QUAY CONTAINER CRANE PRODUCTIVITY EFFECTIVENESS ANALYSIS (CASE STUDY JAKARTA INTERNATIONAL CONTAINER TERMINAL)

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Abstract
The purpose of this study is to determine the effectiveness and productivity of Quay Container Crane (QCC) work through the value of OEE (availability, performance, quality) and identify losses affecting the OEE value of QCC. The method used is an explorative and descriptive analysis, which exposes availability, performance and quality of Quay Container Crane based on actual data and information by collecting, compiling, classifying and analysing data and information about the effectiveness and productivity of Quay Container Crane. The results of the OEE are analysed using the six big losses method to find the loss factor, root cause analysis using the Fishbone diagram and make improvement recommendations using the 5 why analysis method. Based on the research results, the OEE value of Quay Container Crane affected by the loss factor which are reduce speed losses, breakdown losses and idling and stoppage losses. The root of the problem comes from various causes, among others, many breakdown on spreaders, the maintenance schedule is still not correct, the operator's competence and knowledge are still lacking, and the technical problems in the Quay Container Cranes.

Keyword: OEE, Quay Container Crane, Six Big Losses, Fishbone

1. INTRODUCTION
Container Terminal as a productive sector must be able to compete and answer customer needs effectively. In the service of loading and unloading containers, there are many obstacles in operation, including bad weather, inadequate equipment, and delays in ships that are about to dock. The impact of these obstacles will result in losses for the company, ineffective and inefficient loading and unloading equipment and delayed ship docking schedules [1]. Lack of synergy between maintenance management and quality improvement strategies that ignore maintenance as a competitive strategy, can reduce output and reliability of production facilities, resulting in faster breakdowns), reduce equipment availability due to excessive system downtime, decrease production quality, increase inventory, and ultimately lead to unreliable delivery performance [2]. The core of a container terminal company is the ability to serve loading and unloading of containers quickly and efficiently, thereby reducing waiting time for ships. And to support this, of course, the availability and performance of QCC equipment is very important and this task is assigned to the Equipment Department.

Besides being able to ease the work, the management and handling of containers as well as shipments carried out on a large scale can be easily done using the various available...
equipment [3]. Container loading and unloading activities cannot be separated from supporting facilities such as docks and loading and unloading equipment such as Quay Container Crane. All container terminals expect Quay Container Crane to perform operations with the best performance and efficiency. Container terminal operations are increasingly paying attention to improving equipment performance and efficiency, especially QCC [4]. While container terminal operators have been able to use additional QCC, and at the same time have to increase the utilization and performance of individual dock QCC by almost four times [5]. PT Jakarta International Container Terminal (JICT) is a container terminal service company which is an affiliate of a company founded in 1999 with a partnership between Hutchison Port Holding Group (HPH Group) and PT Pelindo (Persero). To support container loading and unloading services, PT JICT has reliable and adequate equipment facilities: 14 units of QCC, 60 units of RTGC, 105 units of Yard Truck, 4 units of Reach Stacker & 6 units of Side Loader. JICT as a large company that wishes to continue to grow and sustain, must carefully consider various supporting factors in realizing the company’s vision and mission and win business competition with the support of facilities and infrastructure owned by JICT [6].

One indicator related to Quay Container Crane (QCC) is Box/Crane/Hours (BCH) or Gross Crane Rate (GCR), namely the ability of Quay Container Crane (QCC) to produce containers in one hour is 27 mph (move per hour) [7]. Figure 1 shows the operational productivity of the container terminal from January to December 2020. The Gross Crane Rate (GCR) decreased in January by 26.25 mph, March by 26.37 mph, April by 25.94 mph and December by 26.07.

