Ergonomic Interventions in Lighting Products Manufacturing Plant

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Abstract. This study emphasizes on ergonomic interventions at an assembly line in lighting products manufacturing plant located at Shah Alam, Selangor. Subjective assessment and direct observation methods were used to the operators and the workplace at manufacturing plant to uncover the problems. Subjective assessment used included interview and questionnaire via modified Nordic Musculoskeletal Questionnaires (NMQs). Direct observation involved site observations throughout the manufacturing plant completed with Rapid Upper Limb Assessment (RULA). The problems found that workers handled heavy lamps between the work station and poor design of lamp burning test station. Two ergonomics interventions were implemented. Wheel tray was applied for transporting the lamps in the assembly line, and new burning test station was introduced on the table. The implemented designs were simple and cost-effective. The ergonomics intervention was analysed and shown reduced in industrial risks and improved the working condition and occupational safety and health.

1.0 Introduction
Ergonomics is a science concerned with the interaction between humans and the work environment. It helps to improve the working surroundings for the use of the workers by fitting jobs to the employees to bring about industrial improvements [1]. Companies seek on various approaches such as ergonomics intervention to increase performance and achieve competitive benefits in terms of quality, productivity, cost savings and workers’ well-being [2].

Ergonomics interventions can be defined as a real life experiment was conducted. It is also one of the efforts to reduce the risk of ergonomics such as the musculoskeletal disorders (MSDs) in the industries. It can be done by improving the existing workstation design to promote the comfort of the workers. Ergonomic interventions involve adjusting a workers’ environment, behaviour, and other long-term educational approaches to treat and prevent further damage due to work-related musculoskeletal disorders [3].

In Malaysia, Social Security Organization (SOCSO) reported that issues of MSDs have increased sharply in recent years. The number of cases has shown 107 times increments from 2006 to 2016 [4]. The rise in MSDs also resulted a negative impact on the economic growth. Employees’ compensation for occupational diseases was recorded increased from RM2.65 million in 2009 to RM14.05 million in 2014 [5].

In this research, an ergonomics study was done at a lighting products manufacturer located at Shah Alam, Malaysia. The works at assembly section demands the workers physical strength and endurance as they deal with heavy lamp that is required to be handled carefully. Figure 1 shows assembly line at the manufacturing plant, while Figure 2 shows a worker assembling a big size of lamp. This study aims to implement an ergonomics intervention at the manufacturing plant. The problems at the
workplace have been detected by subjective assessment and direct observation. Two main problems were identified. Workers were handling big and heavy lamps between the workstations and poor design of lamp burning test station.

![Figure 1. Assembly line at the manufacturing plant](image1)

![Figure 2. Assembly works of lamp](image2)

2.0 Methodology
The purpose of this project is to design for human factors in the manufacturing plant of lighting products. The major focus is to minimize the ergonomics risk in the manufacturing plant. Series of steps were executed in order to complete the study.

2.1 Subjective Assessment
The assessment use to study the people involved in the system as measuring instruments. In essence, we rely on workers to come to some kind of conclusion about the system, and then access that conclusion as a measurement of the system. This assessment contains any method that gets its data from the psychological contents of people’s heads [6]. Typical methods used in subjective assessment are ranking methods, rating methods, questionnaire methods, interviews and checklists. A subjective assessment was analyzed using modified Nordic Musculoskeletal Questionnaires (NMQs). The questionnaire consists of 19 questions and distributed to 12 respondents at the workplace. All respondents were guided during answering the questionnaires to ensure understanding during the study.

2.2 Direct Observation
Direct observation is the method where the person who conducts the study merely walking around an operating human or machine system to see what goes on. Observation methods are useful in collecting not only quantitative data but also in collecting qualitative data on product routings, task sequences, causes of delays and error taxonomies [7]. The direct observation was conducted on the working process at the manufacturing plant to understand overall process and to investigate the problems that occur at the workstations. Observation data was analysed using Rapid Upper Limb Assessment (RULA) ergonomics tool. RULA is a survey method use in ergonomics investigations where work-related upper limb disorders are reported. This method requires no particular equipment in providing a fast appraisal of the postures of the neck, body and upper limbs along with muscle function and the external loads experienced by the body.

