RESEARCH ARTICLE

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Investigation of Human Error by Using THERP Method in Control Room of Incoiler Department in a Pipe Manufacturing Company

Zeinab Sadat Nezamodini[a] ,Zahra Movahedi[a], Bahram Kouhnavard[b], Zeinab Mosavianasl[a*]

[a]Department of Occupational Health Engineering, School of Public Health, Ahvaz JundiShapur University of Medical Sciences, Ahvaz, Iran.
[b]Department of Occupational Health Engineering, School of Public Health, Larestan University of Medical Sciences, Larestan, Iran.

***Correspondence** should be addressed to Mrs. Zeinab Mosavianasl, **Email:** z.mosavianasl@gmail.com

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Background & Aims of the Study: Today, in many sensitive occupational environments, human error can lead to catastrophic events. Given that the sensitive task of a control area operator, which in the occurrence of malfunction or failure leads to irreparable events, it is important to predict human errors to reduce its adverse consequences. Therefore, the present study was perform by aiming to identify human error of the control room operators in a pipe company of Ahvaz in 2017 using by using human error rate prediction technique.

Materials and Methods: After numerous questions from the personnel and observing event sheets, important jobs were identified and then the Hierarchy Task Analysis, critical tasks was carried out and finally, the likelihood of human error in every of the critical tasks was decided by means of the THERP technique.

Results: Totally 5 main tasks and 21 subtasks were analyzed. Most of the errors recognized in this company were functional and among which factors affecting fatigue performance by 19.67% and experience by 18.03% and the training by 16.39% were the most influential factors.

Conclusion: According that maximum of the identified errors are functional, so targeted training courses for personnel and the try to employ people with relevant education and experience can be effective in reducing probability of human error. Also, planning for shift workers can be effective in reducing fatigue.

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Background

Today in an advanced world, accident is weighed as significant problems of developing and developed countries (1). Work-related accident in compared with other accident imposes more severe human and economic costs on societies. For example, daily an average 6,000 people die because of occupational incidents and illnesses and totally number of 2.2 million people per year (2). Studies in the arena of industrial incidents have shown that human factor has the main role in incidents, with 60 to 90 percent of incidents occurring as a consequence of human errors and mistakes (3). Therefore, preventing incidents is an essential for the existence of organizations. This involves rooting out causes of an incident, including unsafe human actions, unsafe conditions and natural catastrophes, among which insecure human behaviors have the main part (88%) (4). Human error as one of the significant types of insecure behaviors is an inappropriate decision or behavior that can decrease effectiveness, safety or functionality of a system (5). Human errors involve the deviation of human performance from the defined rules and tasks beyond the acceptable limits of an organization and have a harmful effect on system performance (6).

Heinrich has reported that human error is the cause of nearly 88% of incidents (7), and Dave considers 80% to 90% of the incidents as a consequence of human error (8). During the previous century, thousands of occupational health specialists had been deployed across industries, organizations, was carried out to examine the reasons of accidents and occupational diseases (8). Also workers frequently and safety policies had an affirmative relationship (9,10). On the other hand, other incidents such as Chernobyl and Three Mile Island led to human error to be evaluated as an inseparable part of safety and process studies of human-machine systems. Many models and theories were presented to identify these errors, and prevent them from occurring (11). In this regard, several techniques have been introduced, each of which, with its own abilities and limits, addresses the procedure of identifying hazards and assessing their effects. One of these methods is a Method for Human Error Level Estimate (THERP). Method for Human Error Level Estimate, a method for predicting human error rates, was used by Swine et al in the 1950s in the American atomic industry. This method has been used to predict human error rates and assessing drop in a human and, machine system that examine the likelihood of human error related to the aspects such as reliability of equipment, methods, and further causes using probability trees and expert judgment (12).

Hence, according to the critical impress of the human factor in working systems, it seems necessary that human error detected and evaluated and necessary control measures taken to decrease the rate of incidents and costs, production, productivity, and work satisfaction in all operating systems, especially in critical systems such as control rooms, which can consequence in serious consequences for human error (13).

Aims of the study:

The purpose of this study is to investigate losing of the control room operator in an incoiler unit of a pipes manufacturing company in Ahvaz by using Technique for Human Error Rate Prediction (THERP).

Materials & Methods

The present project is a cross-sectional analytical study conducted in 2017. After numerous questions about work procedure and the incidents occurring in the company, from personnel and observing fact sheets, it became clear that the incoiler unit was the most sensitive part of the plant, and this unit is the primary point of factory's operation, which, in the incident of a problem or failure, would disrupt the whole line and become obsolete. Therefore, the human error rate was chosen in this project. Staffs are at work in two shifts each one 12 hours. The staff working in this control room is an experienced operator along with a site man to organize the work of operator. According to the industry's health and safety expert, fact sheets investigation and exact observation of the procedure were selected as most risky and repetitive tasks and assessed by THERP method.

