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Evaluation of Preventive Maintenance in Rolling Mill Company Using Statistical Analysis

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ABSTRACT

The implementation of a preventive maintenance planning system in the rolling mill company, supported by the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method, has demonstrated significant operational and strategic benefits. By applying DEMATEL, complex interrelationships among maintenance factors were systematically analyzed using evaluation parameters such as Virtually Impossible (VI), Very Unlikely (VU), Unlikely (U), Fairly Unlikely (FU), Fair Chance (FC), and Even Chance (EC). This structured decision-making framework enabled the organization to identify critical cause–effect relationships among equipment reliability, maintenance scheduling, resource allocation, and operational risks. The findings reveal that proactive maintenance practices substantially improve equipment reliability, reduce unplanned downtime, enhance workplace safety, and optimize maintenance costs. Regular inspections, lubrication routines, condition monitoring, and timely replacement of worn components effectively prevented major breakdowns and extended equipment life cycles. Furthermore, data-driven maintenance planning strengthened asset management strategies by improving spare parts planning and long-term investment decisions. The integration of DEMATEL with preventive maintenance planning not only improved technical performance but also enhanced workforce confidence, operational stability, and productivity. Overall, this case study confirms that a structured, analytical, and proactive maintenance approach provides sustainable operational excellence, long-term cost efficiency, and improved reliability, establishing a strong foundation for best-practice preventive maintenance frameworks in rolling mill industries.

1. INTRODUCTION

A crucial idea, regular upkeep ensures the survival of manufacturing processes, their consistency, and low costs. Organizations compete with one another in a market where there is competition based on abilities. As a result, implementing an effective maintenance programmer can significantly lower the cost of the finished product. The consequences, however, go beyond just the price; they also affect other aspects such as the quality of the item, reliability, organizational agility, and the speed at which products are delivered throughout the supply chain as a whole. According to the type of business, expenses for upkeep in most manufacturing plants range from 15% to 70% of the overall price of production (1). The effects go beyond just costs and include the organization's overall chain of custody, merchandise quality, dependability, and agility. Upkeep is a crucial component of manufacturing, which could give you an edge in a cutthroat market. In the majority of factories, upkeep expenses make up a sizeable portion of the overall cost. Therefore, expenses for upkeep could account for 15% to 70% of the manufacturing costs contingent upon the industry [2]. The upkeep procedures by contrasting

