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FACTORS INFLUENCING THE POTENTIAL MACHINE SAFETY IN MITIGATING THE ACCIDENTS / RISKS IN INDUSTRIES

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ABSTRACT

Background: The study was conducted in an automotive spare part manufacturing industry located in South India. The various machinery safety factors were identified and studied in selected work stations. **Aim:** It is to identify the critical machine safety factors and to analyze the primary data on the Factors Influencing accidents and risks in the manufacturing Industry. **Materials and Methods:** Systematic random sampling method was adopted to collect 142 samples using a developed questionnaire. Twenty Five variables influencing Machinery Safety were identified in the questionnaire, validated and the response of the various categories of employees was measured by applying Likert type five-point scale. **Statistical Analysis:** The data was analyzed by the IBM-SPSS version-20 and the Mini-Tab Version-16. Descriptive Statistics, Factor Analysis using Principal Component Analysis with Varimax Rotation and Pearson's correlation tests were performed. **Results:** The factor analysis revealed that seven factors are the predominant factors that influence machinery safety components in an industry. The result of correlation analysis also confirms the positive correlation among the above seven factors and it is found to be at 5% level of significance. **Conclusions and Implications:** This study has demonstrated that the machinery safety components were varying based on the type of operations, machinery conditions etc. It is concluded that there is a significant level of association and hence the management in manufacturing industries has to consider these factors and focus more on Occupational Health, Safety & Environment policies and practices suitably to create conducive safe & productive work environment.

1.0: Introduction

The use of complex machines, processes and systems is increasing in all sectors, but there is also some evidence that the pace of change is slowing. The drive for automation and computerization stems principally from increasing labour costs and from higher quality requirements and standardization. This development should be seen positively so long as it results in better products and does not affect workers' health. Production technology, particularly manufacturing machines in the manufacturing industry, is especially affected by increasing complexity and increasing use of complex machines, processes or systems. An increase in operators' mental workload and consequently in the risk of errors, means that Human-Machine Interface (HMI) is of particular relevance to high-risk industries. Mechanization and increasing intricacy mean that control room operators have to handle intricate data and alarm and to take safety-critical decision under the pressure of unforeseen and speedily changing hazardous situations.

In general, technical installations are becoming more complex in industrial processes ranging automobilerelated industries to biotechnology. Increased complexity can be found in, for example, cranes, elevators and other transport systems, self-steering transportations, vehicle with extensive driving aids, such as adaptive cruise control and autonomous braking and parking. Operational or system safety, or reliability engineering, considers how accident can result from the interface of dissimilar parts of a system with each other and with their surroundings. Rather than looking at job-related accidents, it is concerned primarily with the avoidance of major accidents that can affect large numbers of people, both employees and public. The element played by human operators in systems – especially those associated to major hazards, such as chemical plants, nuclear amenities, airliners, etc. – is affected to a great degree by the Machinery safety components.

Technological advancement over the last 50 years means that manufacture processes are using machinery which is ever more powerful in terms of speed, quality, and flexibility (Becker, 2006). This extension is evident in almost all sectors, but especially so in manufacturing, air industry, construction (e.g. in-cab devices), production sector and healthcare sector (e.g. computer-aided surgery), (EU-OSHA, 2005).

The high proportion of employees working with machines or computers means that proper design of the machinery safety components is essential. Poor design of machinery safety components can give rise to occupational diseases, such as stress or musculoskeletal disorders, as well as to occupational accidents. The probable cost to a company due to reduced output, smashed reputation, or users' discontent is clear.

2.0: Objectives

The following are the objectives of this study:

1. To identify and study the machinery safety components in the manufacturing industry.
2. To analyze the primary data on the predominant factors influencing machinery safety among varying machines in the manufacturing industry.

3.0: Review of Literature

According to NIOSH, machine-related injuries were the second leading cause of occupational fatalities in the United States between 1980 and 1995 and between 1992 and 2001, an average of 148 mortal and 318,488 non-fatal occupational caught-in-running-machinery-accidents occurred per year.

