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**Research Article**

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# Implementation of Business Process Improvement to Reduce Wastes: A Case Study in Grand Piano Assembly Process

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**Abstract** In general, the ultimate goal of a company is to earn a large profit. Big profits will be gained if the company makes efficiency and wherever possible eliminates waste. One of the manufacturing company engaged in manufacturing and assembling of Upright and Grand piano instruments in Indonesia. With the increasing demand for pianos, the company is always trying to increase productivity so that the output produced can meet demand. However, wastage takes place in the assembly section of a grand piano where too much activity takes the tool, moving the intermediate goods from one process to the next too far, the waiting time between the long process, and the defective product. One way that can be used is to eliminate the waste that takes place inside the assembly of Grand Piano strings. The goal is to make the process efficient, effective with shorter lead times. Business Process Improvement is a tool used in this research. Results after the BPI implementation were 10,032.9 seconds worth of added value and 1.076 seconds non-value additional time, waste in unnecessary movement, waste in the excess process, waste in the form of waiting time, and efficiency levels from 90.3% to 94 % increased by 3.7%.

**Keywords** Efficiency, Value Added Time, Non-Value Added Time, Business Process Improvement, Waste

## Introduction

Industrial Revolution or Industry 4.0 as a new era of industrial world of the country. The industrial world must clean up and increase its capacity to compete. Similarly, improving the capacity of workers as an important component in the industry [1]. Implementation of Industry 4.0 can increase productivity, employment, and market expansion for national industry. However, such opportunities need to require alignment with technological developments and a new set of skills [2]. Business process improvement is a structural approach in analyzing and continually improving corporate activities through a focus on eliminating failed, waste, and bureaucratic products. This approach is done by understanding the company's general picture through the flow of information and materials on the production floor. Activity can be grouped into value added and non-value added. This activity can identify the waste that occurred during the production process so that steps can be taken to eliminate the waste. In one of the manufacturing companies in the assembly of grand piano strings, there are eight operations including fixing frames, pairs of bushing buttons and pin tuning drill holes, tuning pin, music wire and string bass, hikiage, pin tuning leveling, and chipping. The waste of grand piano string is too much activity to grab the tool, move the intermediate goods, from one process to the next one too far, the long waiting time between the process, and the defective product.

In this context, waste is defined as anything different from the absolute minimum of materials, equipment, and labor is needed to add value to the product [3]. The principles of lean management and tools come from the shop floor to improve the manufacturing process. "They are based on Taiichi Ohno's notion of" reducing cost by eliminating waste [4-5]. The Federal Aviation Administration (FAA) has revealed that lean management principles and tools are also effective in improving workflow and/or service delivery processes. In general, lean thinking provides a systematic approach to identifying and eliminating waste through withdrawal strategies to remain competitive in the global market [7]. Any losses arising from activities that result in direct or indirect costs, while not adding value to the product and/or service from the client's point of view, are defined as "waste". While waste is generally measured in terms of cost, there are other types of waste associated with process efficiency, equipment and/or personnel and more difficult to measure since optimal efficiency is not a constant parameter [8]. However, Womack and Jones [9] provide guidelines for setting guidelines, to meet the challenges faced when non-lean industrial organizations try to transform themselves into lean organizations using five lean principles: value, value flow, flow, attractiveness, and perfection, as a framework for organizations to understand the lean transformation strategic approach better. Commonly used terms fall into two categories: "value added" and "value-added activities" (waste): (1) Value-added activities (VAA) change the material and / or information in the search to meet the client's requirements and needs and (2) not value-added (NVAA) is associated with waiting time, excessive resources, needs more space, anything that does not add value to products and/or services that must be delivered to consumers [3]. Therefore, it is important to minimize and eliminate non-value-added activities (NVAA) in maintenance by applying lean tools [10]. Several previous studies have given us an overview and demonstrated the use of lean tools in maintenance activities. Smith and Hawkins [11] identified major lean tools including Value Stream Mapping, 5S and visual management, and Business Process Improvement (BPI). Davies and Greenough [12] developed a comprehensive lean tool template that represents the possibility of lean activity in the maintenance process within the organization. The tools are 5S, TPM, OEE, standard, mapping, inventory management, and visual management. Okhovat et al. [13] suggested six lean tools that fit the organization's maintenance process. These tools include visual controls, 5S, seven wastes, one minute off switch (SMED), and Poka-Yoke (error checking). Putri et al. [14] target eight Lean Manufacturing practices in preparation to target lean projects in Implementation of Value Stream Mapping to Reduce Waste at Piano Buffing Panel.

According to Adesola and Baines, in "Developing and evaluating a methodology for business process improvement", the business environment is very complex. Almost everywhere organizations experience rapid and significant changes that are driven by pressures such as customer expectations, new technologies, and growing global competition. As a result, many business processes within organizations are dynamic and ever-changing. In order to survive in such an environment, practitioners are forced to continue to revise their business processes to respond quickly to change. There are several methodologies and tools available used to help businesses improve their processes, however, not yet support practitioners enough through all stages of business process improvement (BPI) activities. The BPI methodology has been developed based on existing literature and was initially refined through discussions with experts in the field. Through this process, the methodology has proven to be feasible, usable, and usable [15]. Using this method, it is expected to minimize and eliminate the waste that occurs in the assembly of Grand Piano strings. So as to create conditions where the process becomes efficient, effective, and with shorter lead time.

**Literature Review**

Lean Production System (LPS) is the systematic approach to identifying and eliminating all wastage's through continuous improvement to achieve customer satisfaction [18]. The primary goal of LPS is to reduce cost and improving productivity by eliminating major manufacturing waste in all work area [19], [20]. Application of the LPS was guided by five principles: 1. Specifying a value, 2. Identifying the value stream, 3. Making the value flow, 4. Configuring of pull system by the customer, and 5. Pursuing towards perfection [20], [27]. LPS consists of a set of powerful "tools" that assisted in the identification and steady elimination of waste (Muda) such as VSM, 5S, SMED and standardized work [22], [26]. These tools focused on the certain aspect of a manufacturing process to eliminate waste and improve the quality while production time and cost were reduced [23]. VSM provides a tool to start the process improvement through a systematic approach [16]. Value stream mapping is one of a partial method from lean manufacturing which uses symbols, metrics, and arrows to show and improve the flow of inventory and information required to produce a product delivered to a consumer. A value stream map is a visual representation which enables one to determine where the waste occurs [24]. Value stream maps used to assess current processes and create ideal and future state processes Value stream mapping is a tool which enables a company to map the process flow that helps in identifying several factors, like [25];

- Value added time (time taken for producing the end product),
- Non-value added time (time has taken which do not contribute to the production of the end product),
- Cycle time (time required to perform a process) and
- Changeover time (time required to change tool and programming etc., This helps in identifying and eliminating Muda (waste), thereby implementing lean principles.

Value Stream Mapping (VSM) is used to define and analyze the current state for a product value stream and design a future state focused on reducing waste, improving lead-time, and improving workflow [28]. A value stream map provides a blueprint for implementing lean manufacturing concepts by illustrating how the flow of information and materials should operate [29]. VSM is divided into two components: big picture mapping and detailed mapping [30]. Rajenthirakumar and Shankar reported a noticeable reduction in cycle time and increase in cycle efficiency with an application of value stream mapping (VSM). Optimizing the flow of production it can minimize some non-value added activities/time such as bottleneck time, waiting for time, material handling time, etc. [31]. Paranitharan provides a useful platform for research in the implementation of lean tools in any manufacturing unit. The results show a significant increase in productivity, as well as Lead Time and negative preparations. This can be used by creating flow by modifying the layout and balance to the time of tack time [32]. Belokar reported a case study of the application of VSM in an automobile industry where they achieved nearly 67% improvement in cycle time by improvement in value-adding activities [33]. Business Process Improvement (BPI) can be considered a methodology for increasing the business activities of the company in an organized and planned. The definition of BPI according to Lee and Chuah (2001) business process improvement is a systematic methodology, to improve the process of a series of separate and manageable business activities. BPI is a structured approach to be able to analyze and improve the activities of the company in a sustainable manner. BPI provides systems that help in simplifying operations and ensuring customers both internal and external receive satisfactory results or results. BPI is a structured approach to be able to improve the activities of the company in a sustainable manner by focusing on the elimination of waste (waste) and bureaucracy [34].

