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On implementation of health and safety measures in re-beaming department of denim manufacturing – a case study

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Abstract

Increased number of accidents in a work place has raised concerns for cooperate social responsibility. It is condemned to put worker's health and safety at jeopardy and earn maximum profit. A company can lose its competitive advantage if the issues of occupational health and safety are not fulfilled. In this study, antecedent of health and safety incidents in a re-beaming department of denim manufacturer was examined. It was acknowledged that incidents of health and safety issues are linked to the productivity and thus the financial performance of a company. This study established that, adopting an occupation health and safety system can improve the firm financial performance and enhance the competitiveness by creating the safe and socially accepted workplace.

Key words

Textile;
Health;
Safety;
Safety culture;
Ergonomics;
Hazard analysis.

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1. Introduction

The textile industry are categorized as labor intensive industry and valued at approximately $439.1 billion dollars [1]. However, textile industry carries major risks related to personnel health and safety. Primarily, there are different types of hazards involved in the textile industry; biological, physical, chemical and ergonomics which can lead to potential accidents at workplace [2]. Whereas, world health organization (WHO) report suggests that the workforce involved in textile processing are mostly suffers diseases like respiration, lung cancer, kidney stones, deafness, musculoskeletal disorders, insomnia, fatigue, stress and blood pressure [3]. Health related hazards associated with textile industry can be spontaneous or builds-up over the time. Ultimately both could lead to long term disabilities and serious health problems. It is therefore quite crucial to design the job and work station from the workers safety and health point of view, so as to reduced work related injuries and illnesses [4].

Textile processing generally involves exposure to cotton dust, noise, chemical and temperature. Besides, the most common disease prevalent among the textile workers is byssinosis (brown lungs) .This is due to significant exposure to cotton dust [5, 6]. Exposure to chemical is also a foremost issue in a textile sector, especially for those labors who are working in dyeing and printing departments. Benzidine-based chemicals, optical brighteners, solvents and fixatives, crease-resistance agents are widely used in textile manufacturing units releasing formaldehyde, flame retardants which are extremely dangerous to health. Prolonged exposure to these agents can cause lung and brain cancer. Whereas, the direct exposure to these chemicals with skin can also cause serious health issues [7]. Textile workers are continuously exposed to noise (particularly machine sound). It is established that various brain diseases are linked to noise. [8]. It is also significantly responsible in damaging the eardrum, consequently, causing the hear-loss. Besides this, abrupt pulse rate,

blood pressure and sleep disorders problems have also been observed. Chemicals used in dying processes are accountable for eye and respiratory diseases [9]. Whereas, there are also ergonomic related issues in processing textile good. The continuous repetitive nature type of job has increased the musculoskeletal disorders in textile workers. Performing tasks in an incorrect posture, improper ventilation system and improper workplace design has caused the worker serious muscles related injuries and disabilities [10, 11]. Research [12] suggests that more than 50 percent of interviewed workers were dissatisfied due to job-related noise, adoption of incorrect posture, incorrect handing of material and tools, repetitiveness and thermal environment. Further, it has been reported that 336000 individual in 2009 were withdrawal from their job due to work related musculoskeletal disorders [13].

Hussain et al [14] concluded in a research that incorrect posture adoption is the main reason of work related musculoskeletal disorders(WMSDs). Moreover, the associated level of risk is extremely high as per rapid entire body assessment (REBA) method. Isler et al [15], led an investigation using methods such as, REBA, Ovako Working Posture Analyzing System (OWAS) and PLIBEL (Plan for Identifiering av Belastnings faktorer, which is a Swedish acronym describing a method for identification of ergonomics hazards), to studied the working postures and musculoskeletal system stress factors among textile workers. Workers of the six departments; ironing, cutting, quality control, sewing and packaging were observed and photographed. Results were analyzed and it was inferred that strong relationship exist between the working conditions and health factors. It was argued that analysis of ergonomic risk factors should also be plan in order to improve the working conditions of workplace. Comper et al [16] studied two different production sections of a textile industry. The level of exposure to ergonomic related risk factor using job factors questionnaire (JFQ) and quick exposure check (QEC) was evaluated. The critical factors highlighted by JFQ were; incorrect spinal posture, long hour working with injury or uncomfortable feeling and environmental temperature. While, QEC result confirmed that the lumbar spine and wrists/hands are particularly vulnerable. Also, it is evident from world health organization (WHO) and international labor organization (ILO) report that the third major cause of disability and early retirement is work related musculoskeletal disorder [1].

