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Analysis of workload and fatigue Batik Cap workers in Sukoharjo

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ABSTRACT
Batik is an ancestral heritage of the Indonesian people that has been preserved to this day, particularly on the island of Java. In Java, the centers of the batik industry are located in Pekalongan, Yogyakarta, Surakarta, and Sukoharjo. In Sukoharjo, there are several home industries producing batik cloth, especially in the Krendetan Sukoharjo area, which specializes in both written and stamped batik. The batik-making process in these home industries is performed manually using simple tools. A preliminary survey revealed that the batik-making process involves repetitive tasks and imposes a high workload, particularly in the batik stamping process. This study aims to determine energy expenditure during work, energy expenditure during rest, and energy consumption needs for workers in the batik industry. The research was conducted in the stamping section and the boiling process to remove wax from the fabric. The results showed that energy expenditure during the batik stamping process was 382 kcal/hour, while in the boiling process it was 402 kcal/hour. Energy expenditure during rest was 354 kcal/hour in the stamping process and 367 kcal/hour in the boiling process. Energy consumption during the stamping process was 29 kcal/hour, and in the boiling process, it was 36 kcal/hour. The required rest time for the stamping process was 7.43 minutes per 15 minutes of work, while for the boiling process it was 5 minutes per 30 minutes of work.

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1. INTRODUCTION

The Batik is an ancestral heritage of the Indonesian people that is preserved to this day. Batik cloth can be made into various models of clothing for both women and men, even in Indonesia to preserve batik there is a National batik day which falls on October 02, 2020 [1]. Batik is the art of drawing on cloth for clothing. This art of drawing is not just drawing but the motifs that are drawn also have philosophical meaning [1]. The production of batik cloth is spread throughout Indonesia such as in Java, Bali, Kalimantan, and in other regions. Each batik has a different motif that characterizes the region [2].

In Java, the centers of the batik industry are Pekalongan, Yogyakarta, Surakarta and Sukoharjo. In Sukoharjo there are several home industries that produce batik cloth, including Ban Mati, Tawangsari, Nguter, Laweyan, and Krendetan. Especially in the Krendetan area of Sukoharjo, there are 3 home industries for batik cloth, both written and printed batik.

From the preliminary survey that we have conducted at the batik home industry in Krendetan hamlet, we obtained information that there are three types of batik cloth, namely written batik cloth, printed batik cloth and batik cloth combined with written batik. The batik process is also different. The number of workers in the batik industry is 7 men and 3 women. The age of the workers ranges from 52 to 67 years old. 3 of them graduated from primary school, 6 from junior high school, and 1 from vocational school.

The batik process, both written batik and stamped batik in this home industry, is all done manually and with very simple tools. Because the batik process is done manually, it requires special skills, accuracy and also high patience to produce quality batik cloth. After a preliminary survey, it can also be seen that the batik process is a job that is done repeatedly and has a very high workload, especially in the process of making stamped batik. The stamped batik batik process is done using a mold measuring 20x20cm, made of copper. The weight of the mold is approximately 2kg. Apart from being heavy, this mold must also be inserted into a pan containing malam which has been heated to a temperature of 60˚C to 70˚C. So that in doing their work, workers are not only exposed to high heat but also heavy mold loads. This leads to overload, and fatigue.

While 2 kg is not considered a heavy load in general, the strain it places during prolonged repetitive tasks cannot be underestimated, especially when combined with other factors in the batik process. The work environment involves repetitive handling of 2 kg copper molds in high temperatures, which significantly increases the physical and heat load on workers. This double exposure to load and heat creates a cumulative stress effect, making the process strenuous and potentially dangerous [3]. In addition, the risk of fatigue increases due to the repetitive nature of the tasks, the long duration of work, and the ergonomic challenges posed by the equipment. These factors together increase occupational fatigue, musculoskeletal disorders and occupational injuries. Workers with heavy work and a high source of fatigue will cause the risk of work accidents and occupational diseases [4]. Fatigue contributes greatly to the incidence of work accidents [5].

Based on the description above, we will conduct research on "Analysis of Workload and Fatigue in Batik Cap workers in Krendetan Sukoharjo". This research is expected to be able to provide information to home industry about the workload, so that they provide opportunities for adequate rest based on the analysis that has been done in this study. With the provision of adequate rest time, it is also expected that the risk of work accidents and occupational diseases can be minimized.

