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Original

Application of Human Hazop Technique for Identifying Human Error in a Flour Company

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Abstract

Background: It is necessary to identify and determine the probability of human error in order to improve the level of health and safety of employees and reduce accidents. For this reason, this study was conducted to identify human error in the flour production process using the "Hazard and Operability" technique. **Methods:** Data collection was carried out through business case sheets and interviews with workers who have been involved in events as well as affected workers, and through the application of Human Hazop technique. Potential errors of people were predicted, analyzed and the controls were provided. **Results:** Human Hazop work-sheet analysis showed that the total number of human errors detected in the studied job tasks was 144, 75% of which were eliminated. The results of the study on the causes of the error show that the highest cause of the error is fatigue factor with 33.3%. **Conclusion:** With the precise application of the Hazard and Operability Method, possible types of operator errors and their consequences can be identified, and control paths to reduce human error can be provided. It canultimately create a safer environment and reduce the number of accidents.

Keywords: Flour industry; Human error; Human hazop technique

Introduction

Today, many advanced technology-sensitive systems are used in many nuclear, chemical, military, and medical industries. Since these systems are interacting with humans, the potential risks of human error in these processes are high.[1] A human error involves the deviation of the performance of the specified rules and functions, which goes beyond the defined limits of the system and has an adverse effect on the system performance.[2] Some routine errors may have a relatively small impact on people's lives, while under working conditions, and especially in complex systems, the mistake of a human operator in a central control room of a nuclear power plant, chemical or commercial aircraft pilot may cause serious accidents. An overview of the most important historical events that have taken place such as Flensburg (Britain-Chemical Industry-1984), Tri-Mile Island (America-

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Nuclear Power Plant-1979), Bhopal (India-Chemical Industry -1984), Chernobyl (Russia-Nuclear Power Plant- 1986) and many other incidents, shows that the incidence of more than 90% of these industrial was a human error that confirmed the importance role.[3] Furthermore, the survey of incidents in different countries shows that the dispersion of accidents is not evenly threatened in people and in conditions equal to three quarters of accidents for one quarter of the people at risk, and therefore the human factor can be as the most important and major factor in the occurrence of occupational accidents .[4] Investigating the report form of accident and documents in the company and interviewing the industry workers involved in the incident as well as the affected workersshowed that a large volume of accidents occurred in this industry has been related to human errors and humans have played a major role in the occurrence of these incidents. [5] Hence, in view of the critical role of humans in working systems, it seems necessary to identify and evaluate all human error of systems and provide necessary control measures in order to reduce the incidence rate and costs, and increases Productivity and job satisfaction.[6]

In order to control hazards and prevent incidents before their occurrence, several techniques have been introduced, with its capabilities and limitations. These techniques include HEART, THERP, ATHENA, SPAR-H, SHERPA, and etc. One of these methods is the Operations and Risk Study Technique (Hazop), a systematic study by a team under the leadership of the trained leader for the purpose of designing the system in order to identify the hazards, incorrect operation, or incorrect operation of the different parts of the system as well as the consequences of identifying hazards. The application of the hazop technique by Mohammad Fatman et al., as well as by Nikola Stanića, Ján Janošovský, confirmed the effectiveness of this technique in identifying hazards.[7-9] This technique uses special instructions along with actual process conditions to systematically consider all possible deviations from normal conditions. One of the main reasons for implementing this technique in the flour industry is the possibility of interaction between the three groups of industry professionals, safety experts and workers, in which case a comprehensive explanation of the failure concept is provided.[7]

Therefore, the purpose of the present study is to analysis human error in a Khuzestan flour industry by using operational and risk study techniques and provide appropriate control measures to reduce the incidence of accidents, thereby increasing the level of personnel and product health as well as reducing damages to properties and machinery.

Methods

This descriptive-cross-sectional research was conducted in a flour company in Khuzestan province in Iran 2016-2017. The production and loading units are the most important sectors in the industry, which they call the heart of the flour industry. A survey of the incidents reported in the industry also showed that the highest incidence rate of the company was related to two units mentioned above. Therefore, these units were selected as sensitive units for the study.

Data collection was carried out through reviewing documents and interviewingthe process expert, the production manager, the production and loading unit operators. Because of the fact that in the production unit of mill and grain operators there are more sensitive tasks than others, the tasks of these two posts in the production unit have been evaluated and identified. The company staff is 72, with 10 women and 62 men. The personnel of this unit are working in 3 shifts of 8 hours (shifts in the morning with 7 person, shifts in the evening with 5 people and the night shift has 5 people).

