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RESEARCH ARTICLE

Furnace Redesign to Reduce Levels of Dust in the Air, Fatigue, Workload, and Increasing Blacksmith Productivity in Batu Sangiang Village, Tabanan, Bali-Indonesia

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Abstract

Introduction: Exposed to a hot environment for work is a situation that can potentially pose a danger to the safety and health of workers. Besides resulting in pain and injury, it can also cause occupational diseases. Blacksmithing was carried out with furnace and open flame, where the iron that will be heated with a sharp object repeatedly were sharpened again. The working process is quite heavy with exposure to heat radiation from the furnace and dust increasing fatigue and workload of a blacksmith. Therefore, to avoid the occurrence of health problems caused by exposure to high heat furnaces, a need for an ergonomic and good chimney that can provide comfort for its workforce. The purpose of this research is to reduce levels of dust in the air, fatigue, workload, and increasing blacksmith productivity in Batu Sangiang Village, Tabanan with furnace redesign. Methods this is an experimental research study. This research was conducted in the Batu Sangiang Village, Tabanan with a sample of 15 workers. Data collected include: levels of dust in the air, fatigue, workload, and work productivity. Before setting up a different test, the data normality was tested using Shapiro-Wilk test with a confidence level $\alpha = 0.05$. In normal distributed data, Paired Sample t-test with $\alpha = 0.05$ was used and abnormal distributed data were analysed using the Wilcoxon different test, $\alpha = 0.05$, Results After working furnace was redesigned, decreased levels of dust in the air 89.20%, 24.03% reduction in fatigue, reduced workload of 14.48% and 83.26% increase in productivity. Results analysis using Paired Sample t-test, the amount of dust in the air, fatigue and workload in Period I and Period II, there is a significant difference ($p < 0.05$), as well as analysis data using Wilcoxon test, labor productivity in Period I and period II, there is a significant difference ($p < 0.05$). Conclusion: From this study we can conclude, after the furnace redesign was done, there was a significant decrease in the levels of dust in the air, fatigue and workload, and there was a significant increase in labour productivity. Suggested artisan blacksmith always applies and pay attention to the principle of ergonomics for improvements such as the redesign of the furnace shown to reduce levels of dust in the air, fatigue, and the workload and increase productivity.

Keywords: *Furnaces redesign, Levels of dust in the air, Fatigue, Workload and work productivity.*

Introduction

Most workers feel comfortable working at an air temperature of about 20 ° C to 27 ° C, when the air temperature is higher, the person will feel uncomfortable at work. For optimum work efficiency, work should be done in a manner and in an environment that meets health requirements. Environment and the intended manner include heat stress, lighting in the workplace, dust in the working space's air, posture, human and machine compatibility. In a work environment, workers will face the pressure of the environment. The pressure can be physical, chemical, biological and psychological [1, 2]. Especially physical pressure in the form of heat stress plays an important role, therefore, the work environment must be created as comfortable as possible in order to achieve work efficiency and increase productivity. This is a concern of every workplace in order to create health and safety in the workplace. In addition, there are various factors that affect the environment and working conditions in the workplace that must be considered in order to be categorised as a workplace free of hazards, namely physical factors, chemical factors, biological factors, ergonomic factors

and psychological factors [3].Exposed to a hot environment for work is a situation that can pose a danger to safety and health. Heat stress is a combination of air temperature, humidity, speed of movement and temperature of the radiation. Heat stress can affect one of the functions of the human body, such as blood pressure, heart rate or pulse, physical endurance and concentration. Working environment temperature increases or decreases can affect blood pressure decrease or increase .Based on the research that has been conducted in Japan, from 2001-2003 reported 483 people were out of work for more than four days because of illness due to heat and 63 fatalities. Deaths were caused by various diseases caused by exposure to heat on body [4].

The high potential hazards in the work environment of the heat are worth noting and controlled so that the safety and health of a worker are maintained. To prevent this, the government has made the Law of safety and health on Threshold Limit Values (TLV) physical factors in the workplace. TLV (Threshold Limit Value) is the standard factor of acceptable workplace labor without causing any disease or illness in their daily work for a period not exceeding 8 hours a day or 40 hours a week [5,7].

In Indonesia, employment in the industry regarding activities that may pose someone to a hot working environment, stipulated in the Regulation of the Minister of Manpower and Transmigration No. Per. 13 / MEN / X / 2011 were 31.0 ° C for the light workload, 28.0 ° C for moderate workload and 25,0^{0}C for heavy workload in an 8-hour work per day and 1 hour of rest. Domestic industry (home industry) is a small-scale industry. In limited circumstances, the output produced by the domestic industry is also relatively small.