This research aims to determine energy expenditure during work, consumption expenditure during rest and consumption needs for workers in the batik industry. This research was conducted in the painting and boiling section of the cloth to remove the night.

2. LITERATURE REVIEW

2.1. Ergonomics Goals

Ergonomics is the study of the adjustment or balance between all facilities used, both in activities and rest with human abilities and limitations both physically and mentally, so that the quality of life becomes better [6]. Ergonomics is the ability to implement information about human capacities and limitations into the design of human tasks, machine systems, workspaces, and environments so that humans can live and work safely, comfortably, and efficiently [7].

The purpose of applying ergonomics is to improve physical and mental well-being, reduce physical and mental workloads, and create a rational balance between various technical, economic, anthropological, and cultural aspects of each work system carried out, so that the quality of life and work becomes higher [6]. Ergonomics also pays attention to human factors, such as fatigue and workload [8].

Workload can be defined as the difference between workers' abilities and job demands [9]. If the worker's ability is higher than the demands of the job, there will be a feeling of boredom. Conversely, if the worker's ability is lower than the demands of the job, excessive fatigue will appear [10]. Workload is divided into two, namely physiological workload and psychological workload. Physiological workload can be in the form of Physiological workload can be in the form of heavy work such as lifting, caring, pushing. while psychological workload can be in the form of differences in the level of expertise and achievements that individuals have with other individuals [11].

Work fatigue is a state of decrease in efficiency and endurance of a person in work. The term fatigue leads to the condition of weakening of the workforce to perform an activity, resulting in a reduction in work capacity work capacity and endurance [12]. The main factors that are significant to fatigue which include gender, age, nutritional status, workload, body size of the the worker in question as well as time used in work [12]. Fatigue that occurs in employees can be detrimental to both the employee and the company. It has the effect of causing decreased work motivation, low performance, work quality decreases, there are many work errors, work productivity decreases, work-related stress, occupational diseases, and injury due to overexertion work [13].

Ergonomics is also used to avoid workers feeling excessive fatigue. Manuaba and Vanwonterghem (1996) classify physical fatigue by measuring the difference between the working pulse (heart rate) and resting pulse, compared to avoid workers feeling excessive fatigue. The measurement methods is classify physical fatigue by measuring the difference between the work pulse rate (heart rate) and resting pulse rate, compared to avoid workers feeling excessive fatigue [14]. Level of fatigue that happened is visible from level of work load measured by through energy consumption [15]

2.2. Balance Concept in Ergonomics

The concept of balance between work capacity and task demands in ergonomics is influenced by several factors, including work ability, which is determined by personal characteristics, physiological abilities, and psychological abilities; task demands, which depend on the characteristics of the task and materials, working hours, and conditions in the work environment; and performance, which is influenced by the ratio between task demands and an individual's abilities [16]. From an ergonomic perspective, task demands and work capacity must always be balanced to achieve optimal work performance. Work demands should not result in either underload or overload [17]. Excessive workload, in the long run, can reduce a person's productivity due to job fatigue [18]. Additionally, excessive workload can lead to increased stress levels and negatively affect workers' health [19].

2.3. Oxygen and Energy Consumption

Physical work has both energy consumption and energy expenditure. The energy consumption is determined by blood pressure and flow, chemical composition of the body, body temperature, evaporation rate, and the amount of air expelled. The energy consumption is also determined by the difference in heart rate during work or rest [20].

Energy consumption formula:

$$KE = Et - Ei \quad (1)$$

where,

KE :Energy consumption for activity (Kilocalories/minute)

Et :Energy Expenditure during work or activity (Kilocalories/minute)

Ei :Energy expenditure during body rest.

The workload classification table is presented in Table 1.

