Work Load Analysis of Phosphoric Acid Filling Activities Using Ovako Working Analysis System (OWAS) Method

Roslani Ginting¹ and Bayu Suwandira²

¹,²Industrial Engineering Departement, Faculty of Engineering, Universitas Sumatera Utara, Indonesia

E-mail: bayusuwandira27@gmail.com rosnani@usu.ac.id

Abstract. PT. XYZ runs a palm oil processing plant (CPO) into its derivative products with a refinery and fractionation process with a capacity of 600,000 tons per year. The technology used in the process of refinery and fractionation has been done automatically. However, the filling of auxiliary materials is still done manually, specifically in filling the auxiliary material Phosphoric Acid into the tank. This activity is carried out continuously can cause the risk of musculoskeletal disorders in workers. To ensure this, the distribution of the Nordic Body Map questionnaire was carried out to determine the complaints experienced by workers in these activities. In this case the analysis was carried out using the OWAS (Ovako Working Analysis System) method by providing output in the form of work attitudes that are at risk of occupational accidents in the musculoskeletal section. From the results of data processing, it is obtained category 3, where repairs need to be done as soon as possible / as soon as possible. For that reason the authors propose three improvements, namely the operation of TK 300, using a forklift, and designing work facilities.

1. Introduction
In a company, workers are the most important resource for running their business processes. Workers in manufacturing companies also play a very important role that can support the quality of a finished product, especially if the company is still implementing Manual Material Handling (MMH). Excessive physical workload can also cause the risk of health problems or even work accidents [1]. Musculoskeletal Disorders are one of the injuries that are often experienced by workers in carrying out Manual Material Handling (MMH) activities, namely injuries to muscles, nerves, tendons, bones, joints, cartilage caused by work activities [2].

PT. XYZ runs a palm oil processing plant (CPO) into its derivative products with the Refinery and fractionation on process with a capacity of 600,000 tons per year. Products resulting from processing the oil is cooking oil / RBDOL (Refined bleached deodorized olein) or also called olein as the main product and RBDST (Refined bleached deodorized stearin) or also called stearin, RBDPO (Refined Bleached Deodorized Palm Oil) and PFAD (Palm Fatty Acid Destilate ) as a by-product

PT. XYZ produce products Edible oil (olein) and their derivative products more are produced continuously (continuous process) with the raw material of CPO (Crude Palm Oil) and supporting materials it is Phosphoric Acid (H3 PO4 ) and Bleaching Earth (BE) . To be able to maintain its existence, PT. XYZ must be able to maintain the quality of its products. The quality of goods produced is determined by the course of the process from the beginning of production to finished goods produced. The technology used in the process of refinery and fractionation has been done.
automatically. Everything has been done by using software that is monitored in the control room. However, the filling of auxiliary materials is still done manually, especially in the filling of Phosphoric acid auxiliaries to the tank. The difficulty of filling this material makes the involvement of several people must be given the weight of this Phosphoric Acid reaches 35 Kg.

The actual conditions for filling Phosphoric Acid into the tank can be seen in the following image:

![Figure 1. Actual condition of area](image-url)

The results of the questionnaire recapitulation Nordic Standard Questionnaire (SNQ) can be seen in table 1:

Table 1. Nordic questionnaire standard recapitulation results for refinery and helper operators

| No. | Type of complaint                  | Grievance Level |
|-----|-----------------------------------|-----------------|
|     |                                   | Painless | A little sick | Sick | Very ill |
| 0   | Stiff pain in the upper neck      | 2        | 7             | 0    | 0        |
| 1   | Stiff pain in the lower neck      | 2        | 6             | 1    | 0        |
| 2   | Pain in the left shoulder         | 5        | 1             | 3    | 0        |
| 3   | Pain in the right shoulder        | 0        | 4             | 5    | 0        |
| 4   | Pain in the left upper arm        | 6        | 1             | 2    | 0        |
| 5   | Back pain                         | 1        | 4             | 4    | 0        |
| 6   | Right upper arm pain              | 1        | 3             | 5    | 0        |
| 7   | Low back pain                     | 0        | 3             | 5    | 1        |
| 8   | Pain in the lower waist (butt)    | 4        | 3             | 1    | 1        |
| 9   | Pain in the buttocks              | 7        | 1             | 1    | 0        |
| 10  | Pain in the left elbow            | 7        | 1             | 1    | 0        |
| 11  | Pain in the right elbow           | 4        | 3             | 2    | 0        |
| 12  | Pain in the left forearm          | 6        | 2             | 1    | 0        |
| 13  | Pain in the right forearm         | 3        | 2             | 4    | 0        |
| 14  | Pain in the left wrist            | 4        | 2             | 3    | 0        |
| 15  | Pain in the right wrist           | 3        | 2             | 4    | 0        |
| 16  | Pain in the left hand             | 5        | 1             | 2    | 1        |
| 17  | Pain in the right hand            | 0        | 3             | 5    | 1        |
| 18  | Pain in the left thigh            | 7        | 1             | 0    | 1        |
| 19  | Pain in the right thigh           | 6        | 2             | 0    | 1        |
| 20  | Pain in the left knee             | 7        | 1             | 1    | 0        |
| 21  | Pain in the right knee            | 6        | 2             | 1    | 0        |
| 22  | Pain in the left calf             | 4        | 5             | 0    | 0        |
| 23  | Pain in the right calf            | 3        | 6             | 0    | 0        |
| 24  | Pain in the left ankle            | 9        | 0             | 0    | 0        |
| 25  | Pain in the right ankle           | 9        | 0             | 0    | 0        |
| 26  | Pain in the left leg              | 8        | 1             | 0    | 0        |
| 27  | Pain in the right leg             | 7        | 2             | 0    | 0        |

