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# Improving the physical work environment by looking at the effect of work environment factor on SME

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**Abstract.** Each company wants the operator able to work optimally, so that the operator's productivity is expected to increase. Each operator has different productivity at work. Operators who have high productivity in work generate little idle time. One method that can be used to measure how productive someone is at work is the method of work sampling. The method of work sampling is a measurement procedure performed at randomly certain time which is developed based on probability law where the observations are made using randomly taken samples. Using this method, when the operator does the job and when idle can be observed and measured. The performance of work operator I and operator II was 92.77% and 95.18%. While the idle value of operator I and operator II amounted to 7.23% and 4.82%. The data of work operator accuracy I is  $92.7 \pm 6.1\%$  and idle accuracy data is  $7.3 \pm 6.1\%$ . The work operator's accuracy data is  $95.1 \pm 4.9\%$  and the idle accuracy data is  $4.9 \pm 4.9\%$ .

## 1. Introduction

Work sampling is one way to know the standard time, the number of standard operators and also to know the productivity of the operators (Debrina Puspita Andriani, Billy Anugrah, Anissa Dian Islami, 2017). Standard time is obtained from the measurement of working time. The experimental results indicated that to implement an efficient and objective work sampling method is technically feasible by combining the latest techniques of object tracking, optical flow estimation, and activity recognition. This combination achieves the comparable performance of activity recognition with the original method, given these major challenges (Xiaochun Luo, et.al., 2018). The predefined classification of activities from Work Sampling Technique (WST) can be used for recording those undertaken at a specific predefined time interval by an independent observer or self-reported by each worker (Marco Losa, et al., 2017). The method can underpin the implementation of efficient and objective work sampling in labor productivity evaluation and that it possesses great potential for use in practice (Xiaochun Luo, et.al., 2018). One method that can be used in the analysis of standard time and employee productivity is the measurement of time directly using work sampling method. (Albertus L. Setyabudhi, Refdilzon Yasra, HeruSeruwanto, 2017). Definitively, anthropometry can be expressed as a study relating to the measurement of the dimensions of the human body. Humans will basically have shapes, sizes (heights, widths, and sags) of weight and others that differ from each other. (Sritomo, 2008). Work study procedures proposed by International Labour Organization (ILO) is systematic inspection of methods of resounding out doings so as to recover the real use of capitals and to set values of presentation for the doings being approved out. (Carlos Ochoa, et al., 2017) The physical work environment is all physical circumstances located around the workplace where it can affect operators either directly or indirectly. The core factors involved in the physical work environment are



temperature, humidity, air circulation, lighting, noise, mechanical vibration, smells, and color. Physical work environment greatly affect the comfort and work productivity of the operator. The intensity of lighting in the workplace is intended to provide illumination to objects that are the object of work, equipment or machinery and production processes and work environment. For that we need optimal lighting intensity. In addition to illuminating the work object, lighting is also expected to adequately illuminate the circumstances surrounding it. Work study procedures examined how work activities were carried out, then simplifying or modifying the method deployed in the operation. The aim is to reduce

unnecessary or excess work, or the wasteful use of resources, and setting up a time standard for performing that activity. The relation between productivity and work study is thus obvious

(International Labour Organization, 1996). One way to increase the productivity of a company is by designing facilities tailored to the operator (man). In addition, comfort and safety is also a support for increased productivity. Studies relating to the measurement of human body dimensions as ergonomic considerations in the design process are known as anthropometry. Anthropometry will be widely used as an ergonomic consideration in the design process of products and work systems that require human interaction. Anthropometric measurement is done by measuring body dimensions of body, head, fingers, and feet.

The activity that will be done is observing the work activity at the shiny station in SME Sentra Agung Meubel consisting of 2 operators, assessing the lighting of the working environment as well as giving the proposed repair work facility with the principle of anthropometry work done for 2 hours

## 2. Methodology

At SME Sentra Agung Meubel there are 6 work stations namely depiction station, cutting station, painting station, shiny station, drying station, and finishing station. From the station the station is chosen which has a working map as a whole. Primary data used in work sampling is data obtained during preliminary research in the form of operator working hours, breaks, work description and idle of the operator and at the time of observation in the form of activity of operator in the form of work and idle, and the result of its production.

