatives and ranking these alternatives. The alternative solution with the maximum usefulness is consider to be the best possible result.

The subsequent steps are concerned in VIKOR technique:

1) *Step 1: Representation of normalized decision matrix*

The normalized decision matrix can be expressed as follow:

$$F = \left[f_{ij} \right]_{m\times n} \quad (2)$$

Here, $f_{ij} = \dfrac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$, $i = 1, 2, ..., m;$ and x_{ij} is the performance of alternative A_i with respect to the jth criterion.

2) *Step 2: Determination of ideal and negative-ideal solutions:*

The ideal solution A^* and the negative ideal solution A^- are determined as follows:

$$A^* = \left\{ (\max f_{ij} \middle| j \in J) \, or \, (\min f_{ij} \middle| j \in J'), i = 1, 2, ..., m \right\} = \left\{ f_1^*, f_2^*, ... f_j^*, ... f_n^* \right\} \quad (3)$$

$$A^- = \left\{ (\min f_{ij} \middle| j \in J) \, or \, (\max f_{ij} \middle| j \in J'), i = 1, 2, ..., m \right\} = \left\{ f_1^-, f_2^-, ... f_j^-, ... f_n^- \right\} \quad (4)$$

where, $J = \{j = 1,2, \ldots\ldots, n | f_{ij}, if\ desired\ response\ is\ large\}$

$$J' = \{j = 1,2, \ldots\ldots, n | f_{ij}, if\ desired\ response\ is\ small\}$$

3) *Step 3: Calculation of utility measure and regret measure*

The utility measure and the regret measure for each alternative are given as

$$S_i = \sum_{j=1}^{n} w_j \frac{\left(f_j^* - f_{ij} \right)}{\left(f_j^* - f_j^- \right)} \quad (5)$$

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$$R_i = \underset{j}{Max}\left[w_j \frac{\left(f_j^* - f_{ij}\right)}{\left(f_j^* - f_j^-\right)} \right] \quad (6)$$

where, S_i and R_i, represent the utility measure and the regret measure, respectively, and w_j is the weight of the jth criterion.

Step 4: Computation of VIKOR index

The VIKOR index can be expressed as follows:

$$Q_i = \upsilon \left[\frac{S_i - S^*}{S^- - S^*} \right] + (1-\upsilon)\left[\frac{R_i - R^*}{R^- - R^*} \right] \quad (7)$$

where, Q_i, represents the ith alternative VIKOR value, $i = 1, 2, \ldots\ldots, m$; $S^* = \underset{i}{Min}(S_i)$; $S^- = \underset{i}{Max}(S_i)$; $R^* = \underset{i}{Min}(R_i)$; $R^- = \underset{i}{Max}(R_i)$ and υ is the weight of the highest set effectiveness (usually taken as 0.5). The alternative having minimum VIKOR score is determined to be the top result.

VI. EIGHT STAGES OF QUALITY COST ANALYSIS

The cost of quality analysis consider of adequate appraisal effectiveness of the organization and reducing the cost of production. Goal of analysis is identifying the problem that should be taking of cost of production for maintenance and increase the quality level [11]. The certainty of quality cost analysis (Q-C-A) consider on base of calculate evaluation of several dependences, that would be obtain quality analysis and level of symbolic cost quality accounting. continuously obtaining quality level, maintain cost and maintenance of their production firm make a developed organization.

System analysis for achieving the goal and using information for maintain the quality level. Using step for maintain take decision making capacity, decision making refer technically and economically importance aspects.