Domestic industries can also develop into medium or large industrial industry if managed optimally. Although the domestic industry is categorized as a small industry, but somehow in the process or daily activities they involve workers who are mostly from the local village (the village where the industry located). This creates a positive situation for employment, which indirectly the existence of this industry has opened up employment opportunities for the surrounding community. Blacksmithing is one of the small industries that developed in the village of Stone Sangian Tabanan regency. These artisans cultivate blacksmith work long enough and are handed down from their ancestors. They accept their heritage and cultivate this work as the responsibility of his ancestors. In everyday activities, blacksmith will be exposed by heat, dust and smoke caused by heating the iron before it becomes a sharp object like a dagger, a large knife, small knife, and so forth. Based on the preliminary survey of the 10 workers as a blacksmith in the village of Stone Sangian, we found an average pulse 125.20 per minute of work, and from interviews with workers; they feel heavy on their head, thirsty, dizziness, tightness and heavy load on the eye. Fatigue is a different situation, but they all lead to the reduction in efficiency and reduction of business, and none of them was single.

There are two types of fatigue, muscle fatigue and general fatigue. Fatigue is commonly caused by the monotony of work, intensity and duration of mental and physical labor, inadequate environmental conditions, wasted energy, forced attitudes, psychological mental illnesses, which resulted in a decline in the willingness to work. Based on this background, the researchers make improvements to redesign furnace blacksmith work with the aim to reduce fatigue and workload, improve the physical environment, and increase productivity.

Material and Methods

This study was an experimental study with treatment on subject. The research was conducted in the village of Stone Sangiang Tabanan from Week 3 to Week 4 in May 2019 with a population of 98 people. Based on the sample size calculation formula, it resulted in a sample number of 15 persons [8]. Research inclusion criteria include: working blacksmith who lives in the village of Stone Sangiang Tabanan with 25-60 years old, physically fit with a doctor's examination, work experience of at least one year, and willing to be the subject of research.

While the exclusion criteria were not present when the study took place, suffered from pain during the study, due to certain reasons resigned .Samples that met the inclusion criteria were randomly selected using random numbers. Materials used in this study were three furnaces in Period I work with previous working conditions and in the

second period with improvement that is by the addition of appropriate head size anthropometry furace for workers and chimneys. Heated iron and honed with the same size is 50 cm. Data collected includes: 1) the condition of the subject by interview (the data for age) and take measurements of weight and height; 2) the levels of dust in the air by using the tool Environmental Dust EPAM Haz 5000; 3) fatigue by using 30 item questionnaire fatigue, workload measured by Pulse Oximeter, And labor productivity is obtained by comparing the output (the number of plates produced) with input (working pulse) x time. To determine differences in treatment effect then analysis Paired Sample t-Test with α = 0.05 was done for normal distribution of data and Wilcoxon test, α = 0.05 was done for abnormal data distribution,

Results

Subject Conditions

There were 15 blacksmiths who live in the village of Stone Sangiang Tabanan. Subject conditions that are recorded in this study were age, weight, height and body mass index (BMI). Descriptive analysis of the condition of the subject is presented in Table 1.

Table 1: Descriptive Analysis of Subject Conditions

No.	subject conditions	Mean ± SB	Min	Max
1.	Age (years)	53 ± 8.64	32	60
2.	Height (cm)	164.93 ± 0.06	155	171
3.	Weight (kg)	71.60 ± 6.57	60	78
4.	Body Mass Index (BMI (kg/m^2)	26.26 ± 1.05	23.83	27.24

Levels of Dust in the Air

In this study the environmental conditions measured is the amount of dust in the air. The mean levels of dust in the air have decreased by 89.20% from 0.23 ± 0.02 in the first period to 0.03 ± 0.02 in the second period. Normality test data by the Shapiro-Wilk test on the confidence level α = 0.05 indicates normal distribution of data (p> 0.05) so as to determine differences in treatment effects do different test Paired Sample t-Test for the significant level α = 0.05 and get a result there is a significant difference (p <0.05). Results of analysis of significance are presented in Table 2.

