Ergonomic practices for packing tasks in a printing ink manufacturing factory

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ABSTRACT: The purpose of this study was to assess the operational workloads for packing tasks in a printing ink manufacturing factory located in northern Taiwan, with an aim to lower the risk of musculoskeletal disorders (MSDs) among the workers. The packing task operators pack 2000 1-kg ink cans per day on average, with sets of 12 ink cans packed into paperboard boxes. The Key Indicator Method (KIM) was used to evaluate and identify the MSD risk factors associated with the ink packing tasks. The data collected include material weights, work posture, work pace, vertical distances, vertical lifting displacement, and lifting frequency. The mean lifting frequency was 4166 lifts/day and the average lifting weight was 1.44 kg/lift. The KIM risk score of the packing task was evaluated as 40, indicating a risk level of 3. To improve working conditions and reduce health and safety risks for this packing task, a 70 cm height worktable was suggested to replace the original 39 cm height worktable. This simple intervention can allow the operators to move the ink cans more smoothly and efficiently without bending their backs as they pack the cans. In addition, the estimated operator risk score was reduced to 24, indicating a risk level of 2. This suggested change has been adopted by the ink company and implemented for their packing tasks.

Keywords: manual lifting tasks, workstation design, ergonomic risk identification

1 INTRODUCTION

According to occupational injury records, musculoskeletal disorders (MSDs) in Taiwan account for 33% of total work injuries in recent years (Taiwan IOSH 2005). Musculoskeletal disorder is also the most widespread occupational disease in Taiwan (Fig. 1) and the related medical loss of NT$ 2 billion was approximately 0.67% of Taiwan’s GDP for the year 2009 (Taiwan IOSH 2010).

The occurrence of MSDs is usually a result of factors such as excessive force, repetitive movements, awkward postures, prolonged exposure, and exposure to low temperature or vibration (Putz-Anderson 1988). The body parts most often affected by MSDs are the lower back, neck, and upper extremities (shoulder, arm, and wrist). MSDs not only endanger worker’s health but also reduce their productivity. Therefore, addressing the lowering the risks for developing MSDs of the workers is crucial to improving labor health and safety and increasing business productivity.

Several ergonomic interventions, such as workstation redesign, employee training, and working condition improvement, have been reported to mitigate risk factors causing MSDs. This paper presents a case study in which risk factors of MSDs in an ink manufacturing company were evaluated and identified. In addition, simple interventions were also recommended and implemented to enhance the health, safety, and productivity of company employees.

Figure 1. Occupational disease category distribution in 2009
2 METHOD

2.1 Ergonomic assessment tools
This research used the following two checklists to assess the MSDs risks at the worksite of a printing ink manufacturing plant located in northern Taiwan.

2.1.1 Baseline risk identification of ergonomic factors (BRIEF)
The BRIEF checklist was designed to quickly identify occupational engineering risk factors in the workplace (Humantech Inc. 1993). This checklist can evaluate six body parts: hands and wrists, elbows, shoulders (the above three parts, all have right and left sides) along with neck, back, and legs. The main risk factors evaluated by the BRIEF tool are force, posture, repetitiveness, and work duration. Tasks associated with other risk factors, such as exposure to vibration, mechanical pressure, and low temperature, should be referred to professional personnel for further analyses. According to the guidelines of the BRIEF method, if two or more risk factors are identified for a given body part, this body part has a strong possibility of developing MSD.

2.1.2 Key Indicators Method (KIM)
KIM was developed by Germany’s Federal Institute for Occupational Safety and Health (BAuA) and Committee of the Länder for Occupational Safety and Health (LASI). It has been adopted and used by several other EU countries for risk assessment of manual load handling (SLIC 2010). This method evaluates relevant activity data called key indicators. The indicators include duration, frequency and distance with a multiplier for weight, posture and working conditions. The method is quite suitable for application to industrial practice. KIM simplifies the assessment procedure into the three following steps:

1. Determine the time rating point: Identify the task as a lifting, holding, or carrying task and then determine the corresponding time rating point from the KIM rating table, according to the number of daily lifts, the holding duration, or the carrying distance.