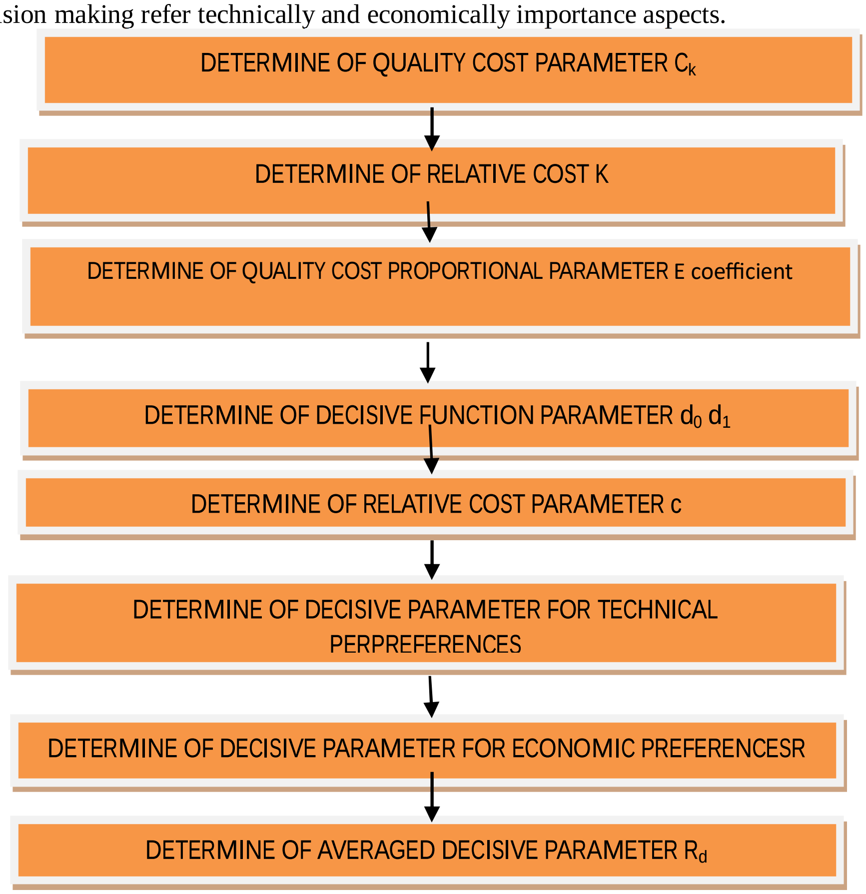

Fig-2 Eight Stage levels of Quality Cost Analysis

1) *Determine Quality Cost Parameter (CK)*

$$Ck = K / Q$$

Where: Q is Quality level in percentage and K is Cost
Lower value of parameter Ck is good for product.

2) *Determine Of Relative Cost K*

$$K = Ka - C / Ka - Ki$$

Ka - The largest cost data of any given cost quality analysis,
Ki - The smallest cost of any quality cost,
C - Temporary cost data of any type of case.

3) *Determine of Quality Cost Proportional Parameter Cp*

Cp= k/qd
Where: k – Relative cost, qd – Quality level expressed by decimal fraction

4) *Determine Of Decisive Function Parameter D0 Or D1*

If value of CP is 0-1 then
D0 = 0.5 CP
If Cp>1
d1=0.5+0.5(1-1/Cp)

The counted values d0 and d1, compared to universal data coefficient,
In that case, when the technical and economic preferences have to be prefer account in taken decisions, the quality cost analysis is continued flow in the following way:

5) *Determine of the Related Cost Parameter Cr*

$$\mathbf{Cr} = \frac{Cka - Ck}{Cka - Cki}$$

Where:
Cka – Maximum Quality cost parameter in the given quality data based cost analysis,
Cki – Minimum quality cost parameter in the given data of quality cost analysis,
Ck –parameter of Quality cost for analyzed the product.

6) *Determine the Decisive parameter for the technical preference Rt*

Rt = 0.0667 (8.qd+4.d+2.cr+ k)

Where:
Qd – Quality level expressed by decimal fraction,
d – Decisive function parameter,
Cr – Relative cost parameter – Relative cost.

7) *Decisive Parameter Determine by Economic Preference Re*

$$Re = 0.0667. (8.K + 4.cr + 2.d + qd)$$

8) *Determine of Averaged Decisive Parameter Rd*

Rd = 0.5 (Rt + Re)
Machine selection criteria by using literature review Machine selection criteria by using literature review

