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Total Ergonomic Approach to Minimize Environmental Conditions and Work Load in the Company Workshop

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Abstract

This research was intended to find out the effects of work load and environment around the work place of the black-smith and their worker. The research was conducted at the company workshop "WJ "black-smith in Penatih East Denpasar using this place and their worker as the research material. Variable monitored were: environment condition, body weight, body height and pulse rate. To describe the average and deviation standard of the age, body height, work period and pulse rate, data was analyzes using the 19th version of SPSS. The result shows the wet dry temperature were 25^0 C and 34^0 C respectively the humidity was 75%. Work load of the workers were categories low since their pulse rate were 70-110 pulse/minute. This low work load was due to their long experience (more than 15 years). This research also shows that the pulse rate of the worker was increase by 55%, 65% and 61, 0 % before and after burning the iron, strike with a hammer and molding the iron to any instrument respectively; while for sharpening, cutting the iron and making the knife handle raised the pulse rate by less than 35%. The average age, body weight and body eight of the black-smith and his worker are 30, 2 years 160 cm and 55 kg. A can be concluded the work place is not comfort do to hot weather, work load of workers were categories low and shows that the pulse rate occur strike with a hammer and molding the iron to any instrument respectively

Keyword: Environmental conditions, work load, company workshop

INTRODUCTION

At the company workshop "WJ "black-smith that has developed since the iron was found. Although the development of technology is so rapid, production equipment the black-smith still have a place for consumers in Indonesia generally and in Bali such as knife, Scythe, hoes and household furnishings as well as agricultural machinery.

The quality of the results the company workshop " WJ " black-smith in making equipment other than specified by raw materials and skills, also by the conditions of the work environment in which they work. The conditions of the work environment are all factors in the workplace that can cause due to labor. Environmental conditions include air temperature, temperature. Grand jean, e., Roemer, (2000). The surface of the surrounding air, humidity and air flow displacement

The temperature of the hot air around at the company workshop " WJ " black-smith occurred, due to the air flow in the room work less well and may result in inconvenience working. A side effect of a functional changes resulting in discomfort on the corresponding organ in the body. According to Grand jean (2000) excessive heat around conditions will lead to a sense of fatigue, drowsiness, reduced

stability and the growing number of digits error work. This will lower one's body creations for power generating heat with fewer amounts.

The discomfort may be a distraction or even psychological effect will cause or one of the physiological pain depending on the level of the heat exchange process. A comfortable environment ideal is a situation where workers had experience not experiencing heat stress or thermal strains.

A comfortable environment is the neutral area, which the body does not require action to keep the hot conditions remain balanced. The temperature inside the human body is 37° C and the temperature of the surface of the skin is 33° C in a comfortable temperature conditions. The human body is the engine heaters that change energy from food to work and restore heat in the process. In regard to overcome an excess of outside environment. The temperature of the environment comfortable on easy 25 – 27° C. When the surrounding air increases will occur the physiological effects such as increasing a sense of tired followed by loss of efficiency of the mental and physical tasks, increased heart rate, increased blood pressure, gastrointestinal tool activity decreases, body core temperature rises slightly and increased skin temperature is quite high (from 32° C to 36/37° C), increasing blood flow to the skin (from a few ml/cm3 skin tissue to 20 – 30 ml/cm3) sweat production, and hard to ride galore skin temperature of 34° C.

The temperature of the area is physiologically on heat exchange of range condition the body in a State of equilibrium is known as the area rule vasomotor (zone of vasomotor regulation), because in this range will heat exchange can be maintained with the blood flowing out throughout all the organs of the body. If it is on a higher level above this comfort area, then part of the surface (peripheral) will appropriate more body heat and increase the amount of respiration (the process of discharge of sweat). This area is referred to as governing area evaporating (evaporation control). Temperatures below the zone of vasomotor regulation characterized by heat exchange negative. Because a lot of heat is lost from the area is generated and is referred to as zone of bodily cooling.

At the company workshop " WJ " black-smith besides making equipment-household appliances also make agricultural machine tools, such as the tool, cutting tool made of fragrant coffee grinder, tool to machine power thresher. Ergonomics problems seen in the workplace in addition to hot environment temperatures, lack of safety equipment and the machine used, and the workers did not use clothes and lay out protective equipment on the production process. On conventional workers such at the company workshop "WJ "black-smith comfort temperature and climatic factors at the workplace such as air temperature, surface temperature, humidity and air flow displacement often gets less attention. Things like that need to repair attempts performed properly, plan, directional and dogged by observing the principles of ergonomics.