![Box/Crane/Hours atau Gross Container Rate Tahun 2020](image)

*Figure 1: Container Terminal Operational Productivity in 2020*  
(Source: Jakarta International Container Terminal, 2021)

The author found the phenomenon that the decrease in the operational productivity of the container terminal was due to the fact that the Quay Container Crane equipment also decreased. According to [8], the operational productivity of the container terminal at the wharf will depend on Quay Container Crane (QCC) equipment. One of the performance values that PT JICT wants to achieve is zero unplanned shutdown and zero restriction for Quay Container Crane (QCC) equipment. Figure 2 shows the obstacles that often occur in container loading and unloading operations which are a problem for companies where the number of QCC breakdowns in January occurred as many as 105 breakdowns, March 149 breakdowns, April 113 breakdowns and December 123 breakdowns.
Figure 3 shows the high percentage of problems with the spreader on the Quay Container Crane when operating. On average 70% of the problems in QCC occur in the spreader. As a result of the high breakdown rate on the spreader section, the company will not be able to achieve zero unplanned shutdown and zero restriction and there will be obstacles to the performance of QCC equipment. Any restrictions that interfere with the performance of the Quay Container Crane (QCC) equipment will have an impact on the operational performance of loading and unloading containers. The effective use of machines and production equipment will determine the quality and quantity of production, so maintenance is needed to keep the machines and equipment in good condition. With a good and proper maintenance system can reduce losses due to machine tools and equipment. It will also increase the productivity and efficiency of machines and equipment. A spreader is a device used to connect containers with cranes and can move across the beam from the pier to the outermost end of the beam. The spreader is equipped with a twistlock at each corner and when it is inserted into the corner casting of the container it locks in position and ensures that lifting of the container is possible. At each corner of the spreader, above the twistlock, there is a metal leg called a seeker attached [9].
The concept used to improve quality and efficiency is to use TPM (Total Productive Maintenance). The goal of any TPM (Total Productive Maintenance) is to eliminate the losses associated with equipment maintenance or, in other words keep the equipment producing only good products as quickly as possible without any planned downtime [10]. In this case, the tools used to measure engine performance use Overall Equipment Effectiveness (OEE) measurements and six big losses analysis to determine the factors that cause failures (losses) so that improvements can be made. Previous research, namely [2] stated that the research conducted to measure the effectiveness of the implementation of Total Productive Maintenance (TPM) at PT. BI to improve product delivery achievement. The study used a quantitative descriptive approach with Overall Equipment Effectiveness (OEE) analysis. The OEE value was analyzed using the Six Big Losses (SBL) method to find the loss factor and fishbone diagram analysis to find the root of the problem and make suggestions for improvement. While other studies such as [11] showed significantly improved equipment production efficiency. This framework structures the deployment of TPM and ties various levels of the organization into the program, from planning, implementation to sustainability of practice.

Based on the phenomenon and problem of decreasing container loading and unloading operational performance at JICT, there is a decrease in container throughput in 2020, from the target of 2 million TEUs to 1.9 million TEUs (Figure 1). The problems that exist are that container throughput is not achieved in 2020, which is caused by the decline in the Gross Crane Rate or Box crane productivity per hour in 2020 from the set target of 27 mph (move per hour) and the high number of breakdowns at Quay. Container cranes, especially in January there were 105 breakdowns, March 149 breakdowns, April 113 breakdowns and December 123 breakdowns (Figure 2). And from the high number of breakdowns at QCC, 70% of the largest number of breakdowns are in the spreader section.

This study aims to determine the value of Overall Equipment Effectiveness (OEE) and productivity on Quay Container Crane (QCC) equipment. This is because by implementing OEE, engine performance will be assessed based on availability, performance, and quality.
In accordance with the standard OEE value introduced by Nakajima (2008) is 85%, availability is 90%, performance is 95% and quality rate is 99% [12]. Furthermore, determining the factors causing the decrease in overall equipment effectiveness can be seen from the six big losses to determine the six types of losses that can reduce the level of effectiveness of a machine that must be avoided by every company. Then, this study uses the fishbone diagram method to determine the causes of low machine productivity from the perspective of humans, machines, methods, raw materials, and the environment.