Table 1 : Representation of Criteria

Sr. No.	Main Criteria /Sub-Criteria
1	Price
2	Capital cost
3	Operating cost
4	Maintenance cost
5	depreciation
6	Quality
7	Scrap & Rework
8	Reliability
9	Product Conformance
10	Number of machines breakdown
11	Flexibility
12	Flexibility in mass production
13	Variety and Flexibility of
14	product
15	Easy to operate
16	Easy to move
17	Machine can handle multiple
18	operation
19	Performance
20	System control and automation
21	Calibration time
22	Utilization
23	Manufacturing rate
24	Productivity
25	Rapid transverse speed
26	Machine speed
27	Part changing time
28	Setup time
29	Reliability
30	Life time of the machine
31	defective rate
32	Professional skill
33	Service facility
34	Communication capacity
35	Service warranty
36	Part warranty
37	On time delivery
38	Lead time of machine
39	Delivery
40	Safety
41	Safe guards
42	Safety device
43	Ergonomically
44	Risk
45	Market & product change
46	adaptability
47	Technological change
48	adaptability
49	Machine breakdown
50	adaptability
51	Availability
52	Resources
53	Services

According to experts' opinion select criteria by 80-20 method for their preference

Given preference 80 % of these criteria	Given preference 20% of these criteria
Quality	Communication capacity
Flexibility	Capital cost
Productivity	Operating cost
Service facility	Maintenance cost
Price	depreciation
Safety	Part warranty
Reliability	Scrap & Rework
	Service warranty
	Product Conformance
	Number of machines breakdown
	Professional skill
	Flexibility in mass production
	Variety and Flexibility of
	product
	Easy to operate
	Easy to move
	Machine can handle multiple
	operation
	Performance
	System control and automation
	Calibration time
	Utilization
	Manufacturing rate
	On time delivery
	Rapid transverse speed
	Machine speed
	Part changing time
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	Life time of the machine
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	Safe guards
	Safety device
	Ergonomically
	Risk
	Market & product change
	adaptability
	Technological change
	adaptability
	Machine breakdown
	adaptability
	Availability
	Resources
	Services

VII. ANALYTICAL HIERARCHY PROCESS (EXTERNAL ANALYSIS)

Analytical hierarchy process (AHP) use for makes decision validation and confirming the decision according to various aspect such as technical, Economical and functional. This is showing recent trend of modernization and also compare with past data manipulation. Nowadays decision making capacity is essential for any organization to achieve their goal and also it is beneficial to make sure goodwill in between the customers. It is multi criteria decision making method which is use to take decision of various technical areas. In that method use drive ratio scale for judgment of small inconsistency. Today industry purpose is fulfilling the need of customer. Using feedback data forecast the features of organization. It will use in uncertain but confidence result make its decision more importance. In this article first, we shall select a machine according to their decision based parameters. According to these parameters decide the demand of customer satisfaction. After that use specification of machine on based of production unit. All logistic and supply of manufactured material depending on machine accuracy. So, this is primary need for deciding features of machine on based of product feedback according to market. AHP method is pair-wise matrix methodology which is finalized after removing inconsistency of prepared matrix. In this Fig. 1 co-related mechanical cutting CNC machine and Laser cutting CNC machine with hieratically model. In Fig. 1 correlation between both machines with given parameters cost, quality, productivity and quantity.

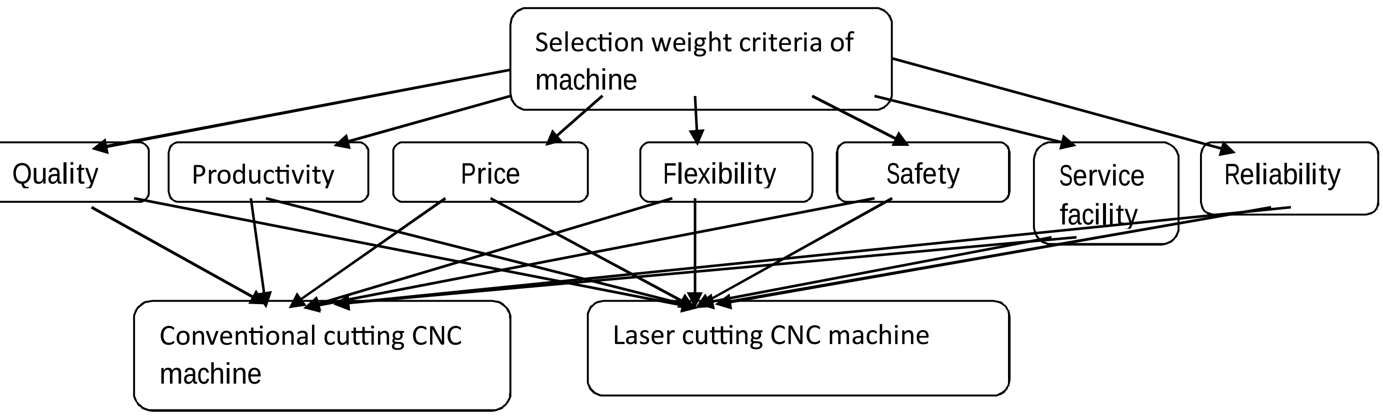

Fig. 3 AHP Figure of both Machines

Determine the relative importance of different attributes or criteria with respect to the goal. First to define the scale of relative importance to each-other.