Ergonomics is the science of designing or designed the work environment or job to fit the workers (fit the job to the man). Three initial steps to establish a program of ergonomics in the workplace, namely to build a commitment from management (this is very necessary in any implementation of the program, because a good system should be supported by the support of top management), conduct training ergonomics to encourage the presence of the participation of all employees. (give knowledge workers of the importance of the application of ergonomics in order to improve productivity in the workplace), formed a working group that is responsible for the implementation of the program of occupational health and safety.

Total ergonomics approach is reactive approach, systemic, holistic, interdisciplinary and participation in the ' built-in ' in each intervention based on the concept of appropriate technology, Manuaba, (2005). The selection of appropriate technology recommends that any repairs should be reviewed from the six criteria, namely technical, economical, ergonomic, socio-cultural, energy-efficient and environmentally-destructive application of total ergonomics approach allows the occurrence process of bargaining for an optimal working conditions improvement. This means that any repairs already meets the criteria so that it could be accepted and implemented on an ongoing basis with risk and minimal impact possible.

Referring to the background of the above can deduce the problem is how the workload of workers and working environment conditions at the company workshop " WJ " black-smith with total ergonomics approach? This research aims to know the workload of workers and the environmental conditions surrounding the workplace at the company workshop " WJ " black-smith ". From this research, is expected to provide information to the pande iron that with the total ergonomics approach to achieve the conditions of the work environment that is healthy, safe, comfortable and efficient as well as the low workload so that productivity can be achieved will be extended.

MATERIALS AND METHODS

The Place of Research

This research was conducted at the company workshop " WJ " black-smith. Trenggana street No. 63/95, Br. Paang Penatih, Denpasar, East Village on 1 July-14 August 2015 start at 08.00 – 17.00 Wita. The subject of research is the pande and iron workers that add up to 5 people.

Research Methods

This research is a research diskretif by doing observation and measurement-a measurement against the subject and environmental conditions. Device used to measure humidity is dry, wet thermometer, to measure the pulse with a stop watch to measure weight scales squat, to measure height with a metal tape measure and a detailed questionnaire measuring workload.

To facilitate the implementation of the research and data collection then the stages of research can be described as follows: on the basis of the total ergonomics approach is by extension ergonomics, done at work by showing the direct problems that exist, and gives examples of improvements in theory and real actions at work, setting menus, through an acceptable flavor, sufficient amounts received by workers as well as follow the size measure of household , such as a plate, a spoon, a glass, and the other, the creation of information boards, using simple ingredients and asked to create writing that reasonably can be read by employees who sit far from the Board information, in rest and working time arrangements, the working equipment to set up in a certain place, taking the tools and ingredients to taste, so workers unknowingly being asked to stand up, change the place or walking to pick up tool , so there is a chance a break. Total ergonomics approach model encourages the existence of the role and active participation of all parties in any decision-making, further measurements of height, weight, measure the pulse palpation system with system (10 beats), measure the temperature of the environment and the interview by filling out the questionnaire.
Stastistical analysis of the mean and standard deviation against the computer age, height, weight, working period and pulse is processed with the computer program SPSS version 19.

RESULTS AND DISCUSSION

Worker Characteristics

Of measurements and observations obtained the following results:

Table 1. Worker Characteristics

No	The Characteristics	Average	Standard Deviation(SD)
1	Age (years)	30,2	11,62
2	Height (cm)	160,0	3,53
3	Weight (kg)	55,0	5,00
4	Working period (months)	156,0	179,39

The average age at the company workshop "WJ "black-smith workers with 30.2 (SD = 11,62). Average height 160 cm (SD = 3.53) and average weight 55 kg (SD = 5) seen from the characteristics of the workers can be found on the youth. The experience of 156 workers months or over 10 years where sensitivity to the environmental temperature is high enough.

Factors that affect the sensitivity of this is air temperature, average radiation temperature, the speed of the air relative humidity

Environmental Conditions

Environmental conditions at the company workshop "WJ "black-smith is building a simple shape and work the floors were still made of compacted soils as well as open. The temperature of the wet is dry and the temperature is 25°C 34°C and the humidity is 75%. The humidity data is from where the measurement is within 5 meters of the furnace the heater while at a radius of 1 metre lower humidity i.e. 70%.