Table 1. Workload classification

Level of Work	Energy expenditure		Heart rate	Energy Consumption.
	Kal/minutes	Kal/8hours	Beats/minutes	Liter/minutes
Unduly Heavy	>12.5	>6000	>175	>2,5
Very Heavy	10.0– 2.5	4800-6000	150-175	2.0-2.5
Heavy	7.5-10.0	3600-4800	125-150	1.5-2.0
Moderate	5.0-7.5	2400-3600	100-125	1.0-1.5
Light	2.5-5.0	1200-2400	60-100	0.5-1.0
Very Light	<2.5	<1200	<60	<0.5

As sho*wn in* Table 1, the "Unduly Heavy" workload category represents the most extreme level of physical activity, characterized by energy expenditures exceeding 12.5 kilocalories per minute or 6,000 kilocalories in an 8-hour workday, accompanied by heart rates above 175 beats per minute and oxygen consumption exceeding 2.5 liters per minute. Conversely, the "Very Light" category reflects minimal physical demands, with energy expenditures below 2.5 kilocalories per minute or 1,200 kilocalories in an 8-hour day, heart rates under 60 beats per minute, and oxygen consumption of less than 0.5 liters per minute. The intermediate levels, ranging from "Light" to "Very Heavy" show a gradual increase in energy expenditure, heart rate, and oxygen consumption, aligning with the intensity of the activity.

2.4. *Workload and Calorie Consumption Categories*

Work is an activity carried out by humans in an effort to ch ange the natural environment with the aim of maintaining and maintaining their survival [21]. Energy consumption can be used to determine the level of physical load [22]. Energy consumption during work can be determined from direct measurements (including blood pressure and flow, body chemical composition, body temperature, evaporation rate, and the amount of air coming from the lungs) [23], this can be measured by pulse rate [24].

The severity of work can be determined by the symptoms of changes that can be done by measuring the limbs which include heart rate, blood pressure, body temperature, inhaled oxygen consumption, and chemical content in the body.

In this regard, the Minister of Labor through Decree No. 51 (1999) establishes workload categories according to calorie requirements, among others: a.) Light workload: 100- 00 Kilo calories/hour; b.) Medium workload: 200-350 Kilo calories/hour; c.) Heavy workload: 350-500 Kilo calories/hour.

Calorie needs can be measured indirectly by determining oxygen demand. The need for 1liter of oxygen is equal to 4.8 Kilo calories [6]. The basis of calculation to determine the number of calories a person in his work activity, can be done with an approach or estimate of calorie needs based on the type of activity performed [25]. Estimated calorie requirements per hour per kg of body weight can be seen in Table 2.

Table 2. Calorie Needs per Hours by Activity Type

No	Type of Activity	Kilo calories/hr/kg body weight
1.	Sleep	0.98
2.	Sitting in a state of rest	1.43
3.	Reading aloud	1.50
4.	Standing in a calm state	1.50
5.	Sewing by hand	1.59
6.	Standing with concentration on an object	1.63
7.	Dressing	1.69
8.	Singing	1.74
9.	Machine sewing	1.93
10.	Typing	2.00
11.	Ironing (iron weight ± 2.5 kg)	2.06
12.	Washing kitchen utensils	2.06
13.	Sweeping the floor at a speed of ± 38 times	2.41
14.	Book binding	2.43
15.	Light exercise	2.43
16.	Light walking at a speed of ± 3.9 km/hour	2.86
17.	Wood, metal and painting work in industry	3.43
18.	Moderate exercise	4.14
19.	Moderate walking at a speed of ± 5.6 km/hour	4.28
20.	Walking down stairs	5.20
21.	Masonry work	5.71
22.	Heavy exercise	6.43
23.	Manual sawing of wood	6.86
24.	Swimming	7.14
25.	Running at ±8 km/h	8.14
26.	Very heavy exercise	8.57
27.	Walking very fast at a speed of ± 8 km / h	9.28
28.	Climbing stairs	15.80

As presented in Table 2, calorie needs per hour vary significantly depending on the type of activity and its intensity. Activities categorized as very light, such as sleeping and sitting in a state of rest, require minimal energy expenditure, with calorie needs per kilogram of body weight as low as 0.98 and 1.43 kcal/hour, respectively. While, activities involving high physical intensity, such as climbing stairs or walking very fast at a speed of 8 km/h, demand significantly higher energy, with calorie needs reaching up to 15.80 kcal/hour per kilogram of body weight.

This variation highlights the correlation between activity intensity and calorie requirements. Light activities, such as sewing by hand (1.59 kcal/hour/kg) or sweeping the floor (2.41 kcal/hour/kg), have moderate energy demands. Instead, heavy activities such as swimming (6.86 kcal/hour/kg) and masonry work (5.71 kcal/hour/kg) demonstrate the increased metabolic cost of sustained physical effort. Very heavy activities like running at a speed of 8 km/h (8.14 kcal/hour/kg) require substantial energy expenditure, underscoring the body's heightened oxygen demand to support such activities.

