Increasing the production capacity of copper drawing machine in the cable industry using SMED method: A case study in Indonesia

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Abstract. *Indonesian Government has electricity program of 35,000 Megawatt. To make this program successful, all cable companies begin to implement strategies to satisfy these needs. Increasing the production capacity is the main program implemented by cable companies in Indonesia. One of the cables companies has production output on copper drawing machine of 11 unit of bobbins per shift with the production process cycle time of 32.32 minutes per bobbin. To improve production capacity, improvements need to be performed to reduce the cycle time of the production process. This research was conducted by applying fishbone and Pareto analysis resulting in three main research problems. SMED methodology was implemented in this research by separating two activities, namely internal setup and external setup, then turning the internal setup to external setup in order to reduce the overall processing duration. From the three main research problems, it results in processing duration reduction from 32.32 minutes to 23.18 minutes or a reduction of 28.28 percent. This reduction can improve the production capacity from 11 unit of bobbins to 16 unit of bobbins per shift or 360 unit of bobbins monthly or increasing the production capacity of 45.45 percent. This SMED program is very suitable for similar companies in cabling field and having old machines so that they do not need to invest by purchasing a new machine.*

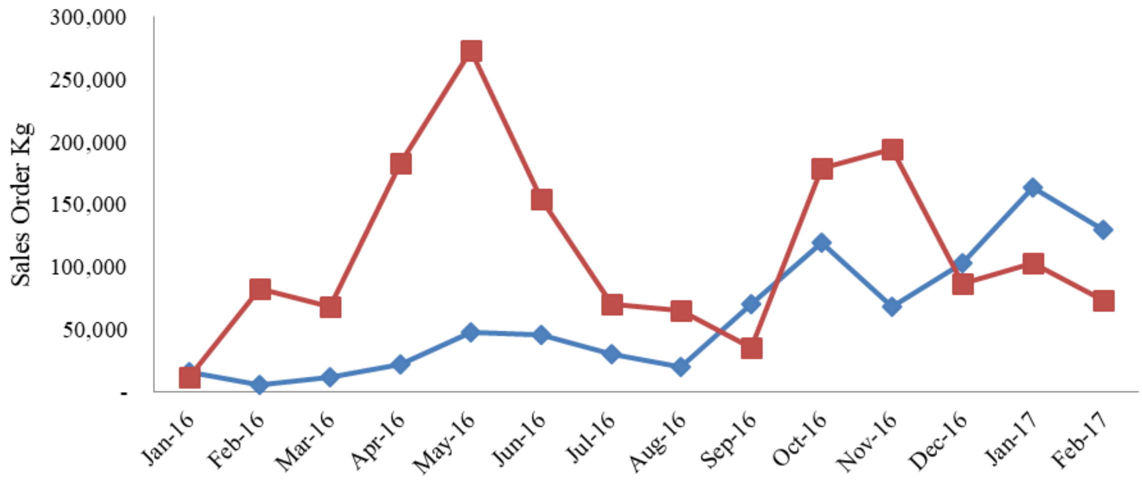
Keywords: cable productivity, cycle time, fishbone, Pareto, SMED.

1. Introduction

As a country with the world's fourth largest population, growth of energy demand of electricity in Indonesia is very large. Estimates of average growth in national electricity consumption per year 1.3 times the economic growth. Based on the Ministry of MINERAL RESOURCES (2018), electricity consumption in Indonesia in the year 2013 is 182,226 MW and in 2020 is estimated at 244,346 MW or increased by 183,226 MW. In the year 2015, the capacity of power plants only able to meet national electricity needs 87.88%. In the year 2019 targeted electrification ratio increased by 97.35% and in the year 2025 is expected to reach 100%. Currently, the electrification ratio in all provinces is already above 70%, except in the province of East Nusa Tenggara and Papua respectively recently reached 60.74%. To meet the growth in consumption of electricity and electrification ratio across provinces in Indonesia, in 2015 the Government has announced a program of increased installed capacity of 35,000 MW 2015-2019 (www.esdm.or.id).

