

Joint International Conference

APCHI-ERGOFUTURE-PEI-IAIFI 2014

"With new mind set and widen horizon to catch the future: Physiology is the basic science for human life"
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Editors :

dr. I Putu Adiartha Griadhi, M.Fis
Dr. dr. I Made Muliarta, M.Kes



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**Proceeding
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WELCOME FROM CONFERENCE CHAIR



Om Swastyastu,

Based on long experiences working in Human Computer Interface (HCI), Ergonomics (Erg), physiology, occupational safety and health (OSH), up to now we are practically still running at the same place. Accident or occupational diseases in fact still happening, even in the workplace equipped with up to date regulation and personal protected devices. Unsafe acts and unsafe behavior must be managed to develop safety behavior. Mindset changes become an important issue to be success. To solve that problem. Balinese Branch of Indonesia Ergonomics Society supported by APCHI, PEI, IEA, IAIFI, Center of Ergonomics Study of Udayana University and Bali Human Ecology Study Group (BaliHESG) organize the Joint Internasional Conference APCHI-ERGOFUTURE-PEI-IAIFI 2014. The conference will be held at Udayana University at Jl. P.B Sudirman, Denpasar - Bali on 22 – 25 October 2014.

The goals are. 1. To provide guidance and direction for young ergonomists, 2. To show the unfit, improper, inappropriate research and application of ergonomics, physiology, computer interface, and OSH, 3. to convince that a total and a more strategic approach must be done in conducting research and application with aim to have maximum benefit.

The scientific program of APCHI-ERGOFUTURE-PEI-IAIFI 2014 including : 1) workshops and tutorials, 2). Keynotes address, 3) Free communication (parallel session) of various topics of physiology, human computer interface, ergonomomy in small scale industries, children, women, cognitive ergonomomy, MSDs, office, communities, agriculture, architecture, etc. and 4) Field Visit and Tour to Bali best tourism object (on request). To make the conference more successfully, the organizing committee invited overseas participants to participate in the conference. Bali is a paradise island with unique attraction culture shall becoming unforgettable experience to all participants.

Om Shantih, Shantih, Shantih Om,

Conference Chair
Dr. Ir. Putu Gde Ery Suardana, M.Erg

GREETINGS AND BEST WISHES TO THIS CONFERENCE



Dear Hosts, Conference organizers, colleagues, and friends,

I would like to use this opportunity to express my congratulations to you for all your efforts and hard work to organize such an important event. Your dedication for promoting ergonomics discipline and profession as well as sharing and enlarging ergonomics knowledge has resulted in this well-organized conference with great contributions. I attended a previous APCHI-ErgoFuture Conference back to 2010, I was positively impressed with the work done by Indonesian scholars.

It is impressive to see how Indonesian researchers dedicate their work on solving local ergonomics needs while reaching out to the world. I truly support your efforts to apply ergonomics knowledge to the priority needs of the local and national community. I recognize clearly the great commitment of the organizers in continuing their efforts of hosting this conference again in four years short. It is equally important to satisfy local ergonomics needs and to network the international ergonomics community.

This conference hold in Bali, Indonesia, has served as an important platform for local and foreign participants to communicate, exchange knowledge and experience, as well as discuss and realize new ideas and mutual cooperation. It is an important event for the big ergonomics family, and is shaping the future development of ergonomics not only in this region but also globally. I hope our efforts could continue and make this conference in a regular basis, so the experience of the pioneers and their contributions could be carried over from generation to generation. Let this event be a place where we will regularly see old friends and meet new friends. Please accept my congratulations and best wishes to the success of our hosts' efforts and this conference!

Eric Min-yang Wang
President, International Ergonomics Association

CHANGING MIND SET AND WIDENING THE HORIZON TO ACHIEVE BETTER FUTURE



Recently we are facing various complex development problems which should be anticipated, - within our limitation -, in attaining our goals to enhance the quality of life and working life of the people at large. Impacts of Globalization, Global Warming, Eruption, Earthquake, 24 hours society, flooded area, drinking water shortage, are some of the problems we have to face and to anticipate.