2.3 Implementing intervention and review
The proposed designs for intervention were introduced at the final assembly line where the problems are identified. After three months, the intervention results were reviewed again using NMQs and RULA methods. The outcomes were analysed and compared to reveal the effectiveness of the intervention.

3.0 Result and Discussion
The case study was done in assembly line at the manufacturing plant. The analysis was done based on the modified NMQs. Table 1 specifies the 9 working stations involved in the line. Based on the
interviewed, the workers mentioned about the requirement of physical strength while performing the works. They deal with heavy lamp and have to withstand stress over prolonged periods of time. Two tasks have been highlighted as the most challenging, handling of heavy lamps from one workstation to another and lifting the lamp during burning test.

Figure 3 shows the most tasks respondents hate doing. The burning test is the most hated tasks the respondents hate doing as agreed with 33% of the respondents. All four tasks required manual handling of heavy lamp especially when it moves toward the end of assembly line.

### Table 1. Working stations in assembly line

| No. | Working station                      |
|-----|-------------------------------------|
| 1   | PCB LED assembly                     |
| 2   | Wiring and PCB LED assembly          |
| 3   | Body and Wing assembly               |
| 4   | Glass assembly                       |
| 5   | Glass plate assembly                 |
| 6   | Top and rubber cover screw assembly  |
| 7   | Inspection and top cover sheet assembly |
| 8   | Roof assembly and packaging          |
| 9   | Burning test                         |

Figure 4 shows the respondents’ opinion on the weight of the product, while Figure 5 shows the needs of respondents to bend their body part while performing their task. Majority of the workers complained about the lamp weight and the needs to bends their body while handling the product in assembly line.

Figure 6 shows respondents’ body part discomfort. From the total of 12 respondents, data demonstrates 10 complaints of wrist/hand discomfort and 9 complaints of hips/thighs/buttocks, elbows and upper back. 8 complaints were found for neck, low back and knees, while 7 discomforts complaints were recorded for shoulder and ankle/feet.
3.1 Ergonomic Intervention 1: Wheel Tray

Transporting of the lamp between the workstations is handled manually by the workers at the assembly line. The task is being identified for improvement by ergonomic intervention due to its criticality. The weight of the lamp that is being handled by the workers is up to 20kg. Muscle effort increase in response to high load required which increases fatigue and risk of MSDs. Furthermore, the workers were working in the same position for a long time involving bending or twisting the back and working in awkward position.

With respect to the ergonomic analytical study, the wheeled tray has been decided to be used for the workers in the assembly line to move the product from one station to another. This wheel tray eases the workers to transport the lamp and reduce the unnecessary load that being carried by them daily. It also will improve operators’ working conditions, occupational health and safety, productivity and quality of the products. The wheeled tray consists of aluminium platform and four wheels as shown in Figure 7. Figure 8 shows a worker handling the heavy lamp manually, while Figure 9 displays after the intervention. The worker just needs to push the lamp on the wheel tray from station A to B to be received by the next worker.

3.2 Ergonomic Intervention 2: Burning test table

The lamp was being tested by switching on for about 30 minutes to one hour to ensure the condition of the lamp before it can be packed for delivery. Before the intervention, burning test was done by positioned the lamp on the test station as shown in Figure 10. The task is physically stressful because the worker needs to lift the heavy lamps (up to 20 kg) to be slotted to the testing pole. Workers are doing the task repeatedly for a long time, involving bending and twisting the back, and working in awkward position. The task can cause the pain to the worker’s neck, shoulder, wrist and low back.
The new intervention burning test table was made of a wooden platform, steel framework and four wheels. This table will ease the burning test process by eliminating the needs to lift the lamp. The lamp is pushed on the wheel tray from the assembly station to the test table and can instantly undergo the burning test. A maximum of five lamps can be tested concurrently. The new user friendly test table improve operators’ working conditions, occupational health and safety, productivity and quality of the products. Figure 11 shows the burning test process on the table.

