The lean ergonomics in green design of crude palm oil plant

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Abstract. Ergonomics can help manufacturing and industrial engineers maximum work output without physical harm to workers. Physiology, biomechanics, anthropometrics, and allocation are the areas of ergonomics most useful to manufacturing in applying the concept of Lean and Green in manufacturing. These systems require efficient production and low use of resources such as energy and material. Its philosophy encourage worker to look at waste. This concept is applied in one of national plant of Crude Palm Oil (CPO) that located in North Sumatera. The problem found in the company are the working posture and excessive workload of the workers. These conditions are affects to the their job performance. The study was carried out by evaluated the worker body position using the Work Posture Assessment (WPA) and Biomechanics method. The WPA results shows the operator's working position was mostly bent more than 30 degrees. This indicates that almost all workers are felt musculoskeletal disorders during work hours. While the biomechanics analysis found the significant relation between the values of Recommended Weight Limit (RWL) and Lifting Index (LI) which the increase of RWL value will decrease the LI value. This indicated that the recommended load for a worker under certain circumstances affects the appointment made so as not to contain the risk of spinal injury. In fact these condition are due to in-efficiency in production which can be maintained the green design of CPO plant by improving the existing work.

1. Introduction
Workers are an important asset for the company, but sometimes, company is less attentive to the needs and interests of workers. There are still many companies don’t have standard methods and ergonomic facilities for supporting the production process, it caused workers often have complaints on the part of their body. Complaints that arise due to the lack of ergonomic facilities and posture of the workers, causing workers feel less comfortable [1].

Manual handling and lifting are major causes of work-related low back pains (LBP) and impairments. Therefore, it is important to design MMH tasks ergonomically and safely from an economic and ethical point of view so that industry-related accidents including LBP can be prevented [2]. In another study, some of the ergonomic factors that could cause increased worker injury were identified [3]. Some of the factors identified were: lifting, bending, stooping, squatting and carrying loads. As for biomechanics, the RWL and the LI are based on the concept that the risk of work-related lower back pain (LBP) increases as the demands of the lifting task increase. In other words, as the magnitude of the LI increases, so does the risk of LBP.
PT. X is one of the largest plantation companies in Indonesia, where there are operators who work in positions that lack of ergonomic in several stations. This palm oil factory has 8 stations consisting of a loading ramp, tripler and track, pressing, kernel plant, clarification plant, boiler, workshops, and sorting. Operators’ complaint found on the loading ramp station, tripler and track, a boiler, workshops and the kernel. Operator complained of pain in the back, arms, neck, shoulders, legs, and thighs.

The improvement for posture and working methods of the operator who works on palm oil plant, is carried out by take the picture of operator working posture, then do the measurement and calculation of the angle based on REBA (Rapid Entire Body Assessment) and Biomechanics because this method can be used to assess the interference factor of the body on the operator. Similar research also has been done in various studies before such as [1, 2, 3].

2. Methodology
This research uses the science of ergonomics to finish problem on Palm oil factory which deals with complaints of fatigue, workload, and work posture.

2.1. Work Posture Analysis (WPA)
REBA (Rapid Entire Body Assessment) is a method developed by Sue Hignett and Lynn McAtamney, this method is effectively used to assess workers posture, effort used, and the type of movement of workers. REBA (Rapid Entire Body Assessment) judge the load that handled within a work system, the coupling and activities undertaken. This method is used because it is relatively easy to find out the value of a member of the body, because it is not necessary to find a specific angle of body, but just a range of angles. In the end the final value of REBA (Rapid Entire Body Assessment) gives an indication of the level of risk of a work and the action to be carried out/taken [5]. Questionnaire of REBA (Rapid Entire Body Assessment) shown in Figure 1.

2.2. Biomechanics
Work biomechanics is the study of interactions of workers with equipment, machinery and materials, so that workers can improve their performance and on the other hand can minimize the risk of injury in workplace (musculoskeletal). According to Frankel and Nordin, biomechanics uses the concept of physics and engineering to describe movement in a variety of body parts and the forces on the body in daily activities. According to [6] occupational biomechanics is the study of the relationships between workers and equipment, the working environment and others to improve performance and minimize the possibility of injuries.
Recommended weight limit is the limit load recommendations that can be raised by humans without causing injury even though the work is repetitive and is done in a long time period. RWL is defined by NIOSH in 1991 in the United States [7]. The equation to determine the recommended load to a worker under certain conditions according to NIOSH as follows:

\[ \text{RWL} = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \]

where:
- \( \text{RWL} \): The recommended load limit
- \( \text{LC} \): Lifting Constant = 23 kg
- \( \text{HM} \): Horizontal Multiplier = \( \frac{25}{H} \), which \( H \) in centimeter.
- \( \text{DM} \): Distance Multiplier = \( 0.82 + \frac{4.5}{D} \) which \( D \) in centimeter.
- \( \text{AM} \): Asymmetric Multiplier = \( 1 - (0.0032 \times A) \) which \( A \) in degree.
- \( \text{FM} \): Frequency Multiplier
- \( \text{CM} \): Coupling Multiplier
- \( \text{VM} \): Vertical Multiplier = \( (1 - (0.003 \times |V - 75|)) \) which \( V \) in centimeter.

