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Risk Assessment in a Wheat Winnowing Factory Based on ET and BA Method

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Abstract: Technological and scientific advances have imposed more serious risks on human force, machineries and assets. On the other hand, it is essential to prevent accidents and preserve human and financial capital. Risk assessment is an organized and systematic method to detect and estimate risks. Based on the results, risk assessment can rank the decisions and reduce the risks to an acceptable level. The present study has aimed at detecting, assessing and controlling the risks in a wheat winnowing workshop affiliated to Kermanshah Province floor factories (Iran). The study was carried out through a descriptive cross-sectional study in 2015. Energy trace and barrier analysis methodswere followed. An analytical method was used based on system safety which has been implemented to detect and define the risks that may cause damage and loss to the system. To collect the data, ETBA worksheets were filled through walking-talking method and technical/operational document reviews. Based on the results, modifications of the systems and standards were recommended to minimize the risks. The results revealed 8 energies and 28 risks, out of which six risks were unacceptable, twenty risks were non-preferred and two risks were acceptable, after revision. None of the risks were at acceptable levels without revision. After implementation of adjustments there were zero unacceptable risk three non-preferred risks and six acceptable risks after revision and 19 acceptable risks, without revisions. Taking into account that most of the risks were at high levels, controlling the measures based on experts' prescriptions in safety areas, pertinent to equipment, training operators and monitoring the measures were recommended.

Key words: Risk assessment, ET and BA, wheat winnow, method, human

INTRODUCTION

Factories play a key role in production processes and economy cycle while as the operators of high technologies, human forces are considered as their most valuable asset. Necessity of preserving and protecting assets, including human assets and improving their capacities-physical and mental capabilities in the case of human resources is unquestionable (Barkhordari *et al*., 2011). Technological advances have increased the risk of accidents in industrial environments (Jouzi *et al*., 2010). Rsearch accidents rate in the developing countries is far more than that in the developed countries (Hamalainen *et al*., 2006). According to the International Labor Organization, 250 million work accidents happen every year which lead to 4 deaths of one hundred thousand individuals. Traditionally, the cause of accidents is examined after that the accident takes place (Sadeghain *et al*., 2013; Rahmani *et al*., 2013) however, variety of new-established assessment methods has enabled us to detect risky and critical spots before the accidents and take required preventive measures (Jouzi *et al*., 2010). Risk assessment has to do with detecting the risks in a process or a job, calculating the risk score and producing control data to control the risk (Christian *et al*., 2009). This method generates valuable

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data for making decisions in the areas of curtailing risks, improving research environment and hazardous equipment, planning and preparing for emergencies, determining acceptable risk level, codifying inspection guidelines for industrial installations and the like. Risk assessment is an organized and systematic method to detect and estimate risk and then, rank the possible decisions based on the results and minimize the risk to an acceptable level (Jouzi *et al*., 2010). Risk assessment is carried out through qualitative and quantitative methods. The heavier the role of quantitative assessment is the better the results of risk assessment are. Quantitative risk assessment method can detect the available risks and the results can be used to make preventive and controlling measures. In general, PHA what if HAZID and HAZOP are qualitative risk assessment methods and LOPA, FMEA, ETBA and William Fine are quantitative risk assessment methods (Jafari *et al*., 2013; Sohrabi *et al*., 2016). As noted, one of the quantitative methods is Energy Trace Barrier Analysis (ETBA) which relies on system safety for analyses. The method is used for detecting and defining the risks including the risk that may cause damage to the system. The method was proposed by Haddon based on managerial survey and risk tree method. It relies on a deep understanding of the resources, natures and types of the unwanted flows of energy that may lead to accidental damages. The results of ETBA are represented as table in special worksheets which can be used to estimate risk values, detect and evaluate special options for removal or more control. The method is generally considered as one of the most effective and informative tools available for surveying the safety in systems (Khandan *et al*., 2012, 2013). The logic behind the method is that the damage is defined as a result of an accident and the outcome of unwanted interactions takes place while the energy flows from the shield into the goals in contact (Ebrahemzadih *et al*., 2014). Given the above introduction, the purpose of the present study is to assess the risks of a wheat winnowing workshop, using ET and BA Method.