And for a small island with all its limitation, likes Bali, in anticipating all those problems should be able to carry out a smart and wise development policy, likes to conduct "Development for Bali" and not "Development in Bali". There is no choice for Bali except to carry out sustainable development, using the three economic potentials: agriculture, tourism and small scale industry in synergist as means to attain the goals. To be different and winning the competition, cultural tourism must be utilized in developing tourism. Agriculture and Small scale industry should be able to show its consistency as the backbone of Bali's economy in crisis.

In all those activities ergonomists and ergonomics associations should be able to give their strong contribution and should be able to play a role as playmaker due to its position and strong role in human-machine-environment interface.

As the problems are so complex a Total Ergonomics Approach which consist of SHIP and Appropriate Technology approaches must be utilized. And to conduct such an approach, mind set change of the human resource must be developed. Holistic thinking and act must be empowered. Team approach must be conditioned. Egoism and arrogant attitude must be thrown away.

And through ergo future 2006, 2010 and 2014, we try to aware the problems, to empower the human resource and to enhance the capability of tools to support. Therefore we have to thank everybody who have already given their concerned and commitment to this efforts by supporting the conferences in various means.

We shall not stop the efforts only by organizing conferences, but beyond that. Fundamental efforts have been planted and time to grow it together by academicians, government and people at large, has already come.

Finally welcome to all participants in the conferences and let us make a jump in our endeavor to enhance the quality of life and working life of the people.

Please enjoy your visit scientifically and culturally. Thank you.

Prof Emeritus Adnyana Manuaba
Initiator Ergofuture

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MEASUREMENT OF LABOR PHYSICAL AND MENTAL WORKLOAD AT CRUMB RUBBER PRODUCTION LINE IN PT P&P BANGKINANG

Yumi Meuthia, Nilda Tri Putri, Afdal Zikri

Industrial Engineering Department, Andalas University, Padang

ABSTRACT: Human resources have a significant role in manufacturing process. Not all the activities in manufacturing process can be done automatically. Human workers or labors have several responsibilities in manufacturing process, such as material handling, or problem solving and analysis. Each job has certain workload and each workload will affect the productivity of a production line. Some of the significant roles of human resources at PT P&P Bangkinang are the human workers as material handling labors (Processing Line 1) and control panel operators (Processing Line 2). To determine the workload of these workers, physiological workload measurement carried out on 6 material handling labors through measurement of heart rate, energy consumption, and %CVL. Meanwhile, psychological workload measurement carried out on 5 control-panel operators in using NASA-TLX method. The result of physiological workload measurement shows that workload at the first processing line (breaker, press, pull, and cutting workstation) is categorized as moderate workload (approaching heavy workload). The highest workload occurred at cutting workstation, with energy consumption of 194.62 kcal/h and 48.62 %CVL which means heavy workload. Meanwhile, the result of psychological workload measurement at the second processing line (checking process, contaminants, and control panel workstation) shows that the highest mental workload for these workers is the Frustration level.

Keywords: physiological workload, psychological workload, material handling, analysis, productivity

INTRODUCTION

Background

Every worker has some kind of workload in his job. Someone is burdened at work when the body receives loads from outside, either in the form of duties or responsibilities. These loads can be categorized as physical or psychological workload. From the ergonomic perspective, the workload received by a person must be appropriate or balanced in physical ability, cognitive ability, or mental capabilities of human beings who receive the loads.

Generally, workload is influenced by many complex factors, such as: (Tarwaka, 2004):

Internal factors

1. Somatic (gender, age, body size, nutrition)

2. Psychological (motivation, perception, confidence, satisfaction).

External factors

- a. Task (physical task such as working attitude, transportation, the lifting load, then the psychological tasks include job complexity and responsibility)
- b. Work organization (working hour, shift, work system and facilities), working condition (physical environment, chemical, biological and psychological condition)

PT P & P Bangkinang is a company that works in manufacturing rubber into crumb rubber. One of the main elements that affect the productivity of the production line at PT P & P Bangkinang is the man that works as a material handling labor (Processing Line 1), and the operator at the control panel (Processing Line 2).

