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Job Stress Analysis for Lathe Machine Operator Based on Human Physiological Feedbacks

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Abstract. *Job stress is a circumstance that every employee could faces in performing their job. They tend to deal with it differently according to their own way. It is basically a mismatch between the individual capabilities and organizational demand. The existing employees must exert their ability to complete their tasks in order to fulfilling the organization's demand. One of the major sources of job stress is excessive workload. Every workload received by employee must fit and balanced with the physical and mental abilities of the employee so that there will be less fatigue and stress that could affect the employee's performance. This study aims to evaluate the workload for the human physiological feedback. The physiological feedback was evaluated based on the activity while operator using lathe machine. The physiological feedback is based on integumentary activities and cardiovascular activities. The results of this research showed that the operators of the lathe machine operator physiological feedbacks has significant correlation with the Galvanic skin response (GSR). All of indicators such as Heart rate (HR), systole, diastole, and body temperature has positive correlation with the GSR values. Moreover, for noise indicators also has positive correlation with the GSR. This mean that the enviromental condition which represented by noise evaluation has significant correlation with the stress.*

Keywords: *job stress, physiological feedbacks, workload, Galvanic skin responses*

I. INTRODUCTION

Designs that are perfectly created could still potentially threatening the security and safety conditions of the workers (Bergheim et al., 2015; Feng et al., 2015). This is due to the work accidents that not only come from external factors of an individual but also come from an internal factor. The internal conditions of a worker are generally much influenced by the surrounding environment. The influence of the environment could be in the form of pressure received by a worker (Chen & Cunradi, 2008), high workload, high uncertainty, and complex jobs (Liu & Low, 2011). These things could cause stress on an individual. Stress is a reaction from someone after getting an action or stimulation from the surrounding environment. When stress occurs in an individual, the impact can occur in the form of health problems. Some of health problems that could arise are ulcers, high blood pressure, asthma, and migraines. Signs of the appearance of stress in individuals can vary, including cold sweat, panic, emotional feelings, etc. If we examine further, stress can include symptoms on the physical, mental, and social relationships of an individual. Some individuals release stress that occurs by smoking, drinking alcohol, drugs, etc. In addition to stress that appears physically, there is also stress that we cannot physically identify that has a higher level of danger towards health.

For companies, stress that arise in their employees could result in changes in productivity. Stress that appears on the employee could caused by the daily activities of the employee. One of them is the workload received by the employee. Workload can have a direct impact on the possibility of stress on employees (Manuaba, 2000). The workload received by employees could be in the form of physical and cognitive load. Both of these loads must be in a certain level that balanced with the capabilities possessed by employees (Nurmianto, 2003). In addition, the

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conditions of the social economic background of an individual could also affect the stress. For example, workers with lower employment status will be more susceptible to the occurrence of stress (Wege et al., 2008), especially for woman employee who has a higher potential for the occurrence of stress (Toivanen & Hemström, 2008).

Employees that feel stress both physically and psychologically, could reduce employee motivation. This is contradictory with Ergonomics analysis which is study the systems of human interaction with work facilities and their environment (Nurmianto, 2003). Physical and cognitive capacity is different one another. Matters that could affect these conditions include skills, physical condition, nutritional, gender, age, and body dimensions of each worker (Tarwaka & Sudiajeng, 2004).

Physical activity could be defined as the overall form of movement carried out by the body accompanied by the energy consumption (Trudeau & Shephard, 2010). Physical activity based on referrals issued by public health services in the United States is divided into two: moderate activities and activities that require higher enthusiasm. Energy calories needed are the indicator that could be used in grouping these activities. Certain cases physical activity has been shown to reduce stress and could improve mood of the worker (Edwards, 2006). Through physical activities, we can improve the health of the workers so that the risk of heart disease could be avoided. In late 1990, Fred Gage from the Laboratory of Genetics at The Salk Institute of San Diego conducted research that shows the human and animal's brain would produce new brain cells or neurogenesis after physical activity. Physical activity will stimulate the process of neurogenesis so as to improve the process of thinking, but we must carry out activities continuously or routinely so that the process of neurogenesis could occur (Reynolds, 2010). In addition, physical activity carried out has a positive impact on our cognitive function and brain function (Roig et al., 2012). There are cross-sectional studies in humans that show the more active an individual, the lower the risk of cognitive impairment and dementia they could possibly exposed(Thomas, 2012). The human cognitive activities effect like stress ccan be evaluated using skin conductanc(Braithwaite et al., 2013; Ding et al., 2019; Lin & Lukodono, 2022).