## Methodology

The BPI methodology has been given module based improvement methodologies and integrated process improvements. This is a generic seven-step procedural approach that guides the actions and decisions of the process design team. The BPI methodology can be used for both repair and re-engineering initiatives. It discusses the "what" to do and the "how" to make it happen with the participate team effort. This is a guide, not a procedure or manual. Each step of the methodology includes the objectives, actions, people involved, results/exits, checklists, hints and tips, and relevant tools and techniques. An outline of the contents of the BPI methodology shows the steps, main activities and equipment, and techniques [35].

Our research has done One of the manufacturing companies engaged in manufacturing and instrument of Upright and Grand piano instruments in Indonesia. Our research was undertaken through steps that include determining objectives, observing and eliminating previous data, and also identifying activities in the process of listing grand pianos assembling, analyzing problems, improving, observing and retrieving data thereafter, and analyzing the final results. After the analysis, suggestions for improvement and success at the implementation stage are not discussed, where the results should provide benefits to the company.

## Result and Discussion

### Phase 1: Organizing for Improvement

Organizing for improvement is the first phase or stage in the BPI approach. In this phase there are steps that can be done, namely:

1. Defining a critical business process
2. Determination of process owner
3. Determining the size of success

### Phase 2: Process Understanding

After organizing for improvement, the next phase is to understand the business process by creating process flow chart.

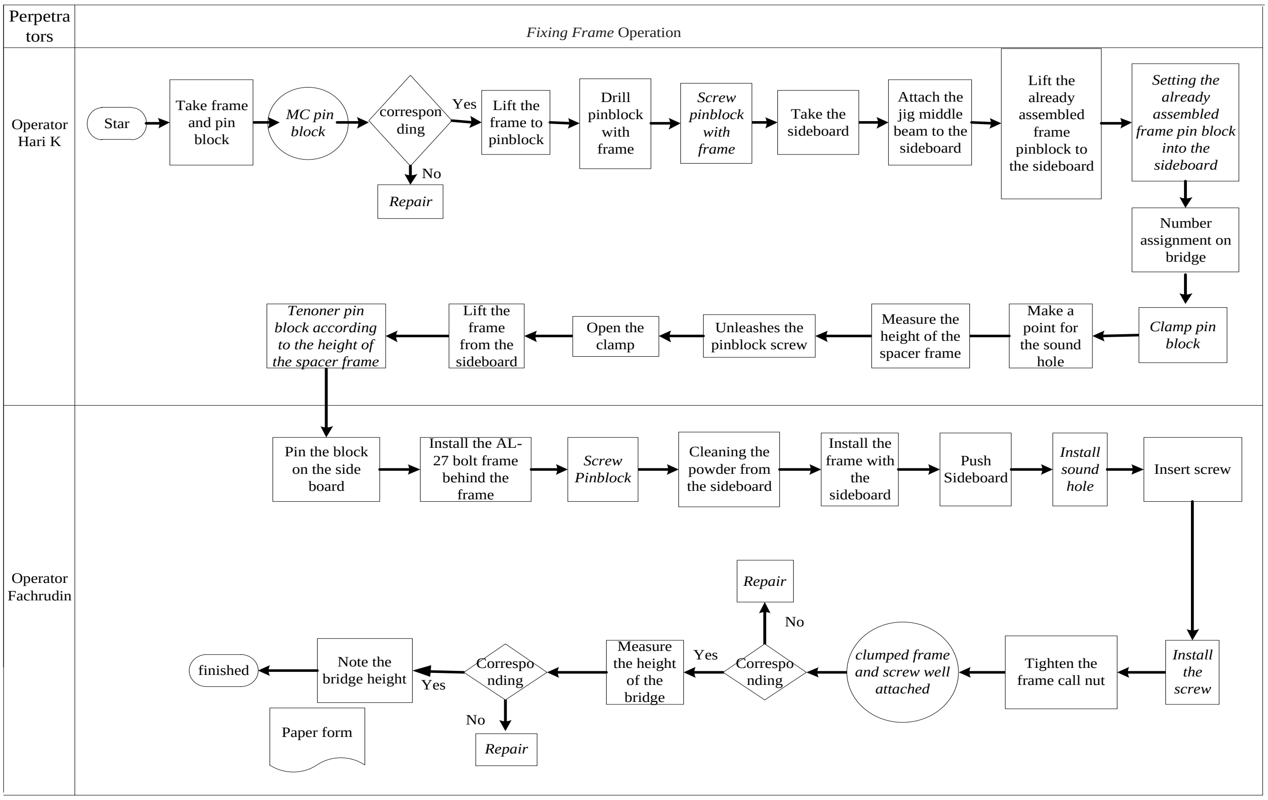


*Figure 1: Flow Diagram of Fixing Frame Operation*

Figure 1. It a pin block and frame assembly operation with sideboard assy using screw. The tools used include hand drill, drill bit, T lock, gauge dial, MC meter, pads, hammer, puller.

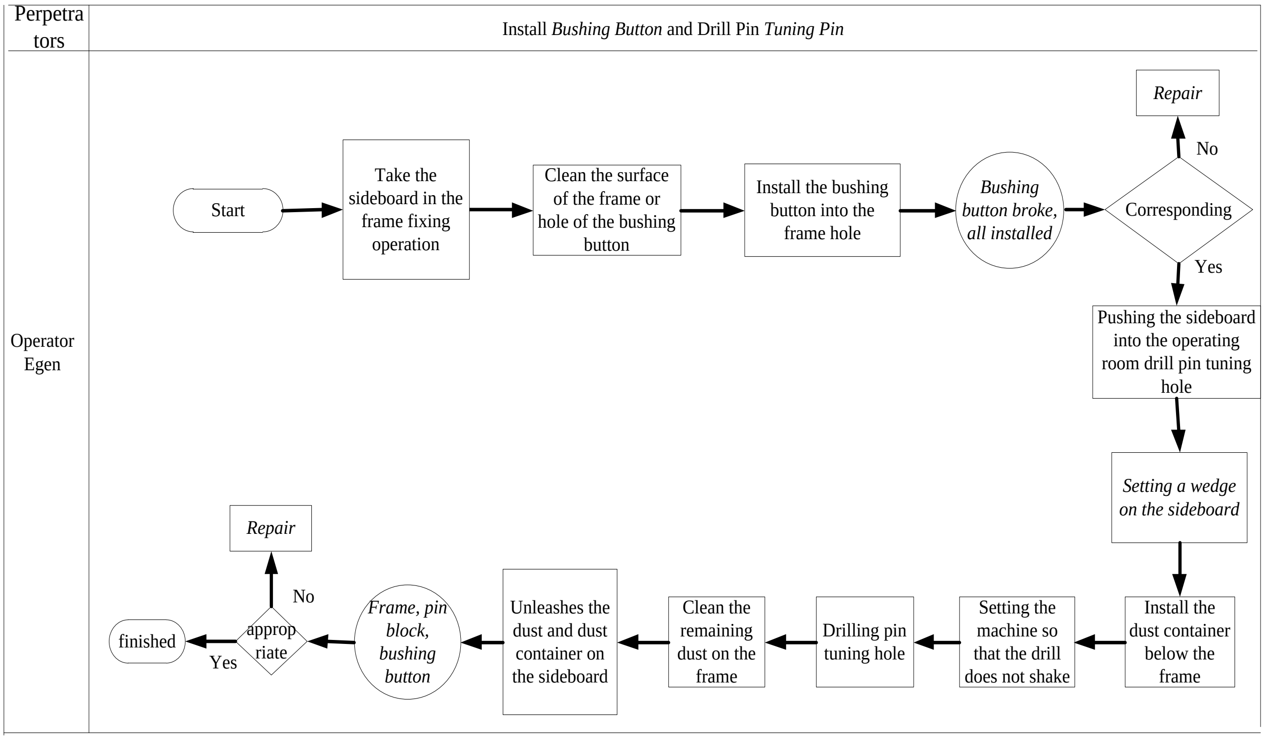


*Figure 2: Operation flow diagram install bushing button and drill pin tuning pin*

Figure 2. It is the process of assembling the bus button into the frame hole that has been assembled with sideboard assy. The function of this bushing button is like bearing tuning pin. Tools used include air gun, visual,

water hammer, gauge. While drill hole bushing button is the process of drilling operation bushing button for pin tuning hole. Tools used include arm drill, wedge, drill, water hammer, drill key, hammer, and torque wrench.