Type of work on the Processing Line 1 associated with material handling and

physical activity, such as lifting raw materials, cutting materials, pushing the material, and moving the material. These job requires physical strength because the material is heavy. The workstations which needs material handling on Processing Line 1 are :

1. Breaker Workstation

Labor lift up the crude rubber pads to the top of the breaker using a hook conveyor tools. The weight of the raw material is approximately 20-30 kg with continuous removal of frequency. In one work shift, a work station has two workers and only allowed to stop at recess .

2. Milling (Press) Workstation

Workers who work at this work station lift up the output of the breaker and locate the material to the milling machine. The material should be kept in the same thickness so that it becomes homogeneous and solid. The output of this process called a *blanket*. The blanket is quite heavy due to high water content in the washing process.

The workers have to maintain the material feeding of the machine in order to avoid bottlenecks. Therefore, the workers do not have a break at work because the material flow does not stop until the break time.

3. Cutting Workstation

The labor works in a standing position and bent their back to cut the blanket out of the milling machine. The non-ergonomic working position, and high working frequencies caused workers to experienced pain on the waist. After cutting the blanket, workers have to lift the pieces into a reels that will hold 12-15 , each roll of blanket weight approximately about 30-35 kg.

4. Blanket Pulling Workstation

Workers who work at this work station lift the blanket that had been loaded on to the cart. Blanket that has been processed then transported to the Wind Hanging Room (Kamar Gantung Angin/KGA) by the workers. The loads that should be

pulled is approximately 300-350 kg. The distance between the milling workstation to the KGA is approximately 50 meters and the frequency of pulling is constant and sustained in rapid movement to avoid the blanket pores to stick to each other.

Labors of those four workstations work with a contract system, so that the amount of their daily wages determined by the amount of raw materials that are processed. Thus, workers here work as quickly as possible in order to quickly processed raw materials and finished on schedule specified by the contract. The contract usually lasts for a year.

Under this system, the company set the working time of each shift for 7 hours per day. Production activities (shift I) start from 07.00 AM to 4.00 PM, and break time from 12.00 PM to 1.00 PM. The next turn of the second shift starting at 4:00 PM until 11:30 PM, with 30-minute rest period starting at 7:30 PM. But in reality the workers would prefer to work overtime (overtime) up to 9 hours per day assuming that they will get more wages. This is contradictory to the government rule (Keputusan Menteri Tenaga Kerja Nomor 51/Men/1999) regarding the Threshold Limit Value for an acceptable workplace for labor without causing disease or health problems, is to work for no more than 8 hours a day and 40 hours a week (Kep. Men. Tenaga Kerja 51/Men/1999).

Working shift system that is not adjusted to the government rules will cause the workers to absent from work due to illness such as muscle sprains and fatigue. Daily overtime system applied also resulted into a loss of over chase laborers working time in order to get higher wages. In addition, the company also set up at the job worker is not allowed to rest because here the flow of production activities continuing, so workers should always be ready in position. When one worker

negligent there will be a company.

Based on the worker, judging there is a provision in Table 1.

Table 1. Experience of labor to the state of labor

Working frequency	Man
once in a while	40
continuous	15-1

Sama'mur, 1989

Workers on the within the adult the work continuing the recommender should carry a in reality the a limited by worker Furthermore, the production line insurance and production line require a human results of production

1. Testing of r Operators p percentage called test assessment visually or texture of rubber ass important f raw materi the assessm whereby p Operators the cause purchase o the appraisal

2. Control pa

negligent in handling his duties, there will be a bottleneck that could hurt the company.

Based on the recommended weight for a worker, judging by the state of its workforce there is a provision that is recommended as in Table 1.

Table 1. Expense Appointment According to the state of labor

Lifting frequency	Adult		Young	
	Man (Kg)	Woman (Kg)	Man (Kg)	Woman (Kg)
once a while	40 kg	15 kg	15 kg	10-12 kg
often	15-18 kg	10	10-15 kg	6-9 kg

Sumarmo, 1989 in Soleman, 2011.

