Study of the Effect Workplace Design Improvement on Productivity in Paving Block Industry SMES

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Study of the Effect Workplace Design Improvement on Productivity in Paving Block Industry SMES

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Abstract: Concrete brick or paving block is a composition of building materials made of a mixture of Portland cement or other hydrolysis adhesives, water, and aggregate. The existing manual production line of paving Block in SMEs in the Tasikmalaya region gain capacity average is 400 pieces/day. Besides quality, the production target must achieve 500 pieces/day to fulfill the market demand. The problem of this study is that workplace design conditions and work tools are not adequate because many waste movement elements and range distances are not according to the Indonesian National Standard (SNI) in need. This research aims to design the workplace system and the preparation method to improve the products in the industry paving block small-scale medium. The experimental research method begins with a design and fabrication workplace and mechanical printing machine. The success of the new workplace and paving block machine on production productivity have been tested with analysis of motion time study and end with comparing the circumstances before and after the repair. Improvements have been successfully cut the number of elements of the labor movement as much as three aspects from 19 to 16 parts, shorten the working time as much as 9,5 s from 48.4 s to 38.9 s, and improve the product output as much as 109 pieces/day from 446 pieces/day to 555 pieces/day. The result is an increase in the productivity index by 25% and an increase in efficiency by 25%.

Keywords: Motion and Time Study, Workplace Design, Ergonomic, Productivity, Machine Design

1. INTRODUCTION

Concrete brick or Paving Block is a composition of building materials made of a mixture of Portland cement or other hydrolysis adhesives, water, and aggregate (Nasional, 1996). Based on June 2020 - November 2020, The manual line productivity of printing paving block in PT. X Tasikmalaya is on average 400 pieces/day. Therefore, to face the market competition by competitors, the production target that must be achieved to fulfill the market demand is 500 pieces/day (see Figure 1).

The production target can be achieved by improving the workplace. The workplace improvement can be made by redesigning the layout, shortening the range distance, and improving work methods (Karim, 2016). The application of lean manufacturing to reduce waste movement operator and adding rack-rise at the coating chamber on the PCB coating process is proven to increase productivity by 16.7% (Janasekaran, 2020).

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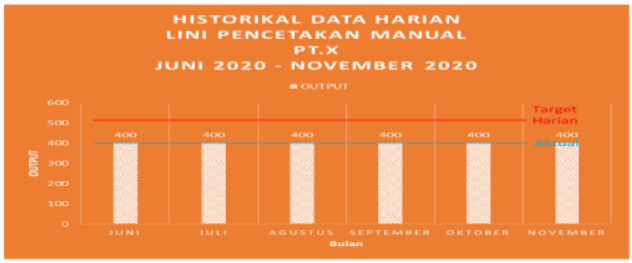

Figure 1 – Historical daily data

Productivity has been improved with the application of lean manufacturing (Janasekaran, 2020; Ker, 2013; Bhamu et al. 2012; 5S and JIT Technique; Kufigwa, 2018), line balancing (Rungreunganun, 2018; Reddy et al. 2016; Tan, 2015; Tajini, 2014) TMS Method (Karthik, 2019). MOST Method (Puvanasvaran, 2019; Karim, 2016), redesign line production layout (Siriya, 2020; Peralta, 2019; Marcelo, 2016; Musavi, 2016; Duran et al., 2015; Bhamu et al., 2012), redesign workplace layout (Marcella, 2019; Kufigwa, 2018; Rungreunganun, 2018; Karim, 2016), reduction/distribution waste the elements of movement (Janasekaran, 2020; Peralta, 2019; Rungreunganun, 2018; Tajini, 2014; Al-Saleh, 2011), Improvement operator work position (Marcella, 2019), reduction the range distance (Siriya, 2020; Karim, 2016; Bhamu et al., 2012), improvement method of work (Karim, 2016)(Caggiano, 2013), reduction cycle time (Siriya, 2020), the addition of support tools/machine (Janasekaran, 2020) (Marcella, 2019; Rungreunganun, 2018; Marcelo, 2016; Reddy et al. 2016), simulation by FlexSim (Siriya, 2020), 3D motion simulation (Caggiano, 2013), discrete event simulation (DES) (Caggiano, 2013), ProModel (Marcelo, 2016), and Arena Software (Reddy et al., 2016; Tan, 2015; Al-Saleh, 2011).

