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Application of biomechanics in industry

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Abstract. Biomechanics is an important factor in ergonomics. Therefore, in this research will be applied biomechanical calculation. This research is conducted in the manufacturing industry engaged in the processing of oil palm. As for the processing process has several stages. The core of this research is to examine the work done by the operator. Where often occur complaints on the insertion of fresh fruit bunches. Common complaints are fatigue of joints and muscles caused by many activities that occur continuously in the sorting. In this study, biomechanical measurements were made, where the measurements consisted of permitted weight limits, lifting index, and the maximum load limit that may be removed. This is considered important because so far the operators and the industry is not aware of it. They do so unwittingly impose body condition. Causing musculoskeletal disorders and other risks that may occur. Based on the Recommended weight and lose weight measurements of the fresh fruit bunches workers who did not meet the fraction it can be concluded that lifting the fresh fruit bunches that did not meet the fraction contained the risk of musculoskeletal disorders and based on the measurement of maximum permissible limit obtained the AL <Fc <MPL, the sorting of fresh fruit bunches that do not meet the fraction should be careful.

1. Introduction

Biomechanics use physics and engineering concepts to explain the movement in various parts of the human body and the acting of forces on the human body in daily activities. This implies that the biomechanics involved several disciplines including problems physiology, physical science, and human behavior.

This research was done in palm oil mills. Sorting part at this plant requires a lot of physical work in sorting activity, is due at the acceptance time of the fruit and sorting activities occur continuously so that can cause fatigue through joints and muscle tissue.

To overcome these problems can be done with biomechanics approach to determine the permissible moment and style that allowed the worker in sorting fresh fruit bunches that are not appropriate with their fractions. Biomechanics uses the concept of mechanics and physiology to explain movements in various parts of the body and the forces acting in everyday activities.

There are many researches about biomechanics, especially specific part of human body, including the study of biomechanics of the shoulder on the human body [1]. In fact, there is research on cells - brain cells involve the calculation biomechanics statistically [2]. There is also a study comparing the biomechanics of the human jaw [3]. There are even researching about breast implants on the biomechanics [4]. Besides that, biomechanical also see the effects of the tools used such as a computer [5]. Other studies also involving children like doing fitness and fatigue effect of biomechanics in overweight and obese children [6]. Other study also concerns about the biomechanics of the human shoulder [7]. Other studies on the biomechanics also addressed the issue of the world of sport, such as research on the impact of the head associated with a concussion diagnosed woman collage ice hockey player [8]. Other studies related to pregnant women, which observed at the time to sit and walk [9].

Some of the above study clearly states that research on the biomechanics it is very important, therefore this research also viewed the biomechanics of workers in the palm oil mills. Why this study is considered feasible, because the workload of workers at the oil mill work is very heavy. Workers often complain about their work.

2. Methodology

The study was preceded by an initial survey and continued with data collection in the palm oil mill. Collecting data in this study conducted by using resources that directly obtained from the review of activities in the field in the form of primary data by recording into video the activity on the part of the sorting plant. Primary data is the attitude of the operator in the sorting job of fresh fruit bunches that are not appropriate fractions.

Recommended weight limit (RWL) is defined for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (8 hour 3 per day) without an increased risk of developing lifting-related LBP (Low Back Pain). RWL formulated as follows:

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \qquad (1)$$

Working biomechanical measurement is used to determine the recommended weight limit, lifting index, and maximum permissible limit so it can be known whether the work of fresh fruit bunches sorting that does not fit fractions can cause spinal injuries and attitudes or actions that should be carried on the work of sorting the raw fruit is not suitable with the fraction.

Lifting index (LI) is a variable that states estimate the relative physical stress of a removal activity. The formula for LI is written below.

$$\text{Lifting Index(LI)} = \text{Load Weight} / RWL \qquad (2)$$

The larger the value LI, the greater the level of risk to get injured in an appointment activity.