Excessive mental activity or workload could have impact towards worker's conditions. The result of the excessive impact on mental workload might not be seen directly, but it culd be observed and monitored periodically. Physiologically, mental activity is known as a type of light work. But when viewed in terms of morality and responsibility, mental activity is clearly heavier than physical activity because it involves more work of the brain (white-collar) than the work of the muscles (blue-collar). Grandjean (1993) reveals that every mental activity will involve many elements of perception, interpretation, and mental processes derived from information received by the sensory organs with the purpose of decision making. Activities that involve thinking from mental activities require a high level of concentration, where the longer people concentrate, the alertness level will be getting lower(Tarwaka & Sudiajeng, 2004).

Measurements that could be use related to stress are by measuring the level of reactivity in the cardiovascular system. This level of reactivity is measured based on the increase in blood pressure (Gasperin et al., 2009; Hu et al., 2015). Through the measurement of blood pressure after performing certain activities, we could find out the level of stress felt by an individual due to performing certain activities. Some studies related to the impact of stress on increasing blood pressure are during the exam, in which the blood pressure would increase due to the work process of answering the questions (Khoshemehry et al., 2014). This becomes an indicator that blood pressure measurement not only could be used to measure the stress level due to performing physical activity, but also on cognitive activities such as thinking or working on a particular case study. Based on this fact that, this paper has objective to evaluate how the physiological feedback can be used to evaluate the human work situation.

II. RESEARCH METHOD

This study has objective to evaluate the effect of physical and mental activities for stress that felt by the operator. The analysis began with figuring the operator's daily work. The wieler lathe has conventional characteristics machine, this mean that for executing process using this machines requires high concentration. A operator has responsible for each wieler lathe machine. The process resulted 1 part which takes approximately 116 minutes. This parts that have high measurement accuracy and sometimes requires the perator work with standing position. Otherwise, the operator can relax by sitting or doing other activities while waiting for the machining process to finish. The man-machine chart was used to figuring out the human and machine interaction in the production activities. The result from man-machine chart will be used to evaluate the machine and human productivities during daily work. Using Man-Machine chart, the utilization for human and machine in the production can be estimated. Based on this estimation, the physical load also can be estimated. Next, physiological feedback which consist of cardiovascular activities and integumentary activities were used to observing operator conditions. Energy consumption is insufficient to estimates the physical workload of worker. Physical workload is not only determined by the amount of calories consumed, but also determined by the amount of muscle involved and the static load received and heat stress from the work environment which could increase the pulse rate. The pulse is easier and can be used to calculate the workload index. Irregular changes in heart rate is resulted from work difficulties (stress), and concluded that the heart rate can measure perceptual load(Lin & Lukodono, 2022; Paritala, 2009). Heart Rate Variability can be used to assess the level of pressure / mental load(Paritala, 2009). Another research Data also consider to evaluate the were obtained from direct measurement results using GSR (Galvanic Skin Response), body temperature sensor, heart rate, and noise (noise) from the enviroment. The placement of the sensor considering the

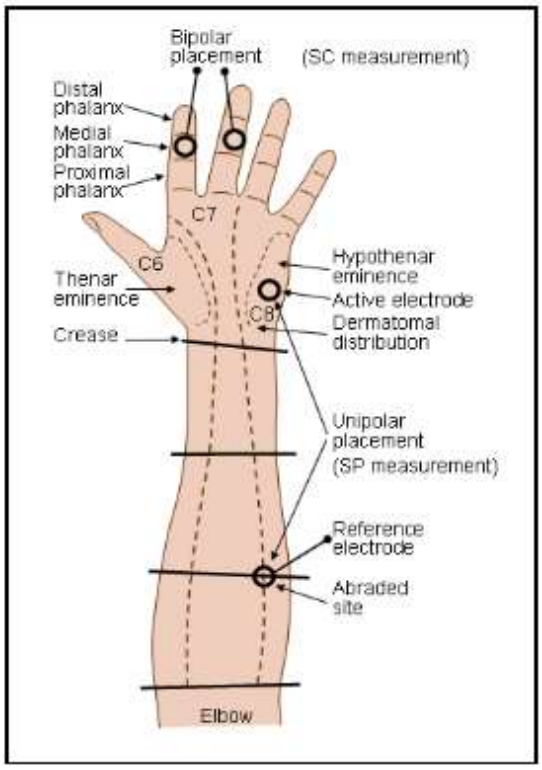

Figure 1. Electodermal Response Area in Hand (Mudhoffar et al., 2014)

references from Figure 1. Sampling data was performed to record the data for 7 days observation. For each day 4 data were collected using randomized time. Then proceed with interviews and filling out a questionnaire filled by operator to know the operator perceptions about the work. The physiological responses were evaluated using rank spearman correlation to know whether each indicator has association in evaluating operator stress. The operator stress were evaluated using GSR.