Power plant construction program 35,000 MW, not only aims to fullfill the needs of electricity in the country. The program also will impact significantly for economic growth outside Java where previously the shortage of electricity supply. Mega Project 35,000 MW requires a variety of components as technical support such as transformers, electrical poles, cables and more. Cable is the main component that gets attention in the 35,000 MW power plant. Until now, cable supplier in Indonesia particularly that produced 20 kV medium voltage cables up to 150 kV high voltage is still limited. While the Government has determined that the whole material or supporting components for the construction of 35,000 Megawatts program must be supplied from domestic companies. The Government decision led to the entire cable manufacturers in Indonesia prepare to attempt to make the meet the needs of the cable. Mega Project 35,000 MW have been pushing cable companies in Indonesia to change strategies to suit the needs of most cable type that has been delivered by PT Perusahaan Listrik Negara or PLN.

PT BICC BERCA Cables is one of the major companies in Indonesia which is engaged in the field of electricity and telecommunications. Products are manufactured is the cable type low voltage, medium voltage and high voltage, while for telecommunications is a type of optical fiber. To the field of electricity, the company produced these kinds of cables are basically grouped into two categories, namely cables copper (Cu) and aluminum (Al) cable. To supply the needs of the electric cable in the 35,000 MW, PT PLN needs against the type of copper wires tend to be larger than the type of aluminum cable. It is also apparent from the growth of cable type requests received by PT BICC BERCA Cables such as presented in Figure 1. From January 2016 to February 201, there is a change request. Aluminum cable needs tend to be declining whereas the needs of copper wires are seen to rise and is expected to continue to occur until the year 2019.



	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17
Cu	16,160	6,340	12,404	21,834	48,174	45,874	30,377	20,031	70,360	119,40	67,966	103,30	163,61	130,22
Al	11,772	83,054	68,213	183,04	273,52	154,03	70,539	64,891	35,144	179,24	193,94	86,353	103,65	73,623

Figure 1 The trend of demand for copper wires and aluminum 2016-2017 year (PT Bicc Berca, 2018).

This stipulation has made all cable companies in Indonesia prepare themselves to make efforts to satisfy the cable needs. These efforts are by increasing the production capacity by means of make new investment in both machinery or other infrastructures as well as improving the production process. Increasing the production capacity by means of improvement in production processes becomes the main matter performed by several cable companies because the cost incurred is less than the investment of new machines cost. One of the best approach for production capacity improvement can be attempted through the reduction of process cycle time. This research was conducted at one of cable companies in Indonesia, namely on drawing Cu machine because this machine is the initial machine of the entire cable process series in which if the production output is not achieved, then it will have impact on the next machine process. The following is cycle time data comparison between maximum speed process and normal speed process on drawing Cu machine as seen on Figure 2.

Based on the specifications of the machine Cu drawing maximum process is 8 m cable/sec so the total processing time machine 1 drums (1200 meter) is 25 minutes 42 seconds. While the existing conditions in normal conditions is 13 m cable/sec, thus the total time the process of 1,200 m cable with quality that keeps satisfying the standard is 28 minutes 45 seconds. Thus, reducing the cycle time of the production process can improve the production capacity. With proper improvement program plan, it is expected that the production process time is faster than 32.32 minutes as the maximum time of current process because there is still a lot of other processing time outside the machine processing time.

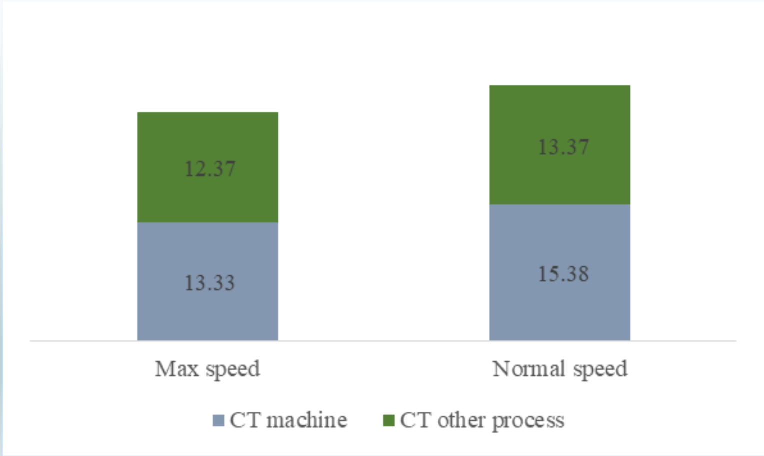


Figure 2 Cycle time of drawing Cu machine (minute).