### 2.1. Work Environment Data

Work environment data collected i.e:

- Data Room by measuring the length and width of the room, high ceiling cavity, high room cavity, floor cavity height by using the meter
- Local Lighting Data. Its data is collected by measuring the intensity of light on the work object by using luxmeter
- General Lighting Data by measuring the intensity of light at points that have been determined based on the room width of approximately 85 cm from the floor with luxmeter
- The area of the room is less than 10 square meters: the point of horizontal line length and width of the room is at a distance of every 1 meter
- The area of the room data among 10 square meters to 100 square meters: the wounding point horizontal line distance and size of the room data is at a distance of every 3 meters
- The area of the room data is more than 100 square meters: the horizontal intersection of distance and size of the room data is at a distance of 6 meters
- Reflectance Value Data by calculating the strength of direct-light illumination that comes directly from the light source and measures the intensity of illumination reflected back by the material. Incoming light measurements are performed with a luxmeter sensor placed at the measuring point and confronted with the light source. While the measurement of reflected rays with the sensor faced with a distance of two inches to the measuring point of the material

## 2.2. Anthropometric Data

The primary data used is obtained from direct measurement by the researcher. The body dimensions used in anthropometry products are Hand Length (PT), Hand Width (LT) and Finger Width 2,3,4,5 (LJ 2,3,4,5).

## 2.3. Data Processing Method

Data processing for work sampling is the calculation of activity proportion, accuracy calculation, uniformity test and data adequacy and calculation of productive working time, and determination of allowance. The data processing of the working environment is calculating the ratio of ceiling cavity, room cavity, floor cavity, calculating the average of local and general lighting, calculating the reflectance value of the room, calculating the fixture and lamp number, doing comparison of the results obtained by standard, proposed repair of lighting systems. The anthropometry data processing methods used are mean calculation, standard deviation, data uniformity and data adequacy, normal test with Kolmogorov  $\rightarrow$ -Smirnov Test, and percentile calculation.

## 3. Result and Discussion

### 3.1. Work Sampling

Based on the percentage of work and idle in both operators it can be concluded that the percentage of work operator I 92.77% and idle 7.23%, while operators II 95.18% and idle 4.82%. In the calculation of the accuracy level, it is found that the accuracy of operator I 6.1% that exceeds the expected accuracy threshold, this can be due to the observed working time of only 2 hours within 1 day only, while the operator's accuracy time of 4.9% and meet the desired threshold.

The work sampling relationship with anthropometry is the work sampling analyzes the operator's standard time in work which is influenced by the allowance rating whereas anthropometry designs a product that can accelerate the work of the working operator and reduce the risk of work with the design of the product being made.

In the work sampling, idle operators I and II are 7.23% and 4.82%, when compared with the allowance of operators I and II which has a large 22%, it can be concluded that the operator has done a good job because it has idle which is far below the allowance assessment provided.

### 3.2. Work environment

The relationship may be moderated by aerobic fitness. Within a complex systems language, this example could be manifested as a "risk profile". This conditions includes workload, aerobic fitness and neuromuscular fatigue as interacting factors within a web of determinants related to an emergent pattern of non-contact injuries (Johan Windt, et al., 2016). Illumination calculation is to get accurate results and can be used as a comparison with the measurement results directly so that the most optimal lighting installation is obtained. The intensity of lighting in a field is a flux that falls in 1m<sup>2</sup> area of the field. Lighting intensity is determined where the activity is carried out. Generally the work area takes 80 cm above the floor. Fields of work can be in the form of a desk or work bench, or an imaginary horizontal plane (Amin, Nurhani. 2011). Reflectance is the ratio between light falling on the working surface with reflected light from the work surface expressed as a percentage (%). The wall reflectance value of the wall is 13.79% and the effective reflectance of the floor is 13.54%. The average wall reflectance value indicates that the walls and floors of the observed work station are less able to reflect light, because the walls and floor of the work station are covered by dust and spraying material attached to walls or floors.

Coefficient of Utilization (CU) is a certain part of the total light that reaches the work (the level of interest). The value of CU (Coefficient of Utilization) is most dominant depending on the surface reflectance. Thus, a higher surface reflect means a higher CU (Coefficient of Utilization) value. Thus, when the surface reflectance rate is increased, the CU (Coefficient of Utilization) value is also higher, so the level of illumination also increases. The value of CU obtained is 1.014.

