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RESEARCH ARTICLE

# Implementation of Tofu Pouring Tool to Reduce Physical Workload and Ergonomic Risks

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**ABSTRACT -** Industrial workers have an important role in influencing productivity and work efficiency. The problem of decreasing worker productivity due to workload and body posture occurs at UD Harapan Jaya Indah, in the production of fried tofu, where there are 3 work stations, namely pouring, cutting, and frying. In this study, body posture analysis was carried out using the Rapid Entire Body Assessment (REBA) method. Workload was measured by analyzing the Cardiovascular Load, and simultaneously conducted interviews to fill out the Nordic Body Map questionnaire, to find out workers' perceptions of the perceived workload. The results of this study are the design of the Tofu Dough Pouring Tool, which is the station that has the greatest workload. Of the 3 design concepts, concept 2 was selected as the best concept. Finally, the prototyping and implementation was carried out. Previously, workers' complaints on their backs were rated 7 (very painful) reduced to 1 (painful) after implementation. The REBA score before implementation had a moderate risk level (score 5-7), and after implementation was at a small risk level (score 3). The percentage of Cardiovascular Load in the pouring before implementation decreased from 31.55% to 28.7%

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## 1.0 INTRODUCTION

In the industrial era 4.0, changes in the industrial world occurred both in the field of technology and in human resources. Besides changes in development, competition is one thing that cannot be avoided. This competition will trigger every company to improve the quality of products and services provided in accordance with the wishes of consumers. Product quality is something that needs to be considered to maintain consumer trust and satisfaction. To achieve this, it is necessary to optimally empower the available resources. However, there are several factors that affect the decline in worker performance/productivity, such as an uncomfortable and hot work environment, an unorganized layout of production sites, to the workload received by excessive workers. Workload is a condition of work with several task details that must be completed by employees in a certain time that affects employee performance [1][2]. The number of tasks and responsibilities given to employees causes the results achieved to be less than optimal because employees only have limited time to complete many tasks.

Work posture which is the action taken by workers in carrying out their work [3] is very closely related to physical workload, where if the work position is ergonomic it will reduce workload and significantly reduce fatigue associated with work posture[4], [5]. If the implementation of ergonomics cannot be fulfilled, it will cause discomfort or pain in certain parts of the body. One health impact that arises as a result of non-ergonomic work postures is musculoskeletal disorders (MSDs) and other disorders that can interfere with work processes [6] [7].

Both of these problems will be dangerous if not addressed. One of the problems with decreased worker productivity due to workload and body posture occurs at UD Harapan Jaya Indah, an SMEs that produce fried tofu. There are 3 work stations that have problems with these SMEs, namely pouring, cutting, and frying. Harapan Jaya Indah is an industry engaged in the food sector, namely by producing various types of tofu. In the production area, there are workers who handle various parts consisting of soaking, cooking, pickling, filtering, pouring, and packing. The main problem that occurs in the production area is the workload received by workers resulting in a decrease in the focus of workers. This decrease resulted in unstable production after doing work for a long time. Productivity at the beginning of working hours is higher when compared to the following hours. The following is data on the amount of tofu production produced, which can be seen in Figure 1.

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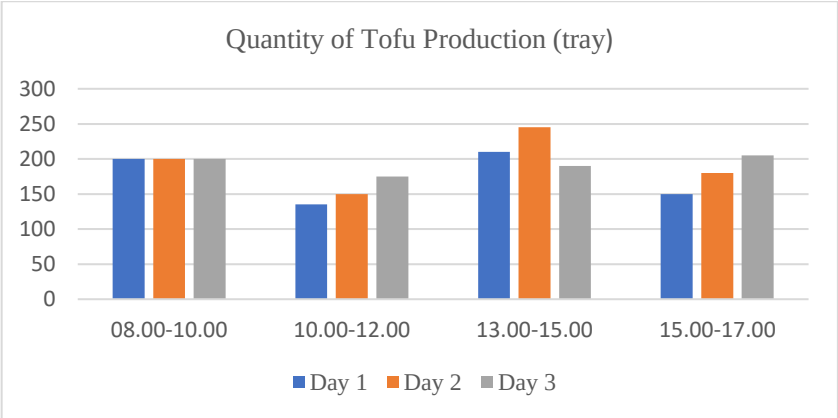



**Figure 1.** Amount of Tofu Production against working time

From Figure 1 above, the production that is produced when workers start working until a few hours after doing work, the results are not constant. This is because workers are repeatedly subjected to heavy and repetitive workloads, such as lifting boxes and moving them from one section to another without any assistance. In addition, the less ergonomic posture of the workers adds to the workload which results in various complaints. The following is a picture of the worker's posture which can be seen in Figure 2.

