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Risk Assessment and Safety Measures in Automotive Manufacturing Industry

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Abstract—The automotive manufacturing industry is characterized by a complex and dynamic operational environment, replete with diverse hazards that pose risks to worker safety, product quality, and environmental sustainability. Risk assessment and safety measures are integral to ensuring the well-being of employees, the preservation of the environment, and the maintenance of high-quality manufacturing standards. The systematic identification and evaluation of potential risks, ranging from physical and chemical hazards to ergonomic, biological, and electrical threats, provide a foundation for implementing control measures. These measures, which encompass engineering, administrative, and personal protective equipment controls, along with robust environmental practices, create a comprehensive approach to mitigating and managing hazards. The industry's commitment to continuous monitoring, adherence to regulations, and a proactive safety culture ensures a safer, more efficient and environmentally responsible automotive manufacturing sector. In this context, risk assessment and safety measures are not just obligations; they are essential components of an industry that values the lives of its workers, the quality of its products, and the sustainability of its operations.

Keywords: Automotive Manufacturing, Hazard Identification, Risk Assessment, Safety Measures, Sustainability in Manufacturing.

I. INTRODUCTION

Automotive manufacturing is a complex and dynamic industry that plays a pivotal role in the global economy. The production of automobiles involves a multitude of intricate processes, from the assembly of components to the integration of advanced technologies. While the industry continually evolves to meet the demands of consumers, it also faces an array of risks that can have far-reaching consequences if not effectively managed. Risk assessment and safety measures are essential components of automotive manufacturing, as they ensure the well-being of workers, the integrity of the final products, and the overall success of the industry.

In the world of automotive manufacturing, risk assessment is the process of identifying potential hazards and evaluating the likelihood and severity of their occurrence. It is the first critical step in creating a safer and more efficient manufacturing environment.

II. METHODOLOGY

The "Risk Assessment and Safety Measures in Automotive Manufacturing Industry," a systematic methodology to identify, analyze, and mitigate risks,as well as evaluate existing safety measures.

Step-1 Project Definition and Objective Setting
Step-2 Literature Review
Step-3 Risk Identification
Step-4 Risk Analysis and Assessment
Step-5 Safety Measure Evaluation
Step-6 Development of Safety Solutions and Risk Mitigation Plans
Step-7 Implementation Plan and Timeline
Step-8 Monitoring and Evaluation
Step-9 Reporting and Documentation
Step-10 Conclusion and Recommendations

FAILURE MODE AND EFFECT ANALYSIS

Failure mode and effects analysis (FMEA) is a comprehensive engineering technique that manufacturers are able to improve the quality, reliability, and safety of their products through applying this technique. In particular, FMEA technique is used to identify, define, and eliminate known and potential failures, problems and errors in the products, programs, systems and services before they reach the customer. FMEA is a systematic method, which is applied because of the following reasons:

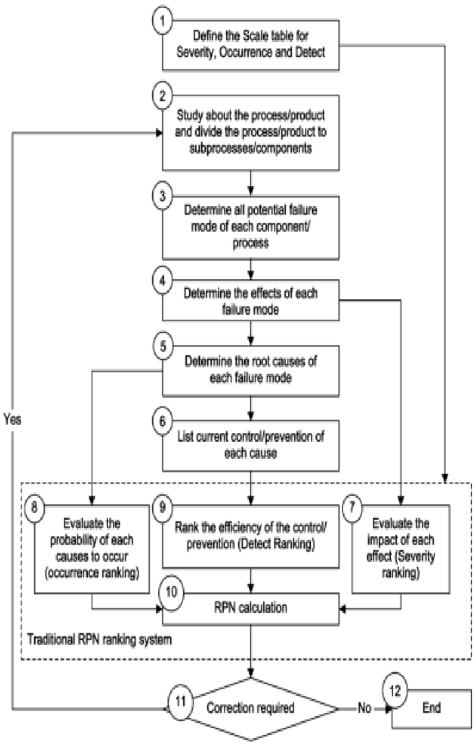

Figure 1 FMEA

1) To identify and prioritize potential failure modes in a system, product, process, or service.
2) To define and run measures in order to eliminate or reduce the incidence of potential failure modes.
3) To record analysis results in order to provide a comprehensive reference for solving future issues and problems. FMEA could be described as a structured method to find and identify failure modes in a system, object, or an activity and calculation of the failure effects on upper steps.