The THERP method is one of the common ways for determining human error level in the process of assessing human reliability. For a variety of errors, such as reading, deleting one step, selecting wrong switch, it is assumed that the errors occur at a constant rate and the same probabilities are considered for them. This method has a strong dependence on analyst and his type of recognition of the process, and the need for an analyst to be familiar with the working environment, in order to finally estimate the likelihood of estimated errors of failure to be as near as probable to actual value (12). The process of evaluation and determination of human error using THERP method is as follows:

1. Identification of susceptible and sensitive occupational systems and tasks related to human error
2. Collecting the required information through studying documentation, field surveys and interviews
3. Hierarchy Task Analysis (HTA)
4. Drawing probability tree

The basis for this work in this way is that at first, the desired job decomposes into its components. Then, at each stage of activity, user's possible mistakes are recognized and divided into two sets of omitting and committing an error, including misconduct of job tasks, such as doing unnecessary work, performing unforeseen tasks, performing activities outside the specified time frame, selecting options or wrong direction (14).

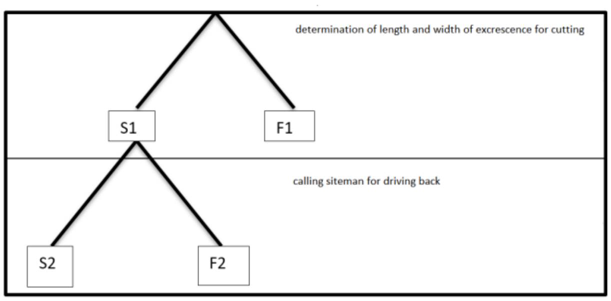

Figure 1) event tree of cutting wastes

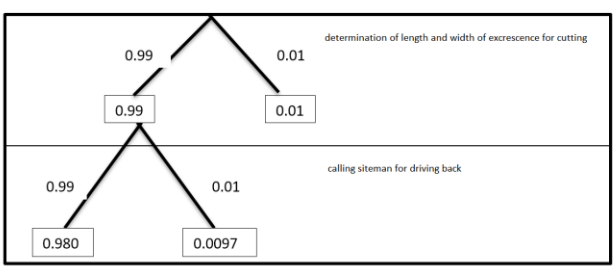

Figure 2) quantification and probability of cutting wastes error

Total Performance Shaping Factor (PSFs) such as time limits, work instructions, training programs, human factors, locating devices, etc. are measured in this technique. In the next step, by referring to the information tables, probability of human error (based on type and error rate) is determined. In THERP method, a probability tree diagram is depicted. Event tree analysis (ETA) method is a comparative modeling technique that, by creating two branches of success and failure, simultaneously evaluates the causes of an individual event. In the next stage, by entering probabilities, failure rate (F) or success (S) of activity at the final of each branch is presented. So, the likelihood of human error (HEP) is estimated from each tree. In figure 1, a case of an event tree is revealed in THERP method. Also figure 2 shows quantification and probability of cutting wastes subtask that done by THERP method for example.

Results

In the present study, which was carried out in the incoiler unit No. 3 in a pipes manufacturing company, 5 main tasks were identified. The tasks and probabilities of each human error in the order of occurrence are presented in Table 1, respectively.

In Table 2, number and percentage of factors influencing probability of human error and their percentage of occurrence are presented. The highest effective reasons are related to fatigue by 19.67%, after which experience (18.03%) and training (16.39%) have the highest percent.

In figure 3, Hierarchy task Analysis (HTA) was done for incoiler unit operator.

In Table 3, the relationship among each of effective factors in occurrence of events in tasks of control room workers is presented.

Table 1) Tasks and likelihoods of human error in order of occurrence probability

Tasks	Human error probability (HEP)	Rank
Problem occurrence and keeping device on	9.9E – 02	1
Mounting coil on the saddle	7.9E – 02	2
Shutting device down quickly	2.6E -02	3
Removing excrescences from roller	1.9E – 02	4
Fixing canvas relay	1.8E – 02	5
Plate Observation and cambric recognition	1.0E – 02	6
Determination of required length and width for cutting	1.0E -02	6
calling site man and driving back and cutting	9.9E – 03	7
Calling site man in order to set cutting length	9.9 E – 03	7
Setting to ring height	9.1E – 03	8
Picking coil by rings	9.1E – 03	8
Lowering tray down and detaching collar	8.8E – 03	9
Checking device daily	1.0E – 03	10
Mounting coil on the cart	1.0E – 03	10