Workers on the first processing entirely within the adult age category and perform the work continuously. Under the terms of the recommended weight, the workers should carry a weight of 15-18 kg, whereas in reality the average weight of the blanket lifted by workers ranged between 30-35 kg. Furthermore, the processing of the second production line activities related to quality assurance and product standards. The production line consists of workstations that require a human operator in analyzing of the results of production activities such as:

Testing of raw material

Operators perform the analysis of the percentage of pure rubber content. Plans called testers or appraiser do an assessment on percentage of work done manually or by looking at the structure and texture of rubber. Percentage of pure rubber assessment process is a very important function in the trade of rubber raw materials, the error rate (errors) in the assessment of the minimum required, whereby permissible tolerance is +0.5%. Operators must be careful in assessing the cause of profit and loss in the purchase of raw materials also depend on the appraiser's ability to analyze.

Control panel

In this workstation operators task is to regulate cooking temperature of the blanket. Prior to cooking, the operator must know how high the water content remaining on the blanket and adjust the temperature and length of cooking time accordingly. If the cooking is not in accordance with the temperature and time, it will generate wasted crumb rubber due to the poor quality. It becomes too dry and reduce quality standards. One of the other problems that cause mental burden here is the condition of the appliance. The control panel machine is getting old.

3. Contaminant/inspection

Each product is produced with standard quality required; one of the standard is that the product should be free of contaminants objects. Operators working in this workstation do the inspection by seeing if there are other objects carried in the crumb rubber pads that are ready to be packed. This work was done in a standing position with the allocated conveyor carrying the crumb rubber pads. Because the use of the conveyor, then the work must be done quickly and accurately. The operators often experience psychological distress in wondering whether they made a mistake, such as dirt in the product. If the mistake is found out in the shipping area, all products in the same container have to be inspected again entirely. It will cost the company more.

It is important for companies to know the level of physiological workload of workers and the psychological burden experienced by the operator, so that the productivity of each production line can be maintained over an increase in the quality of production. The main concern in the production of quality rubber Bangkinang PT P & P is the speed and quality of production activity by a factor of accuracy in determining the temperature and inspection before final packaging (storage).

b. Objectives

The objectives of this study are as follows:

1. To determine the level of physiological workload processing production workers received I.
2. To determine the level of psychological workload experienced production operators processing II.
3. To find the workload measurement and provide recommendations for the better production process.

B. LITERATURE STUDY

a. Definition of work

Work is anything that is done by man to life as a human being. Human work is mentally and physically each has different intensity. The level of intensity is too high allowing the use of excessive energy, intensity is too low otherwise allow feeling bored and tired. Physical work is a job that requires the function of muscle performance and spending a lot of energy. Physical work will make a difference to the oxygen consumption, heart rate, body temperature, and chemical compounds in the body. The psychological workload is closely related to capacity analysis capabilities, precision, spirit or mind of a person.

b. The concept of balance in ergonomic

Ergonomics is a science, art and technology that seeks to harmonize the tools, methods and work environment on the ability, skill and human limitations, so that people can work optimally without the bad influence of his work. From the standpoint of ergonomics, the demands of the task with a working capacity must always be in balance so that the line of work that high performance is achieved. In other words, the demands of the task should not be too low (underload) and also should not be too excessive (overload). Because both the underload and overload of a workers will cause stress (Tarwaka, 2004).

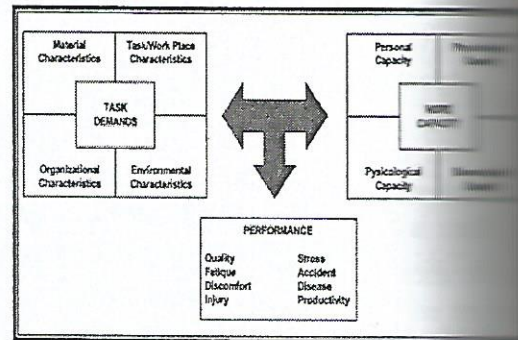


Figure 1. The concept of balance in ergonomics

c. Workload

The work has its own load and pressure either directly or indirectly. It can be influenced by internal and external factors in the work environment. Workload that is experienced physical workload, for workers associated with manual material handling. As for the workers associated with analysis, concentration, and accuracy suffered mental workload / psychological. From the standpoint of ergonomics, workload is received by the person that is appropriate or balanced both in physical abilities, as well as cognitive, as well as the limitations of human beings who receive load. Ability to work a labor differs from one to another and depends on the level of skills, physical fitness, age, and body mass of the workers concerned.