**Figure 2.** Posture of tofu worker production processes

Body posture analysis was carried out by direct interviews, as well as completing the Nordic Body Map questionnaire for several workers. By measuring using the Nordic Body Map, a subjective assessment was obtained in the form of pain that was complained of from a series of identifications carried out [8]. The purpose of this study is to find out the causes of complaints due to workload, provide the right solution for companies in the form of work tool design proposals to reduce these complaints, as well as make prototypes and implement tools. The results of implementing these ergonomic work tools will reduce worker complaints and increase productivity and stability of work output.

## 2.0 METHODS AND MATERIAL

The object of this research is the production of Tofu. The research was conducted to analyze the workload on the production of the fried tofu section using several methods used to collect data and process the data that has been obtained. The data collection used is primary data and secondary data obtained through direct interviews with workers.

The first step taken is to make observations on the company that will be the place to conduct research. Then carry out field studies conducted directly at the company and study literature using journals, books, and other reading sources. After that is to identify the problem, determine research objectives based on the background of the problem, and collect data. Respondents in this study were 7 (seven) persons. Furthermore, it will perform data processing and analyze the data using several methods. The results of the analysis will be proposed for improvement and implementation in the company. There are several methods used in this study, namely:

1. The Nordic Body Map method.

   Is a system for measuring complaints of pain in the body, known as musculoskeletal. The Nordic Body Map is used to identify complaints of musculoskeletal disorders in workers. MSDs complaints are known by using a questionnaire in the form of types of complaints on a map of the human body. Through a questionnaire, it can be known which part of the muscle is experiencing complaints starting from the level of pain A-D, scale A which means no pain, scale B which means quite painful, scale C which means pain and scale D which means very painful [9][10].

2. Rapid Entire Body Assessment (REBA) method
   Rapid Entire Body Assessment or REBA is a method that can be used to accurately assess a work position which includes the posture of the neck, back, arms, wrists and legs of a worker. REBA was developed in the field of ergonomics. This method is also influenced by external load factors supported by the body and worker activities. Assessment using REBA does not take long to complete and performs general scoring on a list of activities that indicate the need for risk reduction due to operator work posture [11], [12][13], [14]. The REBA method is also equipped with a coupling factor, the external load of work activities. In this method, the body segments are divided into two groups, namely group A and group B. Group A consists of the back (torso), neck and legs. Meanwhile, group B consists of the upper arms, forearms and wrists.
3. Cardiovascular Load Method Cardiovascular Load (CVL)
   Is a physical workload analysis method that compares the maximum heart rate, working heart rate and pre-work heart rate [15]. Calculations with this method can be used the following formula [16] :

$$\% \text{ CVL} = \frac{100\ ((\text{Working Pulse} - \text{Resting Pulse}))}{D(\text{Maximum Heart Rate} - \text{Resting Heart})} \quad (1)$$

Where the resting pulse is the average pulse before work begins, the working pulse is the average pulse during work and the maximum pulse. The maximum pulse rate can be calculated, (220 – age) for men and (200 – age) for women.

## 3.0 RESULTS AND DISCUSSION

### 3.1 *Nordic Body Map Questionnaire*

The data used is data obtained from distributing the Nordic Body Map questionnaire to workers at the research site. From this questionnaire, several questions were asked regarding the disturbances or complaints suffered by workers in the form of aches, pains or aches. Data collection for the Nordic Body Map was carried out by interviewing workers at 3 different stations (pouring, cutting, and frying) to obtain information about complaints on body parts experienced before and after doing work. Based on the results of the Nordic Body Map questionnaire, there are several types of main complaints felt by workers from the most sick to the lowest. Physical complaints based on the Nordic Body Map questionnaire can be seen in Table 1.