2. Determine the rating points for load, posture, and working conditions: With the KIM rating table, look up the load rating points for male or female operators that correspond to the effective load (the real action force that is necessary for moving the load). Identify the typical working posture and load position of the task in order to determine the rating points for posture. The rating points for working conditions account for the presence of environmental hazards such as workspace limitation, physical obstacles, uneven or unsteady flooring, inadequate lighting, or poor gripping conditions, etc.

3. Compute risk score and determine risk level: Compute the total risk score of the task by multiplying the time rating point by the sum of the rating points for load, posture, and working conditions. Measure the task’s risk level by consulting the KIM defined risk score range (level 1: risk score < 10; level 2: 10 ≤ risk score < 25; level 3: 25 ≤ risk score < 50; level 4: risk score ≥ 50).

This classification of the risk scores gives an indication of any load bottlenecks.

2.2 Ergonomics investigation process
The ergonomics evaluation process included a formal meeting and a tour of the shop floor (onsite inspection). In the meeting, the chief inspector first introduced the ergonomics investigation process and then dialogued with the employers and major crew members to gather an overview of the work and the key problems experienced by the inspected company. During the tour, inspectors collected field data of specific tasks by talking with individual operators, taking photographic and video evidence of manual materials handling tasks, and measuring task demands and physical dimensions of inspected workstations. BRIEF and KIM tools that enabled the quantification of data were used for explaining problems to management. The inspectors drafted and sent the company an inspection report with adjustment suggestions, and a follow-up meeting was arranged afterward to discuss the efficacy of the suggested adjustments.

3 ERGONOMIC PRACTICES

3.1 Ink packing tasks
In the factory's ink packing station, operators filled ink into 1-kg cans and packed every 12 of those ink cans into a paperboard box. The working area was about 33 m², with a mixer barrel, a filtering tank (Fig. 2), a capping machine on a worktable (Fig. 3), and paperboard boxes on pallets. The filtering tank was fixed on a steel frame (120 cm from the floor) of 50-cm height and 50-cm diameter. The dimensions of the capping machine were 52-, 46-, 60-cm in length, width, and height, respectively, and it was situated on a worktable of 150-, 70-, and 54-cm in length, width, and height, respectively. The dimensions of the pallets and paperboard boxes used for packing ink cans were 1.2 m x 1.2 m x 15 cm and 53 cm x 40 cm x 16 cm in length, width, and height, respectively. A team of 2 to 3 operators, aged from 40 to 50 years, was employed to complete the ink packing tasks.

The shop floor tour inspected the ink filtering, can filling and weighting, and paperboard box labeling procedures. When the semi-finished material in the mixing barrel was pumped into the filtering tank,
one operator stirred the ink in the filtering tank with a stick (Fig. 4) to reduce the viscosity of the ink. Then, the second operator sitting in front of the filtering tank filled the ink can to 1 kg weight. After filling, the second operator moved the can onto the table at her left hand side. Then, the third operator cleaned the can body, capped the can using the capping machine, packing the cans into the paperboard box, and piled the paperboard box on the pallet.

During the stirring operation, the worker was standing with one hand above his shoulder level. For the filling and weighing operations, the worker was sitting with neck flexed to gaze the weight scale and to control the ink filling valve at the bottom of the filtering tank. The third operator packed the cans into the paperboard boxes with a flexed trunk.

The operator conducted the filling task with her neck flexed looking at the weight scale. This static and non-neutral posture could lead to muscle fatigue of the neck and shoulders. Moreover, in order to accurately filling 1-kg of ink into each can, the operator repetitively flexed and extended her dominant wrist to control the outlet valve of the ink (Fig. 4). According to BRIEF tool analysis, the operator had a risk score of 2 at her wrist due to a radial deviation and holding duration > 10 sec; a risk score of 3 at her shoulder due to an elevation angle > 45°, and maintaining an award posture >10sec and 2 times/min; a risk score of 3 at her neck and back due to maintaining a forward bending and twisting posture > 10sec and 2 times/min. The operator had regional risk score at wrist, shoulder, neck, and back all greater than 2, indicating high probability of musculoskeletal disorders and need for working-posture adjustment. For the same operator, KIM assessment showed that lifting a 1-kg can for 2000 times/day with slightly bending and twisting trunk had rating points of 10 (time), 1 (load), and 2 (posture). Due to movement confinement caused by the workspace arrangement, the rating point of the work environment was estimated as 1. Her total KIM risk score was computed as 40 (risk level 4), indicating a highly increased load situation, with physical overload possible for the average persons. Hence redesign of the workstation was recommended according to KIM assessment.

