Cek_OPSI-Analysis of Workload and Fatigue in Batik Cap Workers in Sukoharjo- Mathilda Sri Lestari-turnitin

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Analysis of Workload and Fatigue in Batik Cap Workers in Sukoharjo

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ABSTRACT

Batik is an ancestral heritage of the Indonesian people that is preserved to this day, especially on the island of Java. In Java, the center of the batik industry is in Pekalongan, Yogyakarta, Surakarta and Sukoharjo. In Sukoharjo there are several home industries that produce batik cloth, especially in the Krendetan Sukoharjo area, which produces both written and stamped batik. In this process of batik, both written batik and stamped batik in this home industry, is all done manually with simple tools. After a preliminary survey was conducted, 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 batik stamping. This study 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 Casting section and boiling the cloth to remove the night. From the results of the study, the work energy expenditure in the batik painting process was 382 kkl / hour and in the boiling section the energy expenditure at work was 402 kkl / hour. Energy expenditure at rest in the casting process amounted to 354 kkl, in the boiling process amounted to 367 kkl / hour. Energy consumption in the tasting process is 29 kkl/hour, in the boiling process 36 kkl/hour. The rest time required in the tasting process is 7.43 minutes/15 minutes, in the boiling process 5 minutes/30 minutes.

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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 stamped 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 4 women. The age of the workers ranges from 23 to 57 years old. 3 of them graduated from primary school, 6 from junior high school, and 2 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. Workers with heavy work and a high source of fatigue will cause the risk of work accidents and occupational diseases [3]. Fatigue contributes greatly to the incidence of work accidents [4].

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. MATERIALS AND METHODS

MATERIALS

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 [5].

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 [6].

2.1. Ergonomics Goals

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. [5]. Ergonomics also pays attention to human factors, such as fatigue and workload [7].

Workload can be defined as the difference between workers' abilities and job demands [8]. 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 [9]. 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 [10].

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 [11]. 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 [11]. 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 productivity decreases, work-related stress, occupational diseases, and injury due to overexertion work [12].

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 [13]. Level of fatigue that happened is visible from level of work load measured by through energy consumption [14]

2.2. *Balance Concept in Ergonomics*

In opinion [15] the concept of balance between work capacity and task demands in ergonomics is influenced by several factors, including: 1.) Work ability of a person which is influenced by personal characteristics, physiological ability, psychological ability, and psychological ability; 2.) Task demands that depend on task and material characteristics, working hours, and related conditions in the work environment; 3.) Performance which depends on the ratio of the magnitude of task demands to the magnitude of the ability concerned. Rom an ergonomic point, between task demand and work capacity must always be in a line of balance so that high work performance can be achieved. Work demand can't be underload or workload [16]. Excessive workload in the long run has an impact on reducing a person'a productivity which is causes by job fatigue [17]. Excessive workload can have an impact on stress levels and worker health [18].

2.3. *Oxygen and Energy Consumption*

Person who works physically has energy consumption and energy expenditure. during work, energy consumption is determined from blood pressure, blood flow, body chemical composition, body temperature, evaporation rate and the amount of air expelled by the lungs. energy consumption is determined by the difference in heart rate during work and rest. [19].

Energy consumption formula:

KE = Et – Ei (1)

Description:

KE :Energy Consumption for a particular work activity (Kilocalories/minutes)
Et :Energy Expenditure during a certain working time (Kilocalories/minutes)
Ei :Energy Expenditure during rest.

The workload classification table is presented in table 1.

Table 1 Workload Classification

Level of Work	Energy expenditure Kal/minutes	Kal/8hours	Heart rate Beats/minutes	Energy Consump. Liter/minutes
Undelly Heavy	>12,5	>6000	>175	>2,5
Verry 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

2.4. *Oxygen and Energy Consumption*

Work is an activity carried out by humans in an effort to change the natural environment with the aim of maintaining and maintaining their survival [20]. Energy consumption can be used to determine the level of physical load [21]. energy consumption during work can be determined from direct measurements (including blood pressure and flow, body chemical composition, temperature, evaporation rate, and amount of air from the lungs) [22], and can be measured by pulse rate [23].