In 2000 in Austria, 8% of all occupational accidents occurred at equipment, of which 76% were endorsed to human error (68% errors in use of the machine and 8% removal of protective devices), 17% to machine shortage, 5% to malfunction of a machine component, and 2% to modifications carried out on the machine. The exclusion or tampering with shielding devices is often linked to maintenance, cleaning, repairing, and programming.

Similarly, Backström and Harms-Ringdahl (1984) found that 55% of machine-related accidents resulted from operational failure, whereas 20% were caused by technical failure and 12% by technical as well as operational failure. Further studies, in contrast, feature higher proportions of accidents to technological failures (Backström and Döös (1997) estimate that 84% are due to machine malfunction and in a former study (Döös and Backström, 1994), the same authors found that 86% of accidents with mechanized equipment are due to technical causes).

An investigation of safety inspectors and workers in the industrial sector by the German statutory accident insurance (HVBG, 2006) showed that tampering with safety devices is a noteworthy problem (37% of cases) and this is supported by study showing that safety barriers are now and then removed to make possible the work process (Mattila, Tallberg, Vannas and Kivistö-Rahnasto, 1995). Such safety devices encompass part of the human-machine interface, which if not well designed, may be perceived by operators as an impediment. Other factors such high production targets or pressure to increase output can contribute to this perception.

Other causes of accidents connected to human-machine interface include inadequate operation and maintenance instructions; design that do not let the operator see the hazard zone (Backström & Harms-Ringdahl, 1984; Mattilaet al., 1995); and open access to hazardous areas of the work station (Mattila et al., 1995). Unforeseen movements of machines (Backström & Döös, 1997; Backström & Harms-Ringdahl, 1984; Mattila et al., 1995) or not stopping an out of order machine system also present accident risks (Backström & Harms-Ringdahl, 1984). Moreover, inadequate workplace design such as an unsafe machine which does not stop when removing safety barriers, an emergency stop which cannot be reached by the worker (Mattila et al., 1995) or perplexing control status indicators leading to an unintended contact with a switch (Backström & Harms-Ringdahl, 1984) can be hazardous for workers. Ever since some operators are simply not aware or do not know anything about the functioning of the system they work with (Backström & Harms-Ringdahl, 1984), it is vital that the operative is able to evaluate the information and to monitor the work process (Mattila & Kiviniitty, 1993).

According to Park (1997), there are three main types of causes of human error:

- Complexity of task (tasks differ with regard to their demand on mental resources),
- Situations (some are more likely to lead to errors). The following characteristics increase the probability of human errors: Inadequate workplace design, Inadequate design of work equipment and its HMI, Poor environmental effects, inadequate learning and working aids and inadequate safety instructions.
- Preconditions with regard to human capacities.

The possibility of human error is affected by individual uniqueness such as age, sex, intellect, insightful abilities, physical state, patience, experience, knowledge, motivation, emotion, stress and other social factors (Park, 1997). The combination of stress and inexperience can lead to an exponential raise in human errors (Miller & Swain, 1986). These factors are also named “Performance Shaping Factors”, as they robustly influence human information processing (Bubb, 1994). Exterior Performance Shaping Factors (age, sex) can be well-known from internal Performance Shaping Factors (motivation, patience).

4.0: Materials and Methods

A questionnaire is developed in line with previous research studies. Twenty five components (variables) influencing machinery safety were identified, validated and then measured by applying Likert type scale. The respondents are required to give their responses on a five-point scales ranging from strongly agree to strongly disagree. The Primary data were collected from 142 respondents of varying categories such as contract workmen, trainee/Apprentice, operator, supervisor and manager using random sampling method. The data were carefully analysed using IBM SPSS Version-20 and Mini-Tab Version-16 to extract the potential machinery safety factors using factor analysis, group them and then compute the significant levels of correlation.