d. Physiological workload

Physical work is work that requires physical energy of human muscle as a source of energy. Physical work is also called "manual operation" which means the performance of work will depend on humans that serve as a source of energy (power) or controller of work. Physical work can also be associated with heavy work or manual labor because these activities require strong human physical effort. In the physical labor is a major source of energy consumption because of determinants heavy / light job. In speaking, human activities can be divided into physical work and mental work. This separation cannot be done perfectly because

close to one another. Physical work will result in changes in the function of the organs, which can be detected through (Tarwaka, 2004):

- Oxygen consumption
- Heartbeat
- Air circulation in lung
- bodytemperature
- Concentration of lactic acid in the blood
- Chemical composition in the blood and urine
- Evaporation rate

Physical work will expend energy is closely related to energy consumption. Energy consumption in the working time is usually determined in an indirect way, ie by measuring heart rate and oxygen consumption (Tarwaka, 2004).

Direct method

Direct measurement method is by measuring the energy expended (energy expenditure) by oxygen intake during work. Increasingly heavy workload will be more and more energy is needed for consumption.

Table 2. Based Workload Category Metabolism, respiration, body temperature and heart rate

Workload category	Age (year)			
	<30	30-39	40-49	>50
Light	0,5-1,0	11,0-20	37,5	75-100
Medium	1,0-1,5	20-30	37,5-38,0	100-125
Heavy	1,5-2,0	31-43	38,0-38,5	125-150
Very heavy	2,0-2,5	43-56	38,5-39,0	150-175
Very heavier	2,5-4,0	60-100	>39	>175

(Widodo, 2008)

Table 3. Maximum oxygen consumption

Category	Age (year)			
	<30	30-39	40-49	>50
Very bad	<25	<25	<25	-
Bad	25-33,7	25-30,1	25-26,4	25
Medium	33,8-42,5	30,2-39,1	26,5-35,4	25,0-33,7
Good	42,6-51,5	39,2-48	35,5-45,5	33,8-43,0
Very	>51,6	>48,1	>45,1	>43,1

(Widodo, 2008)

In determining the energy consumption is usually used a form of energy relationship with heart rate is a quadratic regression equation as follows (Manuaba, 1992):

$$E = 1,80411 - 0,0229038 X + 4,71733 x 10^{-4} X^2$$

where :

- E = Energy (Kcal/minute)
- X = heart beat speed (beat/minute)

b. Indirect method

Indirect assessment method is to count the pulse for work. Measurement of heart rate during work is a method for assessing cardiovascular strains with 10 pulse method, this method can be calculated with the pulse of the work as follows (Kilbon, 1992 in Sundari 2011):

$$\text{Pulse} = 10 \text{ beat/calculation time} \times 60$$

Sensitivity to changes in the loading pulse received by the body high enough. Energy consumption alone is not sufficient to estimate the physical workload. Physical workload is not only determined by the number of kJ consumed, but also determined by the amount of muscle involved and received a static load and thermal stress of the work environment that can increase heart rate.

Increased pulse has a very important role in increasing cardiac output from rest to maximum employment. To determine the workload classification is based on the increase in pulse work compared with the maximum pulse because of the burden of cardiovascular (cardiovascular load =% CVL), can be calculated by the following formula (Widodo, 2008):

$$\% CVL = \frac{100 (\text{Denyut nadi kerja} - \text{Denyut nadi istirahat})}{\text{Denyut nadi maksimum} - \text{Denyut nadi istirahat}}$$

Where is the maximum pulse rate (220-age) for males and (200-age) for women. From the calculation of% CVL will then be

compared with a predetermined classification as follows (Widodo, 2008):

- a. <30% = no fatigue
- b. 30<60% = necessary repairs
- c. 60<80% = working in a short time
- d. 80<100% = required immediate action
- e. >100% = not allowed to activity

Under these conditions, the caloric needs can be used as an indicator to determine the severity of the workload (Kep. Men. Tenaga Kerja-51/Men/I999) :

- 1. Light workload :100-200 kcal/h
- 2. Medium workload : > 200-350 kcal/h
- 3. Heavy workload : > 350-500 kcal/h

e. *Psychological workload*

Work is work involving mental thought processes of our brain. The work resulted in mental fatigue when working under the old conditions, not caused by direct physical activity but due to our brains work. Every mental activity will always involve an element of perception, interpretation and mental processes of an information received by the sensory organs to take a decision or process of remembering information that is stored. The sources of stress in the work environment that can lead to psychological stress, physical work space which is not good, just too heavy workload, work tempo is too fast, too simple job, role conflict, relations with superiors and co-workers as well as the unfavorable organizational climate less pleasant. Measurement of subjective psychological workload can be done with the subjective method, namely the NASA-TLX (National Aeronautical and Space Administration Task Load Index).