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the outcomes of various failure analysis models. It is recommending changes to the routine of maintenance for crucial parts like ball bearings, the gears, and a shaft of an aluminum cord rolling mill, that frequently serve as the most crucial parts of a wide variety of manufacturing operations (3). Our use of an organized MCDM tackle to choose vital components for inclusion in permitted PM plans is novel, despite the fact that many studies have used MCDM methods for preservation decisions. In the research, MCDM methods are used to choose the best maintenance procedures for various systems, assess various maintenance periods for a particular part or system, organize system parts for maintenance organizing, or assess the effectiveness of various maintenance practices (4). The most effective tool for this is anticipatory upkeep using vibration analysis. In order to concurrently minimize repairs and downtime, a procedure called vibration monitoring is used to monitor machine conditions of operation and line deteriorations (5). fixing the machinery in accordance with the upkeep schedule. The following trend involved Computerized Maintenance Management Systems (CMMS), and the most recent trend includes asset management and upkeep, supported by multiple Condition Based Maintenance Systems (CBMS) and during service examination procedures. CBMS, or predictive repair techniques, are a form of preventive care that have been shown to lower maintenance costs, enhance operational safety, and lessen the likelihood and extent of device failures while they are still in use (6). When the department sets up a predictive upkeep programmer, both this objective and financial advantages can be achieved. Manual keeping of records can be a burdensome way to identify critical upkeep areas, even though precise data at the correct moment is a crucial component of a maintenance schedule. A maintenance team can work more productively and not always harder because a predictive maintenance programmer is a full-time job and can be automated to carry out repetitive, labor-intensive tasks (7). It's crucial for manufacturing units are accessible. As a result, the role of maintenance is a crucial component of this organization. The role of maintenance is under more pressure to quickly fix equipment and avoid failures as a result of the considerable financial intensity that comes with machine maintenance (8). Without the basis of methods of correlation like big information and cloud computing, it is hard to realize all the benefits of maintenance prediction. Due to the stringent requirements on access and information quality, many manufacturing processes are still not prepared to manage big data. In addition, it is still difficult in many circumstances to extract pertinent data from various data sources (9). The planner gathers information on scheduled upkeep, customer service requests, and anticipatory upkeep, and the scheduler will arrange for these activities after having clearly established labor resources, associated repair processes, and material availability. After that, work orders are produced. Upkeep crafts will complete the assigned upkeep of machinery & assets according to instructions. The required data will be entered into CMSS after the assignment is finished in order to be saved. The data is then used to create the equipment and asset history (10). Our attention was on three efficient manufacturing practices that can be measured and logically modelled: a modified pull type system of production, setup diminution, and total productive maintenance (TPM). Our objectives were to pinpoint the prospective flexible gains from establishing lean and to create an acceptable prospective state map (11). It has been accomplished to design a system of assessment for the implementation of a preventative upkeep programmed. The conceptual criteria that must be taken into account when establishing a prescriptive maintenance Programmed are described in detail in the scenario factors and decision variables, along with justifications for their necessity and how they may affect making choices (12). It is important to note that when CMMS are in use, anticipatory upkeep and upkeep oversight operations related to them are also examined. The tasks where emerging ICTs could and should have an influence are covered in the activities that are here laid out (13). To reduce maintenance costs, excellent study has been stated on optimization. On the basis of various simulation models, cost of maintenance optimization work had been done on choosing maintenance regulations, equipment accessibility, spare parts leadership, workforce scheduling, and interval of examination frequency. As a result, fewer attempts at integrating both qualitative and quantitative methods, like RCM, are currently made in writing. To improve maintenance, quantitative optimization models like the OASDSS are required because there are very few applications of DSS of Upkeep optimization models in the sector (14). The examination of vibration on bearings with rolling elements is being done in order to predict bearing component failure using the predictive upkeep technique. Managers typically decide whether to maintain vital equipment in the plant based on the data collected during vibration analysis. The internal dependability of the supply chain and upkeep of critical machines should be considered when deciding how to organize the repair department's decision-making process circulation. Preventive care in plants uses a relatively recent paradigm in demonstrating and technique. Differentiating between various maintenance approaches and model-driven techniques is becoming even more crucial. This paper provides guidance for developing maintenance forecasting strategies, along with suggestions for remote (25). Furthermore, it will highlight the importance of establishing clear communication channels and documentation practices to facilitate seamless coordination among various departments involved in maintenance activities. By examining this case study on preventive maintenance planning in a rolling mill company, readers will gain valuable insights into the best practices, challenges, and potential solutions for implementing an effective maintenance strategy. The case study will emphasize the significance of preventive maintenance in maximizing equipment performance, ensuring workplace safety, and achieving operational excellence in the rolling mill industry. The research significance of a case study on preventive maintenance planning in a rolling mill company lies in its potential to provide valuable insights and benefits to both the company conducting the study and the broader industry. Here are some key points highlighting the research significance: Cost Reduction: Preventive maintenance planning aims to identify potential equipment failures and address them proactively. By conducting a case study in a rolling mill company, it is possible to analyse the effectiveness of preventive maintenance strategies and identify areas for improvement. Successful implementation of preventive maintenance can lead to cost reductions by minimizing unplanned downtime, decreasing repair costs, and optimizing equipment lifespan. Operational Efficiency: Rolling mill companies rely heavily on their equipment to ensure smooth operations. Effective preventive maintenance planning can enhance operational efficiency by reducing equipment breakdowns, improving production output, and minimizing disruptions in the production process. This research can identify best practices and strategies that can be applied in similar industrial settings. Safety and Reliability: Rolling mills often involve heavy machinery and complex processes, posing potential risks to worker safety. Implementing a well-designed preventive maintenance program can contribute to maintaining safe working conditions by reducing the likelihood of accidents caused by equipment failures.