Table 2- Relative importance between parameters	
Scale	Relative Importance
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2,4,6,8	Intermediate Importance
1/3,1/5,1/7,1/9	Value For Inverse Comparison

Nowadays customer is first oriented quality because of; this is base on its life cycle. Any organization wants to make high life cycle of machine so that production unit can't any type of obstacle and work flow smoothly with continue production. In this survey we found that quality is very strong importance parameter compare to cost so rating become in pair-wise comparison matrix is 7. It will be solving by derived rational scale. In quality has 7X value and cost has X value. So ratio of quality/cost is 5X/X = 5. And cost/quality is X/5X = 1/5. In case of productivity, it will be 3X value of productivity in X value of cost. And quantity will be 7X value for X value of cost. In case of quality and productivity is more importance of quality. There are 7X value of quality as compare to X value of productivity.

On base of this data; we will prepare a pair-wise comparison matrix. That's all-relative importance clarifies with use of Table 2. That is showing relative importance one to another.

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To be create pair-wise comparison matrix with the help of scale of relative importance.

Table 3: Use Survey Data and Prepare Pair-wise Comparison Matrix

	Quality	Flexibility	Productivity	Service facility	Price	Safety	Reliability
Quality	1	5	7	7	5	7	5
Flexibility	0.2	1	1	7	5	5	5
Productivity	0.14	1	1	5	3	5	3
Service facility	0.14	0.14	0.2	1	0.33	0.33	0.2
Price	0.2	0.2	0.33	3	1	3	0.33
Safety	0.14	0.2	0.2	3	0.33	1	0.33
Reliability	0.2	0.2	0.33	5	3	3	1
Sum	2.02	7.74	10.06	31	17.63	24.33	14.86

With the use of relative importance as per collection of data is creating Table 2. That Table no. 2 creates as per norms of AHP Methods. In there all will be related one to another with pair-wise comparison matrix.
To be create Normalized pair-wise matrix

Solved Normalized pair-wise matrix

Table 4 : Solved Normalized pair-wise matrix

	Quality	Flexibility	Productivity	Service facility	Price	Safety	Reliability
Quality	0.49	0.64	0.69	0.22	0.28	0.28	0.33
Flexibility	0.09	0.12	0.099	0.22	0.28	0.20	0.33
Productivity	0.06	0.12	0.099	0.16	0.17	0.20	0.20
Service facility	0.06	0.018	0.019	0.032	0.018	0.013	0.013
Price	0.09	0.025	0.032	0.096	0.056	0.12	0.022
Safety	0.06	0.025	0.019	0.096	0.018	0.041	0.022
Reliability	0.06	0.025	0.032	0.16	0.17	0.12	0.06

Table 5: Result for Decision Making criteria

Main criteria	AHP criteria weight
Quality	0.41
Flexibility	0.19
Productivity	0.1441
Service facility	0.024
Price	0.063
Safety	0.0401
Reliability	0.093

In Table no. 5 create normalized matrix by division of sum of column of pair-wise comparison matrix. In that matrix data form in normalized terms. This Table no. 5 sum of rows will be criteria weight of parameters in normalized pair-wise matrix.