2.4.1. Workload Assessment Based on Work Pulse

Heart rate measurement during work is a method to assess cardiovascular strain. Pulse rate is a measurement of workload based on the movements made by human muscles [26]. Pulse rate can be used to measure a worker's physical condition as a basis for a worker's fatigue level. The greater the level of pulse fluctuation is a sign of the greater the level of workload.

The equipment that can be used to calculate the pulse rate is Electro Cardio Graph (ECG) stimulation. The pulse rate can also be calculated using a stopwatch with the 10 beat method [6]. With this method, the working pulse rate can be calculated as follows:

$$\text{Pulse rate (beats/minute)} = \frac{10\ pulse}{Work\ measure} \text{x } 60 \quad (2)$$

Increased pulse rate has an important role in the increase in heart rate from rest to maximum work. The potential increase in pulse rate from rest to maximum work is defined by Rodalh (1989) as heart rate reserve (HR Reserve). The HR reserve is expressed as a percentage which can be calculated using the following formula:

$$\%\ \text{HRreserve} = \ = \frac{DWorking\ pulse - resting\ pulse}{Maximum\ pulse\ rate - Resting\ pulse\ rate} \text{x } 100 \quad (3)$$

In the next, to determine the workload classification based on the increase in work pulse rate compared to the maximum pulse rate due to cardiovascular load (% CVL). The formula used is as follows:

$$\%\ \text{HRreserve} = \ = \frac{Working\ pulse - resting\ pulse}{Maximum\ pulse\ rate - Resting\ pulse\ rate} \text{x } 100 \quad (4)$$

2.4.2. Work Measurement with Physiological Methods

The physiological approach is a technique for designing work systems and workplaces that require the physical energy of human muscles as a source of power [23]. The physiological approach aims to reduce workload in order to reduce the level of physical fatigue of workers [27].

Assessment of physical workload can be done by two objective methods, namely the direct assessment method and the indirect assessment method. The direct measurement method is by measuring energy expenditure through oxygen intake during work. The heavier the workload, the more energy required or consumed. Although the method using oxygen intake is more accurate, it can only measure for a short working time and quite expensive equipment is required. While the indirect measurement method is by calculating the pulse rate during work [6].

3. METHODS

The object of research with the title Analysis of Workload and Fatigue in Batik Cap Workers in Krendetan Sukoharjo is workers who work in the batik making industry. The research step begins with giving a brief review of the research objectives to the Batik Cap business owner and workers, direct data collection, including: subject data, pulse rate before work, pulse rate during work and pulse rate during rest, tools needed worksheets, stopwatches, and digital camera.

In the next, pulse measurement data is calculated to calculate energy consumption needs, rest time needs and also calculate %CVL. The calculation results are analyzed to determine the conclusion. The following flowchart illustrates the research process in detail, it present in Figure 1.