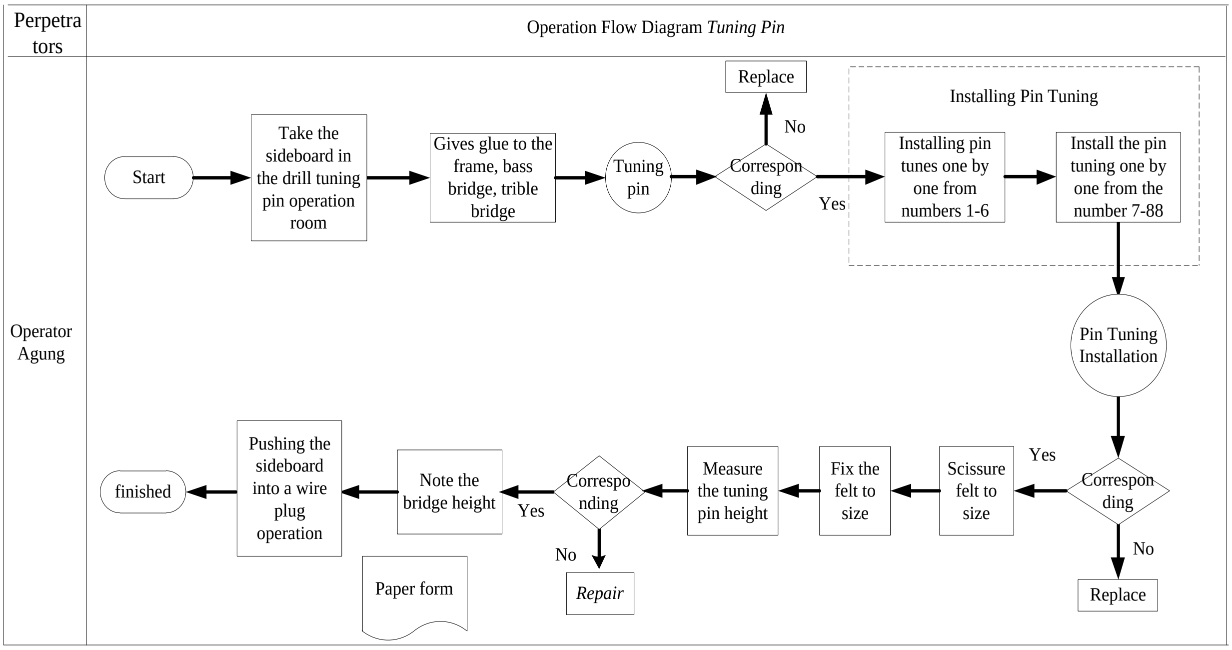


*Figure 3: Operation Flow Diagram Tuning Pin*

Figure 3. Is the process of assembling the pin into the buttonhole bus frame that has been assembled with sideboard assy. Fitting felt is done in this operation. The function of the tuning pin is the raw material for inserting the wire into the pin tuning hole while the felt serves as a silencer. Tools used include air gun, visual, water hammer, torque wrench, hammer tuning, and glue.

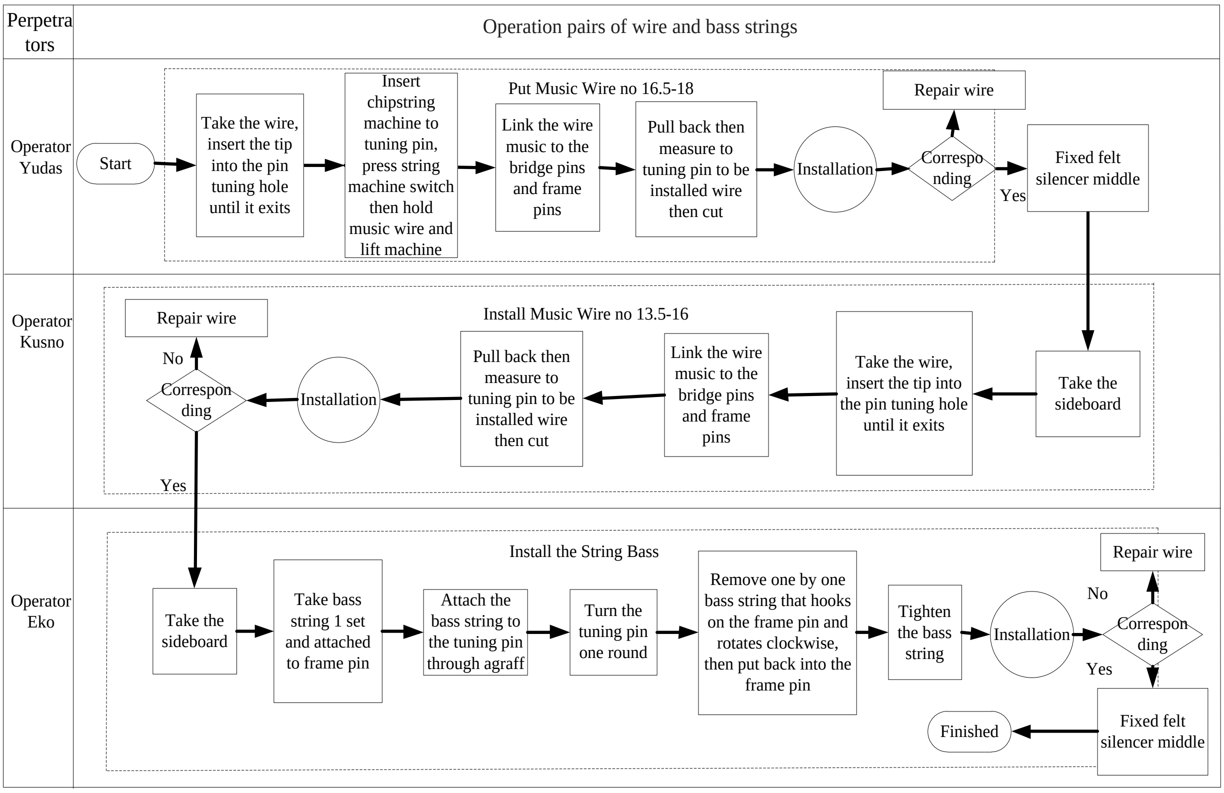


*Figure 4: Operation flow diagram install wire and string bass*

Figure 4. It is the process of assembling the wire and bass strings that are inserted into the tuning pin and then the wire ends are wrapped around the pin tuning. The function of the wire and bass strings is to produce sound. Tools used include string, manual, and visual machines.