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 [5]. The basis of calculation to determine the number of calories a person in his work activities, can be done with the approach or estimated calorie needs based on the type of activity. Estimated hourly calorie requirements per kg of body weight are presented 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

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 muscle movement [24]. Pulse rate can be used to measure the physical condition of workers as a basis for the level of fatigue of a worker. fatigue level of a worker. The greater the level of fluctuations in the pulse rate, indicating the greater the the greater the level of a person's workload.

Equipment that can be used to calculate the pulse rate is Electro Cardio Graph (ECG) stimulation. or it can also be recorded with a stopwatch with the 10-beat method [5]. With this method, the working pulse rate can be calculated as follows:

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

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:

$$\%\ HR_{reserve} = \frac{DWorking\ pulse - resting\ pulse}{Maximum\ pulse\ rate - Resting\ pulse\ rate} \times 100$$

Furthermore, determine the classification of workload based on the increase in work pulse rate compared to the maximum pulse rate due to cardiovascular load (% CVL) which is calculated by the following formula:

$$\%\ \text{HRreserve} = \frac{\text{Working pulse} - \text{Resting pulse}}{\text{Maximum pulse rate} - \text{Resting pulse rate}} \times 100$$

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 [22]. The physiological approach aims to reduce workload in order to reduce the level of physical fatigue of workers [25].

In opinion [5] that the 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.

METHODS

The object of the research with the title Analysis of Workload and Fatigue in Batik Cap Workers in Krendetan, Sukoharjo, is workers who work in the industry. The research steps begin with giving an explanation of the purpose of the research to the Batik Cap business owner and workers, direct data collection which includes: subject data, pulse rate before work, pulse rate during work and pulse rate at rest.Alat yang dibutuhkan lembar kerja, stopwatch, dan kamera digital.

Furthermore, the pulse measurement data will be calculated to calculate energy consumption needs, rest time needs and also calculate %CVL. The results of these calculations will then be analyzed to determine the conclusion of the results of this study.

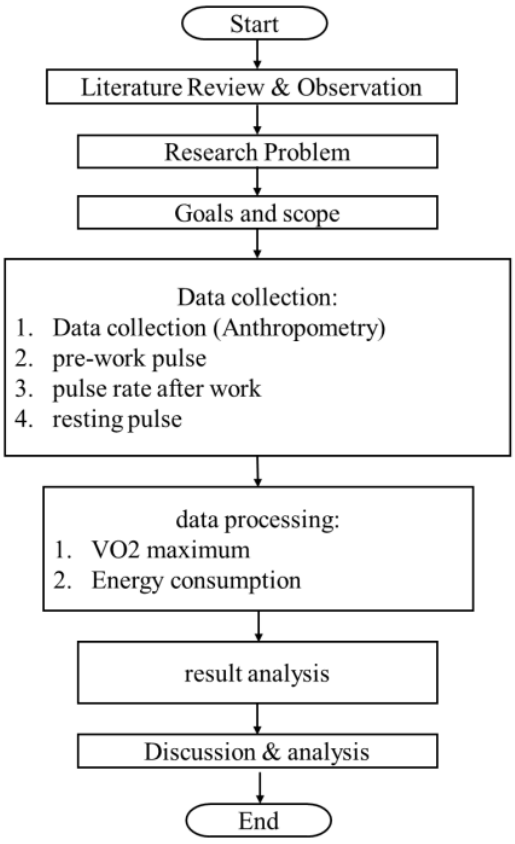

Figure 1. Flowchart

3. RESULTS

3.1 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	L	2	160	45	80	88	72
2	57	L	5	155	55	88	84	96
3	60	L	3	169	53	76	86	76
4	59	L	3	169	49	80	92	92
5	54	L	5	167	49	84	88	88
6	54	L	7	166	75	108	84	132
7	54	L	5	150	40	76	124	60
8	63	L	5	160	49	80	80	84
9	52	L	6	158	50	88	84	88
10	57	L	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.