The third operator made repetitive lifting movements: packing the paperboard boxes with cans and laying them on pallets. He handled 2000 1-kg cans per day, on average, and lifted and laid 12-kg boxes on pallets over 167 times per day. KIM assessment showed that his task risk score was 24 (risk level 2), indicating a possibility of physical overload only for

3.2 Problems statements
The operator who stirred the ink with an over shoulder posture could encounter muscle fatigue in his upper limbs from prolonged operation. Nevertheless, this action of reducing ink viscosity was not frequent. Therefore, investigators did not suggest any amendment to this task.
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3.3 Ergonomics interventions

The inadequate table height (57 cm) caused the operators to adopt awkward postures. A new workstation (Fig. 5) was thus devised to reduce stress on the operators due to inappropriate working posture. The newly designed workstation was L-shaped with 70-cm table height; the base of the mixer tank was raised from 70 cm to 140 cm accordingly. Two fillisters, one on each end of the table, were designed to position the weight scale and capping machine, respectively. The sunken depth of each fillister was designed to keep the surface of the scale and the capping machine at the same level of the table surface so that the ink cans could be moved easily on the surface level (Fig. 6). The capping machine was rotated 90° from its original orientation to have its entry aligned with the moving path of the cans.

The new worktable design allows operators to push cans horizontally to the capping machine after filling them, without any lifting and laying activities (Fig. 7). After workstation adjustment, the weight scale was elevated to a level that allows the operator to read its value comfortably. Furthermore, commercially available tilting devices, located at both ends of the worktable, could be used to raise and tilt a container or paperboard box. This arrangement could facilitate operators taking out empty cans from the container or putting filled cans into the paperboard boxes and sealing them (Fig. 8).

3.4 Efficacy of the ergonomics interventions

The proposed workstation redesign can improve work postures for the filling, weighing, and packing operators. The use of tilting devices can further prevent operators from bending their trunks and picking up empty cans from floor level. In addition, the muscle strain in their waists and upper extremities can be reduced. According to BRIEF analysis, regional risk scores can be reduced from 2 to 1 for the wrists, 3 to 1 for the shoulders, 3 to 0 for the neck, and 3 to 0 for the back (Fig. 9). Therefore, no awkward operator postures are expected to develop after the suggested adjustments are implemented.

For the filling task, KIM analysis shows that the rating points for posture can be reduced from 2 to 1, and the rating points for work environment can be lowered to 0 by means of the suggested workspace rearrangement. In addition, KIM assessment for the filling task after amendment falls within risk level 2, indicating physical overload is unlikely for healthy adults (Fig. 10).
CONCLUSIONS

This study conducted an ergonomic evaluation to reduce the identified risk factors associated with the developing of MSDs in a printing ink manufacturing plant. Based on the results of our ergonomic assessment, the worktable was redesigned to improve work postures for the filling, weighing, and packing operations. The new design can also reduce the repetition of can lifting for the filling operator. In addition, the design of the two fillisters will allow the operator to check the weight of ink in a neutral posture and to push the cans easily to the capping machine without extra effort. The use of tilting devices can further prevent operators from bending their trunks to pick up empty cans from floor level. In addition, the muscle strain in their waists and upper extremities can be reduced. Implementing these ergonomic interventions can not only improve work posture and increase worker comfort, but also reduce the risk of MSDs and potentially increase the productivity of this ink manufacturing factory.

ACKNOWLEDGEMENT

The authors would like to thank the Institute of Occupational Safety, Taiwan for financially supporting this research under Contract No. 973029 and 983067.

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