5.0: Results and Discussions

The results identified and extracted the seven predominant potential machinery safety components in the manufacturing industry. And also, it shows that the significant relationship among the machinery safety components. It has been found that there is a high significance among the extracted and identified seven machinery safety components. Table-1 shows the descriptive statistics among the twenty five variables listed as the components influencing the potential machine safety.

Table 1 Components influencing Potential Machine Safety – Descriptive Statistics

S. No.	Variables	N	M	SD	Skewness		Percentiles		
					Statistic	Std. Error	(Q1) 25	(Q2) 50	(Q3) 75
1	Do you find any risks of falling of persons, falling or flying objects?	142	3.380	1.189	-0.262	0.203	2	3	4
2	Do you find any risks related to slipping, tripping, falling, falling objects?	142	3.711	0.942	-0.681	0.203	3	4	4
3	Do you find any risks of gas poisoning, lack of oxygen, drowning, suffocation?	142	4.021	0.971	-0.986	0.203	4	4	5
4	Do you have the risks of entanglement, cuts, injuries, crushing?	142	3.514	1.171	-0.531	0.203	3	4	4
5	Do you find the workers are not trained to review the maintenance information ensuring the machine to use?	142	3.500	1.070	-0.546	0.203	3	4	4
6	Do you find the maintenance log is not present at the machine? If it is present, not updated?	142	3.549	1.015	-0.363	0.203	3	4	4
7	Do you find the maintenance workers are not trained in safe procedures (e.g. disconnecting the m/c from power sources)?	142	3.923	1.018	-0.702	0.203	3	4	5
8	Do you find operating manuals are not present and not in the languages understood by the workers?	142	3.965	0.971	-0.873	0.203	4	4	5
9	Do you find the workers present are not trained in the emergency response that might arise?	142	3.620	1.230	-0.512	0.203	3	4	5
10	Do you find the workers present are not trained in proper machinery operation, safety features?	142	3.739	1.043	-0.676	0.203	3	4	5
11	Do you find the operating procedures; drawings for the machine are not available and not up to date?	142	3.880	1.014	-0.709	0.203	3	4	5
12	Do you find the workers dress is not safe or suitable to operate the machinery (no jewelry, no loose clothing, hair tied)?	142	3.556	1.101	-0.500	0.203	3	4	4
13	Do you find the right PPEs are not provided and not maintained properly?	142	3.979	0.964	-0.922	0.203	3	4	5
14	Do you find the workers are not properly trained in the use of PPE?	142	3.444	1.206	-0.395	0.203	3	4	4
15	Do you find the conditions of operating switches, access to main switch box are not in place?	142	3.535	1.096	-0.304	0.203	3	4	4
16	Do you find the power supply not provided with suitable fuses, MCB, RCD and protection?	142	3.669	0.943	-0.628	0.203	3	4	4
17	Do you find any electrical connections such as earthing, electrical wire routing are not ok?	142	3.514	1.189	-0.393	0.203	3	4	5
18	Do you find the floor wet, slippery and not safer for worker motion?	142	3.606	1.167	-0.517	0.203	3	4	5
19	Do you find any oil, grease leak or coolant splash in and around the machine?	142	3.380	1.213	-0.284	0.203	3	3	4
20	Do you find the environmental conditions are not conductive to safe working (noise, vibration, heat, lighting, radiation etc)?	142	3.655	1.079	-0.580	0.203	3	4	4

S. No.	Variables	N	M	SD	Skewness		Percentiles		
					Statistic	Std. Error	(Q1) 25	(Q2) 50	(Q3) 75
21	Do you find the ergonomic features, loading, unloading system, hand tools are not comfortable?	142	3.627	1.001	-0.700	0.203	3	4	4
22	Do you find the safety guards, emergency stops are not installed at the point of operation?	142	3.613	1.202	-0.655	0.203	3	4	5
23	Do you find the limit switches, interlocks, clamps, photo cell guard are not installed and not in working condition?	142	4.028	0.945	-0.773	0.203	3	4	5
24	Do you find any loose air hoses, sharp protruding objects in and around the machine?	142	3.493	1.159	-0.495	0.203	3	4	4
25	Do you find the working platform is uncomfortable and inconvenient to work?	142	3.669	1.128	-0.670	0.203	3	4	5