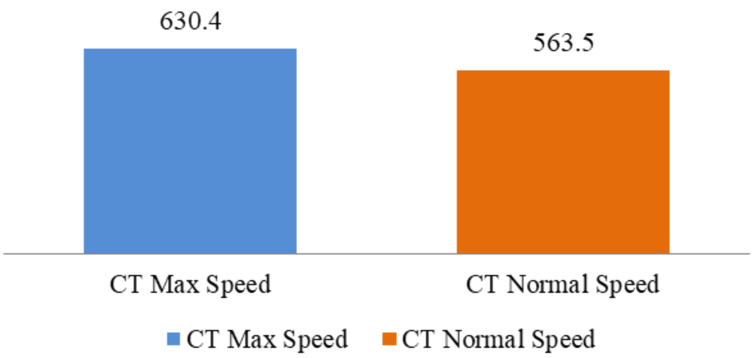


Figure 3 Output wire Cu for 1 day in kilometers.

2 Literature Review

The basic method that has proven effective for reducing setup time or changeover is SMED system pioneered by Shingo. According to Shingo (1985), SMED is a system or method which is series of techniques that allows to implement setup or change over less than 10 minutes, namely the number of minutes stated as only one digit or in other words reducing setup up to under 10 minutes.

According to Shingo (1985), setup or traditional setup operations are implemented through the following basic stages:

a. Preparation, after process Adjustments, checking of material and tools.
   In this step, ensuring all components and equipment are in the place and functioning properly. This step includes removing and returning to storage, cleaning the machine, and so on. In traditional setup, this step is performed when the machine is turned off.
b. Mounting and removing blades, tools and parts.
   This step includes removing components and equipment after production is complete as well as installing components and equipment for the next production. All activities above are performed when the machine is not operated.
c. Measurements, settings, and calibrations.
   This step relates to all measurements and calibration that must be performed, so that the production process runs well. Setting parameters on the machine according to the specified specifications such as temperature, speed, and others.

d. Trial runs and adjustments.
   The last step of the traditional setup operation is after the first trial of the machine. If the measurement and calibration performed is accurate at the beginning, it will be easier to perform adjustment.

According to Mali & Inamdar (2012), the key philosophy behind SMED method is that there are two setup activities as the basis of SMED method, namely: internal setup is only performed when the machine is shut down and external setup is only can be performed when the machine is in operation. Both concepts are very important concepts in the implementation of SMED. According to Adanna & Shantharam, (2013), that in his research the application of SMED in the setup process was able to reduce the total time for axle grinder from the initial time of 24,065 minutes to 14,416 minutes or a reduction of 58,3 percent. According to Sivakumar (2015), in his research on Carriage Building Press that the application of SMED techniques was able to reduce the change over 44.16 percent from the initial average change over time of 98 minutes to 60 minutes. According to Pawar (2014), the application of the SMED and ECRS principles to the machine setup procedure in the factory was able to reduce the total setup time from the initial time of 195 minutes to 114 minutes or a reduction of 41.53 percent.

3 Method

This research was performed at a power cable manufacturing company located in Tangerang Banten. The research variable is improvement process with the implementation of Single Minute Exchange of Dies Method in copper drawing machine process at Cable Industry in order to improve the production capacity by reducing the production process cycle time.