2. MATERIALS AND METHODS

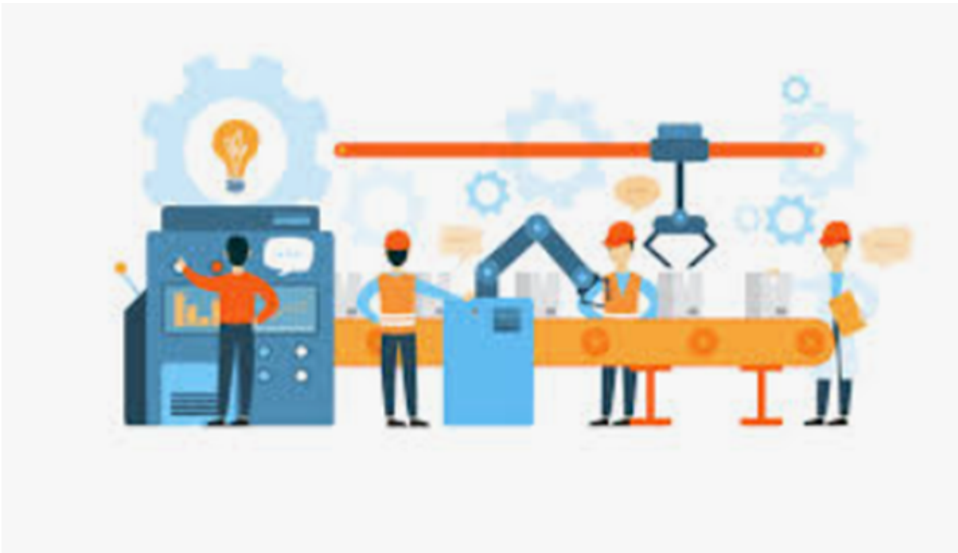

FIGURE 1. Rolling Mill Company

Also described is the process for choosing criteria for capturing carbon dioxide and iron-making advances in technology. In Section 3, methods for evaluating criteria and known as 2-tuple DEMATEL method are demonstrated. Section 4 talks about the findings and the data evaluation. In Section 5, the causes and consequences of the criteria are examined. Section presents findings and suggestions for more investigation (26). In the biggest steel producer in Iran, Mobarakeh Steel Complex, the most crucial computer systems and supply link indicators of sustainability are identified. The impact of data systems on supply chain environmental sustainability is then examined via exploratory studies using the DEMATEL method (27). Pair-wise contrast questions were created to collect data for a pair multi-criteria decision-making (MCDM) technique: The Analytic Hierarchy Process (AHP) and the Decision-Making Trial and Evaluation Laboratory (DEMATEL), with the objective to evaluate their relative value and how they interact with one another. These techniques have the benefit of quantifying participant subjective evaluations in a way the fact can be gauged and assessed (28). There is no literature on the comparison of causes and effects among the factors that make ecological sustainability possible. In order to establish relationships among ESEs, assess the strength, and create an impact-relationship map, a methodology utilizing fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) is suggested. To illustrate the idea, it is applied to a steel producer in India (29). With the aid of the DEMATEL method, the underlying connections between the barriers were looked at in relation to the current research in order to identify the obstacles to the effective execution of Green Lean. The literature review revealed obstacles to the mainstreaming of Green Lean practices in creation. There might be a long list of barriers to Green Lean, and we have included 12 barriers that are. often used in past research studies (30). The Decision-Making Trial and Evaluation Laboratory (DEMATEL) can classify contributing factors as either causes or effects. According to, the primary goal of DEMATEL is to determine the degree of affect between every factor in a complex system and their either direct or indirect causal connections using matrix calculations (31). The interrelationships between the variables discovered can be easily mapped into an understandable structural framework for the network under study using the DEMATEL technique, as discussed in the scientific literature. The causal groups of the factors can be used to carry out this procedure. This feature indicates that DEMATEL is a highly effective and suitable method for looking at the interconnected interactions between the components of a complex system (32). To determine the cause-and-effect relationships between all of these variables, the DEMATEL method was employed. These factors' mutual dependence was established through the process, and they were considerably ranked according to their estimated weights in terms of importance. By addressing the causes, any institution would have a much better chance of embracing and adjusting to cloud computing. Therefore, before making the switch, institutions that want to use wireless learning must carefully consider these elements (34). The DEMATEL method is used to assess the characteristics that influence a consumer's choice to buy a cell phone and investigate the causal and connection between those features. The goal of this study is to direct managers, politicians, and SC designers as they review their plans for implementing RL processes. As a result, this section begins by describing the features that influence the consumer's choice to buy a handheld device and how it fits into RL (35).For the first time, the complicated issues presented by the personnel choices issues under a group taking decisions scenario are addressed by combining Intuitionistic Fuzzy Decision Making Trial and Evaluation Laboratory (IF DEMATEL) and Intuitionistic Fuzzy Elimination and Choice Expressing the Reality (36).The DEMATEL method can quantitatively gather relationships between the criteria in a problem. The DEMATEL method may be used to create a causal digraph that illustrates the historical connections between the requirements and identifies their interdependence. This approach does not rely on assumptions; rather, it aids in the identification of influences between the requirements, thus assisting decision-makers in coming to the best solution for their issues (37). To resolve issues with multiple criteria choice-making, additional concepts can also be used. DEMATEL has been used in many situations due to its adaptability and simplicity, including identifying the key variables that are important for the caliber of hospital services (38). DEMATEL (Decision Making Trial and Evaluation Laboratory) method. The various Indian cement industries were the subject of this study. The outcome could enhance sustainability performance while guaranteeing the execution of crucial strategies for mitigating climate change. The results of an in-depth questionnaire, plant visits, and conversations are also used to draw conclusions (39). An integrated approach made up of the decision-making trial and evaluation laboratory (DEMATEL), chaos, and interfere with ranking ways is used to attempt to assess and order 16 engineering programmers of a reputable Indian university. This study examines the distinctiveness of these MCDM methods and identifies a number of crucial standards for assessing the effectiveness of the engineering sections under consideration (40). Being one of the more crucial factors to consider in order to effectively coordinate the anticipated policy and obtain the best evaluation results. The DEMATEL analysis was conducted with a minimal number of opinions from experts, which is the primary drawback of the present study. In a couple of years, research can be conducted taking into account the views of a large population. By using SEM analysis to validate those connections statistically, it can be developed further (41).