Table 2: Test Result Data Different Levels of Dust in the Air in Period I and Period II

No.	Environmental conditions	period I	period II	t	p
1.	dust content	0.23 ± 0.018	0.03 ± 0.02	29.55	0,001

Fatigue

Measurement Data fatigue performed at the first period before and after work and in the second period before and after work. There was a decrease fatigue after working in Period I and Period II amounted to 24.03%. Normality test data by the Shapiro-Wilk test on the confidence level α = 0.05 indicates all of the data were normally distributed (p> 0.05) so as to determine differences in treatment effects do different test Paired Sample t-Test for the significant level α = 0, 05. Analysis of different test fatigue of data presented in Table 3.

Table 3: Fatigue Data Test Result Differences in Period I and Period II Before and After Work

No.	Fatigue	period I	period II	t	p
1.	Before work	35.93 ± 2.43	35.40 ± 2.29	0.953	0.357
2.	After work	49.93 ± 7.76	37.93 ± 2.96	7.568	0.001

Table 3 shows the different test analysis Paired Sample t-Test in Period I and Period II before work, getting there is not a significant difference (p> 0.05), indicating that the initial conditions in the first period and the second period is the same. While the analysis after working in Period I and Period II were not different significantly (p <0.05)

Workload

The workload was assessed by measuring the pulse before and after working in Period I and Period II. A decline in workload after working in Period I and Period II amounted to 14.48%. Normality test data by the Shapiro-Wilk test on the confidence level α = 0.05 which indicates all of the data were normally distributed (p> 0.05) so as to determine differences in treatment effects by

using Paired Sample t-Test with significant level α = 0, 05 .Analysis of workload data presented in Table 4.

Table 4: Different Test Results of Workload in Period I and Period II Before and After Work

No.	Workload	period I	period II	t	p
1.	Before work	81.33 ± 7.32	81.33 ± 7.74	0.823	.424
2.	After work	112.40 ± 8.53	96.13 ± 5.44	5.756	0,001

Analysis using Paired Sample t-Test for workload data in Period I and Period II showed that there was no significant difference (p> 0.05). This indicates the beginning of the second condition is in the same or a comparable period. The analysis in the first period and the second period after work showed that there was a significant difference (p <0.05)

Productivity

Productivity is the ratio of output to input per unit time. In this study, productivity was assessed through comparison plate works in wrought (output) to the pulse of the work (input) in one hour (time). The mean plate produced in Period I and Period II was increased by 60.80%, i.e. 2.47 ± 0.44 to 3.97 ± 0.74 and after the calculated productivity in Period I and Period II also increased by 83.26 % from 0.023 ± becomes 0.043 ± 0.01 (Table 5). After testing normality in Period I and Period II by using the Shapiro-Wilk Test at α = 0.05 level of confidence it was obtained that all the data distribution is not normal (p <0.05) so as to determine differences in treatment effect in Period I and Period II, we then performed the Wilcoxon test on the confidence level α = 0.05. Analysis of different test productivity data presented in Table 5. Wilcoxon test analysis of data of plates generated and productivity per hour in Period I and Period II resulted in no significant difference (p < 0.05).

Table 5: Productivity Data Test Results in Period I and Period II

No.	Workload	period I	period II	Z	p
1.	The plates produced (1 hour)	2.47 ± 0.44	3.97 ± 0.74	-3.461	0,001
2.	Productivity (1 hour)	0.023 ± 0.01	0.043 ± 0.01	-3.477	0,001

Discussion

Subject Conditions

Subjects who followed the complete study were 15 people, and all were able-bodied tested using physical examination of a physician. Subjects between 32-60 years of age in accordance with the limits defined in the sampling criteria. The type of work to forge metal into a knife is a heritage, so workers will always work even if they are elderly, as long as they are still capable of doing this job. Weight subjects that are in the range of 60-78 kg with a height of 155-171 cm. Having calculated the body mass index (BMI) to determine the nutritional status of the subject, gained an average of 26.26 ± 1.05 IMT subject kg/m^2 with a range of 23.83 to 27.24 kg/m^2.

After comparing with the WHO standard, Average BMI of the subjects was classified as overweight [9]. BMI reflects the balance of one's nutrition. Unbalanced state can be caused by the consumption of nutrients, especially carbohydrates and fat overload in the long term so that this situation needs to be corrected and addressed so that travel becomes obese does not happen on the subject. Good nutritional status will boost immunity and improve health so that they can perform everyday activities better, thus the quality of life also improved.

Levels of Dust in the Air

The mean levels of dust in the air after repair for the provision of the furnace chimney decreased by 89.20%, i.e. from 0.23 ± 0.02 in the first period to 0.03 ± 0.02 in the second period. Results of different test found that there were significant differences (p <0.05). The amount of dust in the air that is set up so that employees feel comfortable in their work environment is 0.15 mg/m^3 10.It could be argued that the amount of dust in the air in the first period is still above the threshold, whereas after repair by administering chimneys, dust levels in air decreases so that it is below the threshold.