The technique or method used to reduce the setup time was SMED Method (Single Minutes Exchange of Dies). SMED was developed by Toyota and was first introduced by Shigeo Shingo. The improvement steps of SMED method consist of 4 stages:

Stage 1: Recording all activities in setup activities. The first stage of SMED is recording and collecting all activities in the setup regardless of whether the activities are included in internal or external activities.

Stage 2: Sorting the internal and external activities. Sorting the setup activities into two categories: internal and external. It will help in reducing the overall setup time due to this stage determines which activities can be performed when the machine is shut down and which activities can be performed when the machine is running. Sometimes the company make a mistake in making the category. Consequently, the setup time will be longer than it should be. To facilitate the implementation of SMED, internal and external activities need to be categorized into 2 activity categories separated between external and internal activities. The total drawing machine processing time calculates the internal activities only because the external activities can be performed without having to wait for the machine to shut down.

Stage 3: Converting the internal activities into external activities. This is the most important stage of SMED, namely converting the internal activities into external activities, so that the total setup time is expected to be reduced. The conversion process is performed by using Pareto diagram method to facilitate in finding the largest and potentially capable in making large cycle time improvement.

Stage 4: Streamlining all activities. This stage is an improvement stage to reduce all activities performed in the copper drawing machine process. In streamlining process, the 3 main research problems were taken using fishbone method.

4 Result and Discussion

SMED Analysis and Improvement Process

The following is the time for each process and the separation between internal event process and external event process as seen in the Table 1.

Table 1 Production process cycle time

No	Steps of the production process	Average (minute)	Classification	
			Internal	External
1	Pick up the material per 11 bobbins	4.71	V	
2	Set up the material at pay off machine per 11 bobbins	1.59	V	
3	Set up dies with pointer per 33 bobbins	2.99	V	
4	Treading wire per 33 bobbins	0.33	V	
5	Provide empty bobbin	8.06		V
6	Loading bobbin to take up machine	0.43	V	
7	Operator take awalk to control panel	0.12	V	
8	Machine run for production	13.67	V	
9	Unloading bobbin for end process	0.42	V	

By implementing Single Minute Exchange of Dies Method, then the internal process category was analyzed by using Pareto diagram as seen in Table 2 and Figure 4.

Table 2 Pareto diagram analysis of production process cycle time

No	Steps of the production process	Minute	Cumulative Frequency	Percentage	Cumulative Percentage
1	Machine running for production	13.67	13.67	56.3%	56.3%
2	Pick up the material	4.71	18.38	19.4%	75.8%
3	Set up the dies	2.99	21.37	12.3%	88.1%
4	Set up material	1.59	22.96	6.6%	94.6%
5	Loading bobbin	0.43	23.39	1.8%	96.4%
6	unloading bobbin	0.42	23.81	1.7%	98.1%
7	Treading wire	0.33	24.14	1.4%	99.5%
8	Operator take awalk	0.12	24.26	0.5%	100.0%