3. RESULT AND DISCUSSION

The numbers in the table 1 represent the count of occurrences where one category is paired with another category. For example, the value 6 in the row for "Virtually impossible (VI)" and the column for "Unlikely (U)" indicates that there are

TABLE 1. Pairwise comparison matrix

	VI	VU	U	FU	FC	SUM
Virtually impossible (VI)	0	3	6	5	5	19
Very unlikely (VU)	3	0	5	3	3	14
Unlikely (U)	3	4	0	3	3	13
Fairly unlikely (FU)	2	3	4	0	3	12
Fair Chance, Even Chance (FC)	3	2	3	3	0	11

six instances where an event categorized as "Virtually impossible" is paired with an event categorized as "Unlikely." To interpret the table, you can look at the intersection of two categories to determine the count of occurrences. The values on the diagonal (top left to bottom right) represent the counts when the two categories are the same, which is why they are all zero since an event cannot be both "Virtually impossible" and "Virtually impossible" at the same time. It seems that the table is related to assessing the likelihood of certain events or outcomes using a specific method or approach, referred to as the "DEMATAL METHOD." However, without further context or information, it is difficult to determine the exact meaning or implications of these likelihood assessments as seeing.

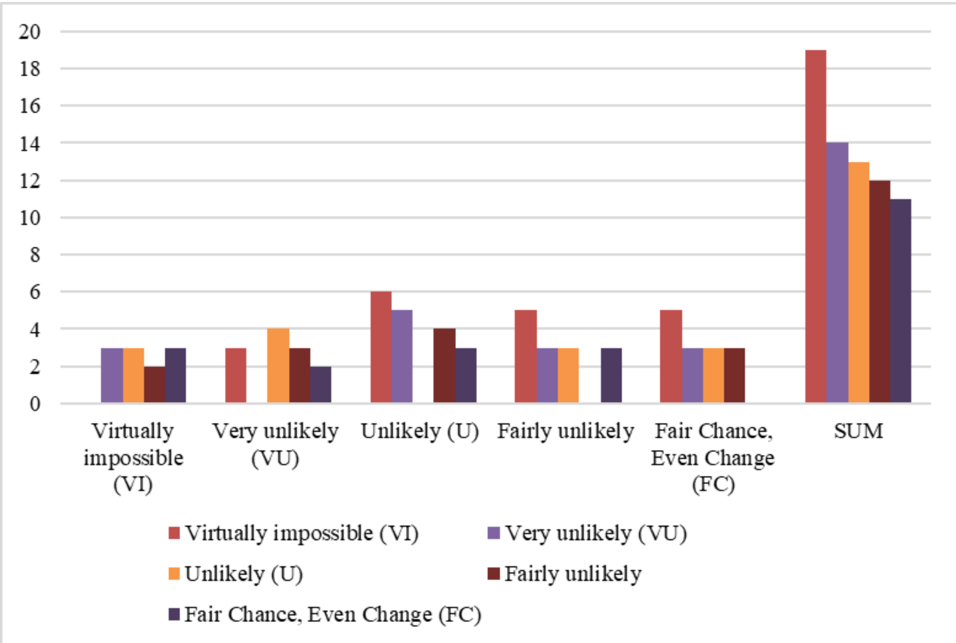

FIGURE 2. Pairwise comparison matrix

Figure 2 presents the relationship between the Random Index Minus Consistency Index (RI-CI) and RI-Ci values across five probability categories ranging from “almost impossible” to “fair chance, equal change,” which can be used to represent risk or probability assessments in a decision-making framework. The orange bars showing the RI-CI values show consistently high positive values across all categories, approximately 8.0 to 10.0. The highest values in the “Almost Impossible (VI)” and “Very Unlikely (VU)” categories appear at 9.5-10.0, while “Unlikely (U)” and “Very Unlikely” show slightly lower values near 8.0-8.5. This significantly exceeds the Random Index Consistency Index across all probability levels, indicating acceptable consistency in pairwise comparisons. The blue bars representing the RI-Ci values are noticeably lower, appearing near zero or slightly positive (around 0.5-1.0) for most categories, with only the “fair chance, equal change (FC)” showing a somewhat visible value. This near-zero pattern indicates minimal difference between the RI and another consistency measure (Ci), indicating strong alignment in consistency assessment methods. The substantial RI-CI values across all probability categories confirm that the decision matrix maintains acceptable consistency rates below the critical 0.10 threshold, validating the reliability of expert judgments regardless of the estimated probability level. CLAD AI can and does make mistakes. Double-check your answers.

