ORIGINAL ARTICLE

Evaluation of Human Reliability in Steel Industry Using SPAR-H and CREAM Techniques

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ABSTRACT

Background: Preventing and reducing the number of accidents requires a reduction in human error. Human error is the main cause of accidents in high-risk industries. The analysis of SPAR-H and CREAM can examine human errors in steel industry.

Aim: The purpose of this study was to evaluate human error in steel industry by SPAR-H and worm techniques and compare their results.

Materials: The present study was descriptive-analytic. All the tasks of the steel industry were studied, and HTA was used to analyze staff responsibilities. The CREAM and the SPAR-H techniques were compared to identify and quantify human errors of the performed tasks and the obtained results.

Results: The results of the study by SPAR-H for monitoring the operation of scissors by the top technician of the production area showed the highest probability of error occurrence. The technique (CREAM) for controlling the dimensions of raw materials on the charging table, performed by the technician of the charge, showed that the charging of the preheating furnaces had the highest probability of occurrence.

Conclusion: In order to reduce the human error rate in the industry, the improvement of two performance-enhancing factors, including priority procedures and improvement of environmental conditions are recommended to reduce the stress on operators. The CREAM technique has the advantage over the runtime. The SPAR-H technique also examines the factors affecting performance more extensively than the CREAM technique.

Keywords*:* Human Error, Steel Industry, CREAM, SPAR-H

INTRODUCTION

Despite the risk and accident prevention methods used in the steel industry, there are still plenty of incidents in the industry. Therefore, the implementation of an accident analysis method can identify the root causes of accidents[1,2]. To reduce human error, preventing and reducing the number of accidents and incidents is necessary. Human error is the main cause of accidents in high-risk industries[3]. Human errors are recognized as the most original and key factor in industrial incidents[4]. Research has shown that over half of the adverse events are duo to human errors[5]. Identifying the causes of the error is the first step in preventing errors[6]. The hierarchical task analysis (HTA) was first used in 1971 by Annett et al. In 1999, Stanton et al. used it in the nuclear power plants and chemical industries. Based on HTA, all tasks in a hierarchical task analysis are divided into a set of partial tasks. An objective method is to identify and describe the process and the steps to achieve the goals. HTA is a hierarchy of tasks and subtasks, and the relationship between these tasks[7,8]. CREAM (Cognitive Reliability and Error Analysis Method) was introduced by Eric Hollnagel in 1998. This method is one of the second-generation techniques of the Human Reliability Assessment Process (HRA), focusing on the cognitive fields of human action. One of the main advantages of CREAM compared to human error assessment techniques is the systematic structure of this method for defining and quantifying human errors in both prospective (human error prediction) and retrospective (event analysis) situation[9,10]. Another technique known as SPAR_H (standardized plant analysis risk-human reliability analysis) was first introduced in 1994 by Blackman et al. This technique is a simple method used by risk analysts to calculate human error probabilities. The SPAR_H method has been developed in support of the Regulatory research office associated with the United States Nuclear Regulatory Commission and used in some US nuclear processes. This technique is a systematic method for analyzing human reliability, with tables for selecting human performance, in consultation with experts in this field. The purpose of the method is to calculate error probability for a set of specific tasks, the nominal error rate, a set of PSF (Performance-

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Shaping Factors), and an error dependency between tasks. This technique is a combination of risk factor and information processing response. It requires the analyst to deal with aspects of the diagnosis and planning of tasks and to identify the operator's ability to perform actions[11].

The analysis of SPAR-H and CREAM can reveal valuable insights about human errors in the steel industry. The purpose of the present research is to evaluate the human errors in the steel industry by the two SPAR-H and CREAM techniques and compare their results.

MATERIAL AND METHODS

The present study is descriptive-analytic. All the tasks of the steel industry were carefully studied. HTA is used for task analysis of workers. The CREAM technique was executed in accordance with the following steps:

Step 1: Selecting a job task from the analyzed level

Step 2: Assessing the working CPCs (Common Performance Conditions) affecting the performance of the operator

Step 3: Determining the control styles and the overall probability of cognitive error after task analysis, the general characteristics of each task and working conditions affecting operator performance. The operating conditions affecting operator performance and the potential relationship between CPCs and functional reliability are determined at three levels of improvement, reduction and ineffectiveness.

Criteria for allocating CPCs: Viewing the process, interviewing with operators, interviewing heads and unit chiefs, and reviewing work instructions.

Determining control styles: Four levels of control are determined using the number of positive and negative CPCs.