Lifting index is an estimate of the relative physical stress associated with manual lifting jobs. When the value of LI increases, the level of risk that is given to workers increased, and the percentage of the workforce who may be at risk will increase as risk associated with lower back pain (LBP).

\[ \text{LI} = \frac{\text{Workload}}{\text{RWL}} \]

Where:
- \( \text{LI} < 1 \) = the work isn’t too risky
- \( \text{LI} > 1 \) = the work have risky potential (specially musculoskeletal disorder)

Then, Biomechanic problems were analyzed by the formulation of RWL and LI of the operators who are experiencing complaints using ErgoFellow Software.

### 3. Result and Discussion

#### 3.1. Work Posture Analysis (WPA)

Work posture using REBA (Rapid Entire Body Assessment) and the improvement for operator that has a score of REBA 'need treatment' and 'need treatment as soon as possible' is shown in Table shown in Table 1.

| No | Activity | REBA Score | Improvement | Description |
|----|----------|------------|-------------|-------------|
| 1  | Real CAD | 10         | (Need treatment as soon as possible) | The operator should use tojok to withdraw palm oil from the top of the mast delimiter |
| 2  |          | 6          | (Need treatment) | Operator can roll up the cord with the position more upright |

Table 1. Reba Recapitulation
| No | Activity Real | REBA Score | Improvement | Description |
|----|---------------|------------|-------------|-------------|
| 3  | 3             | 10         | Operator should push using both hands to reduce the load (Need treatment as soon as possible) |
| 4  | 4             | 3          | -           | (May need treatment) |
| 5  | 5             | 6          | Operator can roll up the cord with the position more upright (Need treatment) |
| 6  | 6             | 3          | -           | (May need treatment) |
| 7  | 7             | 6          | Operator can pull the sticks without having to bend down (Need treatment) |
| 8  | 8             | 1          | -           | (No treatment needed) |
| 9  | 9             | 6          | Operator can pull the sticks with the position of the arm is lowered and the position of the upper arm straight down (Need treatment) |
### Table 1. Reba Recapitulation (Continued)

| No | Activity | Real REBA Score | CAD REBA Score | Improvement | Description |
|----|----------|----------------|----------------|-------------|-------------|
| 10 | Real CAD | 10             | 8              | 8 (Need treatment as soon as possible) | Operator can pull the sticks without having to bend down |
| 11 |          | 11             | 7              | 7 (Need treatment) | Operator can steer sticks without having to bend down |
| 12 |          | 12             | 4              | 4 (Need treatment) | Operator lifted the wheelbarrow with an upright position |
| 13 |          | 13             | 11             | 11 (Need treatment as soon as possible) | Operator can do the welding with the sitting position rather than squat |
| 14 |          | 14             | 8              | 8 (Need treatment as soon as possible) | Operator can sculpt with sitting position rather than squats |

From Table 1, it can be seen that almost 80% operators needed a treatment to improve their performance. Some of REBA score even reach 8-11 score which means the work postures are in dire need of immediate corrective action. Through the assessment of REBA, the results show that bending posture associated with squatting, pushing, and pulling task has high exposure to health problems. Similar finding is also found in various studies such as [8] and [9].

### 3.2. Biomechanics

Biomechanics problems were analyzed by the formulation of RWL and LI of the operators who are experiencing complaints using ErgoFellow Software. The result of the calculation of operators’ RWL and LI shown in Table 2.
Table 2. RWL and LI Recapitulation

| Operator | RWL  | LI   | Operator | RWL  | LI   |
|----------|------|------|----------|------|------|
| 1        | 6.93 | 2.309| 8        | 9.602| 2.43 |
| 2        | 8.182| 2.331| 9        | 9.638| 2.442|
| 3        | 8.823| 2.333| 10       | 9.728| 2.448|
| 4        | 8.874| 2.343| 11       | 9.818| 2.592|
| 5        | 9.395| 2.364| 12       | 9.858| 2.607|
| 6        | 9.419| 2.386| 13       | 9.869| 2.811|
| 7        | 9.466| 2.395| 14       | 9.961| 3.319|

Based on the Table 2, the average of RWL is 9.254, but the standard of RWL is 6.93. It means RWL in the work place is already exceeds the limit. While the average of LI is 2.507, it means a great possibility for operators affected by musculoskeletal disorder. The relationship between the RWL values and LI values was illustrated at the Figure 2.

Figure 2. The Relationship Between RWL and LI

Figure 2 shows that there have a significant relation between the values of Recommended Weight Limit (RWL) and Lifting Index (LI) which the increase of RWL value will increase the LI value. The higher the RWL value the higher is also the value of LI. This indicates that the more weight that is lifted then the risk of experiencing musculoskeletal disorders will be higher. For the recommended improvement, as suggested in [10]; an ergonomic intervention with the aim of reducing external back loading should therefore primarily focus on major factors such as the height and horizontal distance of the load and not just on workers’ technique. Chung &Kee [2] also suggested that the job should be evenly distributed within 2 hours or less work cycles followed by a sufficient recovery period, to keep the lifting frequency less than 0.5 lifts/min.

4. Conclusion

Working postures of operators on the oil palm factory is requires treatment, especially for operator 2, 5, 7, 9, 11, and 12. This result prove that working posture on this oil palm factory have mistake and needs improvement in order operators are not distracted and experience fatigue during the work.

The result of biomechanics of the operators is the RWL was between 6-9.5 kg for all operators. As for LI the entire operator exceeds the limit of LI > 1 = the work has risky potential
Both of these methods indicate that the necessary improvements of work posture, working methods, or working facilities from oil palm factory.

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