Table 1 show that the mean value of the components ranges from **3.380** to **4.028** and it is a good measure of central value since the Std. Deviation (SD) is very low. Percentiles of Q1 range from 2 to 4, Q2 (median) range from 3 to 4 and Q3 range from 4 to 5 respectively. The Potential Machine Safety component's distribution is more on the positive skewness (which is between -1 and greater than 1, the distribution is highly skewed.).

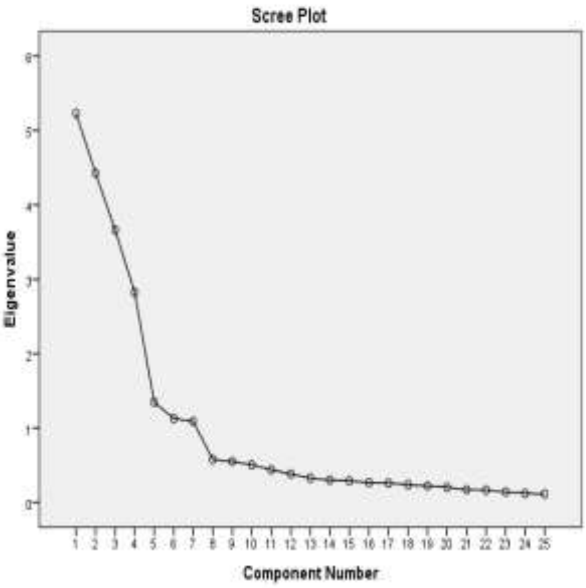
Table 2 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.793
Bartlett's Test of Sphericity	Approx. Chi-Square	2392.088
	df	300
	Sig.	0.000

Communalities

Variables	Initial	Extraction
Do you find any risks of falling of persons, falling or flying objects?	1.000	0.758
Do you find any risks related to slipping, tripping, falling, falling objects?	1.000	0.829
Do you find any risks of gas poisoning, lack of oxygen, drowning, suffocation?	1.000	0.736
Do you have the risks of entanglement, cuts, injuries, crushing?	1.000	0.748
Do you find the workers are not trained to review the maintenance information ensuring the machine to use?	1.000	0.759
Do you find the maintenance log is not present at the machine? If it is present, not updated?	1.000	0.820
Do you find the maintenance workers are not trained in safe procedures (e.g. disconnecting the m/c from power sources)?	1.000	0.752
Do you find operating manuals are not present and not in the languages understood by the workers?	1.000	0.784
Do you find the workers present are not trained in the emergency response that might arise?	1.000	0.785
Do you find the workers present are not trained in proper machinery operation, safety features?	1.000	0.790
Do you find the operating procedures; drawings for the machine are not available and not up to date?	1.000	0.765
Do you find the workers dress is not safe or suitable to operate the machinery (no jewelry, no loose clothing, hair tied)?	1.000	0.754
Do you find the right PPEs are not provided and not maintained properly?	1.000	0.831
Do you find the workers are not properly trained in the use of PPE?	1.000	0.783
Do you find the conditions of operating switches, access to main switch box are not in place?	1.000	0.701
Do you find the power supply not provided with suitable fuses, MCB, RCD and protection?	1.000	0.835

Do you find any electrical connections such as earthing, electrical wire routing are not ok?	1.000	0.784
Do you find the floor wet, slippery and not safer for worker motion?	1.000	0.809
Do you find any oil, grease leak or coolant splash in and around the machine?	1.000	0.787
Do you find the environmental conditions are not conductive to safe working (noise, vibration, heat, lighting, radiation etc)?	1.000	0.809
Do you find the ergonomic features, loading, unloading system, hand tools are not comfortable?	1.000	0.783
Do you find the safety guards, emergency stops are not installed at the point of operation?	1.000	0.842
Do you find the limit switches, interlocks, clamps, photo cell guard are not installed and not in working condition?	1.000	0.838
Do you find any loose air hoses, sharp protruding objects in and around the machine?	1.000	0.800
Do you find the working platform is uncomfortable and inconvenient to work?	1.000	0.834
Extraction Method: Principal Component Analysis.		