Chimney on the fireplace serves to attract dust and smoke of burning, then thrown away tall chimney into the air so that dust and smoke no longer interfere with workers when performing work metal forging. Before the repair, it seems the dust flying around workers while the workers did not wear a mask while working. Dust in the air can get

into the lungs through the respiratory system, and will eventually endanger the health of workers at risk by causing respiratory illnesses.

Dusty and uncomfortable environment will increase the external stress so that workers would aggravate internal stress. The changes appear to be an increase in pulse rate; fatigues more quickly emerged and ultimately reduce productivity. Environment with poor air quality can reduce productivity [10, 11].

Fatigue

The exhaustion issue was an accumulation of physical fatigue, mental, and motivation [12]. Reduction in fatigue after a redesign furnace repair work, was the impact of work stress reduction due to decreased levels of dust in the environment received by workers. The results are consistent with other studies that stated that the improvement of the system-based work ergonomics could reduce worker fatigue. Research on occupational and environmental system repair work has been done and proven to reduce worker fatigue by 22.09% other studies on repair work station ergonomics based SKKB can reduce worker fatigue by 18.84%, and research in the improvement of working tools based on ergonomics principle also proven to reduce worker fatigue by 30,31% [13, 14].

Workload

Workload is one important factor in assessing the severity of a job, including metal forging work. The workload can be predicted from the frequency of the pulse of the workers because the pulse is one of the indicators that can be used to determine a person's level of workload. This study found a decline in workload after repairs amounting to 14.48%. From analysis of the difference test in Period I and Period II after work, there is a significant difference ($p < 0.05$). Decrease of the workload on Period I and Period II predicted due to declining external stress caused by exposure to dust in the work environment. One of the effects of external stress conditions is the increased pulse rate [11]. In this study, external stress can be addressed by improving the provision of the chimney resulted in reduced levels of dust in the air.Occurred efficient use of energy so as to reduce the workload as measured by the pulse of the work. Several studies also found a similar decrease in the workload of 21.43% on the modification of the working conditions based on the ergonomics of Tri Hita Karana for mill workers, a decrease of 15.3% workload on dodol in Bali industry workers, and decrease the workload of 3.41% of industrial workers in Denpasar Steamed Bread [13, 17].

Work Productivity

The final outcome of the improvement of working conditions is an increase in productivity and income for artisans and entrepreneurs. Increased productivity in research is seen from the increasing number of metal plates which successfully forged by workers in the working hours of 60.80%, i.e. 2.47 ± 0.44 to 3.97 ± 0.74. Worker productivity by calculating the output divided by input per unit time also increased by 83.26% from ± 0.023 to 0.043 ± 0.01 becomes 0.01. Analysis of different test in Period I and Period II resulted in no significant difference ($p < 0.05$).

Increased productivity through a number of plates produced will have an impact on increasing the number of blades produced by workers that would increase their income. In addition to the increase in income, these improvements will reduce the risk of workers exposed to respiratory illnesses due to exposure to dust in the workplace had been reduced to under the threshold set MoH RI [10, 18].

Other research also found that the improvement in line with ergonomic approach can improve productivity. Increased productivity is obtained due to the improvement of physiological responses, more rapid processing time, as well as increase the amount of production. Increased productivity is gained by 6.79% to the improvement of working conditions with total ergonomic approach to the painting of metal artisans in Kediri, total ergonomics Application on earthenware industry workers in Bantul can increase productivity by 59.49% intervention by stretching and giving sweet tea on tailors also been reported to increase the productivity of workers 66.67% 54.95% increase in productivity by the use of solar dryers with Techno-ergonomic approach in making dodol in Singaraja [19, 22].

Conclusion

From these results we can conclude that the furnace redesign work resulted in a

significant decrease in the levels of dust in the air, fatigue and workload, and there was a significant increase in labor productivity. Suggested artisan blacksmith always apply and pay attention to the principles ergonomics for improvements such as the redesign of the furnace shown to reduce levels of dust in the air, fatigue, and the workload and increase productivity.

Conflict of Interest

Author has no conflict of interest regarding all elements in this study.