Local lighting is measured based on where the operator is doing the work. The measured point is 2 points ie the point on the spraying table and the paint filler. Performed 2 measurements, before work and after. Then, the result obtained calculated the average value of local lighting. Results from the averages can be seen in Table 1. below.

**Table 1.** Average Local Lighting

Measurement Point	Strong Average Illumination
Point 1 (Charging Place)	265
Point 2 (Workplace)	322

General lighting is the lighting throughout the work area. General illumination is measured by the space width of the observed station. The observed spatial area of 20 m<sup>2</sup>, so that the measurement of the distance of the point of entry lighting on the condition of the space area of 10m<sup>2</sup> to 100m<sup>2</sup> so that the distance for each measurement point as far as 3m and point obtained as much as 1 point. Thereafter, lighting measurements were made at that point. Then, calculated the average value of general illumination, and the results obtained can be seen in Table 2. below.

**Table 2.** Average General Lighting

Measurement Point	Powerful Information (lux)
Point A	244,5

Then calculated the value of Lamp Lumen Depreciation, Luminaire Dirt Depreciation, Room Surface Dirt Depreciation, Light Loss Factor, and the number of lamps needed,

**Table 3.** Results Calculation Number of Lights

<i>LLD</i>	<i>LDD</i>	<i>RSDD</i>	<i>LLF</i>	Number of Lights
0,93	0,8	0,63	0,4677	5

The number of lights in SMEs Center Meubel Great still classified as less, so required the addition of lamps as much as 4 lights. Due to the addition of lights, then the cost will also increase. The number of costs required can be seen below.

Watt lights	= 45 Watt
Number of lamps needed	= 5 lamp
Total Watt Overall	= 45 x 5
	= 225 Watt
Total Watt / Day	= 225 Watt x 8 hour
	= 1800 Watt/ day
Total Watt/ Month	= 16 day x 1800 Watt/ day
	= 28800 Watt
Additional cost /Month	= 28,8 kW x Rp. 1.467/kW
	= Rp 42.249

### 3.3. Anthropometry

Improvement of the operator's work position can have a positive effect on the standard time which is able to shorten the standard time of the product manufacturing process. Improving work position and decreasing the standard time of the flour making process can result in an increase in standard output. The workload felt by the operator becomes lighter. This can be seen from the decreasing consumption of energy released by operators to be smaller than before designing. (Agung Kristanto, et al., 2016). The determination of anthropometry for the height of Elbow Standing (TSB) is the principle of average (50% percentile). This is done on the grounds that the table height should correspond to the average height of the person using the table.

