EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 3
Issue: 12
623-628
Year: 2016

EVALUATING THE RISKS OF CEMENT OPEN MINING ACTIVITIES AND ITS HEALTH HAZARDS BY FMEA METHOD IN ZABOL'S CEMENT MINES BEFORE AND AFTER TRAINING INTERVENTIONS 2015

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Article Received on 10/11/2016 **Article Revised on 30/11/2016** **Article Accepted on 20/12/2016**

ABSTRACT

Introduction: Accidents are close to human beings from the first day they invented the first machines until today. They have complicated reasons to happen. Some common reasons are defect in workers, equipment, sources and environment. This study aimed to investigate the risks of cement open mining activities and its health hazards by FMEA method in Zabol's cement mines before and after training interventions. **Material and Methods:** This was cross sectional study conducted in Zabol Cement Company in 2015. Possible risks and hazards were assessed precisely by FMEA method in every level of the job and before and after the training intervention. The statistical work and analysis was done by SPSS v20. Descriptive tests, frequency, and frequency percentage were used for qualitative variables and mean and standard deviation were used for quantitative variables to report. **Results:** Due to assessment of risks in 7 jobs 34 potential risks were found for open wagon drill operator, cabin wagon drill operator, wagon drill operator assistant, explosion man, bulldozer driver, backhoe driver, and the repairman. According to the results the highest risk was for the shakes which bulldozer and backhoe drivers had experienced during the work (80%) and after that it was the risk of objects falling on the repair team (50%). These potential risk had the priority before doing the corrective actions. **Conclusion:** According to the results of this study the RPN number was high in some activities.

KEYWORDS: FMEA, cement mines, risk evaluation.

INTRODUCTION

Accidents are close to human beings from the first day they invented the first machines until today. They have complicated reasons to happen. Some common reasons are defect in workers, equipment, sources and environment.[1] Safety researchers had shown that unsafe personal behaviors are one of the most common reasons of accidents.[2] Accidents can cause injuries and pain in human resources, wasting the investments, making social and economic costs, destroying the environment and absence from work.[3] Accidents during the work are the 3rd reason of death in the world and the 2nd in Iran after car accidents.[4] Workers are exposed to so many risk which can destroy their lives. These risks can be chemical, physical or mechanical.[5] Industrial activities bring so many pollutions to the environment as dust, smoke, ash and other industrial wastes which can be harmful for human races. Drilling, blasting, cutting and crushing stones bring so many pollution to the work place where the workers are working.[6] Portland cement is the main process in producing cement. This cement is made by crushing the calcareous materials, calcareous stones, gypsum, clay and other additional materials. Working in cement industry expose workers to dust, particulate and gaseous pollutants, polycyclic aromatic compounds, silicate, aluminate, chromium VI and other metals such as nickel and cobalt. Also asbestos is produced due to process which need high temperature.[7] Workers safety and health acts including necessity of evaluating and managing the risk in wok are being extended all around the world. Despite this that the benefits of risk evaluation are not seen and evaluated yet but it is predictable that these evaluations are positive and helpful for planning and managing the process. It can help equipment designers to make much more safe equipment and machines. May be in future it could lead to more safety and outcomes in hole the industries and mines. There are many different methods of risk assessments which everyone has a particular aim.[8] Assessing the risk and hazards is a necessity in safety

management.[9] There so many reasons for work accidents but most of researchers believe that there are three common reasons: unsafe behaviors, unsafe conditions and unpredictable reasons. Risk assessments are usually categorized into three categories including: qualitative, semi quantitative and quantitative analysis.[10] Work accidents effect on workers safety, health and economic situation. Because the work accidents cost too much for the worker.[11] Risk management is a scientific management method for measuring and analyzing the risks in the work to use them for reducing the risks and improve the safety with the least costs.[12] Risk management is a central and strategic part of every organization and it's the most important part of every program for health and safety. Actually the risk management unit is the engine of the system which aims to be sure of the sustainable profits in all the system.[13] FMEA (failure mode and effect analysis) is a risk evaluation method. This tool is really powerful and effective for assessing the defects and eliminating them in designing a system.[14] FMEA seeks to find out and prioritize the failure potentials. So then the mangers and engineers can design a system which they know the potentials of failure in it.