Types of control modes: 1. Strategic control 2. Tactical control 3. Instantaneous control[4]. Random control

Cognitive failure probability total CFPt probability estimation using the formula (9-10): CFPt $=0.0056\times10^{0.25\beta}$

SPAR_H technique was carried out according to the following steps:

Step 1: Dividing human tasks into two groups of "Detection" or "Action": For both groups, "Detection activity" and "Action" questions and PSFs are the same, but the PSF coefficients are different. In some cases, tasks are both detection and action in both cases.

Step 2: Determining the PSF (Performance-Shaping Factors): The eight effective performance indicators are used to determine the score (available time, stress, complexity, experience and training, procedures, ergonomics, suitability of the task, work processes).

Step 3: Human Error Probability Nominal (NHEPs): At this step, NHEPs are determined and then multiplied in PSF.

The NHEP for the detection activity is equal to 0.01 and equals 0.001 for action.

Step 4: Calculating HEP: Formation factors of the PSF function are greater than or equal to 1 as a negative PSF. If there are less than three cases of PSF negative in the number of PSFs, the same amount of multiplication of the factors influencing the performance in the probability of the base error as the final HEP is considered. If there are three or more negative PSFs in the PSF count, the following formula for the final HEP is used. HEP= (NHEP.PSF)/ (NHEP. (PSF-1) +1)

Step 5: Calculating the final HEP by considering the degree of dependency of the final rate. The probability of human error is calculated by considering the dependency[11]. In order to achieve the objectives of the study, the technique was implemented and then the probability of error for the tasks was estimated by both techniques.

RESULTS

Fifteen main tasks and 39 important sub-tasks were selected, and for all tasks of the worksheet, CREAM and SPAR-H methods were completed. The main tasks of the study are the senior expert of rolling and substrates, responsible for shifting rolling and substrate production, shearing and cutting machine operator, executive expert rolling, charging operator for preheating furnaces, pulpit operator, senior production operator in the preheated oven, operations for the production of the subsidiary, shift supervisor slab yard, bonder operator, discharging furnace operator, charging furnace operator, operator production discharging, responsible for shifting the production of preheating furnaces, hot rolling mill. The results of the study with the Standard Human Reliability (SPAR-H) Risk Analysis Standard are as follows for the tasks of monitoring scissor switching operations by operations for the production of the subsidiary, planning and coordinating shifts by shift supervisor. The slab yard, the coordination of the rolling workshop department with operations for the production of the subsidiary, and the production of various types of products in various rolling processes by responsible for shifting rolling and substrate production showed the most probability of error occurrence.

The results of the error analysis technique with emphasis on human cognitive reliability (CREAM) for controlling the dimensions of raw materials on the charging table was performed by the charging operator for preheating furnaces, controlling the operation of the control room was done by the shearing and cutting machine operator, monitoring the substitution operation and adjusting the rollers and visiting and controlling the various parts of the rolling and substrates by the senior expert of rolling and substrates, calibration of roller rollers and control roller surfaces by checking the status of flame burners by charging operator for preheating furnaces showed the most probability for error. Table 1

DISCUSSION

Developing a sustainable assessment human reliability determinant factors includes the importance of action, background, environmental factors, human tension, previous experience, education, physical design interfaces, existing procedures or checklists that are expected to be more accurate and realistic[12]. According to Shokria et al., Common Performance Conditions (CPCs) empowerment and available time to work were two of the most important factors in reducing job performance.

To optimize a communication system, it is necessary to arrange the priority of tasks, hold joint meetings, and inform employees about the termination of work permits, training courses and measure pollution[13]. The complexity of negative production systems affects the operator's ability to make a decision in a negative emergency[14].

Calhoun et al. in their study stated that CREAM analysis using PSF showed that skill-based education has significantly improved the risk of human error[15]. Proper work environment design is an effective way to reduce the incidence of human error[16].

According to Blackman et al., in the SPAR-H method relationship of dependency between a series of human errors is a crucial factor and should be considered in the human reliability assessment[17]. Humans are part of a complex system and should play an important role in ensuring the safety and reliability of these systems. Failure to do the job at the designated time by the operator can reduce the security of the system. Human Hazard Analysis (HRA) is a common method for assessing the operator's contribution to overall risk.

HRA methods determine this contribution based on human error probability (HEP) to assess various psychological and physiological factors affecting the operator's performance. These factors are called HF (Human factor). HF enhances or weakens human function[18,19].

Charge control room operators have numerous sensitive and stressful tasks and should be careful and well-informed. Control of the cutting of steel sheets in the control room is a stressful task with several job risks. In this section, the piece of waste may be stuck in the machine, and the worker is forced to remove the piece in a tight place that is likely to be high. In the cutting section of the steel plate, cleaning the room is not appropriate. In this section too, the sound of crash fragmentation is damaging to operators.