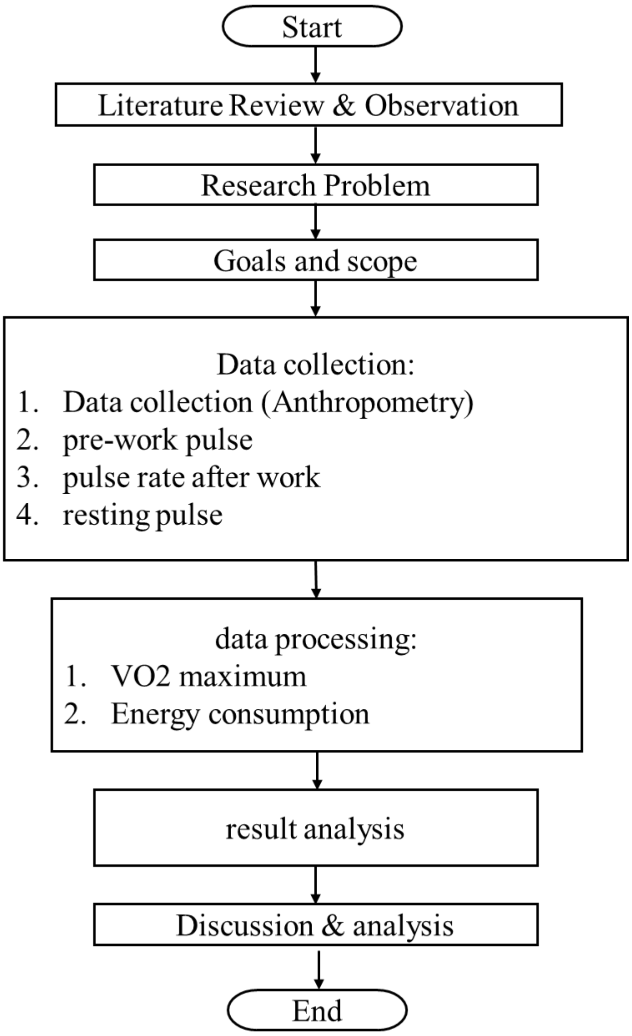

Figure 1. *Flowchart*

As shown in Figure 1, the research process begins with a briefing session to ensure that all participants understand the study's purpose and procedures. This is followed by data collection, where workers' pulse rates are measured under different conditions (before, during, and after work). These measurements are then used to calculate energy consumption and determine the necessary rest time to mitigate fatigue. Furthermore, %CVL is calculated to evaluate the cardiovascular workload. The final step involves analyzing these findings to draw meaningful conclusions about the workload and fatigue levels among the batik cap workers. This structured approach ensures the reliability and accuracy of the results.

The methodology employed in this study is designed to ensure a comprehensive assessment of the workload and fatigue experienced by batik cap workers. The inclusion of pulse rate measurements across different work phases (before, during, and after work) provides a robust dataset for analyzing physiological responses to workload. The use of simple yet effective tools such as worksheets, stopwatches, and a digital camera ensures practicality while maintaining data accuracy. Additionally, the calculation of %CVL offers a deeper understanding of cardiovascular strain, which is critical for evaluating worker health and safety. By correlating energy consumption and rest time requirements with %CVL, this study provides actionable insights that can inform strategies to optimize work conditions, enhance productivity, and minimize fatigue among batik cap workers.

4. RESULTS

4.1. Respondent Data and Pulse Rate Measurement Result

Based on the results of interviews with workers in the batik industry and direct measurements in the painting section/process, data are obtained as in Table 3. In the table, data can be obtained about the worker's gender, age, height, weight, pulse rate before work, pulse rate during work and pulse rate after work.

Table 3. Respondent data and pulse rate measurement results of batik painting workers

Respondent	Age (Yr)	Gender	Working period (Yr)	Height (Cm)	Weight (Kg)	Pulse Rate Before Work	Pulse Rate At Work	Pulse Rate At Break
1	67	M	2	160	45	80	88	72
2	57	F	5	155	55	88	84	96
3	60	M	3	169	53	76	86	76
4	59	M	3	169	49	80	92	92
5	54	F	5	167	49	84	88	88
6	54	F	7	166	75	108	84	132
7	54	M	5	150	40	76	124	60
8	63	M	5	160	49	80	80	84
9	52	M	6	158	50	88	84	88
10	57	M	7	159	47	84	88	76
Total	577	0	48	1613	512	844	898	864
Average	57.7	0	4.8	161.3	51.2	84.4	89.8	86.4

Based on this table, it can be concluded that there are differences in pulse rate before work, during work and also during rest. The highest pulse rate occurs when workers are working. Table 3 provides detailed data on the respondent demographics and pulse rate measurements during different phases of work. The respondents, who are primarily have an average age of 57.7 years, with an average working period of 4.8 years. Their physical characteristics, including an average height of 161.3cm and an average weight of 51.2kg.

The pulse rate data shows clear variations across the three measured conditions: before work, during work, and during rest. The average pulse rate before work is 84.4 beats per minute, indicating a relatively calm baseline state. During work, the average pulse rate increases to 89.8, reflecting the physical effort and cardiovascular response required during the batik painting process. Interestingly, the pulse rate during rest averages 86.4. Suggesting that the recovery period after work may not be sufficient to return the pulse rate to baseline levels for some workers.

4.2. Calculation of Energy Expenditure at Work (Et) in the Batik Casting Process

To find out how much energy expenditure at work can be done by calculating using the following formula:

$$Y = (1.80411 - 0.00229038 + (4.71733^{-4}X^2) \quad (5)$$

where,

X = average energy expenditure at work

X = 898

So then:

$$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\,X^2)$$
$$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\,898^2)$$
$$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\,806404)$$
$$Y = (1.80411 - 0.00229038 + (380407)$$
$$Y = (1.801 + 380.4)$$
$$Y = 382.208 \text{ kcal/hour}$$

Based on the results of these calculations, it can be seen that the energy expenditure at work is 382.208 kcal / hour.