Weighted value of normalized pair-wise matrix

Table 6 : Calculate Weighted Value of Normalized Pair-Wise Matrix

	Quality	Flexibility	Productivity	Service facility	Price	Safety	Reliability
Quality	0.41	0.95	1.008	0.168	0.315	0.2807	0.465
Flexibility	0.082	0.19	0.1441	0.168	0.315	0.20	0.465
Productivity	0.057	0.19	0.1441	0.12	0.189	0.20	0.279
Service facility	0.057	0.026	0.0288	0.024	0.02	0.013	0.0186
Price	0.082	0.038	0.0475	0.072	0.063	0.12	0.0306
Safety	0.057	0.038	0.0288	0.072	0.02	0.04	0.0306
Reliability	0.082	0.038	0.0475	0.12	0.189	0.12	0.093

Weighted sum value	Weighted value/criteria weight
3.596	8.7707
1.564	8.2315
1.1791	8.1825
0.1874	7.8083
0.4531	7.1920
0.2864	7.1421
0.6895	7.4139

In AHP Method have cross-functioning between all values. In Table no.4.5 take criteria weight in column with multiplication pair-wise matrix as per data that column. This type will be create weighted value of normalized pair wise matrix.

λmax =8.7707+8.2315+8.1825+7.8083+7.1920+7.1421+7.4139/7=7.82

Consistency index(CI) = λmax – n/ n-1

=7.82-7/4-1=0.1366 W

here n is the number of compared elements.

Consistency ratio = Consistency index/Random index (RI)

N	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Consistency ratio= 0.1366/1.32 =0.1034 which is less than 0.10.this means it would be consistence.

Collected Data of both machine from Production Unit:

A. Case - 1

Data Analysis of Conventional CNC Cutting Machine:

[1]. Determine of the quality cost Parameter (CK):

$$Ck = \frac{K}{Q}$$

$$Ck = \frac{1250000}{65}$$

$$Ck = 19230.7692$$

[2]. Determine of relative cost k:

$$K = \frac{Ka-K}{Ka-Ki}$$

$$K = \frac{1800000-1250000}{1800000-900000}$$

$$K = 0.6111$$

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[3]. Determine of quality cost proportional coefficient E:

$$CP = k/qd$$

$$CP = \frac{0.6111}{0.65}$$

$$CP = 0.94$$

[4]. Determine of decisive function Parameter d0 or d1

$$d0 = 0.5 \times 0.94$$

$$d0 = 0.47$$

[5]. Determine of relative cost Parameter c:

$$Cr = \frac{Cka - Ck}{Cka - Cki}$$

$$Cr = \frac{27692.3077 - 19230.7692}{27692.3077 - 13846.1538}$$

$$Cr = .61112$$

[6]. Determine of decisive Parameter for technical preferences Rt:

$k = 0.6111$ $cr = 0.6112$ $d = 0.47$ $qd = 0.65$

$$Rt = 0.0667.(8.qd+4.d+2.cr+k)$$

$$Rt = 0.0667\,(8 \times 0.65 + 4 \times 0.47 + 2 \times 0.61112 + 0.6111)$$

$$Rt = 0.57850911$$

[7]. Determine of decisive Parameter for economic preferences Re:

$K = 0.61112$, $Cr = 0.6111$, $d0 = 0.47$, $qd = 0.65$

$$Re = 0.0667.(8.K+4.cr+2.d+qd)$$

$$Re = 0.0667\,(8 \times 0.61112 + 4 \times 0.6111 + 2 \times 0.47 + 0.65)$$

$$Re = 0.587173$$

[8]. Determine of averaged decisive Parameter Rd:

$Rt = 0.57850911$, $Re = 0.587173$

$$Rd = 0.5.(Rt + Re)$$

$$Rd = 0.5.(0.57850911 + 0.587173)$$

$$Rd = 0.582841$$

Table No-7 Stages and Data to Quality-cost Analysis of Two machines

STAGES	Data – Mechanical/conventional Cutting CNC Machine
1. Determine of the quality cost parameter Ck from equation.	K = 1250000 Q = 65%
2. Determine of relative cost k from equation .(2)	K = 1250000 Ka = 1800000 Ki = 900000
3. Determine of quality cost proportional parameter CP from equation (3)	k = 0.6111 qd = 0.65
4. Determine of decisive function parameter d0 or d1 from equations (4A) or (4B)	Cp = 0.94
5. Determine of relative cost parameter cr from equation (5)	CKa = 27692.3077 Cki = 13846.1538 Ck = 19230.7692
6. Determine of decisive parameter for technical preferences Rt from equation (6)	q = 0.65 do = 0.47 cr = 0.61112 k = 0.61111
7. Determine of decisive parameter of economic preference Re from the equation (7)	k = 0.61111 c = 0.61112 d0 = 0.47 qd = 0.65
8. Determine of averaged decisive parameter Rd from equation (8)	Rt = 0.57850911 Re = 0.587173