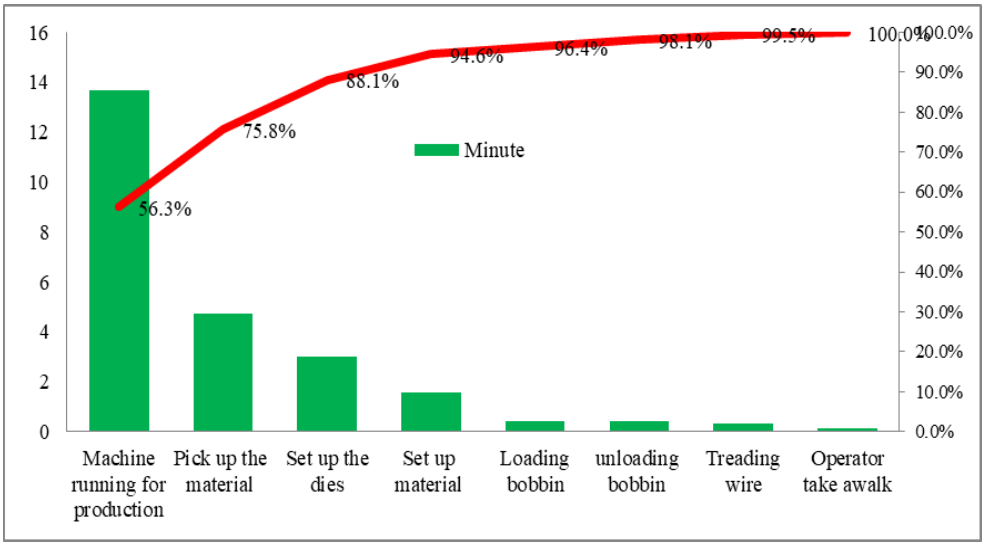


Figure 4 Pareto chart of cycle time of drawing Cu machine.

After the data analysis of Pareto diagram, it was followed by fishbone analysis of the 3 main research problems. The fishbone analysis as in Figure 5.

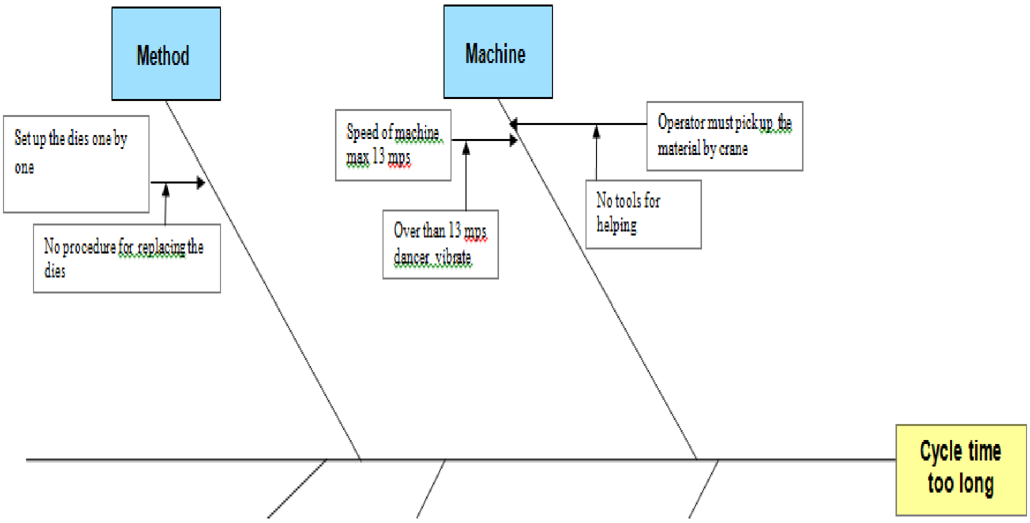


Figure 5 Fishbone analysis of cycle time of drawing Cu machine.

Several caused in overcoming the 3 main problems are:

Machine

The first cause is the operator need to pick up the material by using crane even though the location of crane is not necessarily in the same place because some machines use same crane due to there is only 1 unit of crane. Due to the picking up using crane should be performed when the machine stop, this results longer machine cycle time.

The second cause is the machine speed to perform production process on the size of wire rod cu 8 mm to 2.66 mm speed which is able to produce maximum production output of 13 mps from 18 mps. If the speed is operated over 13 mps, then the dancer wheel will vibrate result less good quality. Therefore, the technical party recommend the maximum speed of 13 mps.

Method

The third cause is the operator must perform setting dies on each capstan amounted to 9 capstans. This process takes long time due to performed manually by the operator using jointing pointer.

Several improvements performed are described below.

Machine

The first Improvement is in order to the operator do not need to stop the production process on the copper drawing machine when picking up the material supply, then the improvement is by creating roller material to perform buffer stock material in the machine area without having to stop the machine when the materials run out. The roller material as in Figure 6, Figure 7, and Figure 8.

The improved roller is able to reduce the cycle time of picking up the material wire rod cu from average of 4.71 minutes to 0 minute.