Predominant factors that constitute Potential Machine Safety have been examined by applying factor analysis. Factor analysis by principal component method reduces the variables into predominant factors of Potential Machine Safety with regard to machines in industries. The application of factor analysis on 25 variables of Potential Machine Safety and the results are given in subsequent tables. Initially the test of validity of data for factor analysis was studied with Keiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of Sphericity. Table 2 shows that KMO and Bartlett's Test had been administered in order to determine sampling adequacy. It indicates that the data set were adequate to perform factor analysis. The KMO test and Bartlett's Test of Sphericity found that all extraction values have as per the expected values and all items can be used for further analysis. The item scales have been subjected to factor analysis using principal component method with Varimax rotation. SPSS statistical package has been used for this purpose.

Table 3 Total Variance Explained

Component	Initial Eigen values			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.232	20.927	20.927	3.312	13.250	13.250
2	4.426	17.705	38.632	3.209	12.834	26.084
3	3.662	14.649	53.280	3.173	12.691	38.775
4	2.825	11.302	64.582	3.163	12.653	51.429
5	1.349	5.395	69.977	2.319	9.277	60.706
6	1.130	4.520	74.497	2.290	9.162	69.867

7	1.090	4.358	78.855	2.247	8.988	78.855
8	0.578	2.312	81.167			
9	0.551	2.205	83.372			
10	0.507	2.027	85.398			
11	0.440	1.760	87.158			
12	0.383	1.531	88.689			
13	0.328	1.313	90.002			
14	0.300	1.202	91.204			
15	0.290	1.159	92.363			
16	0.267	1.070	93.433			
17	0.261	1.043	94.475			
18	0.238	0.953	95.428			
19	0.222	0.888	96.316			
20	0.204	0.818	97.134			
21	0.172	0.688	97.822			
22	0.166	0.666	98.487			
23	0.142	0.566	99.054			
24	0.123	0.492	99.546			
25	0.114	0.454	100.000			
Extraction Method: Principal Component Analysis.						

It is observed from Table 3 that total variance of the observed variables is explained by each principal components. The first principal component explains the largest part of the total variance, it accounts for 13.250 percent of the total variance, second component explains 12.834 percent of the total variance, third component explains 12.691 percent of the total variance, fourth component explains 12.653 percent of the total variance, fifth component explains 9.277 percent of the total variance, sixth component explains 9.162 percent of the total variance and finally seventh component explains 8.988 percent of the total variance. A component displaying an Eigen value greater than 1.000 accounts for a greater amount of variance. Therefore only those components, which have Eigen value greater than 1.000, are considered as principal components. The principal components explain 78.855 percent of the total variance, and the remaining components explain 21.145 percent of the total variance.

Table 4 Rotated Component Matrix [a]

Variables (code)	Component						
	Mechanical Hazards	**Environmental Concerns**	**Training & Procedures**	**Accidents & Risks**	**Electrical Hazards**	**PPE**	**Maintenance & Repairs**
B1.22	0.902						
B2.23	0.901						
B3.24	0.886						
B5.25	0.886						
D3.20		0.877					
D1.18		0.863					
D4.21		0.850					