B. Case - 2

Data Analysis of Laser CNC Cutting Machine

[1]. Determine of the quality cost Parameter (CK):

K = 6500000 Q = 92%

$$Ck = \frac{K}{Q}$$

$$Ck = \frac{6500000}{92}$$

Ck = 70652.1739

[2]. Determine of relative cost K:

Ka = 455959.05 k = 413958.96 ki = 371958.87

$$k = \frac{Ka-K}{Ka-Ki}$$

$$k = \frac{9687000-6500000}{9687000-5500000}$$

k = 0.761165

[3]. Determine of quality cost proportional Parameter E:

k = 0.761165 qd = 0.92

CP = k/qd

CP = 0.761165/0.92

CP = 1.171023

[4]. Determine of decisive function Parameter d0 or d1

Now CP = 1.171023

d0 = 0.5× CP

d0 = 0.5× 1.171023

d0 = 0.573025

[5]. Determine of relative cost Parameter c:

Cka = 105293.478 Ck = 59782.6087 Cki = 70652.1739

$$Cr = \frac{Cka-Ck}{Cka-Cki}$$

$$Cr = \frac{105293.478-59782.6087}{105293.478-70652.1739}$$

Cr = 0.761165

[6]. Determine of decisive Parameter for technical preferences Rt:

Qd= 0.92 d0 =0.573025 cr = 0.761165 k = 0.761165

Rt = 0.0667 .(8.qd+4.d+2.cr+ k)

Rt = 0.0667.(8× 0.92 + 4 × 0.573025 + 2 × 0.761165 + 0.761165)

Rt = 0.796104187

[7]. Determine of decisive Parameter for economic preferences Re:

K = 0.761165 Cr = 0.761165 d = 0. 573025 q = 0.92

Re = 0.0667. (8.K + 4.cr + 2.d + qd)

Re = 0.0667. (8× 0.761165 + 4 × 0.761165 + 2 × 0.573025 + 0.92)

Re = 0.7470

[8]. Determine of averaged decisive Parameter Rd:

Rt = 0.796104187

Re = 0.747

Rd = 0.5 (Rt + Re)
Rd = 0.5 (0.796104187+ 0.7470)
Rd = 0.771552

Table No-8 Stages and Data to Quality-cost Analysis of Two machines	
STAGES	Data – Laser Cutting CNC Machine
1. Determine of the quality cost parameter Ck from equation.	K = 6500000 Q = 92%
2. Determine of relative cost k from equation .(2)	K = 6500000 Ka = 9687000 Ki = 5500000
3. Determine of quality cost proportional parameter CP from equation (3)	k = 0.761165 qd = 0.92
4. Determine of decisive function parameter d0 or d1 from equations (4A) or (4B)	Cp = 1.171023
5. Determine of relative cost parameter cr from equation (5)	Cka = 105293.478 Cki = 59782.6087 Ck = 70652.1739
6. Determine of decisive parameter for technical preferences Rt from equation (6)	q = 0.92 d0 = 0.573025 cr = 0.761165 k = 0.761165
7. Determine of decisive parameter of economic preference Re from the equation (7)	k = 0.761165 c = 0.761165 d0 = 0.573025 qd = 0.92
8. Determine of averaged decisive parameter Rd from equation (8)	Rt = 0.796104187 Re = 0.7470

C. Analytical Hierarchy Process

AHP is use after choose machine. In AHP method describe percentage value of decision making for its feature. AHP focused on decision making of machine when it manufactured.

Table 9: Result for Decision Making criteria	
Main criteria	AHP criteria weight
Quality	0.41
Flexibility	0.19
Productivity	0.1441
Service facility	0.024
Price	0.063
Safety	0.0401
Reliability	0.093

By using consistency ratio find out that these methods have consistence. In Table no. 3 is showing criteria weight of all parameters that results are decide percentages of decision making for all these parameters.