MPL or maximum permissible limit is the limit of the amount of compressive force on the segment L5 / S1 of the activities of the rapture in Newtons standardized by NIOSH (National Institue of Occupational Safety and Health) in 1981. Large compressive force is below 6500 N at L5 / S1. While normal restrictions force (the Action Limit) by 3500 at the L5 / S1. So, if Fc <AL (secure), AL <Fc <MPL (need careful) and when Fc> MPL (dangerous). Limitation of the maximum permissible lifting force, which recommended NIOSH (1991) is based on the compressive force of 6500 N pd L5 / S1, but only 1% of women and 25% of men are expected could go beyond this lift.

3. Result and Discussion

3.1. Determination of recommended weight limit value

The formula used for calculating the value RWL is as follows:

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

where:

RWL = Recomended load limit

LC = *Lifting Constant* = 30 kg

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HM = *Horizontal Multiplier* = 25/H
VM = *Vertical Multiplier* = 1 – 0,00326 |V – 69|
DM = *Distance Multiplier* = 0.82 + 4,5/D
AM = *Asymetric Multiplier* = 1 – 0.0032A
FM = *Frequency Multiplier* (dari tabel)
CM = *Coupling Multiplier* (dari tabel)

1. Origin Data
- LC (Lifting Constant) = 30
- HM (Horizontal Multiplier) = 25/H
= 25/65
= 0.385
- VM (Vertical Multiplier) = 1 – (0.00326|V – 69|)
= 1–(0.00326|110– 69|)
= 1 – (0.00326 (41))
= 1 – 0.10106
= 0.866
-DM (Distance Multiplier) = 0.82 + 4,5/D
= 0.82 + 4,5/50
= 0.82 + 0,09
= 0.910
-AM (Asymetric Multiplier) = 1 – (0.0032 (A))
= 1 – (0.0032 (0))
= 1
- FM (Frequency Multiplier)
According to the multiplier coupling frequency table the multiplier value will be FM. Unknown frequency lift / min isas much as 5, duration of action for 2 hours < t <8 hours and V> 75 then obtained FM 0.35.
- CM (Coupling Multiplier)
Based on object handles fair and V> 75 CM obtained by 1.00.

From the data above, the RWL value is calculated as follows:
RWL = LC × HM × VM × DM × AM × FM × CM
= 30 × 0.385 × 0.866 × 0.910 × 1 × 0.35 ×1.00
= 3.186

2. Destination Data
- LC (Lifting Constant) = 30
- HM (Horizontal Multiplier) = 25/H
= 25/20
= 1.25
- VM (Vertical Multiplier) = 1 – (0.00326|V-69|)
= 1-(0.00326|110-69|)
= 1 – (0.00326 (44))
= 1 – 0.1434
= 0.856
- DM (Distance Multiplier)= 0,82 + 4,5/D

= 0,82 + 4,5/50
= 0,82 + 0,09
= 0,910

- AM (Asymetric Multiplier)= 1 – (0,0032 (A))
= 1 – (0,0032 (60))
= 0,808
- FM (Frequency Multiplier)
According to the multiplier coupling frequency table the multiplier value will be FM. Unknown frequency lift / min is as much as 5, duration of action for 2 hours < t <8 hours and V> 75 then obtained FM 0,35.
- CM (Coupling Multiplier)
Based on fair object handles and V75 acquired CM 0,95.

From the data above, the RWL value is calculated as follows:
RWL =LC × HM × VM × DM × AM × FM × CM
= 30 × 1,25 × 0,856 × 0,910 × 0,808 × 0,35 × 0,95
= 7,848

Table 1.RWL Result Recapitulation

Name	Hand Location	RWL
Agus	*Origin*	3,186
	Destination	7,848

3.2. Determination of Lifting Index Value
The formula used for calculating the value of IP is as follows:

$$LI= \frac{Load\ Weight}{Recommended\ Weight\ Limit}$$

Where:

LI = Lifting Index

L = Load

RWL= Recommended Weight Limit

If : LI ≤ 1, the activity does not have the risk of spinal cord injury.