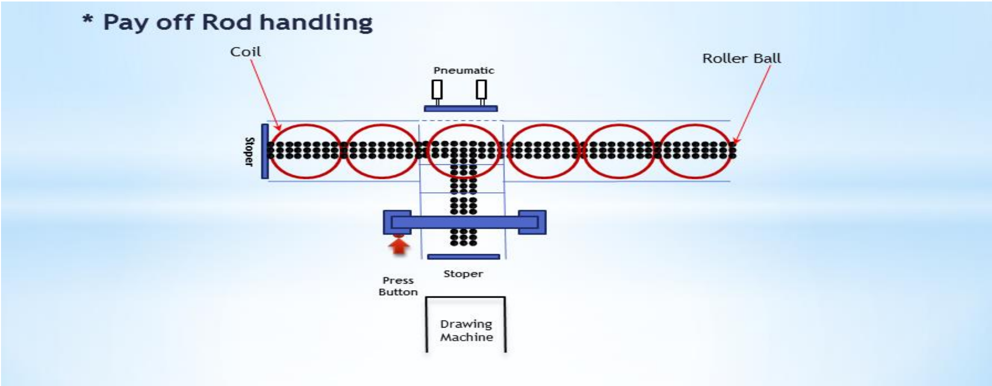


Figure 6 Roller working system of top view.

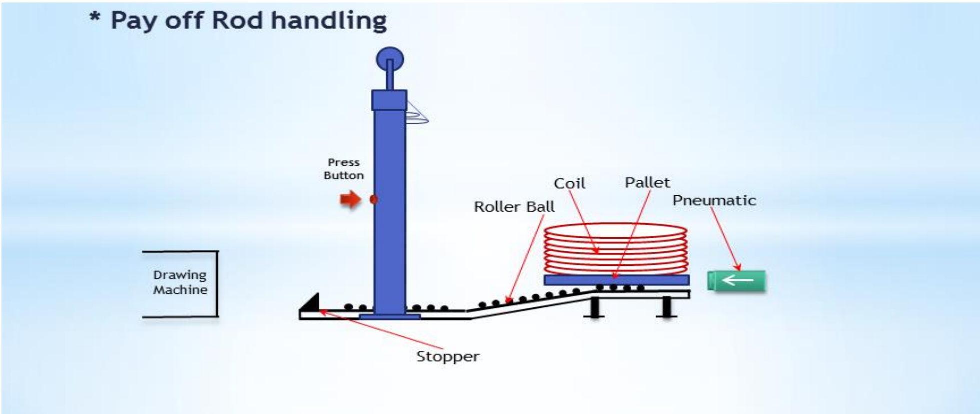


Figure 7 Roller of raw material waiting position.

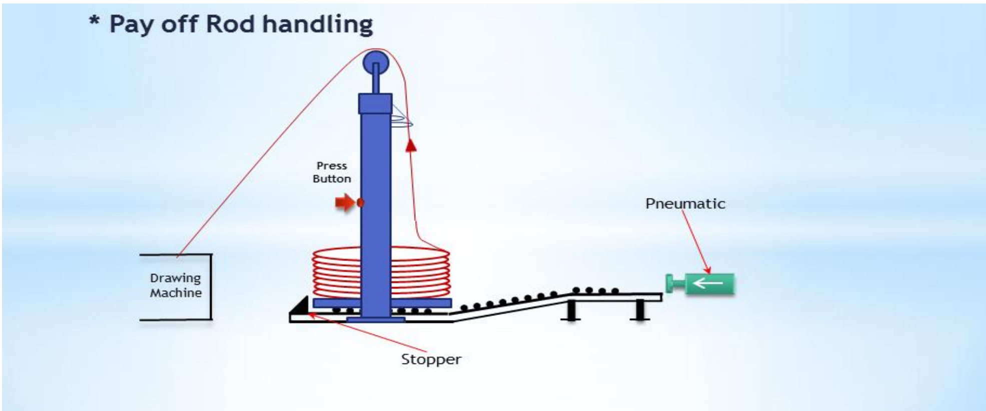


Figure 8 Roller of raw material down automatic position.