4.3. Calculation of Energy Expenditure at Rest (Ei) in the Batik Casting Process

To Calculation of energy expenditure at rest using the formula using the same formula in calculating Ei.

$$Y = (1.80411 - 0.00229038 + (4.71733^{-4} X^2)) \quad (6)$$

where,

X = average energy expenditure at rest = 864

So then:

$Y = (1.80411 - 0.00229038 + (4.71733^{-4} X^2)$

$Y = (1.80411 - 0.00229038 + (4.71733^{-4} 864^2)$

Y = 353.947 kcal/jam

Based on the results of these calculations, it can be seen that the energy expenditure at rest is 353.947 kcal/hour.

4.4. Energy Consumption Calculate

To determine the energy consumption needs, the formula in Equation 1 is used.

where,

KE = 382.208 kcal/hour – 353.947 kcal/hour

KE = 28.261 kcal / hour

Thus, the energy consumption required by workers during the batik painting process is 28.261 kcal/hour.

4.5. Calculation of Break Time in Batik Casting Process

To determine the need for rest time using the formula:

$$R = (T(W-T))/(W-1.5) \quad (7)$$

If:

Working time (T) = 15 minutes

Energy consumption (W) = 28.26 kcal/hour

Then:

R = (T(W-T))/(W-1.5)

R = (15 (28.26 - 15))/(28.26-1.5)

R = 7.4327 minutes

So the time needed to rest for batik-making workers in the painting process is 7.4327 minutes. From the observations that have been made in the boiling process in the batik industry, the respondent data and pulse measurement data are presented in Table 4.

Table 4. Respondent data and pulse rate measurement results for workers in the batik boiling section to dissolve the night.

Respondent	Age (Yr)	Gender	Working period (Yr)	Height (Cm)	Weight (Kg)	Pulse Rate Before Work	Pulse Rate At Work	Pulse Rate At Break
1	67	M	8	160	45	80	88	72
2	57	F	5	155	55	88	84	96
3	60	M	3	169	53	76	86	76
4	59	M	5	169	49	80	92	92
5	54	F	5	167	49	84	88	88
6	54	F	7	166	75	104	100	112
7	54	M	5	150	40	88	92	100
8	63	M	5	160	49	68	76	72
9	52	M	6	158	50	80	96	96
10	57	M	7	159	47	80	120	76
Total	577	0	56	1613	512	828	922	880
Average	57.7	0	5.6	161.3	51.2	82.8	92.2	88

Table 4 provides an overview of respondent data and pulse rate measurements for workers in the batik boiling process. The respondents have an average age of 57.7 years and an average working period of 5.6 years. Their physical characteristics include an average height of 161.3 cm and an average weight of 51.2 kg. The pulse rate data reveals differences in heart rate across three conditions: before work, during work, and during rest.

The average pulse rate before work is 82.8 beats per minute, indicating a relatively calm state before engaging in the boiling process. During work, the average pulse rate increases to 92.2. It's reflecting the physical effort required for dissolving the wax in the boiling process. After work, during the rest phase, the pulse rate decreases to an average of 88, suggesting that although the heart rate lowers, it does not fully return to the baseline pre-work level for some workers.

4.6. Calculation of Energy Expenditure at Work (Et) in the Fabric Boiling Process

To find out how much energy expenditure at work can be done by calculating using the following formula:

$$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ X^2) \quad (8)$$

If: X = average energy expenditure at work

X = 922

So then,

$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ X^2)$

$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ 922^2)$

$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ 850084)$

$Y = (1.80411 - 0.00229038 + (401.01)$

$Y = (1.801 + 401.01)$

Y = 402.81 kcal/hour

Based on the results of these calculations, it can be seen that the energy expenditure at work is 402.81 kcal/hour.