III. RESULT AND DISCUSSION

Results

Based on the observations, the operator's working hours start at 7:00 a.m. up to 4:00 p.m. with a 60-minute break at 11:30 to 12:30. One lathe is accounted by one operator, where each operator is responsible for producing spare parts that are needed. One spare part that need high accuracy, takes approximately 116 minutes to complete. During the wide diameter turning, the

Table 1. Descriptive statistics test result

Statistics

Variable	Mean	Variance	Minimum	Median	Maximum
Sistole	120,36	49,50	109,00	120,00	139,00
Diastole	79,32	42,08	70,00	80,50	93,00
HR	83,18	57,34	70,00	82,00	95,00
Noise	89,821	0,601	88,000	90,200	90,600
Temperature	36,393	0,0874	36,000	36,450	36,800
GSR	3,1054	0,1072	2,4900	3,1500	3,6900

Table 2. Correlation Tesr Result

Pairwise Spearman Correlations

Variable 1	Variable 2	Correlation	95% CI for ρ	P-Value
Diastole	Sistole	0,607	(0,270; 0,811)	0,001
HR	Sistole	0,793	(0,557; 0,910)	0,000
Noise	Sistole	0,857	(0,676; 0,940)	0,000
Temperature	Sistole	0,565	(0,215; 0,787)	0,002
GSR	Sistole	0,860	(0,682; 0,941)	0,000
HR	Diastole	0,540	(0,182; 0,771)	0,003
Noise	Diastole	0,527	(0,166; 0,763)	0,004
Temperature	Diastole	0,584	(0,239; 0,798)	0,001
GSR	Diastole	0,638	(0,314; 0,829)	0,000
Noise	HR	0,771	(0,520; 0,899)	0,000
Temperature	HR	0,615	(0,281; 0,816)	0,000
GSR	HR	0,843	(0,649; 0,934)	0,000
Temperature	Noise	0,560	(0,208; 0,783)	0,002
GSR	Noise	0,889	(0,742; 0,955)	0,000
GSR	Temperature	0,512	(0,148; 0,754)	0,005

operator could relax by sitting or doing other activities to wait for the turning process to complete. However, if the turning process need high accuracy, the operator must do the turning by standing and concentrating. The body temperature of the worker is 36° C (normal body temperature) and they are works in a lay out where there are many other machines. This cause the operator work with a high noise level of 90.1 +. While the lighting using a lamp placed on a lathe all day with adequate air ventilation, and a free access room makes that makes other employees free to pass around the workplace. Man-machine interaction were used to know how the human interact with machine in the production using Lathe machine. Fig. 2 show the Man-Machine Chart.

The data that were taken from GSR, body temperature, blood pressure, heart rate, and noise (noise), then will be tested using autocorrelation analysis. Autocorrelation test analysis is carried out to see the relationship between each variable. The following are the results of the autocorrelation test using minitab.

Figure 2 shows the results for Man-Machine interaction during part production. and the activity schedule above, it can be seen that the percentage of working machines is 70%, it is estimated that humans work full time during production with a work percentage of 100%, meaning that humans will not be idle when doing a job, and 30% of idle machines waiting operator finished setting what will be done. In addition, the operational hours used for productive activities are intermittent for 7 hours. Therefore, it can be said that the physical load that the operator receives is normal every day.