D. *Result And Discussion*

Table 10: Result After Analysis of Both Machine

STAGE	parameters	Data – CONVENTIONAL Cutting CNC Machine	Data – Laser Cutting CNC Machine
1	Quality cost Parameter Ck	Ck = 19230.7692	Ck = 70652.1739
2	Relative Cost K	k = 0.6111	k = 0.761165
3	Quality cost proportional Parameter Cp	Cp = 0.94	Cp = 1.171023
4	Decisive function Parameter d1	do = 0.47	d0 = 0.573025
5	Relative cost Parameter Cr	Cr = 0 .61112	Cr = 0.761165
6	Parameter for technical preferences Rt	Rt= 0.57850911	Rt = 0.796104187
7	Decisive Parameter for economic preferences Re	Re= 0.587173	Re= 0.7470
8	Averaged decisive Parameter ,Rd	Rd= 0.582841	Rd= 0.771552

Here Conventional Cutting CNC Machine is 58.2841% choice of decision making with comparison its cost and quality analysis. and decision preferred 77.1552% of Laser Cutting CNC Machine as compare to same parameters . In table no.10 take all decision with comparison its technically sound data and cost analysis and decide with suitable requirement as decisive parameters.

VIII. RESULTS AND DISCUSSION

The results and discussion section of this research paper presents the findings obtained through the application of various methodologies, including the Analytic Hierarchy Process (AHP) for criteria weighting, the VIKOR method for machine selection, and strategies for optimizing the cost of quality (COQ). This section evaluates the effectiveness of these methodologies and discusses their implications for enhancing industrial efficiency and promoting economic growth.

Criteria Weights Determination using AHP

The AHP method was employed to determine the weights of criteria considered essential for machine selection and COQ optimization. Through a systematic process of pairwise comparisons and mathematical calculations, priority weights were assigned to each criterion based on their relative importance. The results revealed the significance of factors such as performance specifications, reliability, cost considerations, and quality assurance in the decision-making process. These weighted criteria provided valuable insights into the key considerations influencing machine selection and COQ management strategies.

Machine Selection Outcome using VIKOR Method

The VIKOR method facilitated the selection of the most suitable machine from the available alternatives based on the established criteria weights. By considering both the best and worst outcomes for each alternative, the VIKOR method identified the compromise solution that offered the best overall performance. The results of the machine selection process highlighted the importance of balancing multiple criteria to achieve optimal outcomes. Additionally, the VIKOR method provided a structured framework for informed decision-making, ensuring that the selected machine aligned with organizational objectives and stakeholder preferences.

A. *Cost of Quality Optimization Strategies*

The research also investigated various strategies for optimizing the cost of quality within industrial operations. Strategies such as defect prevention, quality assurance, and continuous improvement initiatives were explored to minimize quality-related expenses and maximize benefits. Real-world examples and case studies were utilized to illustrate the application of these strategies in industrial settings, showcasing organizations that have successfully implemented COQ optimization strategies to achieve significant cost savings and performance improvements.

B. *Implications for Industrial Efficiency and Economic Growth*

The findings of the research have significant implications for enhancing industrial efficiency and promoting economic growth. By employing rigorous methodologies for criteria weighting, machine selection, and COQ optimization, organizations can make informed decisions that drive operational excellence and competitiveness. The strategies and techniques explored in this research offer practical insights into improving production processes, reducing costs, and enhancing overall performance. Ultimately, the adoption of these methodologies can contribute to the sustainable growth and prosperity of industrial enterprises, thereby fostering economic development and prosperity.

IX. CONCLUSION

In conclusion, this research has shed light on the critical importance of informed decision-making in machine selection and cost of quality (COQ) management for enhancing industrial efficiency and fostering economic growth. Through the application of methodologies such as the Analytic Hierarchy Process (AHP) for criteria weighting and the VIKOR method for machine selection, valuable insights have been gleaned into optimizing industrial operations. The determination of criteria weights provided a structured framework for prioritizing factors influencing machine selection and COQ management, ensuring alignment with organizational objectives. The VIKOR method facilitated the selection of the most suitable machine, considering both the best and worst outcomes for each alternative and balancing multiple criteria to achieve optimal results.

Moreover, the exploration of COQ management strategies, including defect prevention, quality assurance, and continuous improvement initiatives, has underscored their significance in minimizing quality-related expenses and maximizing benefits. Real-world examples and case studies have demonstrated the practical application of these strategies in industrial settings, showcasing their potential for driving operational excellence and competitiveness.