The Hazard and Operability technique (Hazop) is a legal method for identifying process hazards and determining their effects on the system. This technique is based on the fact that the system is safe when all operational parameters such as temperature, pressure, viscosity, acidity, etc. is normal and acceptable. In this method, a team of engineers examines the probable deviations of the standard state of the process by using a series of key words as well as their possible effects. The present technique has a futuristic and preventive nature that was first introduced by the British chemical industry in 1970 and then regulated by T. A. Kletz[10]. In Human Hazop method, the studied system was divided into smaller subsystems andthe so-called study nodes. Each node of the study referred to a part of the system in which, besides the possibility of determining operational parameters, the probability of the deviation of the parameters was also mentioned. The Human Hazop technique mainly focuses on human errors and their role in reducing system reliability. In other words, human deviation from the assigned tasks, or human errors, was evaluated. The stages of implementation of the research have been as follows.

Step1: Hierarchy Task Analysis (HTA): All user work tasks in a hierarchical process were divided into a set of sub-tasks and presented in the chart or table of the HTA. These tasks were the same nodes or operating nodes. An example of this HTA chart for the task of visiting the flour filter is shown in Figure 1.

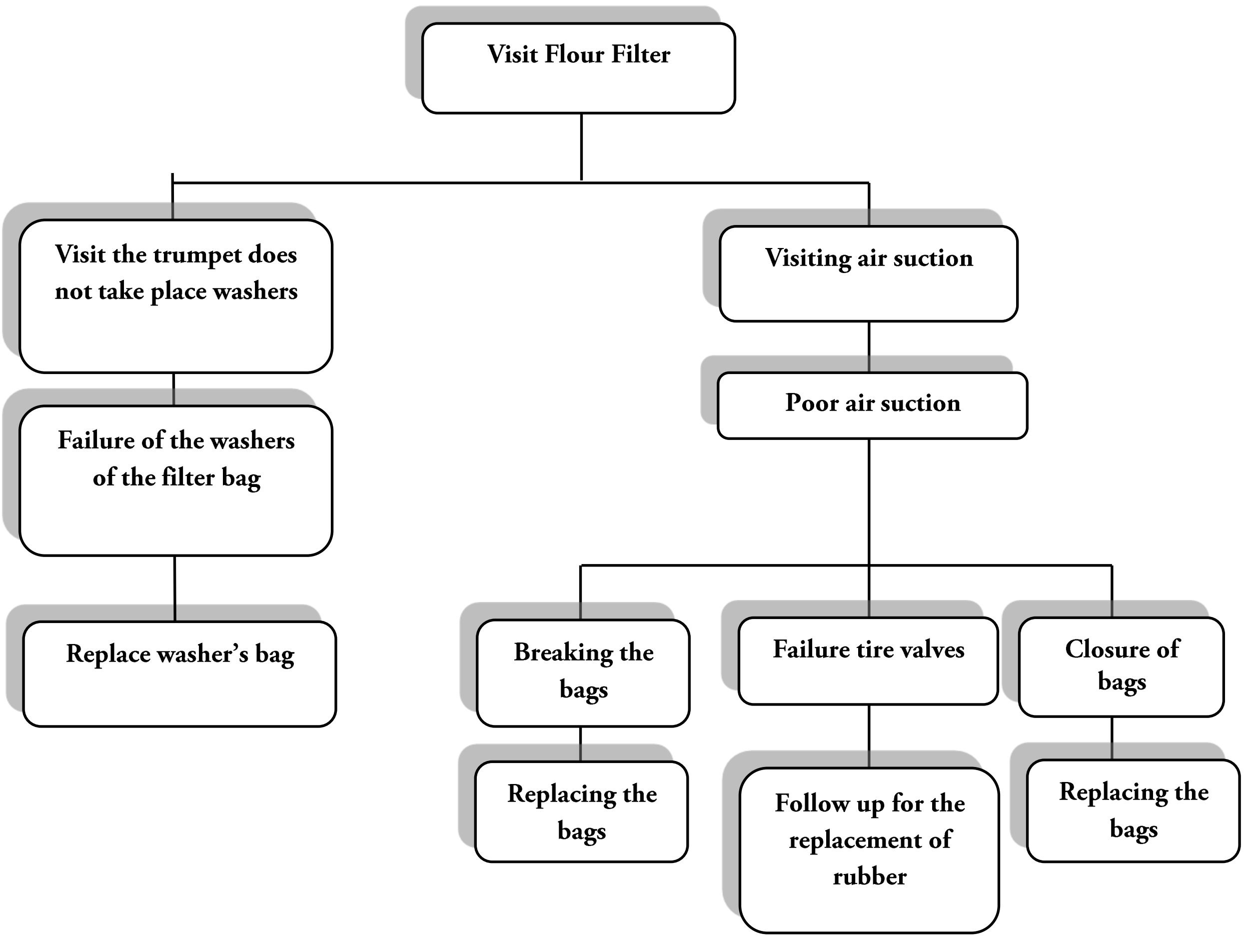

Figure 1. HTA Chart for the Flour Filter Visit Task

Step 2: Identify human errors using keywords: Detection of probable deviations in the operator's tasks is done using a series of keywords corresponding to the type of tasks. Some of these keywords include: part, later, sooner than.

Step3: Determine the type of error, the causes and the outcome of the error :At this point, one of the methods for classifying errors was used to classify errors. In this study, the Sueen and Gutman classification models have been used. Finally, after identifying and categorizing the types of possible errors, the risk level of each of the identified risks could also be calculated. In the current study, the American Military Standard (MIL-STD, 882) has been used to assess risk. After the risk assessment, suggestions were made to reduce the likelihood of occurrence as well as the consequences of the errors, and assuming the implementation of the proposals, the risk assessment was re-evaluated. The Human Hazop worksheet is presented in attachment. This worksheet was completed to identify human error critical tasks in the flour company. The completed sample according to the attachment has different columns. Finally, after the choice of the type error, appropriate keyword, factor and the result of the human error, and the primary risk amount were calculated. By providing and implementing control measures, the number of secondary risk were obtained according to the table.