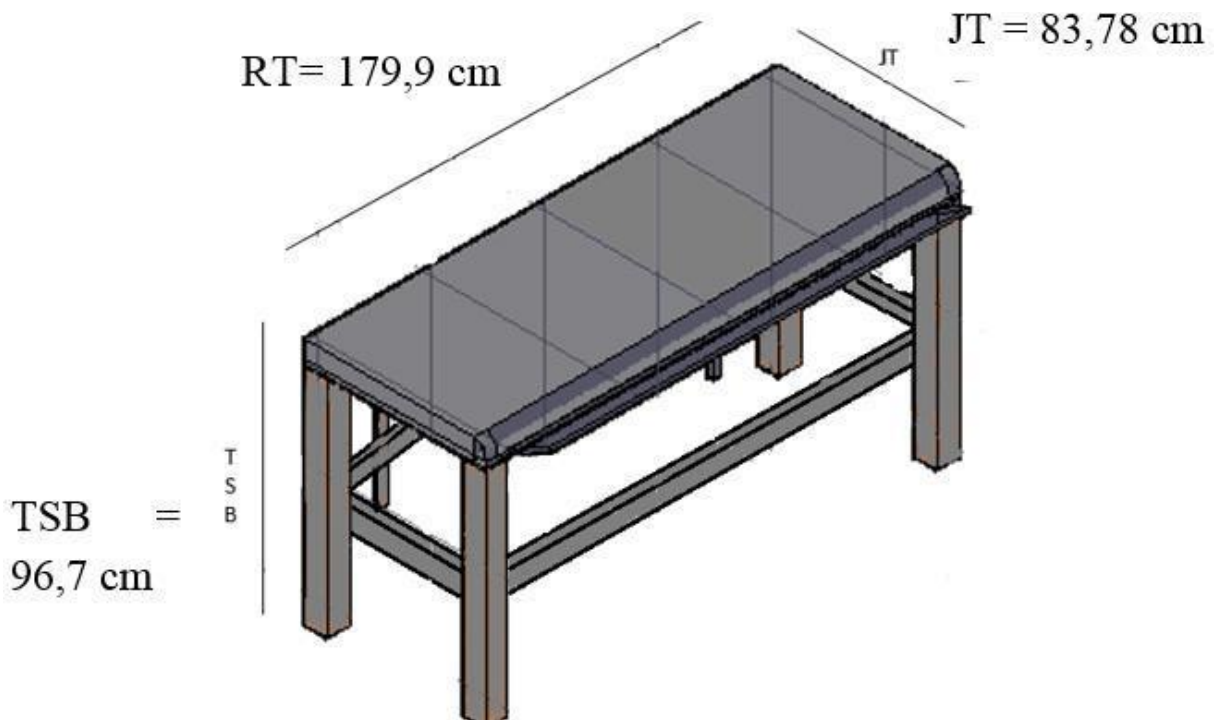
The determination of anthropometry for Hand Span dimension (RT) is the upper extremity principle (95% percentile). This is done on the grounds that the table width should be reachable by the operator in doing the work so that the operator does not have to move left and right to do the job.

Anthropometric determination for Hand Outreach dimension (JT) is the upper extremity principle (95% percentile). This is done on the grounds that the range of the spraying area should be wide in order to load the prabot with all sizes, large or small. The body dimensions required in table design based on percentile calculations can be seen in Table 4.

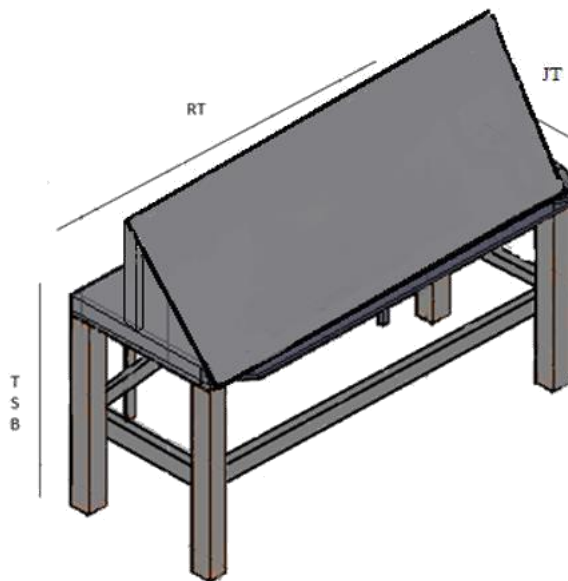
**Table 4.** Dimensional Dimension Table Size

Dimensions	Percentiles(%)	Size(cm)
TSB	50	96,7
RT	95	179,9
JT	95	83,78

The proposed image for the spraying table can be seen in Figure 1. and Figure 2.



**Figure 1.** Table Design Spraying with Dimensions



**Figure 2.** Table Design Spraying

After designing a tool to improve work activities at the polishing station it is expected to improve the performance of the operator in carrying out the activity and also accompanied by the addition of the number of lights in the working environment is expected to reduce the risk of work on the operator working on the station.

#### 4. Conclusion

In this paper we compare the performance of work operator and the idle value of operator. There is 2 operator that we compare the first operator and the second. The performance of work and the idle value of the second operator is higher than the first one. In the calculation of working environment data obtained wall reflectance value of 10.63%, and effective reflectance floor value of 16.7%. To calculate the number of lamps obtained the number of use of lamps as much as 4 pieces of hannoch lamp 45 Watt. The proposed design product is a spraying table using the principle of extreme anthropometry of top (95%) where the reach of Hand Reach dimension (83.78 cm) and Hand Emission dimension (RT) is 179.9 cm. In the product design is also used the principle of anthropometry average (50%) where obtained dimensions Stable Elbow (TSB) of 96.7 cm.

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