MATERIALS AND METHODS

The study was carried out as a cross-sectional descriptive research in a wheat winnowing workshop affiliated to Kermanshah Province floor factories (Iran). ETBA Method was used for risk assessment and it was carried out through five stages. At first, a team of risk assessment experts including authorities and engineers of the factory and the researchers collected the data as per the worksheet of ETBA. The worksheets were filled out using Walking-Talking Method, risk detecting checklists and technical documents as well as plots (Zaroushani *et al*., 2010). To have accurate plot of the energies and their traces, energy detection checklist was used and 15 energies were detected according to EBTA Method is given by Zaroushani *et al*. (2010):

Electrical energy-AC/DC:

- Electrical energy charge/electrical discharge
- Electromagnetic radiations/radiofrequency pulses
- Inducted voltage/inductive currents
- Control voltage/control currents
- Magnetic fields

Potential energy:

- An individual at high altitude
- An object at high altitude
- Objects hung in the air
- Collapsing structures
- Handing heavy objects and materials
- Pressurized springs
- Sloppy surface
- Slippery surface

Rotational kinetic energy:

- Gears and wheels
- Rotating fans and propeller
- Power transfer element, cylinders and rollers

Linear kinetic energy:

- Throne objects, bullets, etc
- Pistons and moving objects
- Scissors and press machines
- Vehicle and moving equipment

Thermal energy:

- Melted and burning materials
- Thermal radiation
- Thermal guidance
- Air movement, expanding heat
- Thermal rotation
- Vapor, chemical reaction of heat generating

Radiation energy:

- Ionizing radiation (beta, alpha, gamma)
- Nonionizing radiation (IR, visible, UV)

Pressure, volume and kinetic energy movement:

- Explosion due to excessive pressure

Chemical agents:

- Chocking and anesthetic agents
- Flammable, oxide and polymerization, toxic, cancerous, mutation and water/soil contaminator agents
- Dusts, fumes, gases and pathological vapors

Noise and vibration:

- Noise
- Vibration

Terrain energies:

- Earthquake
- Ground water flows and land subsidenc
- Aerosol, dust, particles and mists
- Sun light, weather (hot, cold, inversion)

Weather energies:

- Wind speed, direction
- Rain (warm, cold, frozen), acid rain
- Snow fall, hail and rain
- Thunder, electrostatic forces

Living creatures:

- Interaction between human beings
- Interaction between different types of animals
- Herbal life activities
- Others

Improper equipment layout
Complicated equipment and machines
Staff in improper posture:

- Static work

The goals were determined after detecting the energy traces. By examining the effects of the energy traces, the required controls were implemented. Then, risk levels were determined and prioritized based on MIL-STD 882 standard (disastrous, critical, margina and trivial) (Table 1). Risk probability was categorized in frequent, probable, occasionally, unlikely and improbable (Table 2) (Haimes *et al*., 2002). Finally, controls were recommended based on the standards and viewpoints of the safety and occupational hygiene experts. Due to the forecasts of the new conditions, the extent of risk reduction and severity of the risks were computed and finally, modifications were recommended.

Table 1: Risk intensity levels

Definition	Level	Title
Death or failure of system	1	Disastrous
Wound, occupational disease or serious damage to the system	2	Critical
Wound, occupational disease or small damage to the system	3	Marginal
Wound, occupational disease, trivial damage to the system	4	Trivial

Table 2: Risk probability levels

Definition	Level	Title
Frequent occurrence is probable	A	Frequent
Happens during the life cycle of the system	B	Probable
Occasional over the life cycle of the system	C	Occasionally
It is probable while it may never happen during the life cycle of the system	D	Unlikely
Highly improbable it may be assumed that there is no risk	E	Improbable

RESULTS AND DISCUSSION

According to the filled out worksheets, eight energies and 28 risks were identified. Based on the risk categorizations, there were six unacceptable risks, twenty non-preferred risks and two acceptable risks, after revision. There was no risk at acceptable level without revision (Table 3).

As listed in Table 4, after imposing the controls there is zero unacceptable risk, three non-preferred risks, six acceptable risks with revision and nineteen acceptable risks without revision (Table 5-7).