The main goal of any business is to maximize the profitability which is directly linked with the productivity. In a field of industrial engineering number of techniques are available to increase the productivity and among them hazard identification risk assessment, and control (HIRAC) is one. This systematic technique provides organization with an opportunity to anticipate the possible risks and suggest its proactive countermeasures. Risk is the possibility of any uncertain condition; loss, injury, disability or any harmful impact on the lives of human. The end result of risk analysis is to reduce the accidents and improve the efficiency, productivity and reliability of existing process [17]. Risk associated with workplace can be evaluate, prioritized and classify in context to health and safety [18]. Fatih et al [19] conducted an experiment in a textile firm using two multi-attribute decision making criteria; bayesian best-worst method (BWM) and vise kriterijumska optimizacija i kompromisno resenje (VIKOR). BWM method was first use to weight the six crucial factors; frequency, hazardous event, cost sensitivity of not using personal protective equipment, detectability of the hazardous event and ranked the hazards as per VIKOR method. The study concluded that electricity and related hazards have the highest priority among the other prevalent hazard at a workplace. Research has been conducted to identify and mitigate the risk using failure mode and effect analysis (FEMA) integrated with fault tree analysis (FTA) and belief in fuzzy probability estimations of time (BIFPET) in a textile industry [20]. However, it was noted that the study was based on suggesting improved methods for hazard identification rather than the hazard analysis. Bathrinath et al [21], conducted a study to identify the most influential risk that can cause an accident using a hybrid multi-criteria technique AHP-TOPSIS (Analytic Hierarchy Process (AHP) and Technique for order of preference by similarity to ideal solution (TOPSIS)). Factors that were found critical during this study were; poor lightening and ventilation conditions, high noise, dust, poor electrical maintenance and unwillingness to perform work. It was established that all these factors were directly linked with the workers' productivity at workplace and their health. Mathews et al [22] presented that to take a greater competitive advantage, textile industries should have proper luminosity at workplace, layout that improve ventilation, use of personal protective equipment for noise reduction , installation of dust collector and regular preventive electrical maintenance for workers health and safety.

In developing countries, most of the work in a manufacturing industry is being handled manually which puts worker health and safety in jeopardy. It is established [23] that healthy workforce can do maximum contribution. Also, the practices and awareness related to safety at workplace can bring a positive change and enhance the productivity as well. Further, labor in developing countries is unaware to understand the associated risks of practicing unsafe

act. This makes risk control actions quite difficult for the management to observed, implement and handles it. Research suggests that there is a strong correlation exists between the well managed occupational health and safety system and increased productivity [24, 25]. In this work an approach has been developed to reduce the occupational accidents and conceptualized the safety culture by utilizing the proactive approach for safety performance in a textile industry.

2. Methodology section

The study was conducted on the issues raised by a denim textile. An official meeting with the personnel was conducted and issues like occupational health, hazards and environmental impact on worker health were consulted. Issues such as ill health, absentees and less productivity were highlighted during interviewing the staff. It was found that the company was investing huge amount on medical bills due to occupation effecting on the health of workers. To cater the problem, HIRC (hazard identification, risk assessment and control) activity was conducted and implemented.

Following steps were used for this:

1. By using the process flow chart, hazards were identified for each step/job. Premises inspection, accidental history, occupational health and safety checklist (guidelines in ISO 45001 standard) and talking to the workers were the main sources of hazard identification.
2. Risk assessment was performed. For this, risk assessment matrix was developed and the probability/chance, the worker is exposed to the hazard and therefore the injury is determined.
3. Control protocols for reducing the risk and related injuries were developed in order of the risk priority and implemented.
4. The success of the HIRC activity were regularly reviewed and measured.

3. Current scenarios and Study results

In this study, analysis of health and safety is performed in a Re-beaming department of a denim manufacturing as per organization request. Also, as per record of the company, large number of incident and its associated medical cost were spending on re-beaming department employees. Re-beaming process is carried out on a dyed yarn for further processing. The dyed yarn rope is connected to a roller which passes through a comb separating its threads and rolled it again on a beam.

On average, the rope is composed of 450 threads. The rope is pulled by the motor. The speed of this motor is controlled by an operator with an accelerator beneath the foot and its statistics can be noted on the screen. Process setup is shown in Figure 1.

3.1. Employee Participation

The labor is entitled to perform variety of routine tasks for this process.