Results

Work sheets of Human Hazop were completed in of Khuzestan Flour production process (grain mill operators and mills in the production unit and loading operator in the loading unit). As Table 2 indicates, 144 errors were identified. In this table, out of a total of 144 errors, 85 errors (59.03%) were attributed to the failure rate, which has the highest rank.

Table 3 shows other types of errors based on the classification of Sueen and Gutman model. Based on this classification, one of the most important human errors that account for 75% of the causes of the error is the operator removal error in one of the steps.

According to the inspections carried out on the tasks of the quarrying, milling and loading operations in the flour production process, six types of causes were identified with a frequency of 368. The list of identified errors is listed in Table 4. The most common cause of error is fatigue with 34.5%.

Table 5 shows the classification of the consequences of human error. As can be seen in this table, the probability of occurrence of economic consequences is 65.6% higher than human consequences with 34.6%. The assessment risk of identified errors is another result of the current study, as shown in Table 6.

By doing corrective actions, unacceptable and undesirable risk levels will be reduced to zero percent, and the acceptable risk level will be in the first place with the need for revision by 85.4%, which can reduce it in the long time.

Table 1. Errors Detected in the Flour Production Process

Key word	Concept	Number of errors	Percentage error
Not doing	The task is not done	85	03/59
Part of	Part of the task is completed	23	97/15
Later than	The task can be performed much later.	11	64/7
Earlier than	The task can be performed much earlier.	5	47/3
Instead	Completely different work done.	7	86/4
Less than	Task less than done.	7	86/4
More than	More job done, too.	6	17/4
Total		144	100

Table 2. Classification of Errors Identified by the Sueen and Gutman Method

Error title	Number of errors	Percentage error
Delete	108	75
Performance	13	02/90
Sequences	10	94/60
Irrelevant actions	7	9/40
Schedule	6	14/40
Total	144	100

Table3. Distribution of Errors Identified Separately

Cause of error	Number	Percent
Fatigue	127	5/34
Negligence	118	32
Forgetfulness	54	7/14
Busy	36	8/9
Little experience	22	6
System unavailability	11	3
Total	368	100

Table 4. Consequences of Human Errors

The type of outcome	Number	Percent
Economic consequences	121	4/65
Human consequences	64	6/34
Total	185	100

Table 5. Primary and Secondary Risk Levels in Tasks of the Flour Industry

Risk level	Percentage of initial risk	Percentage of secondary risk
Unacceptable	8/2	0
Undesirable	77	0
Acceptable with reconsideration	16	4/85
Acceptable without reconsideration	2/4	6/14