Table 2) Number and percentage of factors affecting performance

Factors affecting on performance	Number	Percentage	Rank
Complexity	3	4.91	3
Stress	3	4.91	7
Experience	11	18.03	2
Training	10	16.39	3
Instruction	5	8.19	6
Environment	6	9.83	5
Focus	8	13.11	4
Fatigue	12	19.67	1
Total	61	100	

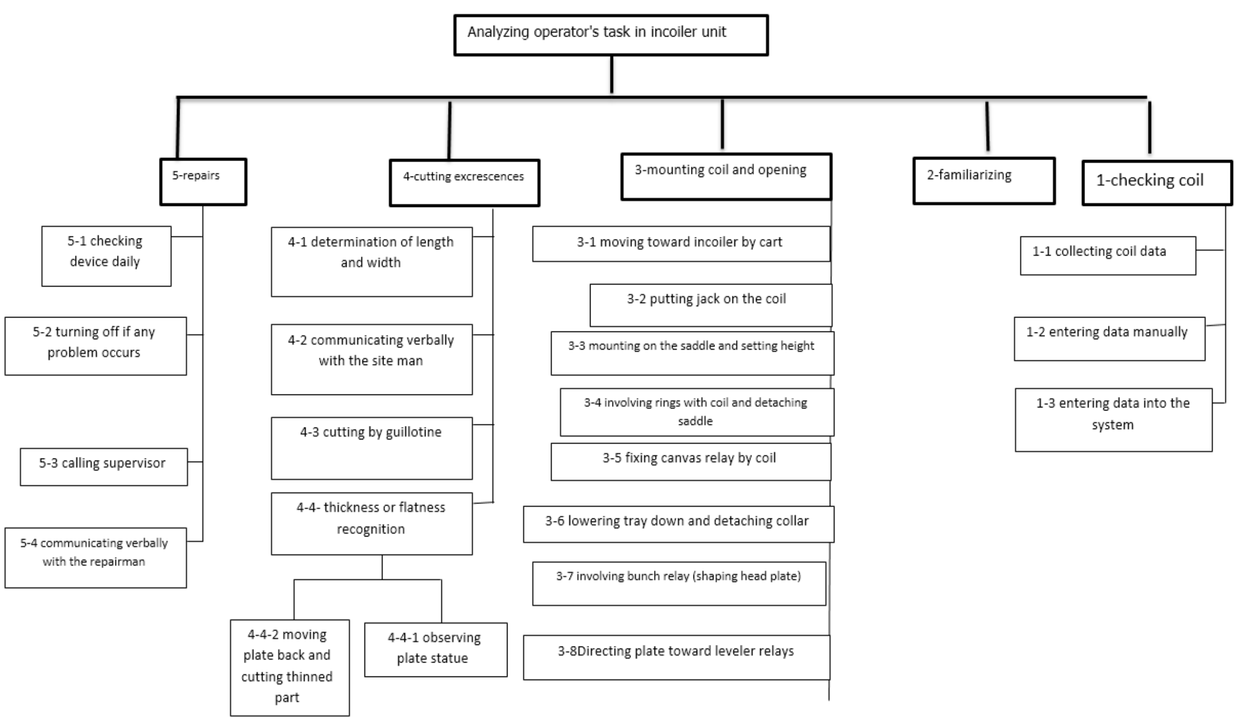

Figure 3) Hierarchy Task Analysis (HTA) of incoiler unit Operator

Table 3) Effective factors in occurrence of incidents in operator tasks

Order	Tasks	Complexity	Stress	Experience	Training	Environment	Instruction	Focus	Fatigue
1	Problem occurrence and keeping device on	*	*	*	*		*		*
2	Mounting coil on the saddle			*	*			*	*
3	Shutting device down quickly	*	*	*	*		*	*	*
4	Removing excrescences from roller				*	*		*	*
5	Fixing canvas relay			*				*	*
6	Plate Observation and cambric recognition	*		*	*	*		*	*
7	Determination of required length and width for cutting			*			*		*
8	calling site man and driving back and cutting				*	*	*	*	*
9	Calling site man in order to set cutting length				*	*	*	*	*
10	Setting to ring height			*		*			*
11	Picking coil by rings			*					*
12	Lowering tray down and detaching collar			*	*				*
13	Checking device daily		*	*	*		*		
14	Mounting coil on the cart			*	*			*	

Discussion

According to the consequences revealed in Table 1, the highest probability of human error is when a problem has arisen for the device, and the operator chooses to keep device clear so the repairman will be dealt with at the end of the shift. Sometimes the operator, because of fatigue or compression because of the manager forcing to produce more, is forced to keep the device on which must be shut off as rapidly as possible and cause more damage to it, and in addition to requiring a device an essential repair, the line also stays off for a couple of days and the company suffers a lot from financial losses. In this item, it is suggested that the device be kept off as possible, and if the device is switched on, the operator must have enough experience to control it, or call the repair team to decrease his responsibility.