Injuries occur every day in the work place. Most of them are cause of lack of training programs for workers.[15] Training aims to teach the workers how to do a job in an appropriate way. Trainings must be coordinated with the responsibility and the job which the worker have. Do not expect a worker to do a job safe when he doesn't know even how to that. This shows the importance of training.[4]

Due to these reasons this study aimed to to investigate the risks of cement open mining activities and its health hazards by FMEA method in Zabol's cement mines before and after training interventions.

MATERIAL AND METHODS

This was a cross sectional study. All the workers working in the occupational processes in Zabol cement mines were participants of this study. This study was done in two phases. A committee was held including an occupational health engineer and the site manager to have an overall visit of different jobs in the mine as fire department, mechanical and welding units and bulldozers and trucks drivers. After collecting the basic data by interviewing workers and unit managers the above mentioned jobs were chosen. Then the researcher tried to evaluate and analyze all the risks that may occur during the work in each level of it by FMEA method before and after training intervention and tried to find the best ways of reducing the hazards and eliminate them. FMEA was suggested by NASA in 1963 for first time. Since then FMEA was used as a strong method of safety system assessment and was used in so many fields such as aerospace, nuclear, cars and medicine.

FMEA has following steps:

1. Describing the process or products
2. Describing the performance
3. Recognizing the failure potential
4. Describing the results of failure
5. Finding the reasons
6. Giving direction to current methods and controls
7. Measuring the risks
8. Corrective actions
9. Evaluating the results

FAEA must be updated after a change in process or design. FAEA has certain advantages for financial assistance toward the project's management. Actually its main emphasis is on preventing the problems.[13] The first step in FMEA is to recognize the possible potentials of failure. For this work mind storm method is used. After this analyzing the necessary factors would be done by considering factors such as occurrence factors (O: Occurrence), possibility of detection (D: Detection), Severity (S: Severity. The FMEA's main aim is to prioritize the failure possibilities to prevent wasting the investments. Prioritizing the failure possibilities for doing corrective actions is usually measured by RPN number. The formula of RPN is:

$RPN = O \times D \times S$.

As the RPN number is high for a problem it means that the system is much more in danger. According to RPN number failure possibilities can be prioritized then appropriate actions can be done for failure situations with high rate of risks. After corrective actions the RPN number must be calculated again to know whether the risk is reduced or not.[16] After evaluating each of the risk with above mentioned method, safety and ergonomic trainings were given to workers coordinated with their jobs. These trainings included safety in: Welding, blasting operations, the correct method of Manual Material Handling and other jobs safety. After 6 all of the risks were evaluated by FMEA method and were analyzed. The statistical work and analysis was done by SPSS v20. Descriptive tests, frequency and frequency percentage were used for qualitative variables and mean and standard deviation were used for quantitative variables to report.

RESULTS

Due to assessment of risks in 7 jobs 34 potential risks were found for open wagon drill operator, cabin wagon drill operator, wagon drill operator assistant, explosion man, bulldozer driver, backhoe driver and the repairman. According to the results the highest risk was for the shakes which bulldozer and backhoe drivers had experienced during the work (80%) due to bad seats in the car and bad body shape. After doing corrective actions the risk was reduced but yet there were hazards and more controlling should be conducted. After that it was the risk of objects falling on the repair team (50%). These potential risk had the priority before doing the corrective actions.

More details about using these methods and additional results are given in the tables below.

Table 1. Evaluating the potential risks of cabin wagon drill operator and its RPN number before and after corrective actions

Case	Potential hazard	Potential effects	Potential causes	O	D	S	Suggested acts	primary RPN	The result of measures			
									Secondary RPN	O	D	S
Wagon drills Operator with cabin	Fall device	injury	distractibility Operator	3	6	9	Education and Inspections	162	90	2	5	9
Wagon drills Operator with cabin	sound more than	Hearing loss	Do not use the protective device	10	2	8	Use PPE and isolation room operator	160	144	9	2	8
Wagon drills Operator with cabin	dust	Respiratory system damage and side effects	Openness in the operator's cabin and gaps in the cabin	6	3	6	Education and Use PPE And isolation room operator	108	90	5	3	6
Wagon drills Operator with cabin	Vibration	Musculoskeletal Disorders	Poor posture while working and chairs inappropriate	6	3	7	Use proper seat	126	105	5	3	7
Wagon drills Operator with cabin	Landslides on the device.	injury	Landslides	4	6	7	Education and Inspections	168	112	4	4	7