3.2 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 X2)

From calculated

X = average energy expenditure at work

X = 898

So then:

Y = (1.80411 – 0.00229038 + (4.71733 -4 X2)

Y = (1.80411 – 0.00229038 + (4.71733 -4 8982)

Y = (1.80411 – 0.00229038 + (4.71733 -4 806404)

Y = (1.80411 – 0.00229038 + (380407)

Y = (1,801 + 380,4)

Y = 382,208 kkl/jam

Based on the results of these calculations, it can be seen that the energy expenditure at work is 382,208 kkl / hour.

3.3 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 Et.

Y = (1.80411 - 0.00229038 + (4.71733 -4 X2))

From calculated

X = average energy expenditure at rest

X = 864

So then:

Y = (1.80411 – 0.00229038 + (4.71733 -4 X2)

Y = (1.80411 – 0.00229038 + (4.71733 -4 8642)

Y = (1.80411 – 0.00229038 + (4.71733 -4 746,496)

Y = (1.80411 – 0.00229038 + (3,521)

Y = (1,801 + 352,15)

Y = 353,947 kkl/jam

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

3.4 Energy Consumption Calculated

To find out how much energy consumption needs using the formula:

KE = Et - Ei

KE = 382,208 kkl/hour - 353,947 kkl/hour

KE = 28.261 kkl / hour

Thus the energy consumption requirement needed by workers in the batik painting process is 28.261 kkl / hour.

3.5 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)

If:

Working time (T) = 15 minutes

Energy consumption (W) = 28.26 kkl/hour

Then:

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

R = (15 (28,26 - 15))/(28,26-1,5)

R = (15 (13,26))/(28,26-1,5)
R = 198,9/26,76
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 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	L	8	160	45	80	88	72
2	57	L	5	155	55	88	84	96
3	60	L	3	169	53	76	86	76
4	59	L	5	169	49	80	92	92
5	54	L	5	167	49	84	88	88
6	54	L	7	166	75	104	100	112
7	54	L	5	150	40	88	92	100
8	63	L	5	160	49	68	76	72
9	52	L	6	158	50	80	96	96
10	57	L	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

Based on table 4, calculations are then made to determine energy expenditure during work, rest energy expenditure, energy consumption and rest time requirements.

Missing "," ETS

3.6 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 X2)

If: X = average energy expenditure at work
X = 922

So then,

Y = (1.80411 - 0.00229038 + (4.71733 -4 X2)
Y = (1.80411 - 0.00229038 + (4.71733 -4 9222)
Y = (1.80411 - 0.00229038 + (4.71733 -4 850084)
Y = (1.80411 - 0.00229038 + (401,01)
Y = (1,801 + 401,01)
Y = 402.81 kkl/hour

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

3.7 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 X2))

If: X = average energy expenditure at rest
X = 880

So then:

Y = (1.80411 - 0.00229038 + (4.71733 -4 X2)
Y = (1.80411 - 0.00229038 + (4.71733 -4 8802)
Y = (1.80411 - 0.00229038 + (4.71733 -4 744400)
Y = (1.80411 - 0.00229038 + (365,31)
Y = (1,801 + 365,31)

Y = 367.111 kkl/hour

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

3.8 Energy Consumption Calculation

To find out how much energy consumption needs using the formula:

KE = Et - Ei

KE = 402.81 kkl/hour - 367.111 kkl/hour.

KE = 35.699 kkl / hour

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

3.9 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)

If:

Working time (T) = 30 minutes

Energy consumption (W) = 35.699 kkl/hour

Then:

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.

3.10 Working Environment Analysis

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

Table 5. Table of measurement results of Work Environment in the Tasting 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
Jumlah	28.08	299	1078
Average	2.808	29.9	107.8

Based on table 5.3. It is known that the average time to complete the batik painting process per meter is 2.8 minutes. The average temperature of the work environment in the painting process is 29.90C 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 280C. 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 tasting 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.

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
Jumlah	348	1586
Average	34.8	158.6

Based on table 6, the average temperature of the work environment in the tasting process is 34.80C so that the work environment in the boiling process is high and exceeds the threshold value set by the Permenkes where the temperature of a comfortable work environment is 280C, so that this section should be given sufficient ventilation or by installing a fan. The average lighting level measured using a Lux Meter is 158.6 Lux so that the work environment in the tasting 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.

5. CONCLUSION

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