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DESIGNING AN ERGONOMIC-BASED WORK FACILITY OF DOUGH STIRRER FOR KERUPUK CIPIR USING RAPID ENTIRE BODY ASSESMENT (REBA) ANALYSIS TO REDUCE MUSKULOSKELETAL COMPLAINTS AND INCREASE PRODUCTIVITY

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Abstract. The small and medium-sized enterprises (UKM) of Kerupuk Cipir are the home industries which produce kerupuk cipir. During the making process, there were still many phases which were done manually using a simple work facility. During the dough stirring phase, the workers used a bending work posture (unergonomic) which caused musculoskeletal complaints and various problems toward the workers. Therefore, a research was conducted by applying rapid entire body assesment (REBA) analysis to decrease musculoskeletal complaints and increase productivity. The research was conducted experimentally at UKM Kerupuk Cipir in Binangun Village, Karangpucung District, Cilacap Regency by using the treatment by subject design. There were two treatments given toward the sample: stirring the dough using the former work facility and stirring the dough using the improved work facility through ergonomic approach. The musculoskeletal complaints were measured using Nordic Body Map questionnaire. The data were analyzed using descriptive and inferential statistics. The results showed a decrease on REBA score from 11 on level 4 which was in the category of high risk into score of 4 on level 2 which was in the category of quite high when the handle position is on the upper side, score of 5 when the handle position is on the front side, and score of 7 when the handle position is on the lower side. The workers' complaints of severe pain on 9 body parts and pain on 6 body parts were decreased into mild pain on 7 body parts and no pain on 20 other body parts. Work productivity increased into 89.62%.

Keywords : Ergonomic, REBA, NBM, Body Posture.

1. INTRODUCTION

The industrial competition, including small and medium-sized enterprises in developing their businesses, are very competitive. An important factor in the success of an industry cannot be separated from the role of the human resources who are able to can do their work well and precisely. Other important factors supporting the success are the comfortable and safe work environment and the ergonomic work facilities. An uncomfortable work environment and the absence of improvement can potentially decrease work motivation, disturb work health, and accumulate decrease work productivity [1]. In the real condition, there are still many small and medium-sized enterprises which are lack of ergonomic principles consideration in conducting their industrial activities. In general, the work activities are done by adjusting the workers to the available work facilities. As an activity that has the characteristics of using the ergonomic-based facility, the work facility designs should consider the human's ability, skill, and capacity (fitting the job to the man) [2]. One of the indicators which can make a work activity be called as a proper one is when it has fulfilled the ergonomic principles and can be measured based on the direct impact which is felt by the workers when doing the work such as comfort, decrease on musculoskeletal complaints,

and further, increase on work productivity. The implementation of a study using an ergonomic solution can give workers better work, a comfortable environment, and also an increase in productivity [3], which can reach up to 10% of the workers' productivity [4].

The small and medium-sized enterprises (*UKM*) of *Krupuk Cipir* are located in Binangun Village, Karangpucung District, Cilacap Regency. These enterprises are the small industries of snack production in the form of *krupuk cipir*. The making of *krupuk cipir* is done through several process phases, which is started by making the dough, stirring the dough, smoothing, steaming the dough, cutting, drying, and packing as the last phase. The phase of stirring the dough was considered as an unergonomic activity because the workers were using bending work posture when stirring the dough. This condition was caused by the dough stirrer, which was located lower than the workers' knees. The unergonomic work facility made the work posture of the workers becoming uncomfortable. A bending work posture is done repetitively and monotonously in a long duration, and muscle stretching exceeds the limit [5][6] can cause musculoskeletal complaints. The complaints can increase as a result of wrong and unnatural work postures [7]. Work done in a long time using inappropriate and uncomfortable work postures can cause musculoskeletal disorders and decrease of productivity [8].

Based on the Nordic Body Map questionnaire result, there were six body parts which experienced severe pain: they were the right and left shoulders, right and left arms, and right and left wrists, and there were nine body parts which experienced pain, they were the upper right and left arms, waist, lower right and left arms, right and left tights, right and left legs. The questionnaire was suitable for measuring the experienced muscle complaints, ranging from no pain to severe pain [9]. The REBA method was used to find out the workers' risk level based on the body posture during the work. The advantage of applying this method is that the application is simple, and the speed in determining the result is accountable [10]. Based on this method, the workers' activity in stirring the dough showed the workers' work posture score of 11, which was in the category of high risk.