Workplace design can be improved by design and fabricates ergonomic tables and mechanical paving block machines. Design and manufacture of a simple jig have been done and proven to increase the productivity at 27.1% in the assembly of the car heating ventilation and air conditioning (AC)(Rungreunganun, 2018).

Based on the background above, the study "Study of The Effect Workplace Design Improvement on Production Productivity in Paving Block SMEs" is essential. This research focuses on the design of workplace systems and the preparation methods of work to improve production productivity in the paving block industry small-scale medium.

2. MATERIAL AND METHODS

This study involves machine design, design of work systems, implementation of compaction process before and after improvement of workplace design and motion and time study. Outline the research method is shown in Figure 2a below.

a b

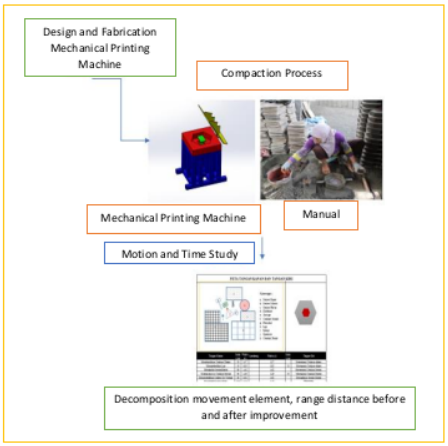

Figure 2 – (a) Outline research method; (b) Design of the table and machine setup

The research flow diagram of this research is shown in Figure 3.

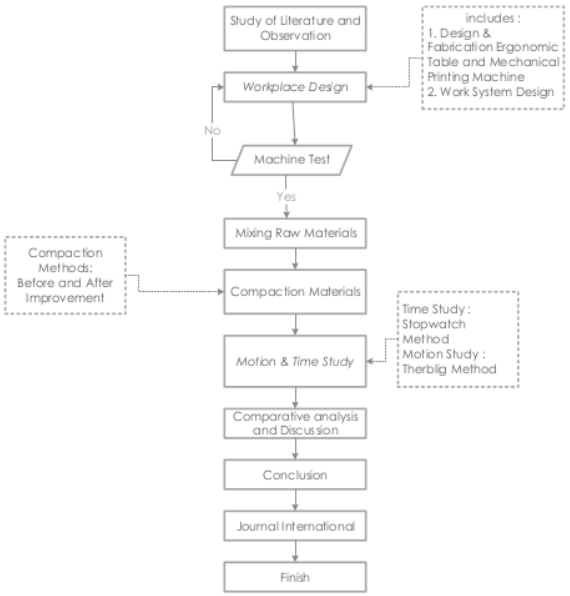

Figure 3 – Research flow diagram

The activity of the research conducted are:

- The study of literature and field observations carried out with the method of fish-bond diagram
- Workplace design involves designing and fabricating paving block machine and Table shown in figure 2b. This step needs time one month to design and fabricate.
- Trial and error on the machine that is made to ensure the machine operates appropriately.
- The operator mixes the raw materials before the work. The composition of which is used to follow the standards of the company.
- Compaction process is done before and after workplace design improvement by the selected operator. The chosen operator is one of the operators that can work typically and has the average ability. The measurement step after workplace design improvement, the selected operator must be trained to adjust the new workplace design so that the operator is not working stiffly.
- Motion and time study is done when compaction before dan after workplace design improvement, See Fig. 2a. The data collection process is done before and after workplace design improvement by decomposition movement to movement elements, measurement of range distance, and measurement time. The therblig method's decomposition movement to movement elements, measuring range distance by measuring tape, and measurement time are done by the stopwatch method. Measurement working time of operators is done for 5,5 hours of work starts at 04.30 – 10.00 WIB. The measurement process is done by two people, one person as a measure and one person as a timekeeper. The position of the two people must be 1.5 meters behind the operator's side so that the operator is measured, not felt in the note by the measure.
- Data collection the beginning of the measurement time as much as 16 times. Suppose processing data on the number of initial data do not still meet the adequacy of the data. In that case, it should be carried out retaking data so that the appropriate amount of information needs to be taken.