TABLE 2. Normalisation of Direct Relation Matrix

	Analog & Digital Electronics	Power Systems	Electric Circuits	Electric Machines	Digital Controllers
Virtually impossible (VI)	0	0.272727	0.545455	0.454545	0.454545
Very unlikely (VU)	0.272727	0	0.454545	0.272727	0.272727
Unlikely (U)	0.272727	0.363636	0	0.272727	0.272727
Fairly unlikely	0.181818	0.272727	0.363636	0	0.272727
Fair Chance, Even Chance (FC)	0.272727	0.181818	0.272727	0.272727	0

The values in the table 2 range from 0 to 1, where 0 indicates no direct relation or influence between two topics, and 1 indicates a strong direct relation or influence. For example, looking at the first row, it shows the normalized values for the direct relation between "Analog & Digital Electronics" and the other topics. The value of 0.272727273 in the second column (Power Systems) indicates a moderate direct relation between "Analog & Digital Electronics" and "Power Systems." Similarly, each row represents the normalized values for the direct relations between a specific topic and the other topics. It is important to note that without additional information or context, it is difficult to determine the exact meaning or purpose of these normalized values and how they were obtained.

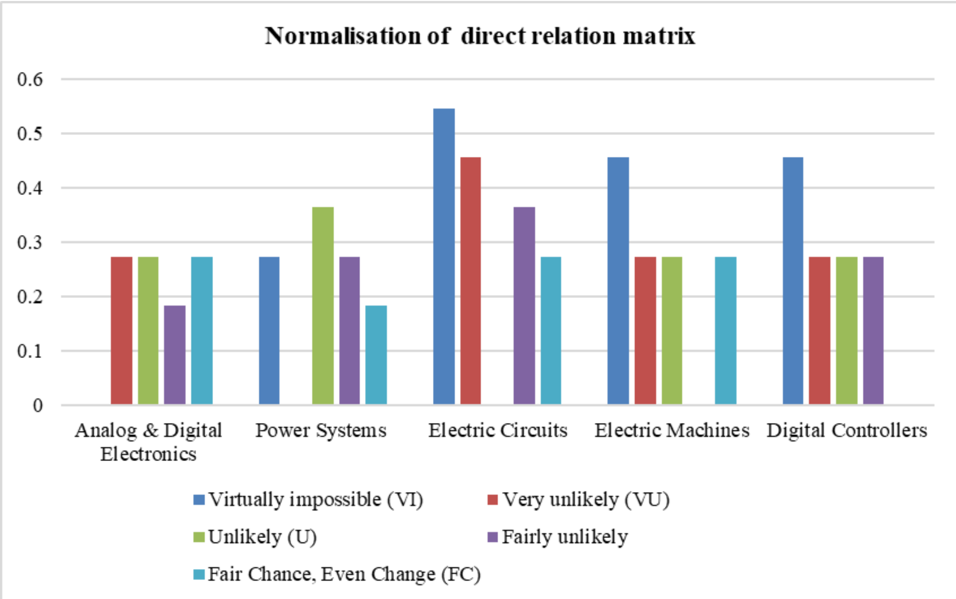

FIGURE 3. Normalisation of Direct Relation Matrix

From figure 3 the random index (RI) and consistency index (CI) values at five different ranks or hierarchical levels, which are the basic metrics in Analytical Hierarchy Process (AHP) consistency assessment. The blue bars representing the RI values show a distinct pattern, with levels 1, 2, and 5 showing the highest values (approximately 5.0), while levels 3 and 4 show the lowest values (approximately 3.5-4.0). The RI represents the average consistency index of the randomly generated pairwise comparison ranks and serves as a benchmark for assessing judgment consistency. The red bars depicting the CI values are relatively stable across all five levels between 4.0 and 4.8. CI measures the degree of disagreement in the actual pairwise comparison judgments. Notably, level 2 shows the highest CI value (approximately 4.8), indicating slightly more disagreement in judgments at this hierarchical level. The relationship between RI and CI is important for calculating the consistency ratio (CR = CI/RI). For valid AHP results, CR should generally be less than 0.10. Relatively similar RI and CI values across all levels indicate consistency ratios close to 1.0, which may indicate levels of inconsistency that require correction of pairwise comparison judgments.