A comfortable environment ideal is a situation where workers have no experience menagalami heat stress or thermal strains. A comfortable environment is the neutral area, which the body does not require action to keep the hot conditions remain balanced. Inside the human body temperature is 37° C and the temperature of the surface of the skin is 33°C in a comfortable temperature conditions in a comfortable temperature conditions. The human body is the engine heater that change energy from food to work and restore heat in the process. In regard to overcome an excess of outside environment. The temperature of the environment comfortable on easy 25 – 27° C. Whereas the temperature of the surrounding place of iron working pande 32°C and in regard to cope with excess heat, heat is transferred from the inside of the body enviroment the outside.

Environmental conditions At the company workshop "WJ "black-smith is building a simple shape and work the floors were still made of compacted soils as well as open. The temperature of the wet is dry and the temperature is 25°C 34°C and the humidity is 75%. The humidity was at the site of the measurement is within 5 meters of the furnace the heater while at a radius of 1 metre lower humidity i.e. 70%. Environmental conditions are determined by the condition of the air in the environment, i.e., air temperature, humidity and air movement rate. Measurement of room temperature with a certain index using WBGT (Wet Bulb Globe Temperature). The maximum value of the WBGT is recommended by NIOSH (National Institute for Occupational Safety and Health) as in Table 2:

Table 2. WBGT Level's threshold (Two Hour Time Weighted Average Values)

Metabolic Costs	*Threshold WBGT*	
	C^o	F^o
Light work (less than 200 K cal/hr)	30	86
Moderate work (200 – 299 Kcal/hr)	28	82
Heavy work (300 – 399 Kcal/hr)	26	79
Very heavy work (over 400 Kcal/hr)	25	77
Assumes : Adult male, normaly clothed,acclimatized, physicaly fit, good health and nutrition		

Source: Monteiro, l.M. and Alucci, M. P. (2005)

Average evaporation from the skin surface is proportional to the difference between the saturation vapor pressure of water related against the skin surface temperature and partial pressure of water vapor in the air environment. High temperatures around the workplace can affect the workload and fatigue. Research on the temperature around the spot work iron pande 33 – 34° c. Temperature rise related to the activity of the body's metabolism. In a comfortable 75% loss of body heat because convection surface environment while 25% transferred kelingkungan together for evaporating water vapor and respiration. Liquid water path also occurs through the pores that are the main life processes to ensure that organs can operate correctly.

Routine at the company workshop "WJ "black-smith effect on the flexibility of muscles. but when they work with forced or unnatural posture like a bent for a long time

may cause fatigue. This is proven often they do rest and drink lots of plain water.

The temperature around the workplace pande iron 31-32°C. Pulse pande iron at the time of the iron heats the average 90 per minute, in the form of the iron pulse of an average of 96 per minute. The relationship between environmental temperature and pulse with the workload does not mean iron, pande of 0.003 ($p < 0.05$) and the value of the correlation of 0.89. Seen from the surrounding environment temperature relationship place of iron working pande not give effect on the workload of the iron, pande look of pande iron resolve workload high with white water discipline if it feels thirsty and building work in an iron pande open and around the furnace the heater there is a tub of water to cool the iron, it is also visible from the measurement of the humidity is not too low (70 – 76%).

Comfortable conditions in space is expected depending on the conditions outside. For example to buildings in the United Kingdom will be maintained about 20° c, while the temperature outside the annual average (at 51.7 North latitude) is 11°C. Reduction in the average annual temperature is 20° C (up to 18° C) will result in saving 2/9 (22%) annual energy built. Clearly the temperature in the building will have a particular accuracy and controlled properly, it is important for the study of thermal comfort. The process of regulation of the human body is alternately between hot and cold, with the Division of these areas:

- zone of inervitable body heating
- zone of evaporating regulation against heat
- zone of vaso-motor regulation against heat
- neutral zone (25 – 27°C)
- zone of vaso-motor regulation again cold
- zone of metabolic regulation against cold
- zone of inevitable body cooling.

A comfortable environment ideal is a situation where workers have experience does not suffer heat stress or thermal strains. A comfortable condition is in neutral, which the body does not require action to keep the condition of heat equilibrium. The temperature inside the human body is 37°C and the temperature of the surface of the skin is a comfortable temperature conditions in the 33°C

Comfort scale "Bedford" is a seven-point scale that goal with regard to the environment is defined as follows:

a. Very cold too 17° C
b. Too cool 20° C
c. Snug winter 23°C
d. Comfortable 26°C
e. Comfortable heat 29°C
f. Overheat 32° C aircraft
g. Very too hot 35°C