- The data will be processed as follows: Determine average data; Determine deviation standard; Determine upper control limit (UCL) and lower control limit (LCL); Uniformity data test; Adequacy data test; Determine average time, and Determine standard time. The output Data generated will refer to the wage-workers so that the level of accuracy and confidence that are used are 5% and 95%,
- The results were analyzed by comparing map work and the productivity before and after improvement.

In this research, the outcome achieved is a workplace design that can improve the productivity of production. This study compares the production productivity before and after workplace design improvement and the selected best workplace. The direct application applies mechanical machining to the modernization of manufacturing processes in the small and medium industries to manufacture paving blocks.

3. DATA ANALYSIS AND DISCUSSION

3.1 Before Improvement Data

3.1.1 Condition Before Improvement

One operator proceeds the production process on manual line production as a compactor paving block. Hexagonal paving block compaction is made by a simple tool and hit method. However, the procedures are done in a squat position for a long time, see Figure 4a. Moreover, the overload range does not follow SNI 03-1979-1990 of Ministry of Public Works, Republic of Indonesia No.306/KTPS/1989. So that, the workers perform the forced movement to reach the raw materials and tools so much movement is not natural, and productivity is not the maximum.

Motion and time study has done in this condition on May 18, 2021, for 5,5 hours of work by stopwatch method and therblig methods. The result is movement elements, range distance, and time.

a b

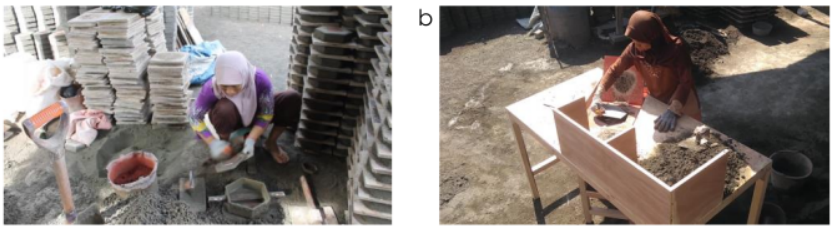

Figure 4 – (a) Before improvement condition; (b) After improvement condition

3.1.2 Movement Elements

The movement element before improvement is shown in Figure 5. The number of movement elements consists of 19 work elements from cleaning base mold to store product paving block.

3.1.3 Range Distance

Figure 5 shows range distance before improvement. Distance from mold to rough cement is 420 mm, Distance from mold to fine cement is 1100 mm, Distance from mold to the base is 1500 mm, Distance from mold to Storage is 1100 mm, Distance from mold to hit tools is 100 mm, Distance from mold to rag are 500 mm.

3.1.4 Production Standard Time and Output

Movement element average time (Ws) is 35,95 s. Normal time (Wn) is 36,67 s from Ws x (1+ Adjustment Factor). The adjustment factor is 0,02 consist of Skill value is average (D) 0, Effort value is average (D) 0, Work condition value is Good (C) +0,02, Consistent value is average (D) 0. Standard time (Wb) is 48,4 s from Wn + (Allowance factor x Wn). The Allowance factor is 32% consist of Power value is 15%, Work position value is 6%, Work movement value is 0%, Eye fatigue value is 3%, Temperature value is 3%, Atmosphere value is 0%, Environment value is 0%, Resistance value is 5%.

Working time per day is 6 hours of work or 21.600 s, while standard time (Wb) for production one-pieces paving block is 48,4 s, so that production output per day is 446 pieces/day.