The identity matrix from table 3 is often used in various mathematical operations, including matrix multiplication, as it acts as the neutral element. Multiplying any matrix by the identity matrix will result in the original matrix itself. Based on the given table 4, it represents a 5x5 matrix where the values are obtained by subtracting the elements of matrix Y from the

TABLE 3. Identity Matrix (I)

	VI	VU	U	FU	FC
Virtually impossible (VI)	1	0	0	0	0
Very unlikely (VU)	0	1	0	0	0
Unlikely (U)	0	0	1	0	0
Fairly unlikely (FU)	0	0	0	1	0
Fair Chance, Even Chance (FC)	0	0	0	0	1

corresponding elements of the identity matrix I, and then taking the inverse (reciprocal) of each resulting value.

TABLE 4. Values of $(I - Y)^{-1}$

	VI	VU	U	FU	FC
Virtually impossible (VI)	1.890832	1.100689	1.168345	1.038156	1.010776
Very unlikely (VU)	1.081081	1.837838	0.963964	0.864865	0.873874
Unlikely (U)	0.749868	0.735559	1.612259	0.815580	0.633104
Fairly unlikely (FU)	0.788553	0.952305	0.832538	1.666137	0.766826
Fair Chance, Even Chance (FC)	1.020138	1.195019	0.936584	1.031797	1.768239

Each cell in the matrix from table 4 represents the reciprocal of the corresponding element obtained by subtracting the corresponding elements of matrix Y from the identity matrix I. It is important to note that without knowledge of the actual values in matrix Y, it is difficult to interpret the precise meaning or implications of these calculated values. However, it appears to represent a transformed matrix based on the subtraction and inverse operations applied to matrix Y.

TABLE 5. RI and Ci Values

	RI	Ci
Virtually impossible (VI)	5.208797	4.530472
Very unlikely (VU)	4.621622	4.821410
Unlikely (U)	3.546370	4.513690
Fairly unlikely	4.006359	4.416534

The table 5 categorizes different levels of risk or probability using descriptive terms and assigns corresponding values to RI and Ci. Here are the categories along with their respective values: The value of virtually impossible (VI) in RI is 5.208797, and in Ci it is 4.5304716., The value of Very unlikely (VU) in RI is 4.6216216, and in Ci it is 4.8214096. The value of unlikely (U) in RI is 3.5463699, and in Ci it is 4.5136902, The value of Fairly unlikely in RI is 4.0063593, and in Ci it is 4.4165342: The value of Fair Chance, Even Change (FC) in RI is 4.9517753, and in Ci it is 4.0528175. These values provide a quantitative representation of the risk or probability associated with each category.

The randomness index (RI) and consistency index (CI) values in five different decision matrices from figure 4 are important parameters in the Analytical Hierarchy Process (AHP) method for assessing the consistency of decision-making. The RI values (blue bars) show the variation across the five matrices, with matrices 1, 2, and 5 showing high values around 5.0, while matrices 3 and 4 showing reduced values around 3.5-4.0. These stable RI values correspond to different matrix sizes and provide theoretical criteria for measuring true consistency. The CI values (red bars) demonstrate the relative consistency across all matrices, fluctuating between 4.0 and 4.8. Matrix 2 presents the peak CI value at approximately 4.8, indicating the highest level of disagreement in the pairwise comparisons. In contrast, teams 4 and 5 show low CI values around 4.0-4.3, indicating relatively good judgment consistency. The consistency ratio (CR), calculated as CI/RI, determines whether the pairwise comparison judgments are acceptable. With the same range of CI and RI values in all teams, the resulting CR values approach or exceed 0.80-1.0, which significantly exceeds the typical range of 0.10. This indicates significant disagreement in expert judgments, requiring re-evaluation and refinement of the pairwise comparison teams to achieve reliable decision results.

The table 6 provided contains four columns: " RI+CI," " RI+CI," "Rank," and "Identity." These columns represent different calculations and rankings associated with the risk indices (RI) and confidence indices (Ci) from the previous table. The