The duty of "mounting coil on the saddle" is ranked second among potential risks. When the collar is wrapped and the coil is completely closed, it is not so damaging. But occasionally, due to the opening of the collar during coil transportation is removed and its edges got open and when it is placed on the saddle, it hits the canvas engine whipping it and cause

Damage to canvas engine. Sometimes, because of the omission of the repair team, the hydraulic valve of saddle jacks, which were closed for repairs, does not and the operator only finds out when the coil pushes on saddle and breaks the jack. In this example, the machine is not appropriate for production and should be repaired. The operator can adjust speed of mounting the coil on the saddle to minimize severity upon saddle and the jack below it, sometimes because of distraction or mental retardation, and putting a lot of pressure on the saddle which causes the saddle jack to disruption in the long run. This mistake causes company to lose financial losses and drops the line for a while. In this item, most events occur due to non-compliance with instructions or incorrect instruction in the company. So there is a need to re-examine instructions and rewrite them. On the other hand, a saddle impactor can be used to decrease some of the pressure on hydraulic jacks.

Among researches that have been done in recent years, Somayeh TajDinan conducted a study on this company who believed that most of errors were due to user's performance, which is at different stages of forgetting, performing incompletely, early or late manner in the task. It should be noted that these factors have a straight association with the factors affecting user's performance (15). A study by Mehdi Ghasem Khani in the petrochemical industry shows that functional error has the maximum score (16). In a Study conducted by Habibi et al. In the control room of the Isfahan oil refinery, functional error has the highest error rate (17). The functional error in most studies has the maximum percentage error (17-20).

Given the probabilities and the reasons for their occurrence, it can be concluded that most of the errors occurred are of a kind of function that whether operator does not do right or does it in a wrong direction while doing it correctly, and sometimes Do it faster or later. On the other hand, all operators' behaviors are influenced by reasons affecting performance (people communication, fatigue, intellectual concentration, work environment, system updates and stress, etc.). According to the consequences, the highest percentage of factors affecting fatigue performance were 19.67% and then the experience (18.03%) and training (16.39%) were the maximum.

One of the reasons for fatigue in operators is to do monotonous and repetitive work, forcing operator to work more, short-term resting and interruptions at the time of work, not providing welfare facilities for the worker, lack of good and effective communication with other workers, and Head of the department. In a study carried out by GhaleNoi et al. Using the HEART technique in a petrochemical complex, one of the most significant factors in human error in control room operators is tiredness, which is ranked first with 32 cases and 13.44% (21). Excessive labor and fatigue are among the factors mentioned in many studies as main causes of human error (16,22-24).

The experience depends on the work experience of worker and training and skills acquired through this period. The training, if included appropriately, plays a very significant role in reducing incidents and human errors. In this case, workers should be given training on the basis of their task, and be given training with control methods and errors that are likely to be issued.

In a study by Mahboubeh Kiani et al. in 2013, they identified and evaluated factors affecting human performance based on fuzzy logic (in operational areas of the Gas Transmission Company). Data analysis showed that among determined factors, regarding to the control room operators, the quality index and amount of training available in the company are undesirable (23). In a study by Hamzeyian in 2010 based on the initial method of Cream technique, one of the factors associated with reducing reliability of performance is the quality of training and work experience (24). In 2009, Doytchev et al. also analyzed the tasks and the tree of error in Bulgarian industry, which indicated that training, experience and complexity of task are among the most important modes of error in operators' behavior (25). In other studies, the importance of training and its role in reducing errors are mentioned (16,19,21,26). Nezamodini et al done a study about identifying human error and mention that with identified operator error and their consequence can reduce number of accident and create a safer environment (27).

Conclusion

According to the consequences of high percentages of errors recognized in this industry, they are functional and due to the sensitive task of operators that control the process, use appropriate solutions such as holding training courses at the beginning of recruitment and performance of training courses related to the task periodic maintenance, improvement and updating of existing instructions in factory, establishment of proper and optimal managerial communication with workers, designing appropriate illumination for control cabin in order to decrease or limit the outcomes of human error and improving system's safety and reliability. Management, with a programmed and adjusted plan, should provide an environment free of stress and ergonomic problems for worker in order to work with highest possible efficiency.

Footnotes

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Conflict of Interest:

The authors declared no conflict of interest.

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