Others observations were made by comparing whether there are correlations between blood pressure, heart rate, body

Man and Machine Chart
Part Production using Wieler Lathe Machine

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Tanggal : 01-02-2023
Lokasi : Lathe Machine area

Machine	Time (Minutes)	Machine Status	Man Status	Time (Minutes)	Man
Idle	5'			5'	Checking machine
Preparation	5'			5'	Preparing tools
Idle	7'			5'	Read manual procedure
				2'	Loading part to machine
Lathe process for front part and drilling	2'			2'	Positioning part in the machine
Idle	4'			2'	Unloading and checking the dimension
				2'	Loading part to Machine
Lathe process for middle part and drilling	4'			4'	Positioning part in the machine
Idle	4'			2'	Unloading and checking the dimension
				2'	Loading part to Machine
Lathe process for product with specification diameter 10 mm and length 176 mm	23'			23'	Positioning part in the machine
Idle	2'			2'	Unloading and checking the dimension
				2'	Loading part to Machine
Lathe process for product with specification diameter 8 mm and length 72 mm	12'			12'	Positioning part in the machine
Idle	4'			2'	Unloading and checking the dimension
				2'	Loading part to Machine
Lathe process for product with specification diameter 5,5 mm and length 68 mm	15'			15'	Positioning part in the machine
Idle	4'			2'	Unloading and checking the dimension
				2'	Loading part to Machine
Lathe Process for product 10 x 36 mm	21'			21'	Positioning part in the machine
Idle	2'			2'	Unloading and checking the dimension
Total Time	**116'**			**116'**	

Indicator	Description
	Man Work
	Machine Work
	Delay

Figure 2. Man-Machine Chart for Part Production using Lathe Machine

temperature, noise, and GSR. The descriptive analysis were shown in Table 1. The operator's GSR value has distribution 3,1054 + 0,1072.

The correlation analysis using rank spearman test were reported in the Table 2. From the results of the correlation test in Table 2, it is can be concluded that all of variable have significant correlation. This result evaluated based on p-value for each variable comparison below than 0,05. With the aim to determine the level of stress felt by the operator which evaluated based on GSR value, all of indicators have positive correlation with the the GSR indicators. For physiological feedback which evaluated based on cardiovascular activities (HR, Systole, and diastole) and integumentary activities (Human body temperature) has same direction value. The GSR tend to increase when others physiological feedback indicators has increased value. Others interesting result found in the analysis is the GSR

values increase when the environment noise indicators increased. The human feel stress when the environment become noise. This maybe the operator required to focus while executing the task using lathe machine.

Discussion

GSR is a device that used to capture the skin conductance. This skin conductance was known to be directly represented the human emotional behaviour. Stress is a pressure for human to adapt or align itself with the environment that could cause physical and psychological effects and can make positive or negative feelings (Hidayati1 & Harsono2, 2021). The level of stress of every worker is relevant to be used as a parameter to determine the level of worker's workload. The results of the measurement analysis on the correlation test shown in table indicates that the stress measurement indicator of an operator that have correlation occurs between all of physiological feedback and noise. Supported by the results of the interviews, operator's health conditions also have an influence towards the level of stress felt by workers. From Table 1 it can be seen that the operator's heart rate tends to be stable in the range of 70-95 bpm, with an average blood pressure of 120/79 mmHg. The operator's heart rate tend to increase when they are performing the work process, but the increasing of heart rate is not significant or still within the normal threshold (60-100 bpm) and will return to normal when they finished performing their work. Therefor we can conclude that the blood pressure of the lathe machine operator is normal.

Based on questionnaire, the level of stress is normal. This normal stress level is due to the good harmony between each work groups, no conflict among members of the work group, good support from each member in developing continuous improvement process, friendliness among the members of the working group, good cooperation among the member of the work group, and the acceptance of differences among member. It can be concluded that the work conflict in the respondent's work group does not support the existence of stress for the worker or respondent.

We found out that data that obtained from GSR is related towards the health conditions of the worker. The systole and diastole of the worker that exceeds the normal limits is confirmed by the results of the questionnaire which is stated that in respondents has experienced headaches quite often in the past month, as well as dry mouth, the muscles feel tight and tense, blood rises, loss of appetite and difficulty in getting sleep have been experienced several times by operator, and often experience abdominal pain, and other illnesses that affect the work of respondents that have never experienced before.

IV. CONCLUSION

The physiological responses can be used to evaluate how the operator feel during the work. This paper take the lathe machine process as case study to evaluate how the human physiological feedback as response during activities. The load that received by the lathe machine operator can be seen from the level of perceived stress. The operator stress level is measured using GSR. Others indicator from human physiological also considered to evaluate the operator's conditions such as HR, systole, diastole, and body temperature. The results shows that all of physiological feedbacks has significant correlation with the GSR output. All of indicators has same direction of pattern in the feedbacks.

The level of stress felt by the operator of Lathe machine is influenced by two kinds of factors, external factors and internal factors. The external factors include the work environment, working period, as well as work assignments given to the operator. While the internal factors is based on the health condition of the body.

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