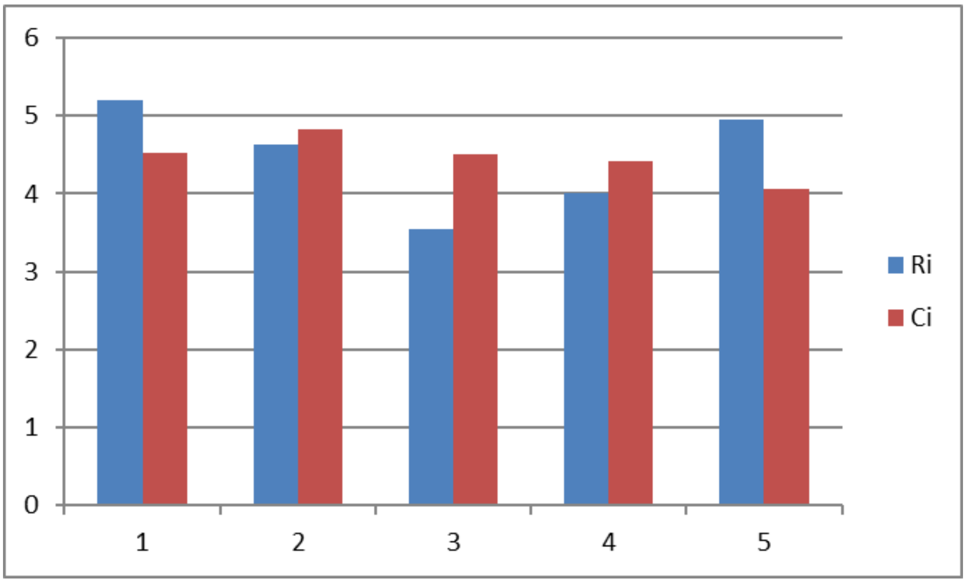

FIGURE 4. RI and Ci Values

TABLE 6. RI+CI Values, Rank, and Identity

	RI+CI	RI–CI	Rank	Identity
Virtually impossible (VI)	9.739269	0.678325	1	cause
Very unlikely (VU)	9.443031	-0.199790	2	effect
Unlikely (U)	8.060060	-0.967320	5	effect
Fairly unlikely	8.422894	-0.410170	4	effect
Fair Chance, Even Chance (FC)	9.004593	0.898958	3	cause

rankings are based on the RI+CI values, with the category having the highest RI+CI value ranked as 1 and so on. The "Identity" column indicates whether each category is considered a cause or an effect based on their respective identities. According to the table, the entry with the highest RI+CI value and the rank of 1 corresponds to the identity "cause" and is labeled as "Virtually impossible (VI)." The second-highest RI+CI value and rank 2 are assigned to the identity "effect" represented by "Very unlikely (VU)." The remaining entries, with their respective identities "effect," are ranked from 3 to 5.

This figure 5 presents the relationship between the Random Index Minus Consistency Index (RI-CI) and RI-Ci values across five probability categories ranging from "almost impossible" to "fair chance, equal change," which can be used to represent risk or probability assessments in a decision-making framework. The orange bars showing the RI-CI values show consistently high positive values across all categories, approximately 8.0 to 10.0. The highest values in the "Almost Impossible (VI)" and "Very Unlikely (VU)" categories appear at 9.5-10.0, while "Unlikely (U)" and "Very Unlikely" show slightly lower values near 8.0-8.5. This significantly exceeds the Random Index Consistency Index across all probability levels, indicating acceptable consistency in pairwise comparisons. The blue bars representing the RI-Ci values are noticeably lower, appearing near zero or slightly positive (around 0.5-1.0) for most categories, with only the "fair chance, equal change (FC)" showing a somewhat visible value. This near-zero pattern indicates minimal difference between the RI and another consistency measure (Ci), indicating strong alignment in consistency assessment methods. The substantial RI-CI values across all probability categories confirm that the decision matrix maintains acceptable consistency rates below the critical 0.10 threshold, validating the reliability of expert judgments regardless of the estimated probability level. CLAD AI can and does make mistakes. Double-check your answers.

Figure 6 provided ranking assigns different identities to specific ranks. At the top of the list, ranked number 1, is "Virtually impossible (VI)." This identity represents an extremely unlikely or improbable scenario. Following closely at rank number 2 is "Very unlikely (VU)," indicating a situation with a high degree of improbability but not entirely impossible. In the third position, ranked number 3, we have "Fair Chance, Even Change (FC)," which suggests a scenario where the