Mental load has a fairly high correlation of the errors made (error). The higher the mental load imposed the higher the error that caused or may be said that given the lower performance if the load exceeds the capacity. This research used the NASA-TLX form of a questionnaire developed by the emergence of the need for subjective measurement easier but more sensitive to the measurement of workload. Developed by the emergence of subjective

measurement needs consisting of nine factors (task difficulty, time pressure, performance, frustration, stress and frustration). Of the nine factors are further simplified into 6 (Simanjuntak, 2010):

- 1. *Mental demand*
- 2. *Physical demand*
- 3. *Temporal (time) demand*
- 4. *Performance*
- 5. *Effort*
- 6. *Frustration*

The following indicators and comparisons in Table 4 and Table 5.

Table 4. Indicators NASA-TLX mental workload

Scale	Questions	Scale
Mental Demand (MD)	According to you how much mental activity is needed for this job? such as: Concentration in viewing, searching, observing	1-100
Physical Demand (PD)	According to you how much physical activity is needed for this job? such as: Event pushing, pulling, twisting, lifting	1-100
Temporal Demand (TD)	According to you how much pressure did you feel due to the time available for this work? such as: Slowly, relaxed, fast	1-100
Performance (OP)	How much do you think your success rate in doing this job? such as: related to job satisfaction and the results obtained	1-100
Frustration Demand (FR)	According to you how much anxiety, feelings of pressure, and the stress that you feel for this job? such as: Convenience and the level of disruption	1-100
Effort (EF)	According to you how much effort (mental and physical) that is issued to do this job? such as: the complexity of easy or difficult	1-100

Table 5. NASA-TLX paired indicators

No.	1	2
1	PD	MD
2	TD	MD
3	OP	MD
4	FR	MD
5	EF	MD
6	TD	PD
7	OP	PD
8	FR	PD
9	EF	PD
10	TD	OP
11	TD	FR
12	TD	EF
13	OP	FR
14	OP	EF
15	EF	FR

To get a score of NASA TLX mental workload, weight and rating for each indicator multiplied, then summed and divided by the total number of pairwise comparisons.

$$= \frac{\sum(\text{obot} \times \text{rating})}{15}$$

$$\text{rata-rata WWL} = \frac{WWL}{15}$$

After obtained the average psychological workload of operators can be categorized based on the average value of the Weighted Workload (WWL). Workload categories displayed in Table 6.

Table 6. Workload Categories

No	Range (average WWL)	Category
1	0 -- 9	Low
2	10 -- 29	Medium
3	30 -- 49	somewhat higher
4	50 -- 79	High
5	80 -- 100	Very High

COLLECTING AND DATA PROCESSING

Recapitulation of physiological data

This is the data that is needed in the study of physiological workload to 6 workers at processing 1 in PT P & P Bangkinang.

Table 7. Pulse of workers

Laborers	Work station	10 heart beat/pulse Before working (seconds)	10 heart beat/pulse While working (seconds)
Rahmat	Cutting Blanket	7,94	4,9
Imah	Press	8,3	7,8
Adisal	Press	8,5	7,2
Damirsan	Breaker	7,8	5,6
Muzarman	Pull	8,2	5,4
Yatno	Pull	8,41	5,7

Recapitulation of the NASA-TLX questionnaire data

The following summary data from the NASA-TLX questionnaire on 5 operators processing II