**Table 1.** Physical Complaints of Workers

| No. | Parts of body | Level of Complaints | | | |
|---|---|---|---|---|---|
| | | PS | LP | P | VP |
| 1 | Pain in the back | 7 | 4 | 17 | 7 |
| 2 | Pain in the waist | 13 | 0 | 15 | 7 |
| 3 | Pain in the right shoulder | 11 | 4 | 15 | 5 |
| 4 | Pain in right wrist | 12 | 2 | 19 | 2 |
| 5 | Pain in the right upper arm | 19 | 1 | 13 | 2 |
| 6 | Pain in the right forearm | 22 | 1 | 11 | 1 |

Where:
PS : painless LP : little pain
P : pain VP : very pain

Based on data collection and processing of the Nordic Body Map questionnaire, there are several physical complaints experienced by workers when doing work. The main complaints occurred on the back, waist, right shoulder, right wrist, right upper arm and right forearm.

### *3.2 Rapid Entire Body Assessments (REBA)*

REBA data collection is done by taking photos or videos of the process of making fried tofu, namely pouring, cutting, and frying. The following is a picture of worker posture and REBA values, which can be seen in Figure 3.

Pouring Process
REBA Score : 7

Cutting Process
REBA Score : 5

Frying Process
REBA Score : 7

**Figure 3.** REBA values for Pouring, Cutting and Frying processes

The result of a score of 7 can mean that the pouring and frying processes are at a moderate risk level, which means that investigation is required. Furthermore, according to the results of discussions with workers, between the two work stations, the work station that feels the workload is heavier is the pouring work position. Based on these considerations, an auxiliary tool is designed to reduce the workload.

### *3.3 Cardiovascular Load*

Heart rate data collection consists of 2 parts, heart rate data before work or rest and heart rate data while working. Data collection was carried out three times. This is done so that the data used is not biased because the data collection process is not only done once. Other data needed to obtain % CVL of workers is data on the age of workers so that they can calculate their maximum heart rate. Heart rate data from workers can be seen in Table 2.

**Table 2.** Worker Heart Rate (Before and After Work)

| No. | Worker Name | Age | Gender | Heart Rate Before Work (pulse average) | Heart Rate After Work (pulse average ) |
|---|---|---|---|---|---|
| ***Pouring Process*** | | | | | |
| 1. | Iwan | 32 | M | 79.0 | 112.0 |
| 2. | Ian | 34 | M | 76.3 | 110.3 |
| 3. | Alung | 30 | M | 78.7 | 116.0 |
| 4. | Iis | 32 | M | 76.7 | 111.7 |
| ***Cutting Process*** | | | | | |
| 1. | Wahuri | 35 | M | 68.3 | 101.7 |
| ***Frying Process*** | | | | | |
| 1. | Siswanto | 34 | M | 76.0 | 114.0 |
| 2. | Slamet | 32 | M | 74.0 | 108.7 |

Calculation of the percentage of cardiovascular load (CVL) is carried out for each worker to determine the classification of physical workload. The following is Table 3 regarding the percentage of cardiovascular load of workers.

**Table 3.** Worker Heart Rate (Before and After Work)

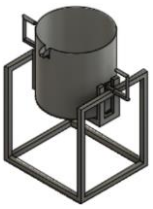
| No. | Worker Name | Age | Gender | % CVL | Average of % CVL |
|---|---|---|---|---|---|
| ***Pouring Process*** | | | | | |
| 1. | Iwan | 32 | M | 30.3 % | **31.55 %** |
| 2. | Ian | 34 | M | 31 % | |
| 3. | Alung | 30 | M | 33.5 % | |
| 4. | Iis | 32 | M | 31.4 % | |
| ***Cutting Process*** | | | | | |
| 1. | Wahuri | 35 | M | 28.6 % | **28.6 %** |
| ***Frying Process*** | | | | | |
| 1. | Siswanto | 34 | M | 34.5 % | **32.45 %** |
| 2. | Slamet | 32 | M | 30.4 % | |

Based on table 3 above, the average percentage of workload received by workers in the pouring section is 31.55% which is classified as the category that needs improvement and workers who have the highest physical workload on behalf of Alung with a workload of 33.5%, which means there must be improvements to reduce high levels of fatigue in these workers. The average percentage of workload received by workers in the cutting section is equal to 28.60% which belongs to the category where fatigue does not occur, and the average percentage of workload received by workers in the frying section is equal to 32.45% which belongs to the category needed repairs and workers who have the burden of the highest physical work is the worker on behalf of Siswanto with a workload of 34.5%, which means that there must be improvement to reduce the high level of fatigue in these workers.

