ORIGINAL ARTICLE

# Risk and Human Reliability Assessments at a Tool Factory and Control Suggestions

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## ABSTRACT

**Background:** Many accidents and damages can be avoided through risk identification and assessment at the workplace. The determining factors must be identified fully to prevent damages and accidents.
**Aim:** The present research goal was to assess the human reliability and risks at a tool factory using the JSA and CREAM methods with the aim of identifying the high-risk tasks and the determinants of risks and errors in this industry.
**Methods:** This research is a case study, in which the main tasks were identified using the HTA method. After breaking the jobs into different phases or tasks, the JSA and CREAM worksheets were completed for 15 main tasks.
**Results**: The high-risk furnace forging, presswork forging, hardening, crack detection, trimming, edge banding, and tagging tasks were identified. It was also found out that an improper posture, exposure to sound, vibration and radiation, unfitting human-machine systems, multitasking, and unavailability of codes and plans were the determinants of accidents and damage.
**Conclusion:** Risk assessment or human reliability assessment cannot fully and inclusively identify and control the potential incidents and damages on its own. Hence, in order to control a large fraction of the accidents and damages, both risk assessment and human reliability assessment methods must be applied simultaneously to identify and control the determining factors.
**Keywords:** Safety, Health, accident, industrial

## INTRODUCTION

Numerous accidents occur on a daily basis in workplaces, resulting in various degrees of damage and mortality. One of the root causes of such accidents is the lack of identification of the potential risk factors in these environments. Therefore, many accidents can be prevented through the identification and assessment of risks in workplaces. Occupational health is primarily aimed at the prevention of accidents and damages in the industries. The determining factors must be fully identified to be able to avoid these incidents and damages. Today, numerous methods for the identification of workplace risks are available. The job safety analysis (JSA) method identifies the risks in advance, and thus it is used as an efficient risk identification method. The implementation of the job safety analysis method dates back to the pre-1930 period. The JSA method is also referred to as the task hazard analysis (THA) and job hazard analysis (JHA). It is a systematic precise way of identifying and assessing risks in every process or job. It involves the precise analysis of the tasks associated with a job, the identification of the safety and health risks, and the identification of the risk elimination or risk control mechanisms. In JSA, job analyses are carried out with the minimum need for human and financial resources as well as the minimum equipment and facilities solely using precise investigations and the competencies of the assessors team and the workers' experience. The job hazard analysis (JHA) approach can help identify and reduce the workplace risks, secure a safe workplace for the workers, and increase productivity.

In addition to risk assessment, the studies on industrial and work accidents have revealed that the human factor plays the most important and principal role in the occurrence of these accidents. Erik Hollnagel (1998) developed the cognitive reliability and error analysis method (CREAM), which belonged to the second generation of the human reliability assessment (HRA) techniques. One of the distinctions of this approach is its emphasis on the cognitive aspects of the human behavior. Moreover, one of the most important advantages of CREAM over the other human error assessment techniques is its organized structure for the prospective (human error prediction) and retrospective (event analysis) identification and quantification of human errors.

The overarching goal of this research was to conduct the JSA- and CREAM-assisted risk and human reliability assessmentsof a tool factory to identify the high-risk and high-error tasks as well as the risk and error factors in this industry.

## METHODOLOGY

This research was carried out as a case study on a tool factory. To this end, first a team consisting of a superintendent, an experienced worker, and a safety and health expert was formed. Afterward, the working processes and operations were identified.

The research goal was explained to the managers and personnel, who were assured that all of the activities would be checked with them in advance. The main tasks were identified using the hierarchical task analysis method. Finally, after breaking the job down into different tasks or

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steps, the JSA and CREAM worksheets were completed for the 15 main tasks.

**Job Safety Analysis Phases**

1. Identifying the risks in each phase: In this phase, the potential or actual risks (ergonomic, physical, chemical, and mechanical risks) associated with each job were identified.
2. Risk assessment: The probability of each given accident or the outcome intensity was identified, and the resulting probabilities were combined to obtain the risk level. The high-risk tasks were also prioritized based on the risk index.
3. Proposing control actions: Control actions were recommended with regard to the identified risks.