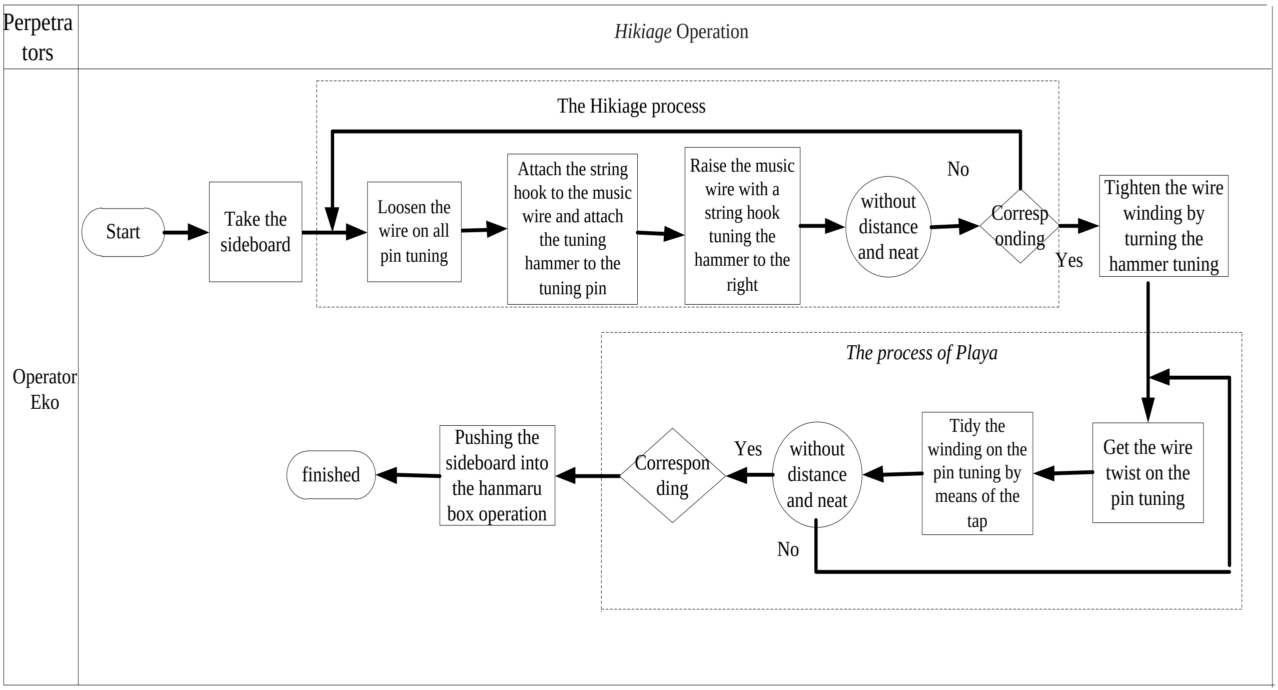


*Figure 5: Flow chart of hikiage operation*

Figure 5. Is an operation to close the wire that has been wrapped around the pin tuning, while playa is a tidy wire bending operation that is wrapped around the tuning pin and felt out. Tools used include string machine, manual, visual, playa, hand maru, hammer. The function of this operation is that the winding of the pin tuning is tight and space music wire is equal and the string tension is evenly distributed.

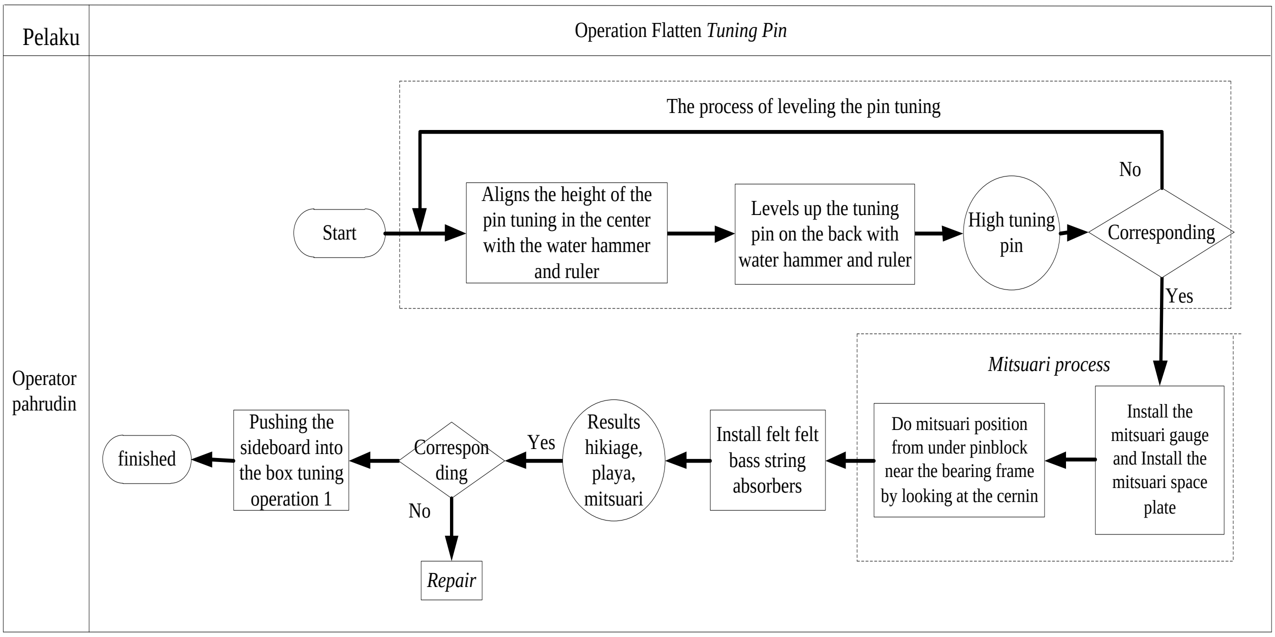


*Figure 6: Flowchart of operation flatten tuning pin*

Figure 6. This operation allows the height of the music wire from the same frame surface (2.5 mm - 3 mm) and the tuning pin does not lose during tuning. While mitsuari is a wire tidying operation with the appropriate distance and has a function to space between the same music wire so that when installing damper no noise.

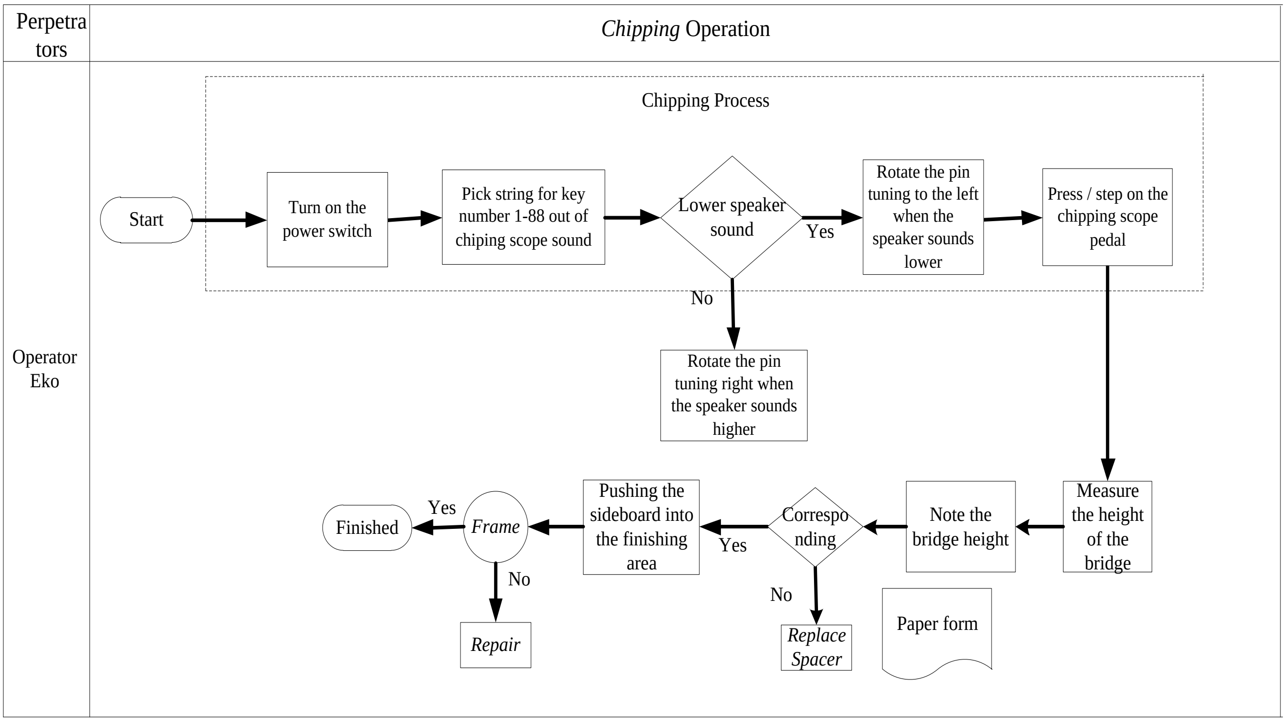


*Figure 7: Chipping operation flowchart*

Figure 7. Represents the operation of tuning the pin to fit the sound on the string. Tools used include shigoki, chipping scope, hammer tuning, here. The function of this operation as a guide in chiping operation so that the tuning result is not altitude or low.