RISK DETECTION PROBABILITY RATE

Detection possibility is an assessment of the ability existing to identify a cause/mechanism of a risk occurrence. In other words, detection possibility is a rating corresponding to the likelihood that the detection methods or current controls will detect the potential failure mode before the product is released for production for design, or for process before it leaves the production facility. Assessing control process of standards, requirements and laws of labor and how to apply them to achieve this number are very useful. In the RPN methodology the parameters used to determine the "criticality" of an item failure mode are assessing control process of standards, requirements and laws of labor and how to apply them to achieve this number are very useful. In the RPN methodology the parameters used to determine the "criticality" of an item failure mode are, the severity of its failure effects, its frequency of occurrence, and the likelihood that subsequent testing of the design will detect that the potential failure mode actually occurs. Tables 1-3 show the qualitative scales commonly used for the severity, the occurrence and the detect ability indexes.

Table 1 Severity guidelines for design FMEA

Effect	Rank	Criteria
No	1	No effect
Very slight	2	Customer not annoyed
Slight	3	Customer slight annoyed
Minor	4	Customer experiences minor nuisance
Moderate	5	Customer experiences some dissatisfaction
Significant	6	Customer experiences discomfort
Major	7	Customer dissatisfied
Extreme	8	Customer very dissatisfied
Serious	9	Potential hazardous effect
Hazardous	10	Hazardous effect

Table 2 Occurrence guidelines for design FMEA

Effect	Rank	Criteria
Almost never	1	Failure unlikely. History shows no failure
Remote	2	Rare number of failures likely
Very slight	3	Very few failures likely
Slight	4	Few failures likely
Low	5	Occasional number of failures likely
Medium	6	Medium number of failures likely
Moderately high	7	Moderately high number of failures likely
High	8	High number of failures likely
Very high	9	Very high number of failures likely
Almost certain	10	Failure almost certain

Table 3 Detect-ability guidelines for design FMEA

Effect	Rank	Criteria
Almost certain	1	Proven detection methods available in concept stage
Very high	2	Proven computer analysis available in early design stage
High	3	Simulation and/or modeling in early stage
Moderately high	4	Tests on early prototype system elements
Medium	5	Tests on preproduction system components
Low	6	Tests on similar system components
Slight	7	Tests on product with prototypes and system components installed
Very slight	8	Proving durability tests on products with system components installed
Remote	9	Only unproven or unreliable technique(s) available
Almost impossible	10	No known techniques available

Consider both risks with high RPN and low RPN having one or two abovementioned factors, i.e. while determining risk criterion and decision making for considering a failure within the acceptable or unacceptable risk domain, the team attention was not only towards RPN values but also each of the tree failure factors were assessed. For this purpose, a criterion was defined as the level of crisis. The crisis is a criterion that expresses the importance of a potential/actual risk in the system studied. In addition, it is used to measure the level of crisis in the system

ANP MODEL DEVELOPMENT

Structuring the problem as a hierarchy is the most significant and creative part in the perfect strategy selection of maintenance alternative. Four related components are incorporated in the structural model of the decision problem. In the hierarchical model the decision problem is placed at the peak and the determinants at the next level. Forefront technology, competitive market, privilege and hazard are the determinants associated with the policy selection criteria. In the third level of hierarchy, four criteria termed as dimensions of the model is placed which supports all the four determinants. The dimensions comprises of professional concerns, decisive terms, payment aspects and safeness requisites. Each of the four dimensions has some sub criteria, which help to achieve that particular dimension. For example, the dimension payment aspects constitutes appliances, operating system, back up inventory and flaw detection. Finally leaf nodes are the alternative maintenance policies to be compared and evaluated. Three alternative maintenance policies of the organization analyzed are RM, TBM and CBM.

CALCULATING PRIORITIES

Priorities are obtained by making pairwise comparisons among inner elements and outer elements and super matrix is created. For prioritizing elements and to prepare a pair wise comparison matrix, a generic question that is put forward is: “Which element exerts more influence on a specific control criterion?” The process to perform pair wise comparisons and to obtain priority vectors of ANP is similar to that of AHP. The relative importance values are described in Saaty’s fundamental scale table.