Table 2. Evaluating the potential risks of open wagon drill operator and its RPN number before and after corrective actions

Case	Potential hazard	Potential effects	Potential causes	O	D	S	Suggested acts	primary RPN	The result of measures			
									Secondary RPN	O	D	S
distractibility Operator	injury	Fall device	Wagon drills Operator Without cabin	9	6	9	Education and Inspections	162	**90**	2	5	9
Do not use the protective device	Hearing loss	sound more than	Wagon drills Operator Without cabin	8	2	8	Use PPE and isolation room operator	160	**144**	9	2	8
Openness in the operator's cabin and gaps in the cabin	Respiratory system damage and side effects	dust	Wagon drills Operator Without cabin	6	3	6	Education and Use PPE and isolation room operator	108	**90**	5	3	6
Poor posture while working and chairs inappropriate	Musculoskeletal Disorders	Vibration	Wagon drills Operator Without cabin	7	3	7	Use proper seat	126	**105**	5	3	7
Landslides	injury	Landslides on the device.	Wagon drills Operator Without cabin	7	6	7	Education and Inspections	168	**84**	3	4	7

Table 3. Evaluating the potential risks of wagon drill operator assistant and its RPN number before and after corrective actions

Case	Potential hazard	Potential effects	Potential causes	O	D	S	Suggested acts	primary RPN	The result of measures			
									Secondary RPN	O	D	S
Vibration	injury	Landslides	Wagon drill operator assistance	3	3	8	Education and Inspections	72	**144**	3	2	8
Do not use the	Hearing loss	sound	Wagon drill	10	2	8	Use PPE and	160	**80**	10	1	8

protective device		more than	operator assistance				isolation room operator					
The nature of the process and Dust caused by drilling holes	Respiratory system damage and side effects	dust	Wagon drill operator assistance	7	3	8	Education and Use PPE	168	**144**	9	2	8
The nature of the process	injury	Throwing stones	Wagon drill operator assistance	3	3	8	Education and comply with safe distance from the danger zone	72	**48**	3	2	8
Do not use caps	Skin effects	Sun burn	Wagon drill operator assistance	6	3	5	use caps	90	**60**	6	2	5

Table 4. Evaluating the potential risks of explosion man and its RPN number before and after corrective actions

Case	**Potential hazard**	**Potential effects**	**Potential causes**	**O**	**D**	**S**	**Suggested acts**	**primary RPN**	**The result of measures**			
									Secondary RPN	O	D	S
Distractions	injury	Carrying explosive materials	undertaking the explosion	2	2	10	Education and Inspections	40	**40**	2	2	10
Do not use the protective device	Hearing loss	sound more than	undertaking the explosion	5	3	7	Use PPE and Observe the safe distance	105	**70**	5	2	7
Distractions	injury	Fall	undertaking the explosion	2	4	9		72	**54**	2	3	9
Failure to comply with safety tips and a safe distance during operation	injury	Throwing stones	undertaking the explosion	4	3	5	Education and comply with safe distance from the danger zone	60	**60**	4	3	5
Do not use caps	Skin effects	Sun burn	undertaking the explosion	5	6	5	use caps	150	**100**	5	4	5
carelessness	Injury And death	explosion During the put seasoned	undertaking the explosion	3	2	9		54	**27**	1	3	9
Failure to comply with safety tips and a safe distance during operation	injury	Landslides	undertaking the explosion	3	3	8		72	**72**	3	3	8

Table 5. Evaluating the potential risks of bulldozer driver and its RPN number before and after corrective actions

Case	**Potential hazard**	**Potential effects**	**Potential causes**	**O**	**D**	**S**	**Suggested acts**	**primary RPN**	**The result of measures**			
									Secondary RPN	O	D	S
Vibration	injury	Landslides	Bulldozer driver	7	5	6	Education and Inspections	210	**168**	7	4	6
Do not use the protective device	Hearing loss	sound more than	Bulldozer driver	7	3	8	Use PPE and isolation room operator	168	**112**	7	2	8
The nature of the process and Dust caused by drilling holes	Respiratory system damage and side effects	dust	Bulldozer driver	5	6	6	Education and Use PPE	180	**60**	5	2	6