2. METHODS

The research was conducted experimentally by using the treatment by subject design [11]. The research location was the *UKM Kerupuk Cipir* in Binangun Village, Karangpucung District, Cilacap Regency. Two treatments were given toward the sample: stirring the dough using the former work facility (treatment 1) and stirring the dough using the improved work facility through ergonomic approach (treatment 2).

The instruments used in the research were Nordic Body Map which was used to measure the musculoskeletal complaints and REBA (Rapid Entire Body Assessment) which was used to analyze the risk as a postural analysis system which is sensitive toward musculoskeletal risks in various works, especially in assessing work postures [12]. The work productivity was measured by comparing the product result before and after the improvement of the work facility. The research data were analyzed and presented descriptively.

3. RESULTS AND DISCUSSION

3.l. Anthropometry Data and Work Facility Design:

The workers' anthropometry data was used as the basic measurement in redesigning the work facility of the dough stirrer. An anthropometry application which uses certain body measurement is very useful in the designing process [13]. The application of anthropometry data on the redesign of the work facility of dough stirrer was expected to be able to give comfort and safety to the workers' work posture in the activity of making the dough. The result of the subjects' anthropometry measurement is served in Table 1.

Tabel 1. Subjects' anthropometry data on the dough work

No	Measured dimension	Mean (cm)	Percentile	
			5	95
1.	Standing shoulder height	135.7	121.66	149.73
2.	Hand reach	75.80	68.97	82.63
3.	Hand span	175	161.12	188.88
4.	Standing elbow height	118.9	105.38	132.42
5.	Hand width	11.4	9.76	13
6.	Palm length	19.26	17.9	21.19
7.	Hand grip length	59.2	57.06	61.33

The workers' anthropometry data in Table 1 above was used to determine the dimension of the dough stirrer design. The dough stirrer's height is 105.38 cm, which was determined based on standing elbow height using the 5th percentile. The flour container height is 121.66 cm, which was determined based on the standing shoulder height using the 5th percentile. The dough stirrer width was 68.97 cm, which was determined based on the hand

reach using the 5th percentile. The length of the dough stirrer is 161.12 cm, which was determined based on the hand span using the 5th percentile. The stirrer handle was determined based on the hand width and palm length using the 50th percentile. The flour container width is 57.06 cm, which was determined based on the handgrip length to the front using the 5th percentile. The design of the work facility on the dough stirring process of *krupuk cipir* is shown in Figure 1.

A work facility design that is designed according to the user's body dimension using an appropriate percentile can increase the work posture into the more natural one. The interrelationship between workers' body dimensions with various workplace conditions can contribute to the work posture in completing the work [5], which then can have an impact on work comfort. The redesign of the ergonomic-based dough work facility also refers to the application of a proper technology that considers the needs and can be used according to its functions.

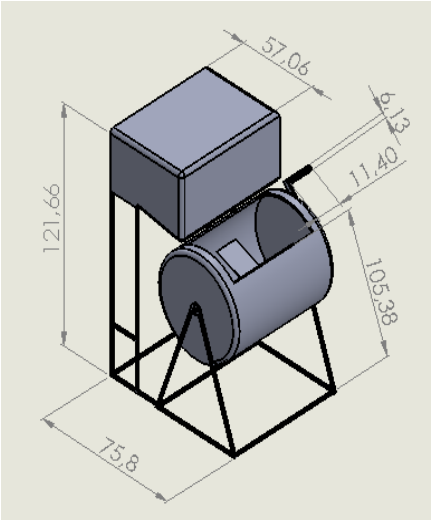

Figure 1. The design of work facility of dough stirrer

3.2. Work Posture Before and After the Design Improvement

In the former condition, the workers worked using unnatural work posture by making a bending work posture repetitively in a long duration, as shown in Figure 2. The work activity of stirring the dough after the application of the ergonomic-based work facility design showed that the workers were not using the bending work posture anymore and the work posture became more natural and comfortable as shown on Figure 3 and 4.

The REBA analysis result on the work posture of the dough stirring process before the improvement of the work facility showed a score of 11 on the level 4, which is similar to the final REBA score on the nurses' activities in handling the patients [14]. This score shows that the activity has a very high-risk score and is recommended to have an improvement in the work posture immediately. This condition also shows that the workers work unnaturally because of the unergonomic work facility. The research evaluation result of the body posture on the small-scale industries using the REBA instrument shows a significant proportion of the workers who work uncomfortably and the painful postures which are caused by the lack of ergonomic knowledge and awareness [15].