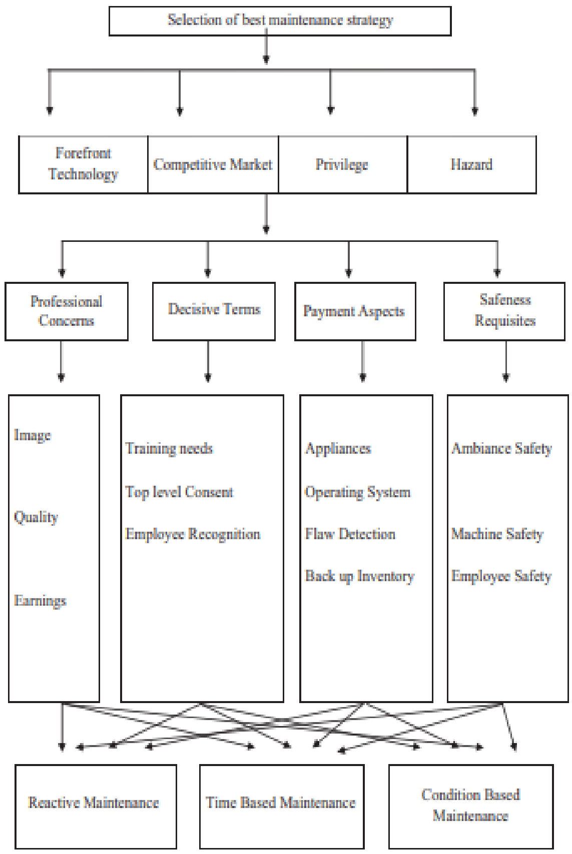

Figure 2 ANP Decision Model For Selection Of Maintenance Strategy

SCHEMATIC DIAGRAM FOR RISK ASSESSMENT IN AUTOMATIVE INDUSTRIES

Schematic diagram of the proposed model for automotive industries risk assessment is provided in Figure. In the remainder of this section, we describe each of the main steps of the proposed model for case study.

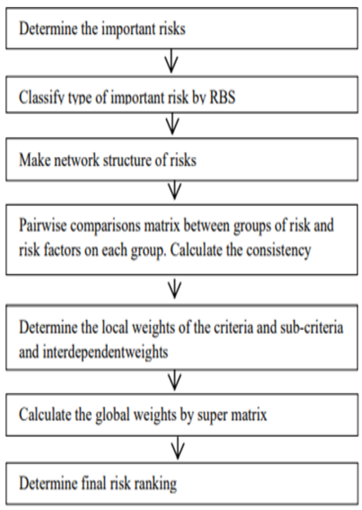

Figure 3 Schematic Diagram for Risk Assessment in Automotive Projects

HAZARDS IN AUTOMOTIVE INDUSTRY

Physical Hazards: The automotive manufacturing process involves heavy machinery, robotic equipment, and production lines with moving parts. Workers are at risk of physical injuries, such as getting caught in machinery, struck by moving vehicles or components, or suffering from slips, trips, and falls. The presence of sharp tools, welding operations, and high-temperature processes also adds to the physical hazard profile.

Various Hazards: Chemical Hazards, Ergonomic Hazards, Biological Hazards, Noise and Vibration Hazards, Fire and Explosion Hazards, Electrical Hazards and Environmental Hazards.

A Network Structure of Risk

Following the identification and categorization of important risks, a network structure on Cement project is constructed by five experts to create mutual influence between risk factors based on risk assessment. There is an outer dependency between different groups and inner dependency within each group of risk and risk assessment criteria in this structure. Indirect dominance comparison of factors in set Bi is carried out according to their influence on Cij by considering factor set Bi (i = 1, 2, . . ., 6) as primary standard and factors set Cj (j = 1, 2, . . ., 8) as a secondary standard, that is, to construct judgment matrix. The ANP network process of the risk factors is shown in Figure.