4.7. Calculation of Energy Expenditure at Rest (Ei) in the Fabric Boiling Process

Calculation of energy expenditure at rest using the formula using the same formula in calculating of Ei.

$$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ X^2)) \quad (9)$$

If: X = average energy expenditure at rest

X = 880

So then:

$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ X^2)$

$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ 880^2)$

$Y = (1.80411 - 0.00229038 + (4.71733^{-4}\ 744400)$

$Y = (1.80411 - 0.00229038 + (365.31)$

$Y = (1.801 + 365.31)$

Y = 367.111 kcal/hour

Based on the results of these calculations, it can be seen that the energy expenditure at rest is 367.111 kcal/hour.

4.8. Energy Consumption Calculate

To determine the energy consumption needs, the formula in Equation 1 is used

Where,

KE = 402.81 kcal/hour – 367.111 kcal/hour.

KE = 35.699 kcal / hour

Thus the energy consumption requirement needed by workers in the fabric boiling process is 35.699 kcal/hour.

4.9. Calculation of Break Time in Fabric Boiling Process

To find the need for rest time using the formula:

$$R = (T(W-T))/(W-1.5) \quad (10)$$

If:

Working time (T) = 30 minutes

Energy consumption (W) = 35.699 kcal/hourThen:

R = (T(W-T))/(W-1.5)

R = (30 (35.699 - 30))/(35.699 – 1.5)

R = (30(5.699))/34.199

R = 170.97/34.199

R = 5 minutes

So the time needed to rest for batik-making workers in the process of boiling the cloth is 5 minutes.

4.10. Working Environment Analysis

Based on the results of measurements obtained data on the work environment which includes temperature and lighting in the process of stamp and boiling as in Table 5 dan Table 6.

Table 5. Table of Measurement Results of Work Environment in The Stamp Process

Respondent	**Time/Meter (minutes)**	**Temperature (°C)**	**Lighting (Lux)**
1	3.06	28	187
2	2.34	29	122
3	2.03	28	132
4	3.3	32	138
5	2.18	31	114
6	1.68	28	70
7	0.39	31	168
8	2.63	28	93
9	4.87	31	26
10	5.6	33	28
Total	28.08	299	1078
Average	2.808	29.9	107.8

Table 6. Measurement Results on Fabric Boiling Process

Respondent	**Temperature (°C)**	**Lighting (Lux)**
1	31	176
2	29	200
3	29	160
4	37	150
5	37	167
6	37	150
7	37	143
8	37	136
9	37	156
10	37	148
Sum	348	1586
Average	34.8	158.6

Based on Table 5, it is known that the average time to complete the stamp process per meter is 2.8 minutes. The average temperature of the work environment in the painting process is 29.9^{0}C so that the work environment in the painting process is high and exceeds the threshold value set by the Permenkes where the temperature of a comfortable work environment is 28^{0}C. so that this section should be given sufficient ventilation or by installing a fan. The average lighting level measured using a Lux Meter is 107.8 Lux so that the work environment in the stamp process the lighting level is still very lacking because the minimum is 200 lux, thus there should be additional ventilation so that there is sunlight entering or by adding several lights as lighting.

From Table 6, the average temperature of the work environment in the boiling process is 34.8^{0}C. So that the work environment in the boiling process is classified as high and exceeds the threshold value set by Permenkes, where it is known that the comfortable working environment temperature is 28^{0}C. The average lighting level measured using a Lux Meter is 158.6 Lux so that the work environment in the stamping process the lighting level is still very lacking because the minimum is 200 lux.

The improvement requires the addition of ventilation, both natural and mechanical, such as exhaust fans or air conditioners, as well as the addition of lighting with LED lights or utilizing sunlight through good ventilation. In addition, providing access to drinking water and organizing work schedules at lower temperature times can help maintain worker conditions. Implementing these solutions not only improves comfort but also work safety and production quality.

5. CONCLUSION

The conclusion of this study is that the expenditure of work energy in the batik painting process is 382 kcal / hour and in the boiling section the expenditure of work energy is 402 kcal / hour. Energy expenditure at rest in the casting process amounted to 354 kcal and in the boiling process amounted to 367 kcal / hour. Energy consumption in the stamp process is 29 kcal/hour and in the boiling process 36 kcal/hour. The rest time required in the stamp process is 7.43 minutes/15 minutes and in the boiling process 5 minutes/30 minutes.

The results of the analysis of the working environment conditions both in the casting process and the boiling process can be seen that the temperature of the work environment exceeds the threshold value, while for the lighting level after measuring the lighting is very less below the threshold value.

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