**Phase 3: Counting Cycle Time**

As for how to calculate the average cycle time is as follows:

$$\overline{X} = \frac{\sum_{i=1}^{N} X_i}{N}$$

$$\overline{X} = \frac{1.460,5}{30} = 48,68 \text{ seconds}$$

Or

$$\overline{X}_{\text{sub grup ke-i}} = \frac{\sum_{i=1}^{n} X_i}{n}$$

$$\overline{X}_{\text{sub grup ke-1}} = \frac{247}{5} = 49,4 \text{ seconds}$$

$$\overline{\overline{X}} = \frac{\overline{X}_{\text{sub grup ke-1}} + \overline{X}_{\text{sub grup ke-2}} + \overline{X}_{\text{sub grup ke-3}} + \overline{X}_{\text{sub grup ke-4}} + \overline{X}_{\text{sub grup ke-5}} + \overline{X}_{\text{sub grup ke-6}}}{n}$$

$$\overline{\overline{X}} = \frac{49,4 + 48,2 + 47,9 + 49,0 + 49,0 + 48,6}{6} = 48,68 \text{ seconds}$$

Where :

$X_i$ = i-cycle time
$\bar{X}$ = average cycle time per sub group
$\bar{\bar{X}}$ = overall cycle time average
N = number of observations
n = number of sub groups

**Table 1**: Time Cycle Activity Frame and Pinblock Taking Data On the operation frame fixing

| Sub Group | Take Frame and pin block | | | | | | |
|---|---|---|---|---|---|---|---|
| | Observation of Cycle Time X (seconds) | | | | | Amount (seconds) | Average $\bar{X}$ (seconds) |
| | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | | |
| 1 | 47.5 | 49.8 | 48.6 | 50.8 | 50.2 | 247.0 | 49.4 |
| 2 | 47.3 | 49.7 | 48.4 | 48.0 | 47.5 | 241.0 | 48.2 |
| 3 | 49.3 | 47.2 | 51.0 | 45.6 | 46.4 | 239.5 | 47.9 |
| 4 | 52.5 | 48.1 | 47.2 | 49.7 | 47.6 | 245.1 | 49.0 |
| 5 | 50.1 | 48.8 | 48.7 | 50.2 | 47.0 | 244.8 | 49.0 |
| 6 | 45.6 | 48.1 | 48.5 | 51.8 | 49.2 | 243.2 | 48.6 |
| | | | Total $\bar{X}$(seconds) | | | | 292.1 |
| | | | $\bar{\bar{X}}$ (seconds) | | | | 48.68 |

It is necessary to calculate the average cycle time of each activity of grand piano stringing assembly process. Calculation of the average operating cycle time frame fixing with the work activity of taking the frame.

**Phase 4: Calculation of normal time and standard time**

Recapitulation of calculation of the average cycle time for fixing the frame to chipping operation is presented in the following table :

**Table 2**: Recapitulation of Operation Cycle Time Average Fixing Frame to Chiping

| No | Work Activity | Cycle Time (second) |
|---|---|---|
| | **Fixing frame** | |
| 1 | Take frame and pinblock | 48.7 |
| 2 | Check MC pinblock | 15.6 |
| 3 | Lift the frame to pinblock | 33.1 |
| 4 | Drill pinblock | 135.3 |
| 5 | Screw pinblock | 43.6 |
| 6 | Take the sideboard | 18.0 |
| 7 | Install the jig middle beam | 27.2 |
| 8 | Setting the frame on the sideboard | 315.4 |
| 9 | Numbered on the bridge | 41.5 |
| 10 | Pinblock clamps | 6.8 |
| 11 | Create a sound hole | 319.9 |
| 12 | Measure the height of the spacer frame | 9.7 |
| 13 | Releasing the screw | 67.6 |
| 14 | Open the clamp | 7.1 |
| 15 | Lift the frame from the sideboard | 24.2 |
| 16 | Tenoner pinblock | 27.6 |
| 17 | Install pinblock | 91.0 |

| | | |
|---|---|---|
| 18 | Install the AL-27 bolt frame | 18.8 |
| 19 | Screw pinblock | 23.5 |
| 20 | Cleaning up | 47.4 |
| 21 | Attach frame to sideboard | 51.2 |
| 22 | Push the sideboard | 7.0 |
| 23 | Install sound hole | 34.6 |
| 24 | Insert the screw into the hole | 86.3 |
| 25 | Install the screw | 394.3 |
| 26 | Tighten the frame call nut | 76.4 |
| 27 | Check frame | 17.8 |
| 28 | Measure the height of the bridge | 71.1 |
| 29 | Record the results | 65.4 |
| | Total Cycle Time (seconds) | 2126.2 |
| | **Attach the bushing button and drill pin tuning hole** | |
| 1 | Take the sideboard | 21.9 |
| 2 | Clean the frame surface | 62.9 |
| 3 | Install the bushing button | 442.0 |
| 4 | Check the installation of the bushing button | 15.1 |
| 5 | Push the sideboard | 17.3 |
| 6 | Attach the dust and dust container | 43.2 |
| 7 | Setting machine | 26.0 |
| 8 | Drilling pin tuning hole | 96.0 |
| 9 | Clean the dust | 48.6 |
| 10 | Releasing the dust and dust container | 9.0 |
| 11 | Check frame | 17.4 |
| | Total Cycle Time (seconds) | 799.3 |
| | **Install Tuning pin** | |
| 1 | Take the sideboard | 16.3 |
| 2 | Giving glue | 135.5 |
| 3 | Check material tuning pin | 18.9 |
| 4 | Installation of pin tuning | 516.6 |
| 5 | Check Installing pin tuning | 25.3 |
| 6 | Scissure felt to size | 15.1 |
| 7 | Install felt | 138.6 |
| 8 | Push the sideboard into the wire pairs | 17.8 |
| | Total Cycle Time (seconds) | 884.2 |
| | **Attach wire and bass strings** | |
| 1 | Install music wire number 16,5 mm - 18,5 mm | 418.0 |
| 2 | Check wire mounting number 16,5 mm - 18,6 mm | 17.8 |
| 3 | Painting felt silencer middle | 121.1 |
| 4 | Install music wire number 13,5 mm - 16 mm | 523.4 |

| | | |
|---|---|---|
| 5 | Check wire mounting number 13.5 mm - 16 mm | 18.2 |
| 6 | Attach the bass string | 912.8 |
| 7 | Check the bass string installation | 18.5 |
| | Total Cycle Time (seconds) | 2030.1 |
| | **Hikiage** | |
| 1 | Take the sideboard | 7.2 |
| 2 | The hikiage process | 591.8 |
| 3 | Check the density and tidiness of wire | 19.4 |
| 4 | Tighten the wire winding | 210.0 |
| 5 | Playa | 109.1 |
| 6 | Check wire winding on pin tuning | 20.1 |
| 7 | Push the sideboard to flatten the pin tuning | 17.5 |
| Total Cycle Time (seconds) | | 975.0 |
| | **Flatten pin tuning** | |
| 1 | Flatten pin tuning | 216.1 |
| 2 | Mitsuari | 117.1 |
| 3 | Check high tuning pin | 16.7 |
| 4 | Leveling wire | 108.7 |
| 5 | Check the results of hikiage, playa | 30.9 |
| 6 | Fix felt silencer bass string | 111.6 |
| 7 | Push the sideboard into the boxing chip | 17.5 |
| | Total Cycle Time (seconds) | 618.5 |
| | **Chiping** | |
| 1 | Turn on the power switch | 5.0 |
| 2 | Chiping | 453.6 |
| 3 | Measure the height of the bridge | 68.4 |
| 4 | Push to the finishing area | 26.5 |
| 5 | Finishing | 318.6 |
| | Total Cycle Time (seconds) | 872.1 |

Perform the calculation of cycle time, normal time and standard time per workstation that exists for each element of work on the process of assembling a grand piano stringing. To calculate the normal time required rating factors that are based on the Westing House System of Rating. These Rating factors are seen from the operator's ability to do his job. As for setting the standard time, it is necessary to allow allowance as a leniency factor of the operator while working.

**Phase 5: Determining Value Added Time and Non-value Added Time**

To find out whether in the process of assembling a grand piano stringing there is no or no waste, must first determine the activity of value added and non-value added time. One way to identify waste is when in this business process there is non-value added. So that steps can be taken to eliminate waste.

**Phase 6: Counting Process Time before Improvement**

Processing time is obtained from the sum of time value added time and non-value added time of each working element. From the table above the value added and non-value added process of assembling grand piano stringing can be seen that the process time is 11.108,9 seconds or 185,15 minutes.