Attachment. Worksheet of Human Hazop For the task of visiting the flour filter

Unit name : Production - Section Mill									Task name : Visit Flour Filter	
Row	Subtask	Keyword	Classification error	Describe the cause	Cause	Consequences	Existing controls	Initial Risk Number	Suggested controls	Secondary risk number
1	Visit the washers	Not doing	Delete	Visit the trumpet does not take place washers	Negligence Busy Fatigue	Choking load- ExistenceRound And Dust IntenseFlour At Environment Work - Lack of the transfer Appropriate Bar	Objective and experimental observation	C 3	Run routine maintenance program - Supervision More - Education – correction Instructions	E 3
2	Visiting air suction	Part of	Delete	Czechair intake gaskets,but notCzech.	Frivolity negligence	Choking load- ExistenceRound And Dust IntenseFlour AtEnvironmentWork - Lack of the transfer Appropriate Bar		C 3		E 3

Discussion

In the present study, by analyzing the results, out of 144 extracted errors, 85 (59.03%) were the non-performing ones with the highest rank. The main reason for this error is to forget about one of the stages of work and the most appropriate control option to prevent and mitigate this error, to prepare and use a checklist for the installation of equipment and more supervision of the authorities. In several studies, the "lack of duty" error has been high, and in most of these studies negligence and forgetfulness are mentioned as the causes of this error.[11-15] The second rank among the identified errors is "performing part of the task" with 23 errors 15.97%. Negligence, lack of sense of commitment to others' property or fatigue can be the main reasons behind this error, which can be rooted in dissatisfaction with the job, having two simultaneous jobs, and etc.. The best way to prevent these cases is to oversee authorities more on the work of operators, as well as to prepare a checklist for conducting work, modifying or compiling a work instruction. Conducting training courses along with high-level strategies to inform a person about the consequences of failures and shortcomings in tasks can be effective. The "late performance" error is third in the range of 64.7%. That is, the task is done much later than it should, which is the main cause of fatigue. Zanganeh, Nizameddin and Taqi Dinan have similar results in this regard.[12-16] The "removal error" is ranked first by the Sueen and Gutman classification model with a rate of 75%. In a study by Mehrjeri in Margarin Company by Hazop method, the elimination error has been ranked first with 67.5%.[17] In the study of Afshari et al., 85% of the errors occurring in the control room were of a functional type, and often the failure of the operation and failure to do so, or the frequency of errors in the execution of the errors, resulted in an error.[16] Ghasemi's study in the petrochemical industry has also reported similar results.[13]

One of the ways to reduce the likelihood of human errors is to carefully examine the causes of this error. If the causes of the errors are properly identified and analyzed, by eliminating these causes, it can be expected that the likelihood of human error will be much lower. The results of this study show that among the 6 main causes identified in the current research, fatigue (34.5%) is ranked first. In a research carried out by Ghale Noi et al., using the HEART technique in a petrochemical complex in 2009, one of the most important factors in human error in control room operators was fatigue, which was ranked first with 44/13%.[18] Excessive labor and fatigue are among the factors mentioned in many studies as the main causes of human error.[19-23] The second leading cause of error is 32% due to negligence. In a study conducted by Nizameddini et al. after checking the worksheets for PHEA, the cause of 21.39% of mistakes was negligence of individuals and 11.76% was caused by people's forgetfulness[14] due to the large share which is a negligent factor in the occurrence of accidents, it seems that it is necessary to reduce the contribution of this factor to error by implementing appropriate training programs, as well as motivating and changing people's attitudes.

The results of the risk assessment clearly show that the adverse risk level with 77%, the acceptable risk level with the need to revise 16%, the acceptable risk level without a revision of 16% and the unacceptable risk level with 4.2% are respectively the highest to the lowest values. After implementation of this technique and implementation of the control strategies, the risk values are reduced to the level of the initial risk. In Ghasemi et al. study in one of the petrochemical industries, unacceptable risk of 71.25% and undesirable risk accounted for 75.76% of the total risk, after corrective actions of each of these values, decreased to 0 and 4.35. As the current study, it indicates the impact and importance of implementing corrective actions after identifying human errors.[24]

Conclusion

Although the problems that lead to human error are often unavoidable, there are many ways to prevent and mitigate errors or limit the consequences of them. Of course, it should be noted that in the successful prevention program of human error and subsequent cost reduction, identifying these errors play a key role. Therefore, identification of human errors and, consequently, their causes and factors to provide control strategies is an important part of the hazard identification program and should be used in the risk assessment program in work environments. In the end, in order to reduce the probability of occurrence of human errors and their consequences, it is recommended to develop appropriate training programs, prepare a checklist, formulate instructions, and monitor their implementation.

Conflict of interest

There is no conflict of interest between authors.

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