| Total | 126 | 69  | 51   | 6    |
2. Theoretical Background
The term ergonomics comes from the Latin words "Ergon" and "Nomos" (law nature) and can be defined as the study of aspects of deep humanity of its work environment which is reviewed in anatomy, physiology, psychology, engineering, management and design or design. Ergonomics also deals with optimization, efficiency, health, safety and human comfort at work, at home, and recreation areas. In ergonomics, the study of ergonomics is needed people, work facilities and their environment interact with the main goal namely adjusting the work atmosphere with humans [3]. Ergonomics is also referred to as "Human Factor". Ergonomics is also used by various experts or professionals in their respective fields, for example, such as: anatomist, architecture, designer ergonomics products, physics physiotherapy, occupational therapy, psychology and ergonomics techniques [4].

2.1. Workload
Workload is a group or a number of activities that must be completed by an organizational unit or position holder for a period of time certain [5]. Regulation of the Minister of the Interior No. 12/2008 states that workload is the amount of work that must be shoulerd by a position / organizational unit and is the product of volume work and time norms. If ability workers are higher than demands work, boredom will emerge. But on the contrary, if ability workers are lower than demands work, it will appear tired which is more. Workload charged to employees can be categorized into three conditions, namely workload that conforms to standards, workloads are too high (over capacity) and burden work that is too low (under capacity) [6].

2.2. OWAS (Ovako Work Analisys System)
OWAS is a method of attitude analysis work that defines movement body parts of the back, arms, legs, and heavy lifting. Each these limbs are classified be work attitude [7]. The selection of humans as internal labor carrying out material handling activities not without reason. Material handling manually it has several advantages as follows:

- Flexible in motion so provide ease of transfer load on confined spaces and irregular work.
- For light loads it will be cheaper when compared to using machine.
- Not all materials can moved with the tool.

3. Research Methodology
This research is applied research because it aims to solve real problems in the company. Based on the method, this research is a type of work analysis and activity research. This study seeks to investigate in detail the activities or jobs in order to get recommendations for improvement so that efficiency is obtained.

The object of research was the Operator / Helper who worked on the filling of Phosphoric Acid auxiliaries, work postures, workloads and work facilities.

The determination of research variables is based on preliminary studies, literature studies and company experience relating to the problems being faced [8]. The variables contained in this study are:

- Independent Variable, a variable -free affecting the dependent variable either positively or negatively. The independent variables in this study are:
  - Operator's working posture in lifting Phosphoric Acid.
  - Workload on removal of Phosphoric Acid which weighs up to 35 kg.
- Dependent Variable, is a bell variable whose value is influenced by the value of other variables. The dependent variables in this study are:
  - Improvement Design, namely the design of improvements to the filling of Phosphoric Acid by making a work facility design.
Providing repair options in the form of operating TK 300, using forklifts and building work facilities

The design used in this study is a descriptive analysis which analyzes the work and activities undertaken. The research carried out aims to investigate the activities and work carried out by humans in more detail. The results of research that have been done are expected to provide information for the needs of a company in the future.

4. Result and Discussion
Primary data collection is carried out by distributing questionnaires to operators, specifically refinery operators and helper who are directly involved in filling this Phosphoric Acid helper. The questionnaire regarding complaints - complaints experienced by the operator after filling the activity Phosphoric Acid. The questionnaires were distributed to all operator refinery and Helper PT. XYZ, amounting to 9 people.