The second improvement is to increase the operation speed by keeping the quality as the standards, then improvement is performed by replacing analog drive control motor with digital drive control. This is performed to facilitate the technician when setting the parameter of the drive control for synchronization between each machine part, especially on the dancer wheel so as not vibrating.

Figure 9 and Figure 10 are the components of analog drive control with Eurotherm brand which is replaced by digital drive control with Parker brand.

Figure 9 Analog drive control

Figure 10 Digital drive control.

The improved drive control components can increase the speed from 13 mps to 15 mps or reducing the cycle time from the average of 13.67 minutes to 11.83 minutes. Table 3 shows the cycle time results from the improvement of the drive replacement.

Table 3 Cycle time after improvement the drive control at speed 15 mps

No	Operator	CT (Menit)	No	Operator	CT (Menit)
1	Sangidin	11.92	16	Wahyudin	11.87
2	Try	11.88	17	Sangidin	11.85
3	Wahyudin	11.82	18	Try	11.85
4	Sangidin	11.85	19	Wahyudin	11.83
5	Try	11.87	20	Sangidin	11.65
6	Wahyudin	11.78	21	Wahyudin	11.85
7	Sangidin	11.77	22	Sangidin	11.87
8	Try	11.83	23	Try	11.92
9	Wahyudin	11.77	24	Wahyudin	11.80
10	Sangidin	11.82	25	Sangidin	11.82
11	Try	11.83	26	Try	11.83
12	Wahyudin	11.85	27	Wahyudin	11.87
13	Sangidin	11.92	28	Sangidin	11.85
14	Try	11.75	29	Try	11.83
15	Wahyudin	11.67	30	Wahyudin	11.88
	Avarage	11.83			

The improvement 3 is to reduce the setup time when replacing the copper wire rod specification which is performed due to the dies must be replaced according to the wire rod size in the cable design, thus the improvement is in form of 1 set buffer stock system for each process.

In Figure 11 is buffer stock dies system which is stored in machine in which the dies will be used when needed, so that the operator simply moves it to the available place without having to remove and perform connection activity one by one.

Figure 11 Buffer stock system of dies on drawing Cu machine

The improved buffer stock dies system is able to reduce the cycle time from average of 2.99 minutes to 0.4 minutes because it lefts when the connection activity at the beginning and the end. Table 4 shows the cycle time results from the improvement of the buffer stock dies.

Table 4 Cycle time after improvement for buffer stock system of dies

No	Operator	Cycle Time (Minute)	No	Operator	Cycle Time (Minute)
1	Sangidin	12	16	Wahyudin	12
2	Try	13	17	Sangidin	13
3	Wahyudin	13	18	Try	13
4	Sangidin	12	19	Wahyudin	14
5	Try	13	20	Sangidin	14
6	Wahyudin	14	21	Wahyudin	14
7	Sangidin	13	22	Sangidin	14
8	Try	14	23	Try	12
9	Wahyudin	13	24	Wahyudin	13
10	Sangidin	13	25	Sangidin	13
11	Try	13	26	Try	13
12	Wahyudin	14	27	Wahyudin	14
13	Sangidin	12	28	Sangidin	13
14	Try	14	29	Try	13
15	Wahyudin	15	30	Wahyudin	13
	Avarage			13.20	

Average 0.4 per bobbin

The three improvements are able to reduce the production process cycle time. The following is the cycle time results both before and after the improvement using Single Minute Exchange of Dies Method as seen in Table 5.

Tabel 5 Cycle time after improvement

No	Steps of the production process	Before (minute)	After (minute)	SMED
1	Pick up the material per 11 bobbins	4.71	0	From Internal To External
2	Set up the material at pay off machine per 11 bobbins	1.59	1.59	Internal
3	Set up dies with pointer per 33 bobbins	2.99	0.4	From Internal To External
4	Treading wire per 33 bobbins	0.33	0.33	Internal
5	Provide empty bobbin	8.06	8.06	External
6	Loading bobbin to take up machine	0.43	0.43	Internal
7	Operator take awalk to control panel	0.12	0.12	Internal
8	Machine run for production	13.67	11.83	From Internal To External
9	Unloading bobbin for end procesing	0.42	0.42	Internal
	Total	32.32	23.18	

Increasing the production capacity

Figure 12 shows the reduction results of cycle time after performing improvement using SMED method which is from the average of 32.32 minutes to 23.18 minutes or 28.28 percent.