Poor posture while working and chairs inappropriate	Musculoskeletal Disorders	Vibration	Bulldozer driver	7	5	6	Use proper seat	210	**48**	3	2	8
Carelessness and inattention to risks in the workplace	Injury	Fall device	Bulldozer driver	3	2	7	use caps	42	**28**	2	2	7
Failure to comply with safety tips and a safe distance during operation	injury	Landslides	Bulldozer driver	4	1	7	Education	28	**28**	4	1	7

Table 6. Evaluating the potential risks of backhoe driver and its RPN number before and after corrective actions

Case	**Potential hazard**	**Potential effects**	**Potential causes**	**O**	**D**	**S**	**Suggested acts**	**primary RPN**	**The result of measures**			
									Secondary RPN	O	D	S
Do not use the protective device	Hearing loss	sound more than	Excavator driver	7	3	8	Use PPE and isolation room operator	168	**112**	7	2	8
The nature of the process and Do not use the protective device	Respiratory system damage and side effects	dust	Excavator driver	5	6	6	Education and Use PPE	180	**60**	5	2	6
Poor posture while working and chairs inappropriate	Musculoskeletal Disorders	Vibration	Excavator driver	7	5	6	Use proper seat	210	**144**	6	4	6
Carelessness and inattention to risks in the workplace	Injury	Fall device	Excavator driver	3	2	7	use caps	42	**28**	2	2	7
Failure to comply with safety tips and a safe distance during operation	injury	Landslides	Excavator driver	4	1	7	Education	28	**28**	4	1	7

Table 7. Evaluating the potential risks of repair man and its RPN number before and after corrective actions

Case	**Potential hazard**	**Potential effects**	**Potential causes**	**O**	**D**	**S**	**Suggested acts**	**primary RPN**	**The result of measures**			
									Secondary RPN	O	D	S
Lifting heavy things careless	Injury	Falling objects	Repairman	5	5	8	Use PPE And Lifting style	200	**128**	4	4	8
Recklessness by doing and do not use local exhaust ventilation when working with batteries	Injury and death	Fire and explosion	Repairman	5	6	6	Education	180	**60**	5	2	6
Do not use the protective device	Injury	pouring acid on body	Repairman	4	3	8	use the protective device	96	**72**	3	3	8
Carelessness and inattention to risks in the workplace	Injury	Stuck a hand between the work piece	Repairman	6	1	6	use caps	36	**36**	6	1	6

DISCUSSION

According to the results the highest risk was for the shakes which bulldozer and backhoe drivers had experienced during the work (80%) and after that it was the risk of objects falling on the repair team (50%). These potential risk had the priority before doing the corrective actions. In Rezvani and colleagues study 28 jobs were evaluated and 380 hazards were recognized in a milk company. The results of his study had shown that the most danger and hazard was for voice of machines specially tetra Pac and basket washing machine (64%). After that they were inhalation of vapors and acid profits (32%) and burning by acid (32%). Ebrahimzadeh and colleagues study had stated that the most danger

according to FMEA method was for Lifting and carrying activities and scraping the inner surfaces in Shiraz Refinery Company. Controlling actions such as safety classes, internal audit, repairing and keeping fresh the equipment were suggested in this study[17] In Khodarahmi and colleagues study 6 jobs were evaluated and 100 hazards were recognized in a ship and boat repairing company. 10 of these hazards had a high score of RPN. In this range the highest RPN was for reclining posture during the grinding and facing dust and sand and color mist in Sandblast and ernes machines. This study suggested following points:

1. Increasing the number of specialists.
2. Preparation and implementation of comprehensive guidelines for periodic inspection of systems for troubleshooting.
3. Preparation and implementation of comprehensive programs for maintenance.[18]

Corrective actions and suggestions: Above mentioned corrective actions are done to reduce the RPN number. If it is possible to eliminate the hazard it should be done immediately.

Suggestions

1. Mounting first-aid kit boxes in sufficient numbers in different parts of the Repair hall and teaching first aids to someone who is always in that hall.
2. Installing warning and training signs near devices
3. Teaching the workers not to talk to each other while working
4. Cleaning the workplace after every work day
5. Preventing using loose and with sleeve dresses
6. Making the workers to use proper tools instead of hands
7. Turning off the devices while repairing
8. Using brushes instead of hands for cleanings

CONCLUSION

According to the results of this study the RPN number was high in some activities. So it is suggested to reduce this number by using proper controlling actions, communication between managers and workers and considering safety and health roles.

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