3.3 RULA Score Analysis

The postural analysis was done using RULA method. A musculoskeletal loading associated with the worker’s posture were calculated for the posture of workers body part by giving a grand score. The analysis involving two main groups. Group A includes arm and wrist analysis. While group B represents neck, trunk and legs analysis. The posture scores of group A and B were then considered with muscle used and force load to obtain each group final score. The combination of these scores generating a grand score that represents the level of MSD risk. The RULA scores in Table 2 estimate the different levels of MSD risk and the resulting requirements for action.

| Score | Level of risk and Requirements for Action |
|-------|------------------------------------------|
| 1 or 2| Negligible risk, no action required       |
| 3 or 4| Low risk, changes may be required         |
| 5 or 6| Medium risk, investigation and changes are required |
| 7     | Very high risk, changes are required immediately |

Table 3 shows the comparison of RULA score before and after intervention 1. The grand score of RULA before the intervention is 7 indicates very high risk in handling heavy lamp to transports manually to the next station. The task required for engineering and/or work method changes to reduce or eliminate MSD risk immediately as outlined in the Table 2. The intervention was successfully reduced the risk of MSD with score 3.

The introduction of wheel tray on the assembly line minimize industrial risk such as the repetition of awkward posture and reduces excessive force on the workers while doing their tasks. The workers feel less tired compared to task before intervention. The workers are now more motivated as they feel comfortable.

Table 4 shows the comparison of RULA score before and after intervention 2. The grand score before the intervention is 7 indicates that task to lift the lamp for burning test is very high risk and required immediate action. Huge reductions for final score A and B indicates the task before intervention demand highly for workers strength and energy. Only big size of workers fit for the task.

The introduction of burning test table has improved the workers working condition and occupational safety and health. The issues such as lower back and neck pain have been eliminated because burning test process after intervention removed the unnecessary lifting process. The problem
of workers fails to do/ skip the burning test due of tiredness was eliminated and the workers can now focus on their daily task.

**Table 3.** Comparison of RULA score before and after intervention 1

| Part of RULA assessment | Before Intervention | After Intervention | Reduction |
|-------------------------|---------------------|--------------------|-----------|
| Score A                 | 5                   | 3                  | 2         |
| Final Score A           | 8                   | 4                  | 4         |
| Score B                 | 4                   | 2                  | 2         |
| Final Score B           | 7                   | 3                  | 4         |
| Grand Score             | 7                   | 3                  | 4         |

**Table 4.** Comparison of RULA score before and after intervention 2

| Part of RULA assessment | Before Intervention | After Intervention | Reduction |
|-------------------------|---------------------|--------------------|-----------|
| Score A                 | 6                   | 2                  | 4         |
| Final Score A           | 9                   | 2                  | 7         |
| Score B                 | 4                   | 2                  | 2         |
| Final Score B           | 7                   | 2                  | 5         |
| Grand Score             | 7                   | 2                  | 5         |

3.4 Respondents’ Body Part Discomfort (After Intervention)

After three months of running the assembly line with the new intervention, workers body part discomforts were evaluated again. Figure 12 shows respondents’ body part discomfort after intervention. The finding was compared to data before the intervention. The neck discomfort experienced by the workers have decreased from 8 to 2. Shoulder discomfort complaints were reduced from 7 to 3. Only 2 upper back problem recorded compared to 9 previously. Only 3 workers complaints about low back and knees pain. 4 workers mentioned about elbows and hips/thighs/buttocks discomfort, while 5 complaints regarding wrist/hands and ankle/feet discomfort. The result in overall shows ergonomics improvement for workers’ wellbeing after the intervention.

![Figure 12. Respondents’ Body Part Discomfort (After Intervention)](image)

4.0 Conclusion

This project executed an ergonomics study to improve operators’ working conditions, occupational health and safety and quality in the lighting products manufacturing plant. Two interventions have been applied to reduce the industrial risk and improve ergonomics condition on the assembly line. Besides direct observation and interview, modified questionnaires have been used to study the ergonomics in the manufacturing plant. Analyses conducted give the results that the workers in the assembly line were exposed to awkward working postures due to poor design of work station and the manual handling of heavy lamp. Wrist/hand, elbow and lower back were indicated as having the most work-related musculoskeletal disorder problem among the manufacturing plant workers. The results of RULA analysis after ergonomic interventions in the assembly line shows that industrial risks were minimized and working condition and occupational safety and health were improving.
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