1. A new beam is carried by a forklift from storage to the machine.
2. Two people place the beam inside the machine and a profoundly high pneumatic load is applied to fix the beam.
3. The threads which compose the rope are expanded and passed through the comb by the operator.
4. The rope is manually winded by an operator on the beam and the rotational speed of the beam is kept minimum.
5. The operator run the motor at fine speed and removes a knot that holds the threads together to form a rope at intervals by his hands. The formic acid spreads into the atmosphere while the machine operates.
6. If the rope coming out of the drum is entangled than a person tangled it.
7. The threads winded on the beam are taped by a person at low rotational speed before taking it out of the machine.
8. The beam is carried by a forklift operator to the next department.
9. A person is responsible to clean the floor continuously so that the cotton dust does not compile and disturb the process.

Looking into the Re-beaming process, variety of segments were identified that may excite the incidents/accidents. In order to reduce the associated hazards a technique HIRC was utilized. This method can be applied to the processes and could be a help to rapidly estimate the risk involve by simply identifying the hazards and its exposure. First of all, a systematic methodology of decision matrix risk-assessment technique, based on severity and likelihood rating was contemplate to evaluate the involved risk [26]. According to decision matrix risk assessment technique, the likelihood and severity scale is first determined then decision table is constructed.

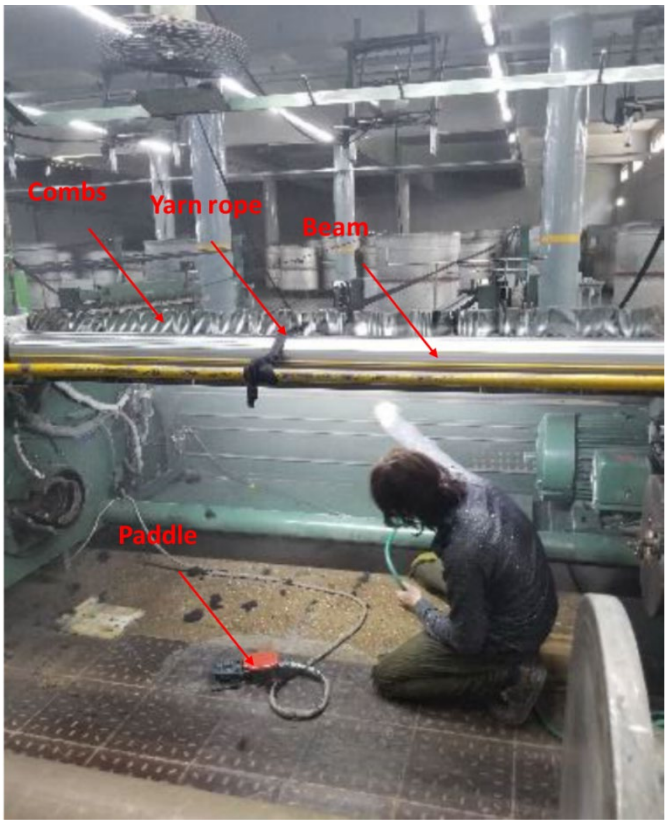


Fig.1. Re-beaming process setup

Table 1 shows the qualitative and quantitative scale description for the likelihood and severity for the selected process. The scale was identified based on the reports of previous events in the company and on the research studies on the selection and evaluation of scale ratings [27, 28]. Table 2 shows the matrix of risk assessment. Classes of risk (insignificant, tolerable, significant, and unaccept-able) were recognized by multiplying the probability (likelihood) and the magnitude (severity).

The risk analysis was initiated by identifying the hazards. All the conditions at the department were methodically observed for the identification of hazards. The scope of hazard identifications was kept limited to the process that involves labor in a routine task, in a re-beaming process. Table 3 presents the hazards analysis at re-beaming department.

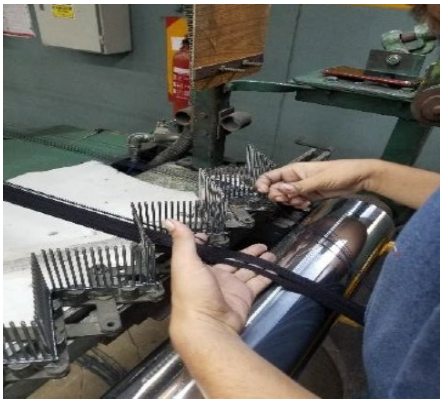
Table 1. Qualitative and quantitative scale for likelihood and frequency

Term	Scale	Description
Likelihood		
Frequent	5	Occurs frequently
Probable	4	In a life span of the element will occur several time
Occasional	3	Will occurs sometimes
Remote	2	Might a possibility
Improbable	1	Assumed occurrence is not possible
Severity		
Catastrophic	5	Lost (causality/system lost)
Critical	4	Major illness /Major occupational injury/ major damage to system
Minor	3	Minor illness /Minor occupational injury/Minor damage to a system
Inconsequential	2	illness /occupational injury/damage to a system (Less than minor)
Negligible	1	illness /occupational injury/damage to a system (ignorable)