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References

1. Suma'mur PK (2011) Work safety and prevention of accidental work injury. Jakarta: CV Haji Masagung.
2. Suma'mur PK (2009) Industrial hygiene and employee health. Jakarta: Sagung Seto.
3. Santosa IG, Sutarna I (2018) Use of Solar Energy Hybrid Drayer with Techno-Ergonomic Application to Increase Productivity of Dodol Workers in Buleleng Bali. Journal of Physics: Conference Series, 953: 012-087.
4. Yoshi K, Hirosi H (2006) Heat Illness during Working and Preventive Considerations from Body Fluid Homeostasis. Industrial Health, 44: 345-358
5. Tarwaka, Solichul HA, Bakri M, Lilik S (2004) Ergonomy for safety, work health and productivity. Surakarta: Uniba Press.
6. Grandjean E (2005) Fitting the Task to the Man. A Textbook of Occupational Ergonomics. 4th. Edition New York: Taylor and Francis.
7. Nasir M (2003) Research Metodelogy. Jakarta: Ghalia Indonesia.
8. Colton T (1974) Statistic in Medicine First edition. USA: Little Brown Company, 142.
9. Almatsier S (2009) Basic Principle of Nutrition. Jakarta: Gramedia Pustaka Utama.
10. Indonesian Ministry of Health (2016) Ministry of Health Decree on Standard of Work Safety And Health In Office. Jakarta: Indonesian Ministry of Health.
11. Wyon DP (2004) The Effect of Indoor air quality on performance and productivity. Indoor Air, 14: 92-101.
12. Husein T, Kholel M, Sasono A (2006) Design of ergonomic work environment to reduce fatigue: National Proceeding on Ergonomic Seminars. Surabaya.
13. Santosa IG (2012) Improving Working Conditions and the Environment with Ergonomic Interventions Improving Product Performance and Quality in Dodol Craftsmen in Penglatan Village, Buleleng [Disertation]. Denpasar: Post Graduate Program in Ergonomy Universitas Udayana.
14. Setiawan H (2013) Ergonomic-Based Wet Blanket Work Station Design Improves Quality of Life and Productivity of Workers at PT Sunan Rubber Palembang, South Sumatra Province. [Disertation]. Denpasar: Post Graduate Program in Ergonomy Universitas Udayana.
15. Yusuf M (2016) The Design of Plastic Mulch Hole Maker and Work System With Ergonomic Intervention Increase Productivity and Income of The Farmers in Bedugul Bali [Executive Summary Disertation]. Denpasar: Post Graduate Program in Ergonomy Universitas Udayana.
16. Ruliati LP, Adiputra N, Sutjana DP, Sutajaya IM (2017) Modification of Working Condition Based of Ergo THK Reducing Workload, Muscle Tension, and Fatigue of Rice Milling Workers in J Village. In AIP Conference Proceedings, 020-042.
17. Santosa IG, Yusuf M (2017) The Application of a Drayer Solar Energy Hybrid to Decrease Workload and Increase Dodol Production in Bali. International Research Journal of Engineering, IT & Scientific Research, 3: 95-101.
18. Dinata IMK (2018) Pouring Tools Based on Total Ergonomic Approach Improve Physiological Responses and Increase Worker Productivity on Steamed Sponge Cake Industry in Denpasar [Executive

Summary Disertation]. Denpasar: Post Graduate Program in Ergonomy Universitas Udayana.

19. Adiatmika IPG (2007) Improvement of Working Condition by Total Ergonomic Approach Decreases Musculoskeletal Complaints and Fatigue and Increases Productivity and Income of Both Employees and Employers of Ironwork Painting at Kediri Tabanan [Executive Summary Disertation]. Denpasar: Post Graduate Program in Ergonomy Universitas Udayana.
20. Purnomo H, Manuaba A, Adiputra N (2012) Sistem Kerja Dengan Pendekatan Ergonomi Total Mengurangi Keluhan Muskuloskeletal, Kelelahan dan Beban Kerja serta Meningkatkan Produktivitas Pekerja Industri Gerabah di Kasongan Bantul. Journal of Biology Medicine and Biochemistry, 3(1):22-29.
21. Rusni NW, Tirtayasa K, Muliarta IM (2017) Workplace Streching Exerise and Giving Sweet Tea Improve Physiological Response and Increase The Productivity among Tailors in PT Fussion Hawai. Journal Ergonomi Indonesia (The Indonesian Journal of Ergonomics), 3:1-10.
22. Santosa IG, Sutarna I (2018) Use of Solar Energy Hybrid Drayer with Techno-Ergonomic Application to Increase Productivity of Dodol Workers in Buleleng Bali. Journal of Physics: Conference Series, 953: 012-087.