### *3.4 Tool Design*

The following is the design of the tofu dough pouring tool in the fried tofu pouring section which can be seen in table 4. Based on the results of screening concepts, the best concept selected is the second concept.

**Table 4.** Morphology of Tofu Pouring Tool Design

| Alternatives | Characteristics | | |
|---|---|---|---|
| | Material | Usage Mechanism | Concept Drawing |
| Alternative 1 | *Stainless Steel* | Move the handle to the left to pour the tofu dough by rotating the parallel handles. |  |
| Alternative 2 | *Hollow Steel* | Move the handle to the left to pour the tofu dough by turning the handle higher and longer. |  |
| Alternative 3 | *Aluminum* | Move the handle to the left to pour the tofu dough by turning the handle in a square shape. |  |

### *3.5 Implementation of Tofu Pouring Tool Design*

The Nordic Body Map questionnaire was given to pouring, cutting and frying workers to find out the complaints felt after workers used the tool designs and suggestions that had been given. Questionnaires were given to 7 workers. Figure 4 is a prototype of the pouring tool and the working position when using the tool.


**Figure 4**. Implementation of the Tofu Pouring Tool

Comparison of the results of REBA and Cardiovascular Load scores before and after implementation which can be seen in Table 5. From the table it can be seen that the use of pouring tool can reduce the workload and reduce worker complaints.

**Table 5.** Results of the Implementation of the Pouring Tool

| Activity | Before Implementation | | | | After implementation | | | |
|---|---|---|---|---|---|---|---|---|
| | **REBA Score** | **Risk Level** | **CVL Score** | **Risk Level** | **REBA Score** | **Risk Level** | **CVL Score** | **Risk Level** |
| Pouring | 7 | Moderate | 31.55 % | Improvements are needed | 3 | light | 28.70 | No improvement required |
| Cutting | 5 | Moderate | 28.60 % | No improvement required | 3 | light | 27.70 | No improvement required |
| Frying | 7 | Moderate | 32.45 % | Improvements are needed | 3 | light | 29.10 | No improvement required |

From the Table 5 it can be seen that the use of pouring aids can reduce the workload and reduce worker complaints. In this study there were limitations, namely the limited number of sample workers and the short implementation time. It is recommended for further research to add respondents with various working time conditions, as well as carry out implementation for sufficient time.

From the results of the study, it can be concluded as follows:

1. Based on the results of the Nordic Body Map questionnaire, it is known that the highest complaints of tofu industry workers, especially the pouring, cutting, and frying parts are on the back, waist, right shoulder, right wrist, right upper arm and right forearm.
2. The Rapid Entire Body Assessment (REBA) score for assessing body posture for the pouring work station was 7, for the cutting section it was 5, and for the frying section it was 7. This meant that an investigation was necessary.
3. The average percentage of workload received by workers based on Cardiovascular Load in the pouring section is 31.55%. For the cutting part is 28.60% and for the frying part is 32.45%. The workload on the pouring and frying sections is classified as the category that needs improvement.
4. Based on the results of analysis and interviews with workers, suggestions for improvements are made in the pouring section, namely designing a pouring tool for fried tofu dough that is adapted to the worker's position so that the worker's posture is more comfortable and reduces bending. Of the 3 design alternatives, the best design chosen is proposal number 2.
5. Prior to implementation, workers' complaints on the back were rated 7 (very painful) and 17 (painful) and became 1 (painful) and 17 (rather painful). The REBA score before implementation showed that the fried tofu work station had a moderate risk level (score 5-7), and after implementation the REBA risk level was at a small risk level (score 3). The percentage of Cardiovascular Load in the pouring before implementation decreased from 31.55% to 28.7%, in the cutting section it decreased from 28.6% to 27.7%, and in the frying section it decreased from 32.45% to 29.1%.

## 4.0 CONFLICT OF INTEREST

All authors declare that there is no conflict of interest, either financial or non-financial, from the conduct of the research to the publication of this manuscript.

## 5.0 AUTHORS CONTRIBUTION

L Widodo (Conceptualization; Methodology; Data curation; Writing; Supervision)

C O Doally (Methodology; Validation; Formal analysis, Investigation)

B Lawresa (Conceptualization; Formal analysis; Visualization; Implementation)

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