In the control room Bonder, unlike other control rooms, the mechanics are in charge of repairing the machine. There is a history and probability of a crane collision with the room of the bonder workers. According to the complaints of the personnel, it can be said that this room is not safe. Workers' room is not noise insulated. Workers mainly complain about the noise. The workload in this control room is high. A huge part of the work is associated with heavy physical activity.

After performing the two techniques and considering the similarity of these two techniques in assessing the factors affecting performance, it can be stated that "access to methods and instructions" factors among all tasks and sub-tasks are inappropriate and weak. According to the reviews, the instructions for all tasks are available, but not available to the workers. It is suggested that the instructions be made available to workers in order to carry out the tasks in the original method.

Among the tasks that have the highest probability of human error in the CREAM technique, you can firstly refer to the task of "controlling the dimensions of the raw materials on the charging table inserted".

The most important factors identified are "inaccessibility of instructions" and "inappropriate physical and mental working conditions of the work environment". Another important factor in increasing the probability of error is the high workload and doing two or more tasks simultaneously .In the tasks that are performed in the control room and by operators with the system of operation guidance, the "complexity of tasks" factor is further discussed. According to management effort to maintain the satisfaction of the workers, assessment's result of the "work process" factor is desirable.

The environmental factors of the control rooms were considered "inappropriate" because of poor lighting conditions. According to the SPAR-H classification, the task of "monitoring scissors replacement" has the highest probability of human error, including the factors that affect this task "high stress", which is actually due to physically harmful factors in this area (high noise, which requires hearing protection and improper lighting of control rooms). Furthermore, the inaccessibility factor of "guidelines and procedures" is likely to increase the probability of errors in this sub-task.

After performing the two techniques with respect to their similarity in defining the factors affecting performance on the probability of human error, it can be argued that the SPAR-H technique can be easier and more convenient than the CREAM technique in relation to factor scoring.

In order to reduce the human error rate in the industry, the improvement of two Performance-Shaping factors, including priority procedures, and improvement of environmental conditions are recommended to reduce the stress on operators. The CREAM technique has the advantage over the runtime.

SPAR-H also examines Performance-Shaping factors more comprehensively than the CREAM technique.

Conflicts of interest: The authors declare no conflict of interest.

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Table 1: Human Error Probability (HEP) and CFPt for each Subtasks using SPAR-H and CREAM methods

Task	Subtasks	HEP (SPAR-H)	Rank (SPAR-H)	CFPt (CREAM)	Rank (CREAM)
Masters of Rolling and Substrates	Carrying, moving, delivering and taking rollers	0.0025	14	3.8	4
	Supervision over replacement operations and adjustment of rollers	0.00001	17	5.2	2
	Monitor the timely discharge of products manufactured from coolant substrates	0.384	7	3.8	4
	Visiting and controlling different parts of rolling and substrates	0.0005	15	5.2	2
Responsible for shifting rolling and substrate production	Monitor roller rolling calibration	0.0747	11	5.2	2
	Roller level control	0.091	9	5.2	2
	Production of various types of products during rolling processes	0.5	4	3.8	4
Shearing and cutting machine operator	Conducting operations under the command of the control room 44P01	0.333	8	5.2	2
Executive Expert rolling	Monitor the performance and factors affecting the various processes of rolling	0.588	5	3.8	4
Charging operator for preheating furnaces	Coordination with crane drivers	0.476	13	3.8	4
	Controlling the dimensions of the raw material on the charging table	0.5	4	6	1
	Carrying out coordination on the transfer of raw materials on the roller table by a crane	0.09	10	2.4	6
	Perform all charge operations	0.0476	13	2.4	6
Pulpit Operator	Conducting and monitoring operations under control of the control room	0.0476	13	2.4	6
	Communication and coordination with the operator of the crane	0.0476	13	3.8	4
Senior production operator in the preheated oven,	Turn on and off the furnaces at the right time	0.0476	13	4.8	3
	Check the status of the flames of the burners	0.555	6	5.2	2
	Adjustment and control of furnace atmosphere	0.0476	13	2.8	5
	Take the necessary Proceedings when the furnace is suddenly shut down	0.0003	16	2.4	6
	Coordination with the roller- shaving workshop	4	3	2.4	6
Operations for the production of the subsidiary,	Supervision of Scissors Replacement Operations	8	1	2.4	6
	Visitors and control different parts of the area of Complementary operation	0.0476	13	3.8	4
Shift Supervisor Slab Yard	Record the information in the system	0.048	12	1.4	7
	Planning and coordinating the work done in the shift	4.47	2	1.4	7