The data used in the OWAS (Ovako Working Posture Analysis System) Method is to use one of the Helper documentations when manually removing the Phosphoric Acid to the tank. Following documentation, a Helper lifts the conductor of Phosphoric Acid into the tank can be seen in Figure 2.

![Figure 2. Work posture](image)

Can be seen a Helper who was lifting Phosphoric Acid up the stairs to fill the tank. This process is still done manually which causes many of the fatigue effects felt by the operator and the Helper. Dose Phosphoric Acid every day that must be filled into the tank about 35 conductors which this activity can take approximately 30 minutes for the appointment process, not the filling stage. Based on the picture above, the work posture code can be determined using the OWAS method as follows:

- Back attitude
  OWAS Code : 2
  Attitude   : Bowing

- Arm Attitudes
  OWAS Code : 1
  Attitude   : Both arms are under the shoulders

- Leg attitude
  OWAS Code : 7
  Attitude   : Walking

- Weight Load
  OWAS Code : 3
  Load weight: Greater than 20 Kg (W> 20 Kg)
OWAS Attitude Result: 2-1-7-3

The following results of calculations with OWAS method 2-1-7-3 can be seen in table 2.

| Back | Arms | Back | Arms | Back | Arms | Back | Arms | Back | Arms | Legs |
|------|------|------|------|------|------|------|------|------|------|------|
| 1    | 1 1 1 1 1 1 | 1    | 2 2 2 2 2 2 | 1    | 3 3 3 3 3 3 | 2    | 2 2 2 2 2 2 | 3    | 3 3 3 3 3 3 | 4    | 4 4 4 4 4 4 |
| 1    | 2 2 2 2 2 2 | 2    | 3 3 3 3 3 3 | 2    | 4 4 4 4 4 4 | 3    | 5 5 5 5 5 5 | 4    | 6 6 6 6 6 6 | 5    | 7 7 7 7 7 7 |
| 1    | 3 3 3 3 3 3 | 2    | 4 4 4 4 4 4 | 3    | 5 5 5 5 5 5 | 3    | 6 6 6 6 6 6 | 4    | 7 7 7 7 7 7 | 4    | 8 8 8 8 8 8 |
| 1    | 4 4 4 4 4 4 | 3    | 5 5 5 5 5 5 | 4    | 6 6 6 6 6 6 | 5    | 7 7 7 7 7 7 | 5    | 8 8 8 8 8 8 | 6    | 9 9 9 9 9 9 |

Based on the OWAS attitude code obtained, the category value falls on code 3. Category 3 value means that this attitude is dangerous in the musculoskeletal system, work posture results in a very significant tension effect. Need repairs as soon as possible.

4.1. Proposed Improvement

4.1.1. Operate TK 300. TK 300 is a Phosphoric Acid tank with a capacity of more than 5 tons, which has not yet been operated because the Phosphoric Acid vendor in a tank truck does not yet exist. If TK 300 is used, it certainly will greatly help supply Phosphoric Acid to the Degumming process. Because there is no lifting activity carried out by the operator / helper. Because the filling principle is that the truck will be near TK 300 then Phosphoric Acid in the truck will be pulled using a pump to enter TK 300. Following the actual conditions TK 300 can be seen in Figure 3.

![Figure 3. The actual condition](image)

4.1.2. Using a Forklift. Forklifts are one of the material handling materials commonly used to assist human work in lifting heavy loads. In this case the forklift is used to help lift the Phosphoric Acid to TK 312 (Phosphoric Acid tank). Following pictures of the forklift and TK area 312 can be seen in figure 4.
The working principle is that the conductor of the Phosphoric Acid is lifted using a forklift and immediately lifted up the stairs. But the obstacle is in the forklift entrance to the plant. The narrowness of the fork lane makes it vulnerable to crashing incidents on the sidewalk lane. So the researchers suggest making a new path for the forklift to enter in front of the plant entrance. Next, the entry point of the forklift into the plant can be seen in Figure 5.

4.1.3. Make Work Facility Design. The proposed improvements made by this work posture obtained the results of the category of 3 which has the meaning that this attitude is dangerous to the musculoskeletal system, work posture results in a very significant tension effect. Need immediate repairs as possible with these results it can be concluded that the work posture used in his work carrying out the appointment process of Phosphoric Acid which is done manually is not ergonomic [9]. Based on the results of interviews with operators and Helper, they said that some parts of their body felt pain such as aches, numbness cramps and even could hurt the palm of the hand if something goes wrong during the appointment process. Therefore it is necessary to improve this station to improve time efficiency and minimize workplace accidents.