The working posture on the dough work facility after the improvement using the ergonomic approach showed that there was a decrease on REBA score into 4 on level 2, which is categorized in the quite high score when the handle position is on the upper side, and score of 5 when the handle position is on the front, and score of 7 when the handle position is on the lower side. It means that there was a decrease in the risk level from very high to quite high. The REBA approach is considered as suitable to measure work postures of workers in doing their work from a high-risk condition into a lower or more natural one. Hignett and McAtamney stated that this method is suitable for assessing the posture of the upper and lower limbs quickly along with muscle function and external loads on the body [16], from high-risk work postures to under-post work. The assessment result using REBA analysis suggests that the improved dough stirrer facility is more ergonomic or more natural and is suitable to be applied even though it still requires to have further improvement.

Figure 2. Body posture on the former condition

Figure 3. Body posture on the condition after the design improvement when the handle position is on the upper side.

Figure 4. Body posture on the condition after the design improvement when the handle position is a little bit straight

3.3. Musculoskeletal Complaints

Based on the Nordic Body Map questionnaire before the redesign was applied, the workers experienced severe pain on six body parts; left and right shoulders, left and right arms. There were nine body parts that experienced pain; upper left arm, back, waist, lower left, and right arms, left and right tights, left and right legs.

This stirring dough activity was categorized in the manual work using an awkward and unnatural body posture using a high frequency of repetition, therefore having the potential of causing musculoskeletal complaints. A physical work condition using an awkward work posture, high frequency of repetition, excessive power, static work, cold and containing vibration have a strong correlation in causing musculoskeletal disorders [17], which can cause injuries if it is not being managed ergonomically [18]. An awkward or unphysiological work posture is caused by the inappropriateness of the worker's body dimension toward the work facility, which is used [19], which was similarly experienced by the workers on the dough stirring activity.

By using the ergonomic-based design of the work facility, there was a decrease of category from severe pain and pain into the mild pain and no pain. It shows that a design that uses an ergonomic approach can impact the workers' comfort, which is shown by the decrease of musculoskeletal complaints on certain body parts. The ergonomic intervention on the wok molder design can lower musculoskeletal complaints of the workers from the score of 54.44 on the former design into 40.44 or decreases 25.71% [20].

3.4. Productivity

Productivity was calculated based on the production output divided by the time required to produce the product. On the condition before the work facility improvement, to produce the product with the capacity of 25 kg, it required 13.63 minutes. After the application of the ergonomic-based dough stirrer design, the total time required to produce 25 kg decreased into 7.20 minutes. It shows an increase of time efficiency. Based on the production capacity and finishing time, the application of the ergonomic-based work facility of the dough stirrer could increase productivity as much as 89.62%. An increase in productivity up to 47.79% is also achieved at Ud. P. Jatayu, Ud. Rinna Dewata Sari, Ud. Agus in Kapal and Tangeb Village by using proper technology and an ergonomic work station [21].

Factually, the ergonomic intervention on the improvement of the dough stirrer work facility can decrease the musculoskeletal complaints, shorten the work time, and in the end, increase productivity. The improvement in work facility using a proper ergonomic application will give impacts on the decrease of fatigue, decrease of work accidents, increase of work comfort, shorter production time, and in the end, an increase of productivity [22]. The application of the ergonomic-based dough stirrer facility design is suitable to be applied to the *UKM Krupuk Cipir*.

4. CONCLUSSIONS

Based on the research results and discussion, it can be concluded as follows.

1. The application of the ergonomic-based work facility of the dough stirrer could decrease the musculoskeletal complaints of the workers, which formerly was severe pain on six body parts and pain on nine body parts into mild pain and no pain.
2. Based on the work posture analysis using the REBA method, the ergonomic-based work facility design could decrease the work risk from the score of 11 with category of high-risk level, which requires an improvement immediately into the score of 4 when the handle position is on the upper side, a score of 5 when the handle position is on the front, and a score of 7 when the handle position is on the lower side with the category of low-risk level and improvement can be applied if it is required. It was also followed by an increase in productivity, which reached 89.62%

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