Looking ahead, future research directions could include further investigation into emerging technologies and trends reshaping the industrial landscape. Additionally, continued emphasis on market analysis and leveraging modern technology trends will be crucial in driving organizational success. By embracing innovation and adopting a proactive approach to decision-making, organizations can position themselves for sustained growth and prosperity in an increasingly competitive global marketplace. Ultimately, the findings of this research underscore the imperative of strategic decision-making in machine selection and COQ management as pivotal drivers of industrial efficiency and economic growth.

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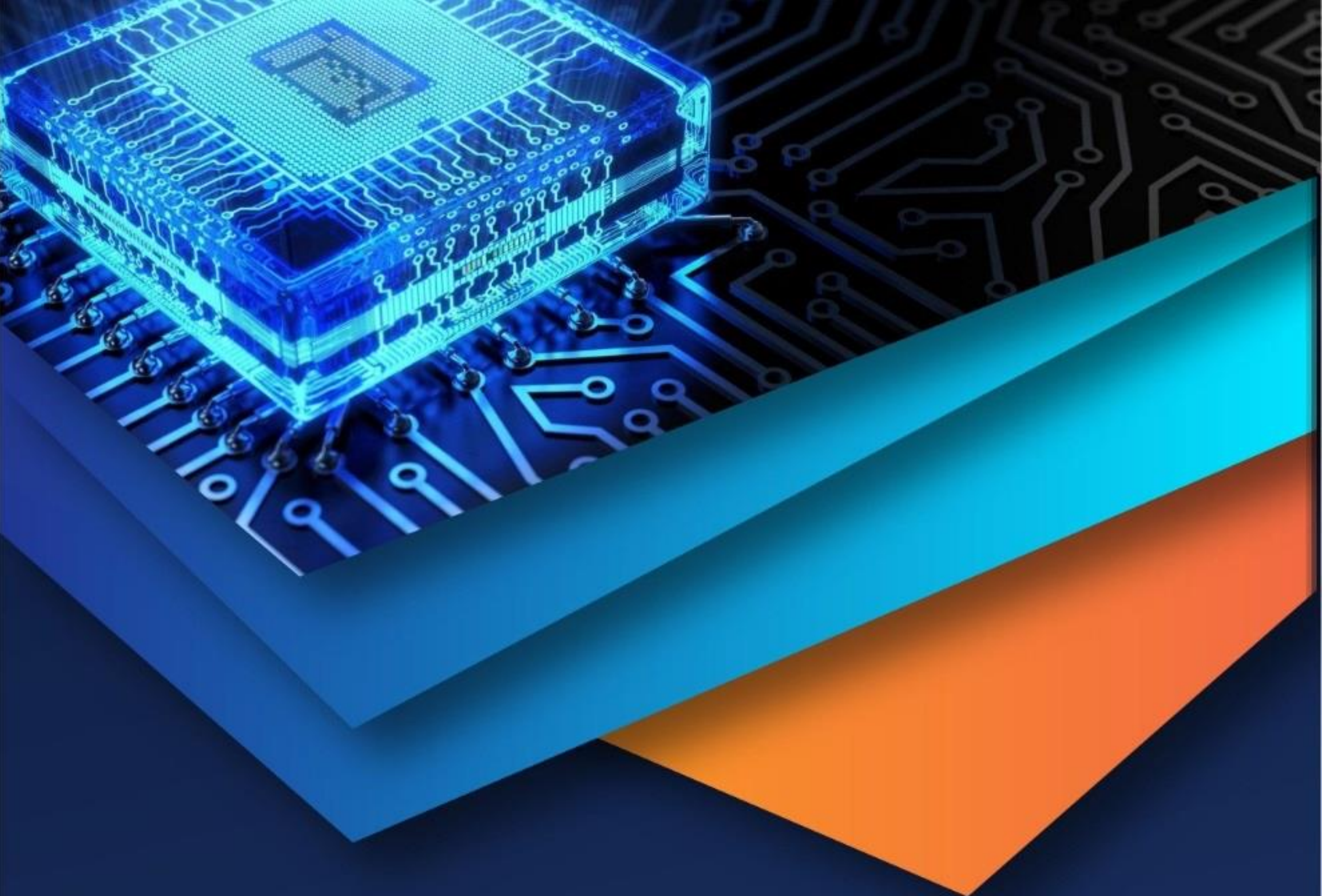

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