**Table 3:** Recapitulation of Process Time

| No | Business process | Non-value added time (Seconds) | Value added time (Seconds) | Process Time (Seconds) |
|---|---|---|---|---|
| 1 | Fixing frame | 625,3 | 2.186,3 | 2.811,6 |
| 2 | Attach the bushing button and drill pin tuning hole | 84,5 | 985,7 | 1.070,2 |
| 3 | Put the pin tuning | 68,6 | 1.112,9 | 1.181,5 |
| 4 | Attach wire and bass strings | 47,9 | 2.694,1 | 2.742 |
| 5 | Hikiage | 58,9 | 1.239,1 | 1.298 |
| 6 | Flatten pin tuning | 65,9 | 784,7 | 850,6 |
| 7 | Chiping | 124,9 | 1.030,1 | 1.155 |
| | **Total Process Time** | 1.076 | 10.032,9 | 11.108,9 |

**Phase 7: Calculation of Throughput Efficiency Before Improvement**

The purpose of the calculation of throughput efficiency to determine the level of efficiency of the existing process, namely the business process of assembling a string of grand pianos. The total standard time calculation for value-added time work activity is 10,032.9 seconds. While the total standard time calculation for work activity non-value added time is 1.076 seconds. Then throughput efficiency is the comparison between value-added time with the total processing time of assembling the grand piano stringing that is:

$$Throughput\ Efficiency = \frac{ValueAddedTime}{TotalProcessingTime}$$

$$= \frac{10.032{,}9 \text{ seconds}}{11.108{,}9 \text{ seconds}}$$

$$= 0.903 = 90.3\%$$

**Phase 8: Standard Time Value Added and Non Value Added Analysis**

In the process of assembling the grand piano stringing there are seven operations that is the first operation of fixing frame, the second operation of bushing button and drill pin tuning hole, the third operation pin tuning pin, the operation of the four pairs of wire and bass string, the fifth operation hikiage, the sixth operation leveling the pin tuning, the seventh chipping operation. Of the seven assembling operations of the grand piano stringing, there are activities that do not provide added value and provide added value.

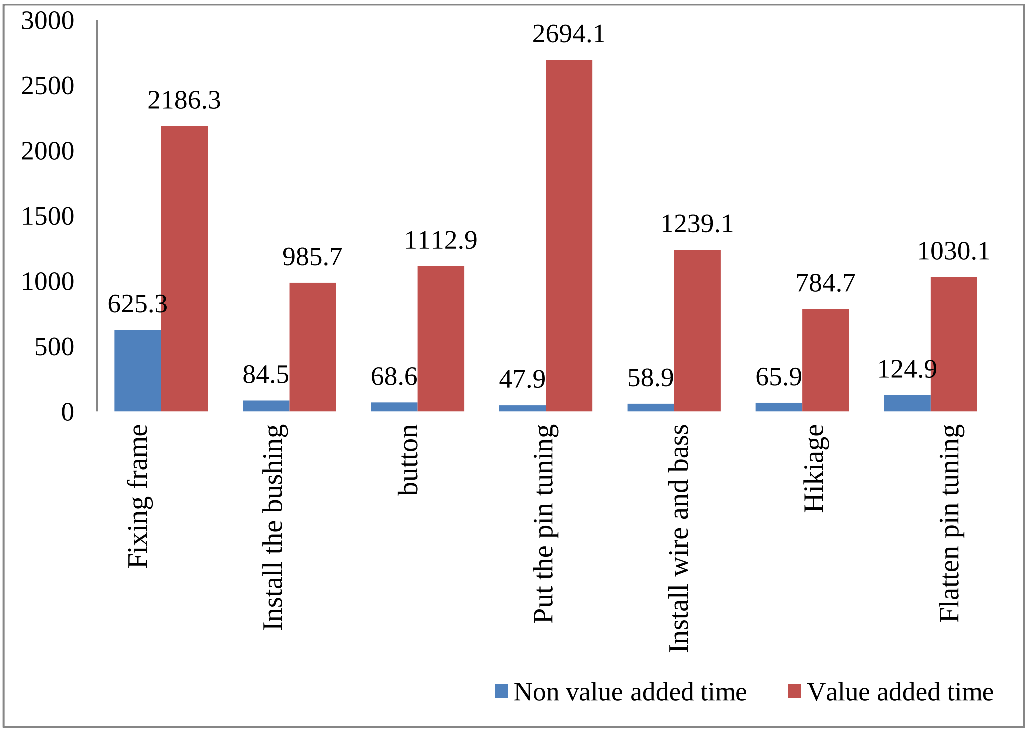


*Figure 8: Bar chart Comparison of Standard Time Non-value added with value added*

**Phase 9: Business Process Time Analysis before Improvement**

The business process time on the assembly of the grand piano stringing is obtained from the sum of value added time with non-value added time of each work activity on the fixing frame operation, install the bushing button and drill pin tuning hole, install tuning pin, attach wire and bass string, hikiage, leveling pin tuning, and chiping, it is known that value-added time is 10,032.9 seconds and non-value added time is 1.076 seconds, so the process time is 11,108,9 seconds. Berit this comparison between value-added time with non-value added time on the assembling of the grand piano stringing.

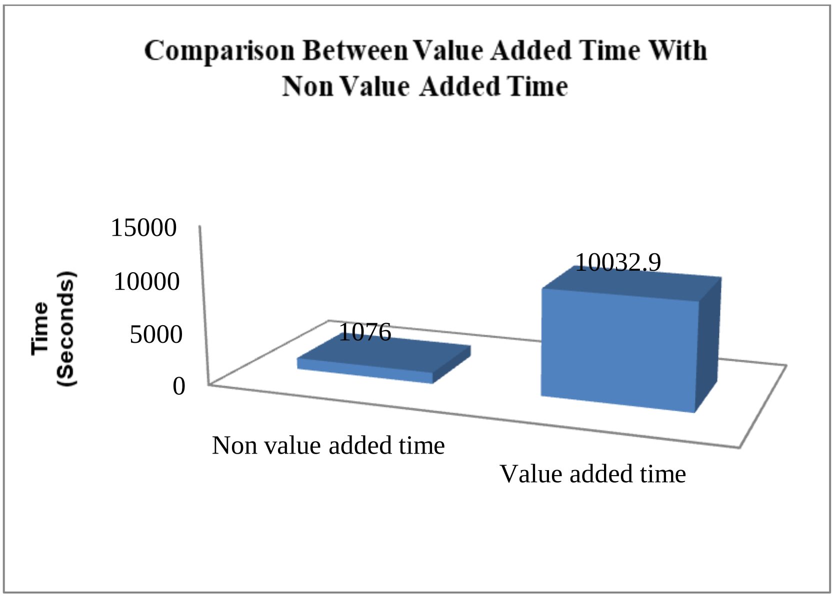


*Figure 9: Bar Chart of Value Added Time Comparison With Non Value Added Time*

**Phase 10: Analysis of Efficiency Throughput Before Improvement**

It can be known that throughput efficiency is 90.3%. The throughput efficiency level of a critical business process can still be improved if the non-value added time completion time can be minimized or eliminated. From data processing that has been done, still seen non-value added time. Although not too big but must be done continuous improvement in order to reduce waste. Efforts that can be made to reduce waste are:

Use tools to shorten non-value added time. Conducting non-value added activities in conjunction with other activities. Fixed the method of work used.

**Phase 11: Analysis of Causes of Wastage**

Wastage that occurs in the assembling of the grand piano stringing there are three types of waste that are excessive transportation, excess process, and waiting time. To find out the cause of waste using the tools 5 why.

**Table 4:** Analysis of Causes of Wastage

| Problem: The Wastage In Unnecessary Movement Form | |
|---|---|
| 1. Why? | Processing time is quite long |
| 2. Why? | There are unnecessary movements |
| 3. Why? | Too much activity pushing and picking up the sideboard |
| 4. Why? | Each operation is done inside each box |
| 5. Why? | Each box has an entrance and exit sideboard |
| **Problem: Excessive Waste in Excess Form** | |
| 1. Why? | The process of assembling the stringing of the grand piano is long enough |
| 2. Why? | Carry out inefficient work activities |
| 3. Why? | Each operation performs unnecessary work activities |
| 4. Why? | There is an operation doing the same work activities |
| 5. Why? | Too much work activity inspection |

| | **Problem: Waste in the Form of Time Waiting** |
|---|---|
| 1. Why? | The flow of the grand piano stringing assembly process |
| 2. Why? | The workload on each operation is uneven |
| 3. Why? | There are half-finished items waiting for further processing |
| 4. Why? | There are several operators waiting to perform the operation |
| 5. Why? | The standard operating time of pin tuning and leveling tuning is faster than other operations. |

**Phase 12: Reduction of Process Time**

One of the parameters used to measure the success rate of BPI approach is process time. If the processing time is reduced, the BPI is said to be successful in improving the business process.

In the fixing frame operation, there are elements of work to take the frame and pinblock. Repair that can be done is to change the position of the position on the frame rack. So as to facilitate the operator in taking the frame.