	Right Hand	Distance (cm)	Time (s)	Sign	Time (s)	Distance (cm)	Left Hand
1	Clean Base Mold	50	1,37		1,37		Hold Mold
2	Return Rag	50	0,83		0,83	35	Assy Base Mold
3	Take Fine Cement	110	1,47		1,47		Waiting
4	Put into Mold	110	1,16		1,16		Waiting
5	Arrange Fine Cement		0,62		0,62	35	Waiting
6	Get Closer Rough Cement	60	4,93		4,93		Waiting
7	Take Rough Cement	42	2,76		2,76		Hold Mold
8	Put Into Mold	42	2,76		2,76		Hold Mold
9	Flatten The Surface		0,67		0,67		Waiting
10	Take Hit Tool	10	0,42		0,42	10	Take Hit Tool
11	Hit Mold		5,27		5,27		Hit Mold
12	Reflatten The Surface		3,31		3,31		Waiting
13	Take Base	150	0,79		0,79		Waiting
14	Assy Base to Mold	150	0,94		0,94		Assy Base to Mold
15	Flip Mold		0,88		0,88		Flip Mold
16	Clean Around Mold		1,69		1,69		Hold Mold
17	Lift Mold		1,50		1,50		Lift Mold
18	Take Base Mold		1,19		1,19		Waiting
19	Store to Storage	110	3,40		3,40	110	Store to Storage
	Total	**884**	**35,95**		**35,95**	**190**	**Total**
	SUMMARY						
	CYCLE TIME				**35,95** [s]		
	NORMAL TIME				**36,67** [s]		
	STANDARD TIME				**48,4** [s]		
	OUTPUT MINIMUM 6 HOURS OF WORK				**446** [Pieces]		

Figure 5 – Left and right process chart before improvement condition

3.2 After Improvement Data

3.2.1 Condition After Improvement

After improvement, the condition of the manual line production paving block is better than before. Change work tools and work position orient improvement. The work tool is changed by a mechanical paving block machine, while the work position is altered from squat to standing; see Fig 4b. Moreover, the range distance has adjusted Indonesian National Standard 03-1979-1990 Ministry of Public Works No.306/KTPS/1989 by table so that workers do not have the potential to make force movements.

Motion and time study has done in this condition on June 09, 2021, for 5.5 hours of work by stopwatch method and therblig methods the result is movement elements, range distance, and time.

3.2.2. Movement Elements

Movement element after improvement is shown in figure 6. Moving consists of 16 work elements from taking base mold to re-position zero-point machine.

3.2.3 Range Distance

Figure 6 shows range distance after improvement. Distance from operator to rough cement is 630 mm, Distance from operator to fine cement is 630 mm, Distance from operator to spoon is 350 mm, Distance from operator to the base is 700 mm, Distance from operator to the machine is 500 mm, Distance from operator to storage is 630 mm.

3.2.3.1 Production Standard Time and Output

Movement element average time (Ws) is 31,27 s. Normal time (Wn) is 31,90 s from Ws x (1+ Adjusment Factor). The adjustment factor is 0,02 consist of Skill value is average (D) 0, Effort value is average (D) 0, Work condition value is Good (C) +0,02, Consistent value is average (D) 0. Standard time (Wb) is 38,9 s from Wn + (Allowance factor x Wn). The Allowance factor is 22% consist of Power value is 15%,Work position value is 1%, Work movement value is 0%, Eye fatigue value is 3%, Temperature value is 3%, Atmosphere value is 0%, Environment value is 0%, Resistance value is 0%.

Working time per day is 6 hours of work or 21.600 s, while standard time (Wb) for production one-pieces paving block is 38,9 s, so that production output per day is 555 pieces/day.

	Right Hand	Distance (cm)	Time (s)	Sign	Time (s)	Distance (cm)	Left Hand
1	Take Base Mold	70	0,71		0,71		Waiting
2	Put Base Mold to Machine	63	1,74		1,74		Waiting
3	Take Spoon	35	0,58		0,58		Waiting
4	Take Fine Cement	63	0,81		0,81		Waiting
5	Put Fine Cement to Machine	63	1,01		1,01	70	Arrange Fine Cement
6	Take Rough Cement	63	2,60		2,60		Waiting
7	Put Rough Cement to Machine	63	2,60		2,60	70	Arrange Rough Cement
8	Put Spoon	35	0,69		0,69		Waiting
9	Direct Hands to Handle	50	0,92		0,92	50	Direct Hands to Handle
10	Close Cover		0,67		0,67		Close Cover
11	Pressing Process		5,39		5,39		Pressing Process
12	Open Cover		0,99		0,99		Open Cover
13	Inject Paving Block From Machine		0,97		0,97		Inject Paving Block From Machine
14	Take Paving Block	50	3,24		3,24	50	Take Paving Block
15	Store to Storage	63	4,10		4,10	63	Store to Storage
16	Set Zero Point Machine	50	4,27		4,27	50	Set Zero Point Machine
	Total	**668**	**31,27**		**31,27**	**353**	**Total**