Table 2. Risk assessment matrix

Likelihood	**Severity**				
Scale	**1**	**2**	**3**	**4**	**5**
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25
Risk category: **1-4: insignificant, 4-8: tolerable, 8-12: significant, 12- above: unacceptable**					

Table 3. Hazard analysis in re-beaming department with respect to labor Involvement in routine processes

Description	**Identified Hazards**
A new beam is carried by a forklift from storage to the machine.	Crushing, Slip and fall of a beam
 Machine is being cleaned before starting the new process.	Eye problems Respiratory Problems due to chemical inhalation Skin Problems Straining & Spraining Cleaning noise temporary deafness Glare Beam fall Hit while standing up
 The new beam is being setup.	Cutting & Tearing Squeeze-point Run-in points Straining & Spraining Puncturing Hit by machine component.
 A helper is setting the rope through the different stages of the setup and removing the entanglements.	Skin Problems Trip and fall Slip and fall Hit and fall Eye injury
 The operator is combing the threads soaked with formic acid.	Skin Problems Cutting & Tearing Splash of acid droplets. threads cut comb cuts or puncturing eye injury

Description	Identified Hazards
 The operator uses his hands to keep the layers of thread straight onto the cylinder.	Skin Problems Cutting & Tearing Finger crushing Puncturing
 The operator uses his foot to control the rotational speed of the beam.	Straining & Spraining Crushing Foot entangled Trip and fall
 The forklift operator is transporting the processed beam to the output storage zone.	Crushing Squeeze-in-point Run-in points Straining & Spraining
 During process cotton dust is stacked up on the ground.	Respiratory problems Slip Dirt accumulation

From close inspection of the situation and as evident in Table 3 it was found the majority of identified hazards lies under the category of working conditions, ergonomic and chemical hazards (appendix).

In a present situation the risk incidence in a re-beaming process is labeled in table 4.

Table 4. Current risk incidence in a re-beaming process

Operations	Types of hazards			
	Physical	Conditions	Ergonomic	Chemical
1. A new beam is carried by a forklift from storage to the machine	9	10	4	1
2. Machine is being cleaned before starting the new process	4	9	9	1
3. The new beam is being setup	4	12	12	1
4. A helper is setting the rope through the different stages of the setup and removing the entanglements	2	8	9	5
5. The operator is combing the threads soaked with formic acid	3	10	10	12
6. The operator uses his hands to keep the layers of thread straight onto the cylinder	3	9	4	9
7. The operator uses his foot to control the rotational speed of the beam	3	10	8	4
8. The forklift operator is transporting the processed beam to the output storage zone	2	12	12	4
9. During whole process cotton dust is stacked up on the ground	2	8	10	10
Risk category: 1-4: insignificant, 5-8: tolerable, 9-12: significant, 13- above: unacceptable				

From Table 4 it is evident that the extraordinary risk involved, in all the steps of re beaming process is associated with conditional and ergonomic hazard. At the same time the risk of chemical hazard was also identified. This was mainly valid to step five, six and nine. Thus, the strategies were developed to reduce the associated risk.

3.2. Control Strategy

In general, companies invest lot of energy in developing training programs that challenges difficult issues that make workers realize the danger encounter in their work place. Mostly this is with respect to machinery, equipment and using personal protective equipment. However, the awareness programme developed in this research will describe the activities that will be beneficial to the management to manage occupational injuries and illness and hence the medical expense and absentees. By adopting this programme, in long term business will enjoy increased productivity and profitability.

The first step of the programme is to develop the human factor circle. It should consist of worker, supervisors, managers, engineers, safety personnel and ergonomist. The purpose of this circle is to serve as a regulatory body within the organization on the health and safety issues of the labor. Yet, all and above top management commitment in providing resources and keeping worker included in whole process is a key to a success. The proposed programme is consisted of the following three phases as per the guidelines of ISO 45001 standard.

Phase 1: Deterrence and control of hazards

Phase 2: Training and educating employees

Phase 3: Health Administration

However, the details of the programme were extended keeping the textile sector of less privileged countries.

3.2.1. Phase 1 - Deterrence and control of hazards

The first phase of the programme is to reduce or eliminate the sources of identified hazards. The following four controls measures were realized to minimize the hazards.