D2.19		0.830					
G310			0.866				
G2.9			0.849				
G4.11			0.833				
G1.8			0.822				
H2.2				0.882			
H1.1				0.835			
H3.3				0.821			
H4.4				0.797			
C2.16					0.838		
C3.17					0.835		
C1.15					0.787		
E2.13						0.851	
E3.14						0.813	
E1.12						0.784	
F1.6							0.856
F2.5							0.833
F3.7							0.776

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

In Table-4, the rotated component matrix explains rescaled factor loading correlation to estimate which variables load on all factor. The commonly used procedure of Varimax orthogonal rotation for factors whose Eigen values were greater than 1 was employed in the analysis. The rotation was converged in 7 iterations. In Table 4 the rotated components show rescaled factor loadings. The rescaled factor loadings display "Mechanical Hazards", as first factor (with factor loadings 0.902, 0.901, 0.886, 0.886,), "Environmental Concerns" as second factor (with factor loadings 0.877, 0.863, 0.850, 0.830), "Training & Procedures" as third factor (with factor loadings 0.866, 0.849, 0.833, 0.822), "Accidents & Risks" as fourth factor (with factor loadings 0.882, 0.835, 0.821, 0.797), "Electrical Hazards" as fifth factor (with factor loadings 0.838, 0.835, 0.787), "PPE" as sixth factor (with factor loadings 0.851, 0.813, 0.784), and "Maintenance & Repairs" as seventh factor (with factor loadings 0.856, 0.833, 0.776).

The factor analysis resulted in seven important Potential Machine Safety components from the respondents and the Principal Component Factors were considered based on the list of variables and its characteristics and the respective loadings of the variable. The Eigen value and the percent of variance explained by factors are presented in Table 5.

Table 5 Factors Constituting Potential Machine Safety

Sl. No.	Predominant Factors	Number of variables	Eigen value	Percent of variation explained	Cumulative percent of valuation
1	Mechanical hazards	4	5.232	20.927	20.927
2	Environmental Concerns	4	4.426	17.705	38.632
3	Training & Procedures	4	3.662	14.649	53.280
4	Accidents & Risks	4	2.825	11.302	64.582
5	Electrical Hazards	3	1.349	5.395	69.977
6	Personal Protective Equipment	3	1.130	4.520	74.497
7	Maintenance & Repairs	3	1.090	4.358	78.855

It is clear from Table 5 that seven dominant Potential Machine Safety factors out of twenty five Machine Safety components, accounted for 78.855 percent of total variance. "Mechanical Hazards" is the dominant factor that influences the Potential Machine Safety since its Eigen value and percent of variation explained are 5.232 and 20.927 respectively. "Environmental Concerns" is the next significant factor with Eigen value of 4.426 and percent of variation explained is 17.705. "Training & Procedures" is the third important factor with Eigen value of 3.662 and percent of variation explained is 14.649. "Accidents & Risks" is the fourth important factor with Eigen value of 2.825 and percent of variation explained is 11.302. "Electrical Hazards" is the fifth important factor with Eigen value of 1.349 and percent of variation explained is 5.395. "Personal Protective Equipment" is the sixth important factor with Eigen value of 1.130 and percent of variation explained is 4.520, and finally, followed by "Maintenance & Repairs" in terms of their Eigen value of 1.090 percent of variation explained with value of 4.358 respectively.

It is concluded by the above studies that "Mechanical Hazards (MH)", "Environmental Concerns (EC)", "Training & Procedures (TP)", "Accidents & Risks (AR)", "Electrical Hazards (EH)", "Personal Protective Equipment (PPE)" and "Maintenance & Repairs (MR)" are the predominant factors of Potential Machine Safety.