Table 3: Classification of risk frequency based on risk before imposing the controls

Risk index	Risk category	Frequency	%
Unacceptable	1A, 1B, 1C, 2A, 2B, 3A	6	21.4
Non-preferred	1D, 2C, 2D, 3C, 3B	20	71.5
Acceptable with revision	1E, 2E, 3D, 3E, 4B, 4A	2	7.1
Acceptable without revision	4C, 4D, 4E	0	0.0

Table 4: Classification of risks frequency based on risk indices after imposing the controls

Risk index	Risk category	Frequency	%
Unacceptable	1A, 1B, 1C, 2A, 2B, 3A	0	0.0
Non-preferred	1D, 2C, 2D, 3C, 3B	3	10.7
Acceptable with revision	1E, 2E, 3D, 3E, 4B, 4A	6	21.5
Acceptable without revision	4C, 4D, 4E	19	67.8

Table 5: The frequency of risks based on energy

Energy	Frequency	%
Potential	4	14.2
Rotational energy	8	28.6
Chemical	5	17.9
Radiation	1	3.5
Noise and vibration	2	7.2
Atmospheric	2	7.2
Electrical	4	14.2
Others	2	1.2

Table 6: The frequency of risk severity levels and probability of risk before imposing controls

Severity level and probability of risk	Frequency	%
2C	5	17.8
2D	5	17.8
2E	1	3.5
3D	2	7.2
1C	3	10.7
2B	3	10.7
3C	2	7.2
3B	6	21.6
1D	1	3.5

Table 7: The frequency of risk severity levels and probability of risk after imposing controls

Severity level and probability of risk	Frequency	%
2D	2	7.2
2E	4	14.2
3D	2	7.2
4E	7	25.0
4D	10	35.7
4C	2	7.2
1D	1	3.5

The available risks were detected using ETBA Method which is a widely used method. Erickson concluded that this method is a reliable method to detect the risks. Senstos reported that one of the main methods for risk assessment in industrial processes is to assess the control system which is being used by them, as it is in ETBA Method (Reyes *et al*., 2010). Mandal and Maiti (2014) confirmed that energy sources and control layers needs to be examined before achieving more effective control methods instead of merely focusing on errors and human factors (Mandal and Maiti, 2014). The same approach was followed in this study and the results showed that 26 risks were at unacceptable and non-preferred levels which were at higher priority for controlling the measures. Nezhadali *et al*. (2008) used ETBA Method on spherical container and showed that ten unacceptable risks, seven non-preferred risks, eight acceptable risks before revision, and five acceptable risks after revision were found out of 30 detected risks. In addition, Zaravashani, used ETBA in metal casting industry and found that out of 156 detected risks, 40 were unacceptable, 68 were non-preferred and 46 were acceptable after revision. Sarsangi studied central air conditioning system of a hospital using ETBA and found eight energies and 35 potential risks out of which 12 were unacceptable, 20 were non-preferred and three were acceptable. Our results indicated that eight energies out of which rotational kinetic, chemical and potential energies with frequencies of 8, 5, 4 and 4 had the highest frequencies, respectively. Doshmanfana *et al*. (2006) used ETBA Method in a car painting workshop and found that two groups of risks or energies were at higher priorities for implementation of control approach. The first group was chemical energies that might lead to disastrous accidents (e.g., fire outbreak and cancer) and the second group was the energies that frequently cause an accident at the studied workshop. Zeroshani *et al*. (2010) reported that potential and thermal energies with respectively 51 and 38 risks were the most risky energies argued that the highest risk levels were pertinent to chemical and electrical risks.

CONCLUSION

Communication is one of the critical issues in controlling for detected risks. Mutual communication between the supervisors and the workers which ensures dissemination of safety information from the supervisors to the researchers and recognition of safety problems and issues and controlling recommendation brought in by the researchers would be of great helps. Another way to improve the safety level of the workers is to educate the workers at different levels; so that they are empowered to control the risks through curtailing hazardous and unsafe behaviors. Safety educations must be provided along with professional educations so that the staff would be equipped with technical knowledge of how to handle and operate the equipment. Throughout professional education, the employees would learn about their positions in the organization as well as the regulations and specifications of their jobs, knowledge, skills and their tasks' description (Zaroushani *et al*., 2010). Based on the findings, the following recommendations are made to attenuate the risks in thestudied workshop: to promote, emphasize and motivate the usage of proper personal safety equipment to control noise levels to reduce the exposure time to noise to implement an effective repair and maintenance services to implement the job rotation to establish strategies and safety goals and to codify safety programs for realizing annual goals. Finally, since the results put more emphasis on the risks of kinetic and rotational energies, using the standard and proper shields and safety equipment are recommended.

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