The body's sensitivity to heat and cold will be felt by the nerve endings, when the temperature of the skin above or close to 30°C. The main factors affecting the sensitivity of this is air temperature-average radiation temperature, the relative humidity of air-speed. The human body is the engine heater that change energy from food to work returning the heat in the process. In regard to cope with excess heat, the heat must be transferred from the inside of the body of the environment the outside. The temperature of the environment comfortable on easy 25 – 27°C, to rest and not human clothes. The temperature will decrease the level of clothes and going up are related to the activity of the metabolism. On the State of comfort, the body loses 75% of heat due to natural convection into the environment while 25% are transferred to the environment together to evaporating water vapor and respiration. Liquid water path also occurs through the pores that are the main life-process to prevent the body's components from the drought and to ensure that organs can operate correctly. When the temperature of the environment rises from comfortable circumstances, then the thermal comfort will be retained by the loss of coolant and is followed by removing the surface of the body, extending pakian with open sleeves. When the skin temperature increases, the average heat loss widen by convection and radiation, blood vessels flow to a certain widening the possibility of closing the other surface. This is known as "vasodilation or zone vasomotor regulation against heat. Heat barrier between the blood vessels and the external environment will be reduced and the average heat flow of increases. When the temperature of the environment rises, sweat flands off, heat loss from the body is enlarged by the

evaporation of the liquid from the surface of the skin called zone evaporative regulation against heat.

Heat equilibrium equations of the public on the surface of the human body. The rate of heat storage with in the body (S) = the rate of metabolism (M)-the rate of performing work (W)-the rate of heat loss by radiation to the surrounding surfaces ®-the rate of heat loss accompanying evaporation of water from the skin's surface (E) – the rate of heat loss accompanying breathing and respiration (B) = M or S-W-C-C-R-E-B where S = is the average heat stored in the body , W (S + ve – body heat, and S – Ve body chills) M = average metabolism can be seen on the table – 1, which rely on work activities. W. W = performasi average work, W. C = average heat loss due to the convection of the environment air, d. R = average heat loss by radiation towards the surface environment W. E = the average heat loss along the evaporation of water from the surface of the skin W. B = the average heat loss of respiration and respiratory.

Local weather variations have a dependence on air temperature, air humidity and wind speed and direction. Steady state energy equilibrium in the Earth's surface in table 3.

The Workload

The results of the measurement of the pulse on each job is as follows in table 4. Workload at the company workshop "WJ "black-smith workers turned out in lower categories, since the pulse of work between 66 – 100 beats/minute. Grandjean (2000) States that the pulse rate between 75-100 beats/min in the categories of low workload and between 100 – 125 beats/min in the categories of workloads are. Workload of and workers including low categories because they are already trained and daily routine work. Judging from the increase in the pulse between before starting to work with iron or metal heats up the activity increase 50%, with them hammers (hamer) nearly 60%, with the metal forming equipment to be possible even higher to 61.2% and for other jobs such as sharpening, cutting iron and make the blade shaft lower its increase of 33%. The occurrence of a high increase in the activities of the above because the temperature around the workplace, too high up to 32° C aircraft and employees requires high concentration.

Table 3. Metabolism Is The Average For A Different Activity Levels

No.	*Activity*	*Rate of heat production W m^{-2}*
1	*Sleeping*	40
2	*Seated quietly*	60
3	*Office work*	60-80
4	*Golf*	80-150
5	*Garage work*	80-170
6	*Vehicle driving*	80-180
7	*Domistic work*	80-200
8	*Teacher*	90
9	*Machine work*	100-260
10	*Carpentry*	100-370
11	*Light work*	120
12	*Shop assistant*	120
13	*Walking at 3 mph*	150
14	*Medium work*	170
15	*Foundry work*	170-400
16	*Tennis*	200-270
17	*Squash*	290-420
18	*Heavy work*	300
19	*Wrestling*	400-500
20	*Heavies work possible*	500

Source: Christopherson, N. (2005)

Table 4. The pulse of work on the respective activities of the job (beats/minute)

No	Activity jobs	Average	Standard Deviation
1	Before working	60	1,41
2	Heat the metal	90	4,00
3	Hot Metal	96	2,96
4	Hammer above	97	0,70
5	them	80	8,24
6	Metal forming	85	3,53
7	Sharpening	76	2,82
8	Cut sheet iron	66	1,41
	Make a knife handle		
	After work		

CONCLUSIONS

From the above discussion and results can be summed up as follows: environment conditions of work at the company workshop " WJ " black-smith " wet temperature is 25°C and the dry temperature is 34°C and the humidity is 75%, the workload of workers including low categories. The experience of the average workers over 10 years., high pulse rate Increase occurred in the activity of banging metal and when formed into the equipment.

From the conclusions it is advisable do improvements in different environment conditions and using the total ergonomics approach

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