Table 8. Summary data from the NASA-TLX questionnaire

Operator	work station	MD	PD	TD	OP	FR	EF
Rahmat	Control Panel	75	50	50	75	80	60
Imah	Control Panel	75	80	80	80	75	60
Adisal	Kontaminan Inspeksi	95	50	80	80	90	50
Damirsan	Kontaminan Inspeksi	80	50	80	70	60	90
Muzarman	Pengelasan bahan baku	80	60	50	90	75	70

Table 9. comparison indicator of NASA-TLX summary

Responden	Rafta Rizal		Andrestus		Nurma		Subarman		Asmuni	
workstation	Control panel		Control panel		Kontaminan		Kontaminan		Testing	
1	PD	MD	PD	MD	PD	MD	PD	MD	PD	MD
2	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD
3	OP	MD	OP	MD	OP	MD	OP	MD	OP	MD
4	FR	MD	FR	MD	FR	MD	FR	MD	FR	MD
5	EF	MD	EF	MD	EF	MD	EF	MD	EF	MD
6	TD	PD	TD	PD	TD	PD	TD	PD	TD	PD
7	OP	PD	OP	PD	OP	PD	OP	PD	OP	PD
8	FR	PD	FR	PD	FR	PD	FR	PD	FR	PD
9	EF	PD	EF	PD	EF	PD	EF	PD	EF	PD
10	TD	OP	TD	OP	TD	OP	TD	OP	TD	OP
11	TD	FR	TD	FR	TD	FR	TD	FR	TD	FR
12	TD	EF	TD	EF	TD	EF	TD	EF	TD	EF
13	OP	FR	OP	FR	OP	FR	OP	FR	OP	FR
14	OP	EF	OP	EF	OP	EF	OP	EF	OP	EF
15	EF	FR	EF	FR	EF	FR	EF	FR	EF	FR

c. Data Processing

Processing is done to obtain physiological and psychological workload received by workers and operators in PT P & P Bangkinang.

a. Energy consumption

Calculation of energy consumption is performed to determine the amount of energy released by each operator on the production of crumb rubber in PT P & P Bangkinang.

Table 10. Energy consumption at rest

No.	Laborers	Work station	Recapitulation Energy Levels At Rest	
			Number of Pulse / Minute	Energy Level (kcal/min)
1	Rahmat	Cutting Blanket	75,5668	0,0113
2	Imah	Press	72,2892	0,0092
3	Adisal	Press	70,5882	0,0082
4	Damirsan	Breaker	76,9231	0,0122
5	Muzarman	Pull	73,1707	0,0097
6	Yatno	Pull	71,3436	0,0086

Table 11. Energy consumption at work

No.	Laborers	Work station	Recapitulation Energy Levels At Work	
			Number of Pulse / Minute	Energy Level (kcal/min)
1	Rahmat	Cutting Blanket	122,4490	0,0628
2	Imah	Press	76,9231	0,0122
3	Adisal	Press	83,3333	0,0171
4	Damirsan	Breaker	107,1429	0,0423
5	Muzarman	Pull	111,1111	0,0473
6	Yatno	Pull	105,2632	0,0399

Table 12. Total consumption of energy

No.	Laborers	Work station	Workload Energy (kcal/h)		Energy consumption (kcal/h)
			Energy While in Rest	Energi While Working	
1	Rahmat	Cutting Blanket	42,575	237,202	194,627
2	Irwah	Press	37,496	49,737	12,241
3	Adisal	Press	34,475	71,861	37,387
4	Damisan	Breaker	51,200	177,463	126,263
5	Muzaman	Pull	32,091	156,117	124,026
6	Yatno	Pull	31,091	143,755	112,664

Example :

$$\text{Energy consumption (KE)} = E_k - E_j$$

$$= 237,202 - 42,575 = 194,627 \text{ kcal/h}$$

Cardiovascular load (%CVL) is used to determine the classification Based on the increase in workload between resting pulse rate (DNI) with a working pulse (DNK), which in comparison with the maximum pulse (DNmax). The maximum pulse value obtained by subtracting a constant with age operator, example (220-age) for males and (200-age) for women. % of CVL calculation is then compared with a predetermined classification.