LI > 1, the activity has the risk of spinal cord injury.

Based on the formula above, the calculation of the data LI origin or destination data. The steps in the calculation is as follows:

1. Origin Data
   LI = L/RWL= 8/3,816= 2,10
2. Destination Data
   LI = L/RWL= 8/7,848 = 1,02

3.3.Determination of Lifting Index Value

1. Origin dan Destination Data

Figure 1. Origin Position

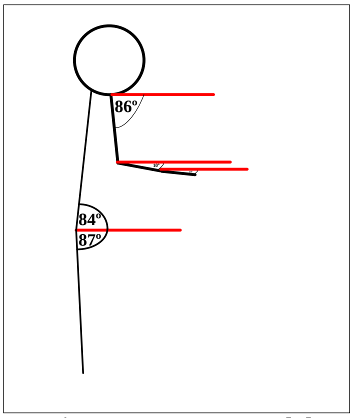

Figure 2. OriginModel

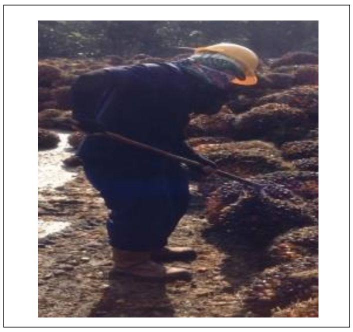

Figure 3. Destination Position

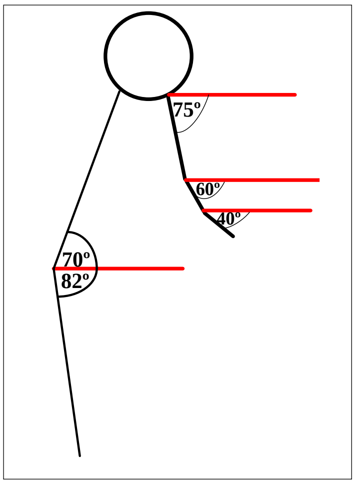

Figure 4. Destination Model

Table 2. Force recapitulation at each body segment

Hand Location	Palm		Forearm		Upper Arm		Back	
	WH	Fyw	WLA	Fye	WUA	Fys	WT	Fyt
Ori	0,36	4,36	1,02	5,38	1,68	7,06	35,04	49,16
Dest	0,36	4,36	1,02	5,38	1,68	7,06	35,04	49,16

The recapitulation of the calculation of forces table on each segment of the body of the operator Agus can be seen in table 2.
The recapitulation of the calculation of moments table in each segment of the body of the operator Agus can be seen in table 3.

Table 3. Moment recapitulation at each body segment

Hand Location	Mw	Me	Ms	Mt
Origin	74,036	192,178	204,329	609,084
Destination	57,637	117,202	162,289	980,379

The recapitulation of carriers Agus Fc calculation table can be seen in table 4 and table 5.

Table 4. Fc calculation result recapitulation

Hand Location	PA	FA	FM	Wtot
Origin	2,540	1184,100	-2483,2	49,16
Destination	3,787	1761,282	-3678,744	49,16

Table 5. Fc Calculation result recapitulation

Hand Location	Fc	AL	MPL	Kategori
Origin	3662,16	3500	6500	Hati-Hati
Destination	4642,31	3500	6500	Hati-Hati

4. Conclution

Recommended Weight Limit (RWL) operator sorting TBS improper fractions to the data origin and destination data are each 3.186 and 7.848 with a frequency of removal of as much as 8 times and asymmetrical destination angles of 60º which produce Lifting Index (LI) is greater than one (LI> 1) the removal of the TBS activity that does not fit fractions containing the risk of spinal cord injuries and risks that obtained by calculation Maximum permissible limit (MPL) are Fc, AL <FC <MPL, the activities need to be handle carefully.

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