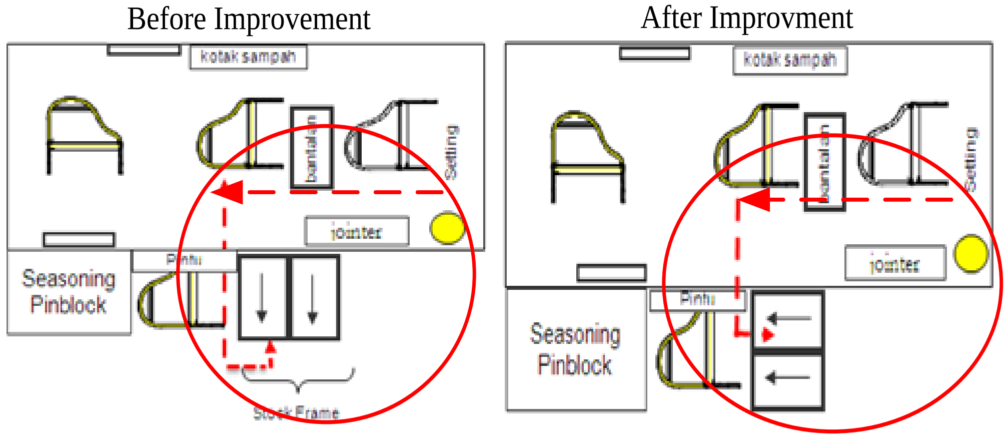


*Figure 4: Repair Frame Rack*

Prior to the improvement seen in Figure 3, the flow of zig-zag frame material makes the distance take the frame farther 0.5 meters. Meanwhile, after the improvement of material flow U-shaped so it only takes a distance of 2.5 m to take the frame.

While the improvement in taking pinblock is reducing the size in taking pinbock from seasoning pinblock. Originally the size of pinblock picking is too large which is 20 units so that the operator takes longer to take pinblock one by one, the proposed improvement is to reduce the size of pinblock taking into a capacity of only 10 units. The standard time required to retrieve the frame and pinblock before the repair is 61.8 seconds. Standard time after the repair is expected to be shorter than before and it can improve business process efficiency on the assembly of the grand piano stringing. Perform indirect working time measurement with standard data method on work activity take frame and pinblock (suggestion)

**Table 4:** Working Cycle Time Taking Frame and Pinblock (Proposed)

| No | Movement Elements | Time (Seconds) |
|---|---|---|
| 1 | Reach a frame of 2.5 meters | 5.9 |
| 2 | Take a frame of jig | 4.2 |
| 3 | Transporting the frame as far as 2.5 meters | 6.3 |
| 4 | Reach pinblock as far as 0.5 meters | 1.2 |
| 5 | Take the pinblock from the jig | 1.0 |
| 6 | Transporting pinblock as far as 0.5 meters | 1.5 |
| | **Total** | 20.1 |

In frame fixing operations there is a work activity setting frame on the sideboard and make soundhole. Improvements that can be made is to reduce the time of work activities by making a tool for wheeled tool for storage tool, so it can move and do not require steps to move.

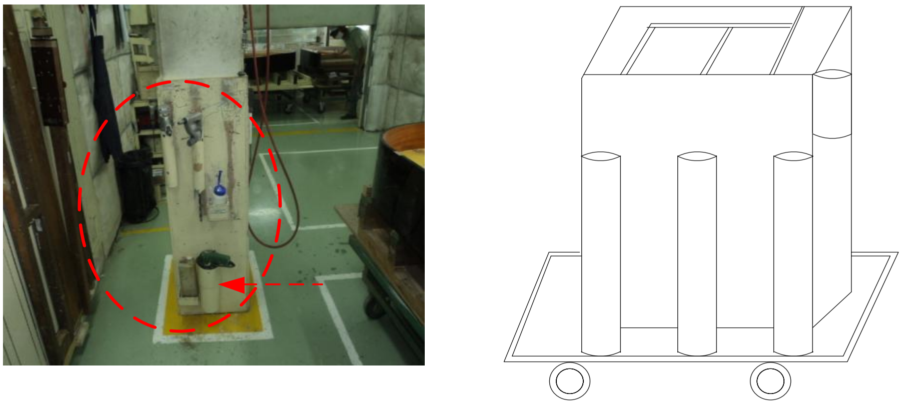


*Figure 5: Repairing Storage Tool*

**Phase 13: Measurement Improvement Analysis**

Repairs are done by changing the layout, changing the size of pinblock taking, creating a tool that has wheels, merging multiple activities and eliminating repetitive activities. After the repair, it is necessary to re-measure the throughput efficiency. With the streamlining then non-value added time and value added time change.

**Table 5:** Recapitulation of Process Time After Repair

| No | Business Process | Non value added time (Seconds) | Value added time (Seconds) | Process Time (Seconds) |
|---|---|---|---|---|
| 1 | Fixing frame | 401 | 2.117,9 | 2.518,9 |
| 2 | Attach the bushing button and drill pin tuning hole | 28 | 985,7 | 1.013,7 |
| 3 | Put the pin tuning | 43,7 | 1.112,9 | 1.156,6 |
| 4 | Attach wire and bass strings | 0 | 2.694,1 | 2.694,1 |
| 5 | Hikiage | 36,1 | 1.239,1 | 1.275,2 |
| 6 | Flatten pin tuning | 46,2 | 784,7 | 830,9 |
| 7 | Chiping | 33,8 | 1.030,1 | 1.063,9 |
| | **Total Process Time** | 588,8 | 9.964,5 | 10.553,3 |

Then throughput efficiency after improvement is the comparison between value-added time with the total processing time assembling of the grand piano stringing that is:

$$Throughput\ Efficiency = \frac{Value\ Added\ Time}{Total\ Processing\ Time}$$

$$= \frac{9.964,5\ seconds}{10.553,3\ seconds}$$

$$= 0.944 = 94\%$$

From the above calculation, it can be seen the level of efficiency of the business improvement process is 94%. There is a business process efficiency before improvement of 90.3% and business process after improvement of 94%, so there is a business increase of 3.7%.

**Phase 14: Comparison Analysis Throughput Efficiency between After and Before Repair**

With the design with improvements using Business Process Improvement approach (BPI) is expected waste can be reduced or eliminated. BPI succeeds if the level of efficiency after improvement has increased. Comparison of efficiency between after and before repair.

**Table 6:** Comparison of Efficiency Levels between After and Before Repair

| No | Change | Before | After |
|---|---|---|---|
| 1 | Value added time | 10.032,9 Seconds | 9.964,5 Seconds |
| 2 | Non value added time | 1.076 Seconds | 588,8 Seconds |
| 3 | Process Time | 11.108,9 Seconds | 10.553,3 Seconds |
| 4 | Throughtput efficiency | 90.3% | 94% |

It can be seen that there is an increase in efficiency between before repair with after repair. The difference between after and before the improvement of 3.7%. Value added time has decreased because there is a business value-added business activity that is done by the improvement. After simplifying by eliminating waste in the assembly operations of grand piano stringing, it shows that business processes with BPI approach succeed.

Based on the research and the results of analysis and discussion, the business process of assembling the grand piano stringing still looks a waste. Known value added time amounted to 10,032.9 seconds and non-value added time of 1.076 seconds. So in the process, there waste 1.076 seconds. The cause of waste in the process of assembling a grand piano stringing there are three is the existence of waste in the form of unnecessary movements, the waste in the form of excessive process, the waste in the form of waiting time. Corrective actions that can be done in the process of assembling the grand piano string is on the fixing frame operation there is work activity taking the frame and pinblock that is by changing the position of the position on the frame rack and reduce the size of pinbock picking from the seasoning pinblock, the work lifting activity frame can be removed that is with how to create jig for setting pinblock, at work activity make sound hole by way of make tool which has wheel for appliance storage, at work activity pinblock clamp can be removed, merging execution some working elements. In the business process performed by the operator of the assembling of the grand piano stringing, there are still wasteful activities that provide less value. As with repeated checks, this element of work is a waste of excessive processes. Then the improvements can be done by combining elements of work at a time. This can be done if it has done an assessment of the activity. Proposed design of corrective actions that can be implemented in the process of assembling the grand piano stringing is on the fixing frame operations there are elements of work to take the frame and pinblock improvements that can be done is to change the position of the position on the frame rack and reduce the size of pinbock picking from the seasoning pinblock, work frame setting activity on the sideboard and make the sound hole can be implemented by making a tool that has a wheel for tool storage, combining and eliminating the implementation of work activities, the business process of fixing frame operation that can be improved is pinblock clamp activity and open the clamp can be removed, coupled with the frame check activity on the operator pairs of bushing button operations and drill pin tuning holes. In the business process operation activity pairs of bushing button and drill hole tuning pin, the improvements that can be done is to change the layout, so that the layout of the bushing button with the drill hole tuning pin into one so there is no activity pushing the sideboard and engine settings, then the activity pushed the sideboard can be eliminated . In the business process operation activities pairs tuning pin activity that can be done repair check material pin tuning, this activity can be eliminated, because rarely found defective tuning pin material. In the business process operation activity of pairs of wire and bass strings there are two activities that can be repaired, namely, check wire mounting number 16,5 mm - 18,5 mm and check wire installation number 13,5 mm - 16 mm, this activity can be eliminated. In business activity hikiage operation activity there is one activity that can be done after the repair, that is pushed from sideboard to box leveling tuning pin this activity better done by operator leveling tuning pin. In the business process of hikiage operation activity, there is one activity that can be done the repair, that check result hikiage, and playa. Hikiage and playa check activity are done on hikiage operation, so no need to do again. In the business process activity of chiping operation, there is one activity that can be done improvement, that is measuring bridge height, this activity can be eliminated because when fixing frame operation has been done.