1. *Engineering control:* Modifying the design of process as per the comfort level of the worker to eliminate the hazard.
2. *Administrative control:* limiting the exposure to the hazards by rotating the workers timing. It's a temporary solution.
3. *Work practices:* Developing standard operating procedures so that the workers become habitual to use safe practices during their work. Nonetheless, it was noted that SoPs were developed but not implemented. On implementation strategy, human factor team was made responsible to train every employee on safe work performing techniques, monitoring the work place to reduce risks, breaks and pauses and ensure proper housekeeping and maintenance.

4. *Personal Protective Equipment (PPE):* PPE should be provided and workers should be trained to understand the benefits of using PPEs to reduce the risk of injuries.

Meanwhile, it is to note that engineering control is a technological control while other three are behavioral control. Table 5 presents the suggestion for control measure however, company was more focus to adopt behavioral control measures.

Table 5. Suggestion for control measures

Engineering control
1. Use slasher dying process as it will combine dyeing and sizing into the single process. 2. Comber machine to combe the threads should replace hand combing. 3. Role of actuators should be introduced to govern the mechanical movement of the machine, example setting and aligning the beam. 4. Sensor technology should be incorporated to generate the signals which enable the control requirement, example the torque on rollers. 5. Guarding system should be in placed so as to restrict the worker from the direct contact on the rollers.
Administrative control
1. Display warning signs on the machines. 2. Monitor the working area for human comfort, such as temperature, luminosity, ventilation etc. 3. Introduce the concept of supervising by foot, so as to ensure that SOPs are being followed.
PPES
1. Provide gloves for handling chemical. 2. Place rubber mats for machine paddle. 3. Proper safety suit should be provided (avoid loose clothing). 4. Safety boots should be warned.

3.2.2. Phase 2 - Training and educating employees

The aim of this phase is to enhance the common understanding of the workers, regarding the probable risk of injuries, their symptoms, causes, treatment and deterrence. For this a session was planned that covers the participants from manger levels to worker level. The contents of the training were carefully organized that includes the topic on the following:

- Hazards in textile industries
- Musculoskeletal disorders / psychosocial problems
- Responsibilities of organization
- First aid
- Safe practices to prevent occupational injuries
- housekeeping
- In house safety rule and regulations / promoting safety
- Labor law and work compensation
- Training evaluation and periodic assessment of the trainings were also made part of the programme. It was suggested that such trainings should be judicially employed so as to take the greater advantage of this tool. This can ensure the reinforcement of safe practices in building the safety culture within an organization.

3.2.3. Health administration

The purpose of health administration was to ensure that the health care resources were utilizing effectively. The medical management program was prepared and its prime focus was on injury and illness dissuasion, early mediation of injuries and illness and management of chronic injury. This program is in the initial phase of its establishment at the studied company.

4. Conclusion

This study identifies that the health and safety aspect of a company is linked to productivity and financial performance of a company. The information that was collected during the study suggests that workers were working in poor working environment while have no knowledge of correct postures to perform a job. Also, it was revealed through symptom survey form and interviews that there are related health issues too. The HIRAC activity results also highlights that there are conditional and ergonomical hazards associated with the re-beaming process. In this study an awareness program was anticipated and implemented to educate the workers regarding the injuries and illnesses that are prone by job and postures to perform that job. It is recognized that if the suggested awareness programme is employed and followed in its true essence, it will assuredly upsurge the worker morale and their commitment to perform job and help management to increase its yield and cost-effectiveness. It is determined that it is better, to train the workers for adopting preventative measures to ensure the guaranteed safe and healthy working environment.

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6. Appendix

In this research context, following definitions were thought-out as per ISO 45001:2018 guidelines.

Safety: The condition of being protected from injury.
Injury: damage to a body (temporary or permanent) that compromise the effectiveness and efficiency of a person and thus the productivity.
health: Identifiable, adverse physical or mental condition arising from and/or made worse by a work activity and/or work-related situation that result in absentees.
Hazard: An agent that has a potential to cause injury or ill health.
Risk: Exposure to the danger
Chemical hazard: Hazards that results in health and physical impact such as, skin irritation, respiratory problems, blindness or blurriness, dizziness, confusion etc.
Biological hazard: Include viruses, bacteria, animals, insects, molds, fungus, plants, blood etc. that cause adverse impacts on health.
Physical hazard: Environmental factors that can harm an employee, not necessarily by touching them, like fall of an object, noise, air pollution etc.
Ergonomic hazards: Postures and gestures that can results in musculoskeletal injuries or diseases.
Condition hazards: Hazards as a result of unsafe working conditions, damage things, exposed wires, no safeguards etc.