Table 6 Correlation among Predominant Factors of Potential Machine Safety

Correlations								
Factors		MH	EC	TP	AR	EH	PPE	MR
MH	Pearson Correlation	1.000	-0.104	-0.171*	-0.134	-0.044	-0.160	-0.156
	Sig. (2-tailed)		0.217	0.042	0.113	0.600	0.056	0.064
	N	142	142	142	142	142	142	142
EC	Pearson Correlation	-0.104	1.000	-0.016	0.107	-0.050	0.152	0.507**
	Sig. (2-tailed)	0.217	-	0.854	0.205	0.552	0.071	0.000
	N	142	142	142	142	142	142	142
TP	Pearson Correlation	-0.171*	-0.016	1.000	0.034	0.571**	0.036	0.051
	Sig. (2-tailed)	0.042	0.854	-	0.689	0.000	0.670	0.546
	N	142	142	142	142	142	142	142

AR	Pearson Correlation	-0.134	0.107	0.034	1.000	0.002	0.595**	0.052
	Sig. (2-tailed)	0.113	0.205	0.689	-	0.978	0.000	0.537
	N	142	142	142	142	142	142	142
EH	Pearson Correlation	-0.044	-0.050	0.571**	0.002	1.000	-0.041	-0.052
	Sig. (2-tailed)	0.600	0.552	0.000	0.978	-	0.630	0.538
	N	142	142	142	142	142	142	142
PPE	Pearson Correlation	-0.160	0.152	0.036	0.595**	-0.041	1.000	0.101
	Sig. (2-tailed)	0.056	0.071	0.670	0.000	0.630	-	0.232
	N	142	142	142	142	142	142	142
MR	Pearson Correlation	-0.156	0.507**	0.051	0.052	-0.052	0.101	1.000
	Sig. (2-tailed)	0.064	0.000	0.546	0.537	0.538	0.232	
	N	142	142	142	142	142	142	142
*. Correlation is significant at the 0.05 level (2-tailed).								
**. Correlation is significant at the 0.01 level (2-tailed).								

In order to find out whether there is an association among the predominant factors, Pearson's Correlation analysis was done. The following null hypothesis has been framed.

H_0: There is no correlation among factors of Potential Machine Safety.

The Pearson's correlation test has been applied to find out the existence of association and the degree of association among the predominant factors. Table 6 shows the correlation among the predominant factors such as "Mechanical Hazards (MH)", "Electrical Hazards (EH)", "Environmental Conditions (EC)", "PPE", "Training & Procedures (TP)", "Maintenance & Repairs (MR)" and "Accidents & Risks (AR)". It is found that there exists a high positive correlation among Accidents & Risks and PPE, Maintenance & Repairs and Environmental Concerns, Training & Procedures and Electrical Hazards, and a negative correlation exist among Training & Procedures and Mechanical Hazards.

The analysis of correlation among predominant factors of Potential Machine Safety shows that there exists a positive correlation among Accidents & Risks and PPE (0.595) at 0.05% level of significance. In addition, Factors has a positive correlation with Maintenance & Repairs and Environmental Concerns (0.507). Another factor is positively associated with Training & Procedures and Electrical Hazards (0.571) and finally the last factor is negatively correlated with Training & Procedures and Mechanical Hazards (-0.171).

6.0: Conclusions and Recommendations

Machinery Safety Factors are highly essential issue in an industry with best practices of HSE. The study was able to measure the various components of machine safety and established the fact that "Mechanical Hazards", "Environmental Concerns", "Training & Procedures", "Accidents & Risks", "Electrical Hazards", "Personal Protective Equipment" and "Maintenance & Repairs" are the critical and predominant determinants which influenced the potential machine safety in an industry. The analysis also reveals that the above seven predominant factors constitute the machine safety in an industry. The result of correlation analysis also confirms the positive correlation among the predominant factors. In a manufacturing industry, the operation management has to consider the above seven factors and focus more on Occupational Health, Safety & Environment policies and practices suitably and create a conducive, safe work environment to the working population to improve their performance.

Further studies may focus on larger samples of machines and industrial segments to get a better picture for taking policy and procedural compliances to HSE concerns and decisions at the national level. It is also recommended further to focus on operation and machine wise studies to understand various factors influencing the machinery safety in various sectors.

Conflicts of Interest

Author does not have any conflicts of interest to declare.

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