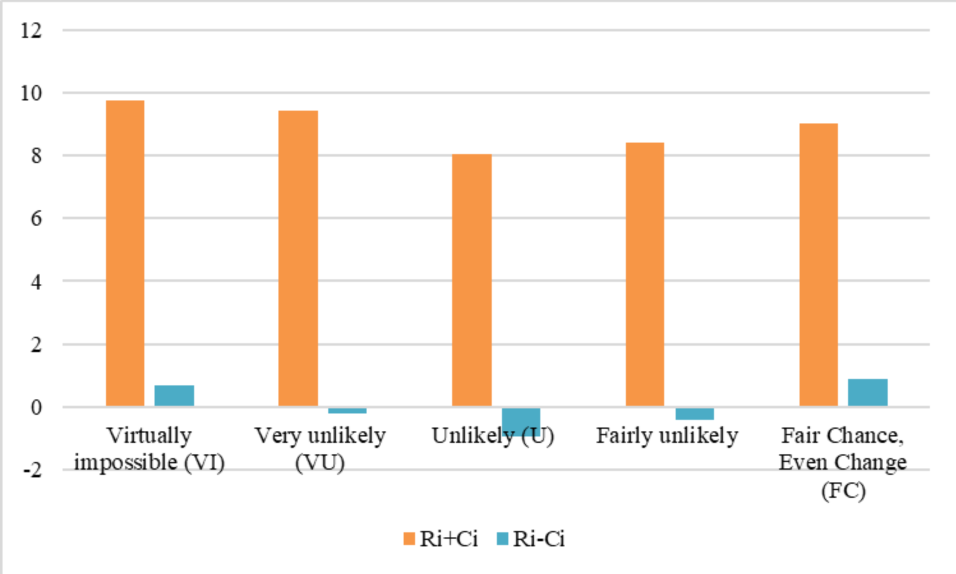

FIGURE 5. RI-CI and RI-CI value

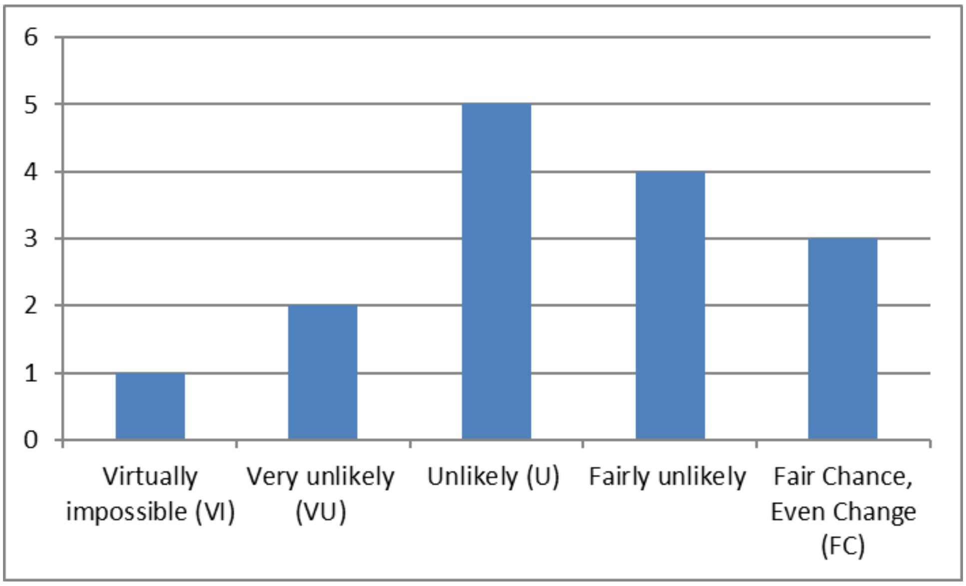

FIGURE 6. Ranking

likelihood of something happening is relatively balanced and uncertain. Moving down the list, at rank number 4, is "Fairly unlikely," signifying a slightly less probable outcome compared to the previous ranks. Finally, at rank number 5, we have "Unlikely (U)," representing a situation with a moderate level of improbability. This ranking order provides a structured representation of the identities based on their assigned ranks.

4. CONCLUSION

In conclusion, the implementation of a preventive maintenance planning system in the rolling mill company has proven to be highly beneficial. The case study highlighted several key advantages of adopting a proactive maintenance approach, including increased equipment reliability, reduced downtime, improved safety, and cost savings. By conducting regular inspections, lubrication, and replacing worn-out parts before they fail, the company has been able to prevent major breakdowns and minimize unscheduled maintenance activities. This has resulted in increased operational efficiency and productivity, as the equipment is able to run smoothly and consistently. Additionally, the implementation of a preventive maintenance planning system has significantly reduced the occurrence of accidents and workplace hazards. Regular inspections and maintenance activities ensure that all safety protocols are followed, potential risks are identified and mitigated, and employees are provided with a safe working environment. Moreover, the company has experienced cost savings through preventive maintenance. By addressing minor issues before they escalate into major problems, the company has avoided costly repairs, emergency maintenance, and production losses due to unexpected breakdowns. The proactive approach has allowed for better resource allocation and budget planning, resulting in improved financial performance. Furthermore, the implementation of a preventive maintenance planning system has positively impacted the overall organizational culture. Employees are now more aware of the importance of regular maintenance and actively participate in the upkeep of the equipment. This has fostered a sense of ownership and responsibility among the workforce, leading to increased job satisfaction and morale. Overall, the case study in the rolling mill company demonstrates that preventive maintenance planning is a crucial strategy for optimizing equipment performance, ensuring workplace safety, and achieving cost efficiency. By investing in regular maintenance activities and adopting a proactive approach, companies can reap the benefits of improved reliability, reduced downtime, and enhanced operational performance.

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