**CREAM (Cognitive Reliability and Error Analysis Method) Phases**

1. Determining the common performance conditions (CPCs): The general characteristics of each task and the working conditions influencing the worker's performance were determined.
2. Identifying the expected effects on performance reliability: The expected effects on the performance reliability were identified on the improvement, reduction, and neutral levels.
3. Identifying the $CFP_t$ (cognitive failure probability total)

The total cognitive failure probability was calculated using the following formula.

$$CFPt=0.0056\times10^{0.25\beta}$$

*(the number of performance improvements – the number of performance reductions = the beta coefficient)*

In order to attain the research objectives, the results from these two methods were analyzed to identify the determinants of risk and human reliability as well as the high-risk tasks.

## RESULTS

In phase I, the following tasks were identified: cutting, heating, forging, cold trimming, cold piercing, motor vibration (stone cutter), shot blasting, calibration and tagging, edge banding, broaching, crack detection and fitter work, hardening (thermal operations), sanding, final shot blasting, plating, packaging, and storing.

The results from the JSA and CREAM methods were different.

The improper posture of the wrists, neck, and waist (3B), exposure to sound (3A), exposure to vibration (3A), and exposure to infrared and ultra violet radiations (3C) were the hazards identified by JSA. Moreover, this method assessed the presswork and furnace forging, trimming, edge banding, and tagging tasks as the riskiest tasks.

The unsuitable human-machine systems, lack of effective operating support, multitasking, unavailability of methods and plans, and disruption of tasks by physical conditions had the largest effect on the workers' performance according to the CREAM results. The tasks with the highest cognitive reliability error probability were presswork forging (CFPt=0.0995), furnace forging (CFPt=0.056), hardening (CFPt=0.0314), and crack detection (CFPt=0.0314) in the order mentioned.

## DISCUSSION

Precise investigations into accidents and pre-operational safety analysis by competent experts can considerably reduce the workplace accidents. Workgroups should collaborate to effectively implement the safety assessment and control methods. The management, supervision, and worker workgroups should also analyze the assessment results to reduce the frequency of the incidents and their intensity. The identification of the roots of the accidents through safety and human reliability assessments prior to and during operations can also prevent accidents[7]. Risk identification is one of the most important challenges to safety management. In a conventional risk assessment conducted through a job safety analysis (JSA) the goal is to identify all potential risks. The internal changes (i.e. training, experience, and fatigue) or the external changes (i.e. environmental and working conditions such as the weather, workplace temperature, vibration, workload, and stress) affect the likelihood of human errors[8]. Investigation results also indicated that a job safety analysis significantly increased the belief of the studied workers in the detrimental workplace factors, workers' overall perception of accidents, the understanding of the possible post-incidence risk of damage to the personnel, workers' perception of the likelihood of being harmed in the workplace, workers' perception of production versus safety, workers' perception of the causes of accidents, and workers'trust in the personal protective equipment (PPE). However, these effects vary by profession, age, work experience, and academic degree. Furthermore, a job safety analysis significantly contributes to the improvement in the workers' understanding of the risks[9]. Research results showed that prevention through design (PtD) is the most economic and effective way of increasing safety. The necessity of prevention through design (PtD) has been discussed for many years. The inspection data also reflects the significance of the engineering design and unveils the mechanism of the effects of design on behavior. According to the result, design is effective in preventing human errors[10]. Human reliability assessment reveals the human errors, the failure mechanisms, and the factors influencing performance. The knowledge of the importance of occupational safety and health actions improves the occupational safety standards, prevents occupational damage, increases productivity, reduces the loss of working hours, saves costs, and improves the standards[11].

## CONCLUSION

Using tables and chairs with adjustable height, adequately dark shields or goggles, press springs, and earmuffs, reducing exposure to sound, and periodically inspecting the ventilation systems of the plating units are among the control suggestionsprovided based on JSA.

Providing operating supports through special designs, establishing computerized working stations, providing accessible data in the control panels, reducing the number of the tasks to be considered simultaneously, reducing the number of the tasks to be accomplished simultaneously, presenting response instructions for the possible incidents, providing response instructions for the emergency operations and processes, developing the ongoing operations and processes plan, and improving the workplace physical conditions are the control measures suggested based on CREAM.

Finally, risk assessment or error assessment fails to comprehensively identify and control the damages and risks on its own. Hence, in order to control a large fraction of the accidents, damages, and errors, the risk assessment and human reliability assessment methods must be implemented simultaneously to identify and control the factors determining the accidents, damages, and errors.

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