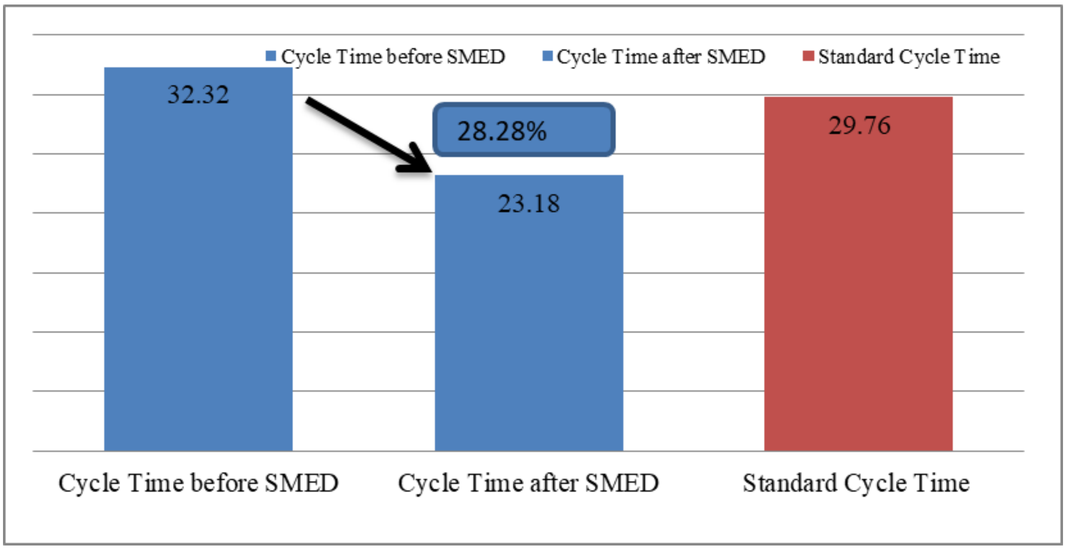


Figure 12 Cycle time reduction of copper drawing machine (minute).

By cycle time reduction in the process of copper drawing machine, the output of each shift increases from 11 bobbins to 16 bobbins or increasing 5 bobbins in each shift. Thus, if in 1 month the machine runs for 24 days, the total increase in output (15 x 24) is 360 bobbins. Therefore, the capacity improvement reaches 45.45 percent.

5 Conclusion and Suggestion

The identification process of the length cause of cycle time in the Cu drawing machine process using SMED method and analyzed by using fishbone are: the operator has to pick up the material by using crane, the machine speed in the production process from the size of wire rod cu of 8 mm to 2,66 mm is maximum 13 mps only, and the operator have to perform setting dies on each capstan manually by using jointing pointer.

The steps of improvement process performed to reduce the cycle time on the Copper Line Drawing machine is to make roller material in order to the production process keeps running during the wire rod replacing, replace analog drive control motor to digital drive control to simplify the technicians when setting the drive control parameter, and make buffer stock system of 1 set each production process, so that the operator does not need to set dies manually.

The benefit of the improvement is to be able to increase the production output from 11 bobbins to 16 bobbins or increase 5 bobbins in each shift. Therefore, if in 1 month the machine runs for 24 days, the total increase in output (15 x 24) is 360 bobbins. The production capacity improvement may reach 45.45 percent.

Based on the results of SMED method implementation on the copper drawing machine, especially for similar industries such as cable industries or wire industries as well as industries having old machines are suggested to implement the SMED method because it is effective in increasing the production capacity which is able to see all stages of the processes by turning the internal process into external process, so that the companies do not need to invest by purchasing new machine in order to improve the production capacity.

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