Here the authors make a work facility design by adding a temporary container to facilitate the operator and helper in filling the Phosphoric Acid. The author sees an opportunity / space to be added next to the Phosphoric Acid tank to make a temporary tank. The following is the actual condition of the Phosphoric Acid tank area can be seen in Figure 6.
Figure 6. Actual conditions of area

From the picture above we can see that there is still enough space to do additional temporary phosphoric acid tank tanks. The aim is to minimize the level of fatigue and risk of accidents at the musculoskeletal site. The working principle is that the operator / helper only pours Phosphoric acid into a temporary tank, then the Phosphoric acid will be pumped upwards. The pump used uses a citric acid pump (besides the Phosphoric Acid pump). So this design requires the addition of pipes and valves that are integrated with the Citric Acid pump line. Her aim to reduce the cost / charge on this draft. Then the purpose is to make the tub like to avoid a Phosphoric Acid spill falling to the floor which causes the floor to be damaged [10].

Seeing the problems above, we know how risky it is if this continues. For that reason, the writer wants to design a work facility that can minimize the above problems such as damage to the floor due to the spill of Phosphoric Acid, the risk of work accidents when transporting the Phosphoric Acid conductor up the stairs for the filling process to the musculoskeletal risk arising from the heavy load carried by the operator on the when transporting up the stairs. Following the results of the temporary tank design Phosphoric Acid can be seen in Figure 7.

Figure 7. Results of temporary phosphoric acid tank design

5. Conclusion
Based on research conducted at PT. XYZ can be drawn as follows; PT. XYZ is a subsidiary of PT. Perkebunan Nusantara III (Persero) and PT. Perkebunan Nusantara IV, which runs a palm oil processing plant (CPO) into its derivative products with a refinery and fractionation process with a capacity of 600,000 tons per year. The problem that occurs is in filling Phosphoric acid auxiliaries which are still done manually. This causes a workload and risks an accident at the operator / helper who does this work. There are 3 proposed improvements related to the problem, namely operating TK 300, using a forklift and making work facility designs. This settlement is based on distributing questionnaires to the operator / helper who is doing the work and an analysis using the OWAS (Ovako Working Posture Analysis System) method.
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References
[1] Putra Widhi Adwitya Setiawan and Sriyanto Sriyanto 2018 Analisis Postur Kerja Menggunakan Metode Ovako Work Posture Analysis System (OWAS) (Studi Kasus: PT Sanggar Sarana Baja Transporter) Industrial Engineering Online Journal 7(2)
[2] Wignjosoebroto Sritomo 1995 Tataletak Pabrik dan Pemindahan Bahan. (Surabaya: Prima Printing)
[3] Tarwaka 2010 Ergonomi Industri; Dasar-Dasar Pengetahuan Ergonomi dan Aplikasi di Tempat Kerja (Solo : Harapan press)
[4] Nurmianto Eko 2004 Ergonomi Konsep Dasar dan Aplikasi Edisi ke-2 (Surabaya : Guna Widya)
[5] Apep and Syafei 2002 Analisis Musculoskeletal Disoders dalam Perbaikan Tempat Kerja Prosiding Seminar Nasional Teknik Industri III 2002. (Surakarta: Universitas Sebelas Maret)
[6] Wijaya Andy 2008 Analisa Postur Kerja dan Perancangan Alat Bantu untuk Aktivitas Manual Material Handling Industri Kecil (Studi Kasus: Industri Kecil Pembuatan Tahu di Kartasuro) (Surakarta : Universitas Muhammadiyah)
[7] Astuti R dan Suhardi B 2007 Analisis Postur Kerja Manual Material Handling Menggunakan Metode OWAS (Ovako Work Postur Analysis System). Jurnal Gema Teknik. 10 (1): 67-75.
[8] Sinulingga Sukaria 2011 Metodologi Penelitian (Medan : USU Press)
[9] Kristianto A and Manopo R 2010 Perancangan Ulang Fasilitas Kerja Pada Stasiun Cutting yang Ergonomis Guna Memperbaiki Posisi Kerja Operator Sebagai Upaya Peningkatan Produktivitas Kerja. Jurnal Informatika 4 (2) pp 467-479
[10] Wignjosoebroto Sritomo 2008 Ergonomi, Studi Gerak Dan Waktu : Teknik Analisis untuk Peningkatan Produktivitas Kerja, Edisi Keempat, Cetakan Keempat (Surabaya : Guna Widya)