	B1	B2	B3	B4	B5	B6
B1	1	3	5	6	5	2
B2	1/3	1	3	5	4	1/2
B3	1/5	1/3	1	3	2	1/3
B4	1/6	1/5	1/3	1	3	1/3
B5	1/5	1/4	1/2	1/3	1	1/4
B6	1/2	2	3	3	4	1
CR= 0.0660						

Table 4 Pairwise Comparison Matrix between Groups of Risks

	C61	C62	C64	C65
C61	1	2	4	3
C62	1/2	1	2	3
C64	1/4	1/2	1	2
C65	1/3	1/3	1/2	1
CR= 0.0363				

Table 5 Pairwise Comparison Matrix of Inadequate Design Quality

Cluster node	B1: Political risk					
B1: Political risk		C11	C12	C13	C14	C15
	C11	0.170	0.170	0.170	0.170	0.170
	C12	0.072	0.072	0.072	0.072	0.072
	C13	0.106	0.106	0.106	0.106	0.106
	C14	0.163	0.163	0.163	0.163	0.163
	C15	0.050	0.050	0.050	0.050	0.050

Table 6 Limit Matrix of Political Risks

DISCUSSION AND RESULTS

The final ranking of each risk factor using ANP weights are presented in Table. The assessment of risk factors shows that Political sanction (C11) is the most important risk factor of0.1701. Among the other risk factors, Change in law (C13) and Delay in design (C61) are the most important factorof 0.1067 and 0.0994 respectively. On the other hand, Harsh environmental conditions (C44), Building materials production ability (C53) and Disorderly vicious competition (C54) are the least important with score of 0.00009 and 0.0003 respectively. The final evaluation result of group of risks is shown in Table. Political risks group and Design risks group are the most important risk group than the other risks in EPC refinery projects in Iran. We used pairwise comparisons for assessing risks with respect to criteria and sub-criteria so as to increase the accuracy of risks assessment.

Risk factors	Weight of risk factors	Risk factors	Weight of risk factors
C11	0.1701	C36	0.0017
C12	0.0725	C37	0.0014
C13	0.1067	C38	0.0009
C14	0.1630	C41	0.0281
C15	0.0507	C42	0.0013
C21	0.049	C43	0.0007
C22	0.0267	C44	0.00009
C23	0.0133	C51	0.0201
C24	0.0081	C52	0.0007
C25	0.0074	C53	0.0003
C26	0.0351	C54	0.0003
C27	0.0060	C61	0.0994
C31	0.0405	C62	0.0506
C32	0.0033	C63	0.0090
C33	0.0026	C64	0.0095
C34	0.0055	C65	0.0113

Table 7 Weight of Each Risk Factor & Group

Risk assessment findings can be applied in the risk response step. Risk sources and affected work elements were defined in this step. After that a list of the candidate was determined to enable risk reduction actions followed by estimation of their associated costs and expected effects such as time, cost and quality. This information can be utilized to select appropriate actions

CONCLUSIONS

In order to prevent potential accidents, improve safety and production in Automotive industrial sector, systematic management of safety is essential in these processes. It seems that the implementation of a documentation system(Risk assessment and safety measures) for recording equipment deficiencies and events can be basic information needed to assess the subsequent safety ideally. In addition, performing preventive maintenance can reduce the possibility of the equipment defects and their consequences. Our results showed that compared with other methods of risk assessment, FMEA can identify more risks and an important point is that choosing an appropriate method plays a crucial role in identifying more risks. Analytic Network Process (ANP) Methodology is used to mitigation of risk. For this purpose, health and safety policy should be adapted with other policies of the company. Additionally, risk management policy of company should be developed, and risk assessment should be performed regularly and efficiently

REFERENCES

[1] William G. Duff - "Health Hazards in the Textile Industry" Volume 9 | Issue 1 | June, 2023
[2] Dharamvir Mangal - "Risk Assessment of Occupational Health Hazards in Textile Industry" – Volume 22 | Issue 4 | Sep, 2023
[3] K. P. Kalra - "Safety Measures and Hazards Identification in Textile Manufacturing Units" – Volume 10 | Issue 3 | May 2022
[4] M. J. Khan - "Occupational Hazards and Safety Measures in Textile Factories" – Volume 44 | Issue 7| Dec 2022
[5] Pradip Kumar Ray - "A Review of Health and Safety Issues in the Textile Industry" – Volume 8| Issue 5| Nov 2022
[6] A.K. Bhowmick - "Textile Industry Hazards and Worker Safety: A Comprehensive Review" – Volume 12| Issue 4| Dec 2022