Table 13. load of %CVL

No.	Laborers	Work station	Number of pulse/Minute		%CVL
			rest pulse	work pulse	
1	Rahmat	Cutting Blanket	75,567	122,449	48,62
2	Irwah	Press	72,289	76,923	4,60
3	Adisal	Press	70,588	83,333	11,65
4	Damisan	Breaker	76,923	107,143	32,12
5	Muzaman	Pull	73,171	111,111	39,59
6	Yatno	Pull	71,344	105,263	33,37

Calculation of psychological workload with NASA-TLX method is obtained by calculating the average Weighted Workload (WWL) of each operator. WWL value obtained by multiplying the weight rating and the NASA-TLX questionnaire that was completed by each respondent. The weight values obtained from pairwise comparisons in the questionnaire.

Table 14. workload category based on %CVL

No.	Nama Responden	Stasiun Kerja	Nilai WWL
1	Rafia Rizal	Control Panel	68,9
2	Andresius	Control Panel	71,9
3	Nurma	Kontaminan/Inspeksi	80,9
4	Suharnen	Kontaminan/Inspeksi	74,0
5	Asmuni	Pengetesan bahan baku	72,9

b. Energy consumption

The average type of work performed in the first processing line (breaker, cut blanket, press) which are at moderate light level with a range of energy expenditure (kcal/h) is 100-200 kcal / hour. It is obtained by reducing the energy when working before doing the work. The energy consumption is felt by the operator. The cut blanket (Grace) with energy expenditure of 194.627 kcal / h. The energy expenditure is nearly the kind of hard work and the operator may exceed the limits. This is as breach of employment may also occur if the worker does not compensate the activities with the rest.

c. Analysis of %CVL

Determination of the energy value and %CVL known by changes in pulse rate at work, and the maximum pulse rate by sex. CVL value% sequentially from highest to the lowest are cut blanket (48.62), workers pull 1 (39.59), pull 2 (33.37), labor breaker (32.12), milling workers (11.65), and milling 2 (4.60). Based on the value of% CVL, operators in the range of values <30% not experience fatigue, but that was > 30% is necessary to repair the system work. In general, workers experiencing job system, the work should be done. This can be seen from the value of% CVL experienced workers cut blanket (Rahmat) is too high compared to other workers. This means the distribution of the work is too heavy on cutting workstations, and working conditions is also not good because it is too high stand. Repairs may be done by

labor activity by increasing the number of workers on the cutting blanket or add pieces of work stations that blanket the weight distribution of the work is not centered on one side only.

Analysis of NASA-TLX

Generally, workers are under pressure at the level of anxiety about how the product is produced, this includes a frustration demand indicator (FR), because they expect that the production of high quality so that the goal can be achieved, because if there is an error and inaccuracy, it will cause a huge loss for the company. As for some of the causes of high perceived mental burden on the type of treatment works II (contaminants, control panel, testing) is influenced by some of the factors, such as high risk work to guarantee the quality of the product, as well as the responsibilities of the job that must be maintained.

CONCLUSION

Conclusion

Calculation of physiological load on the production line processing I (breaker, press, pull, cuts) shows a system repair work needs to be done to increase the work station to work with the old frequency and high production weights, because the type of work on a production line processing including job I moderate light, which is approaching the workload quite heavy. Based on energy consumption, the heaviest workload experienced by workers cutting energy consumption blanket with 194.62 kcal / h and CVL = 48.62%, the value of the show to do repair work system, by changing the way of working, as well as the designing tool.

On the production line II (testing, contaminants, control panel) the mental load experienced by the operator is at a high level. This is because the type of work here prioritizes accuracy and requires the operator to avoid mistakes to minimum. Mental burden is generally on the biggest frustration indicator

Demand (FR) which causes the operator to feel anxious about the results and the pressure due to fear of making mistakes. Indicators frustration Demand (FR) can be affected due to the convenience and level of disturbance while doing the job.

3. Need improvements such as the addition of a working system operator or the distribution of load is more evenly job with better rules on working hours on the production line I, and increased motivation of workers, the number of operators as well as the adjustment of the working conditions on the processing line II.

b. Sugestions

1. For further research can design a tool that can reduce the physiological workload in processing line 1.
2. Allocation order for the company to add the number of operators who work on the second processing work station so that accuracy can be maintained in the work.
3. Conduct periodic evaluation of job satisfaction that can be known complaints and obstacles experienced by workers in their duties.

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