## Conclusion

Comparison of the achievement of the efficiency level of the grand piano string assembly process between after and before the improvement is the efficiency level of the grand piano string assembly process before the improvement is 90.3%, after improving the efficiency level of the grand piano string assembly process to 94%. Then there is an efficiency increase of 3.7%. suggestions given to the company include: need to improve business processes continuously, although the increase only slightly but affect the company, identify waste, eliminate or minimize non-value added activities so that standard time on business processes can be minimized and improve efficiency, need to flatten the workload on each operation on the assembly of the grand piano stringing so that there is no waste in the form of waiting time.

**References**

[1]. KOMPAS: revolution industrial 4.0 demanding workers to increase capacity, https://ekonomi.kompas.com/read/2018/04/08/160000226/ [accessed on May 09.2018].
[2]. KEMENPRIN: Industry 4.0 Increase Productivity, Labor, and Market, http://www.kemenperin.go.id/artikel/17503/ [accessed on May 09.2018].
[3]. Alarcón, L. F., & Mardones, D. A. (1998, August). Improving the design-construction interface. In *Proceedings of the 6th Annual Meeting of the International Group for Lean Construction* (pp. 1-12).
[4]. Holweg, M. (2007). The genealogy of lean production. *Journal of operations management*, *25*(2), 420-437.
[5]. Wenchi, S., Wang, J., Wang, X., & Chong, H. Y. (2015, September). An application of value stream mapping for turnaround maintenance in oil and gas industry: Case study and lessions learned. In *Proc. 31st Annual ARCOM Conference* (pp. 7-9).
[6]. Stadnicka, D., & Ratnayake, R. C. (2017). Enhancing Aircraft Maintenance Services: A VSM Based Case Study. *Procedia Engineering*, *182*, 665-672.
[7]. Sawhney, R., Kannan, S., & Li, X. (2009). Developing a value stream map to evaluate breakdown maintenance operations. *International Journal of Industrial and Systems Engineering*, *4*(3), 229-240.
[8]. Aziz, R. F., & Hafez, S. M. (2013). Applying lean thinking in construction and performance improvement. *Alexandria Engineering Journal*, *52*(4), 679-695.
[9]. Womack, J. P., & Jones, D. T. (1997). Lean thinking—banish waste and create wealth in your corporation. *Journal of the Operational Research Society*, *48*(11), 1148-1148.
[10]. Jasiulewicz-Kaczmarek, M. (2013). Sustainability: Orientation in maintenance management: Case study. In *EcoProduction and logistics* (pp. 135-154). Springer, Berlin, Heidelberg.
[11]. Smith, R., & Hawkins, B. (2004). *Lean maintenance: reduce costs, improve quality, and increase market share*. Butterworth-Heinemann.
[12]. Davies, C., & Greenough, R. (2001, December). Maintenance survey-identification of lean thinking within maintenance. In *ADVANCES IN MANUFACTURING TECHNOLOGY-CONFERENCE-* (Vol. 15, pp. 37-42). TAYLOR & FRANCIS LTD.
[13]. Mostafa, S., Lee, S. H., Dumrak, J., Chileshe, N., & Soltan, H. (2015). Lean thinking for a maintenance process. *Production & Manufacturing Research*, *3*(1), 236-272.
[14]. Puteri, R. A. M. (2015). Implementation of Value Stream Mapping to Reduce Waste at Buffing Panel UP PT. Yamaha Indonesia.
[15]. Adesola, S., & Baines, T. (2005). Developing and evaluating a methodology for business process improvement. *Business Process Management Journal*, *11*(1), 37-46.
[16]. Rahani, A. R., & Al-Ashraf, M. (2012). Production flow analysis through value stream mapping: a lean manufacturing process case study. *Procedia Engineering*, *41*, 1727-1734.
[17]. Ketkamon, K., & Teeravaraprug, J. (2009). Value and non-Value added analysis of incoming order process. In *Proceedings of the International MultiConference of Engineers and Computer Scientists* 2, 18-2.
[18]. Azizi, A. (2015). Designing a future value stream mapping to reduce lead time using SMED-A case study. *Procedia Manufacturing*, *2*, 153-158.
[19]. Womack, J. P., Jones, D. T., & Roos, D. (1990). The Machine that Changed the World (HarperPerennial, New York, NY).

[20]. Čiarnienė, R., & Vienažindienė, M. (2012). Lean manufacturing: theory and practice. *Economics and management*, *17*(2), 726-732.

[21]. Chopra, A., Kalra, P., & Jawalkar, C. S. (2014). Reduction of process lead time through value stream mapping: A case study of Indian electronics industry. *International Journal of Advanced Engineering Applications*, *7*(3), 19-26.

[22]. Yadav, R., Shastri, A., & Rathore, M. (2012). Increasing productivity by reducing manufacturing lead time through Value Stream Mapping. *International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN*, (2231-6477).

[23]. Salonen, K. (2008). Setup optimization in high-mix surface mount PCB assembly.

[24]. Purba, H. H., Mukhlisin, & Aisyah, S. (2018). Productivity improvement picking order by appropriate method, value stream mapping analysis, and storage design: a case study in automotive part center. *Management and Production Engineering Review*, *9*(1): 71–81.

[25]. Venkataraman, K., Ramnath, B. V., Kumar, V. M., & Elanchezhian, C. (2014). Application of value stream mapping for reduction of cycle time in a machining process. *Procedia Materials Science*, *6*, 1187-1196.

[26]. Azizi, A. (2015). Designing a future value stream mapping to reduce lead time using SMED-A case study. *Procedia Manufacturing*, *2*, 153-158.

[27]. Rowland, R. (2006). *The Smt Step-by-Step Collection 2006*. PennWell Books.

[28]. Rother, M., & Shook, J. (2003). *Learning to see: value stream mapping to add value and eliminate muda*. Lean Enterprise Institute.

[29]. Rother, M., & Shook, J. (2009). *Learning to see: Value-Stream mapping to create value and eliminate muda* (No. 658.012. 4). Lean Enterprise Institute.

[30]. Hines, P., & Taylor, D. (2000). Going lean. *Cardiff, UK: Lean Enterprise Research Centre Cardiff Business School*, 3-43.

[31]. Rajenthirakumar, D., & Shankar, R. G. (2011). Analyzing the benefits of lean tools: a consumer durables manufacturing company case study. *Annals of the Faculty of Engineering Hunedoara*, *9*(3), 335.

[32]. Paranitharan, K. P., Begam, M. S., Abuthakeer, S. S., & Subha, M. V. (2011). Redesinging an automotive assembly line through lean strategy. *International Journal of Lean Thinking*, *2*(2), 1-14.

[33]. Belokar, R. M., Kumar, V., & Kharb, S. S. (2012). An application of value stream mapping in automotive industry: a case study. *International Journal of Innovative Technology and Exploring Engineering*, *1*(2), 152-157.

[34]. Lee, K. T., & Chuah, K. B. (2001). A SUPER methodology for business process improvement-An industrial case study in Hong Kong/China. *International Journal of Operations & Production Management*, *21*(5/6), 687-706.