SUMMARY	
CYCLE TIME	**31,27 [s]**
NORMAL TIME	**31,90 [s]**
STANDARD TIME	**38,9 [s]**
OUTPUT MINIMUM 6 HOURS OF WORK	**555 [Pieces]**

Figure 6 – Left and Right Process Chart After Improvement Condition

4. DISCUSSION

4.1 Comparation Condition Before and After Improvement

Based on the before and after improvement left and right process chart is shown in Figure 5 and Figure 6, the number of moving elements decreases from 19 parts to 16 parts. The result improves removing force movement, which is not adjusted with movement economics. Remove force movement influence to standard time.

Moreover, the range distance has decreased, see Fig. 5 and 6. The range distance with the table has qualified optimum range distance. The range of all movement elements is already below 800 mm of full-length match SNI 03-1979-1990 Ministry of Public Works No. 306/KTPS/1989 (Direktorat Jendral Perumahan Rakyat, 1989). While in before improvement condition, range distance is still above 800 [mm] like distance from mold to fine cement.

The improvements that have been made have resulted in a reduction in the moving element and minimize the range. This improvement affects the standard working time. For example, based on Figure 5 and Figure 6, the ordinary working time has been reduced by 9,5 s from 48,4 s to 38.9 s.

4.2 Comparation Index Productivity

Eliminating one movement that is not following the economic principle of motion and reducing the range according to the Indonesian National Standard shortens the standard time from 48,4 s to 38.9 s. This shows that using a table, and a mechanical printing machine, normal time experienced a savings of 19,6%. In addition, output increased by 24.4% from 446 pieces/day to 555 pieces/day.

After repair, standard time savings and increased output affect the productivity index and work efficiency index values on the printing line. Table 1 and figure 7 show that an increase in the number of outcomes by 24,4 % from 446 pieces/day to 555 pieces/day causes the value of the productivity index and work efficiency index after both improvements to increase by After repair, standard time savings and increased output affect the productivity index and work efficiency index values on the printing line. For example, table 1 and Figure 7 show that an increase in the number of outcomes by 24,4 % from 446 pieces/day to 555 pieces/day causes the value of the productivity index and work efficiency index after both improvements to increase by 25%.

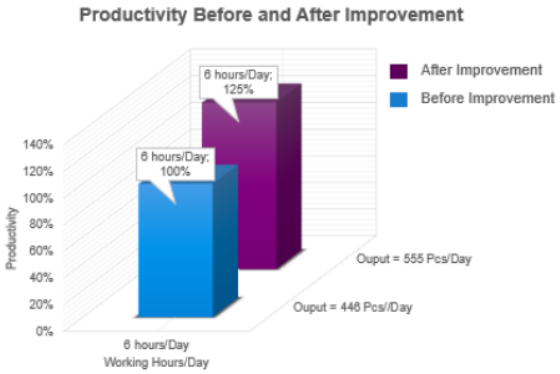

Figure 7 – Graphic productivity improvement

Table 1 – Efficiency Index

Productivity Index					
Condition	Output (Pcs/Day)	Labor	Output/Hours Before (Wb Awal = 49,2)	Efective Capacity Before	Index
a	b	c	D = 3600/Wb	e = (c x d)*6	f= (b/e)
Before	446	1	74,4	446	100%
After	555	1			125%

5. CONCLUSION

The performance of the small and medium industries in paving block manufacturing has increasingly been marked by increased productivity and work efficiency. The Improvement of workplace design shortens the standard work time by 9,5 [s] from 48,4 [s] to 38.9 [s] and production output by 24,4% from 446 Pcs/day to 555 Pcs/day. This improvement affects an increase in the productivity index by 25% and increases efficiency by 25%.

A workplace design improvement shortens the movement elements from the previous number, namely 19 movement elements into 16 movement elements. It shortens the range according to SNI 03-1979-1990 Ministry of Public Works No.306/KTPS/1989 so that the workplace becomes more optimal than before improvement. The new workplace design affects the size the range becomes more optimal (short) below 800 [mm] following SNI 03-1979-1990 Ministry of Public Works No.306/KTPS/1989.

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