2. MATERIALS AND METHODS

2.1 Quay Container Crane (QCC)

Quay Container Crane (QCC) is the main equipment to play the core role of loading and unloading containers in port terminals. In addition to having the interface function between the waterside and loading and unloading systems, QCC performance is naturally one of the most important indexes to assess the efficiency of a container terminal. QCC scheduling problems not only consider setting service time windows, but also need to avoid crossing each other and to assign cranes to ships [13]. Vessels can be equipped with cell guides to facilitate the placement of containers in the hold. A spreader is a device used to connect containers with cranes and can move across the beam from the pier to the outermost end of the beam [9]. Quay Container Crane (QCC) has different operating configurations such as gauge, reach, rear reach, lift capacity and height. This parameter is usually proportional to the type and size of the vessel being served but operates at a faster cycle time (hoist and trolley speed) so that a standard operating crane movement per hour (move per hour/mph) can be achieved.

2.2 Overall Equipment Effectiveness (OEE)

The concept of Overall Equipment Effectiveness (OEE) was first written in 1989 from a book entitled TPM Development Program: Implementing Total Productive Maintenance which was edited by Seiichi Nakajima of the Japan Institute of Plant Maintenance. This is translated from the Japanese book TPM tenkai published in 1982 [14]. Before OEE, people monitored equipment performance through Availability or Downtime. Overall equipment effectiveness (OEE) as a statistical measurement of engine efficiency, it is a key metric of TPM. The correct OEE percentage usually indicates whether the equipment is running at optimal capacity and producing quality output or experiencing unnecessary downtime. It is a comprehensive indicator of the condition of the equipment in use, availability, performance and quality. It can be used to assess the efficiency with which factories add value. OEE as a measure in evaluating equipment effectiveness, is able to identify production losses and hidden costs that contribute to total production costs. An OEE rating of 85% is the world's standard performance. The calculation of OEE can be seen in Figure 4.
2.3 Six Big Losses

According to Ahuja (2008) the goal of TPM is to eliminate or minimize all losses associated with a manufacturing system to increase overall production effectiveness. TPM focuses on six main disadvantages, which most reduce the efficiency of the production system. One of the main objectives of Total Productive Maintenance (TPM) and Overall Equipment Effective (OEE) is to reduce or eliminate the six big losses as the main cause of loss of efficiency in manufacturing. The relationship between losses and effectiveness in TPM is defined in terms of product quality and equipment availability [2].

<table>
<thead>
<tr>
<th>No</th>
<th>Variable</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Availability</td>
<td>(1) Equipment Failure / Breakdown Losses</td>
</tr>
<tr>
<td></td>
<td>Rate</td>
<td>(2) Setup and Adjustment Losses</td>
</tr>
<tr>
<td>2</td>
<td>Performance</td>
<td>(3) Idling and Stoppage Losses</td>
</tr>
<tr>
<td></td>
<td>Rate</td>
<td>(4) Reduce Speed Losses</td>
</tr>
<tr>
<td>3</td>
<td>Quality Rate</td>
<td>(5) Defect Losses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6) Yield Scrap</td>
</tr>
</tbody>
</table>

2.4 Total Preventive Maintenance (TPM)

According to Nakajima in [15] TPM (Total Productive Maintenance) is a fundamental development program of the maintenance function within an organization, which involves all of its human resources. If implemented directly in a comprehensive manner, TPM will be able to increase productivity, quality, and minimize costs. The machine operator is responsible for the maintenance of the machine, in addition to being responsible for its operation. The implementation of TPM can realize huge cost savings through the productivity improvement process that is realized by TPM. Total Productive Maintenance (TPM) aims to maximize the effectiveness of the equipment used in the industry, which is not focused on maintenance but in all aspects of operations including to increase the
motivation of workers in the company. According to [16] during the development period, TPM focused on maintenance (supporting the company's production processes), so JIPM provides a complete definition into five elements:

1) TPM efforts to maximize overall equipment effectiveness (OEE).
2) TPM is a Preventive Maintenance (PM) system within the age range of a company.
3) TPM involves all company departments (Design, operation and maintenance).
4) TPM Involves all personnel from top management to production floor workers.
5) TPM as a basis for promoting PM through motivational management in the form of independent small group activities.

2.5 Pareto Chart
Alfredo Pareto (1848–1923) undertook an extensive study of the distribution of wealth in Europe. He discovered that there were some people with a lot of money and many people with little money. This unequal distribution of wealth became an integral part of economic theory. Dr. Joseph Juran recognized this concept as something universal that could be applied in many fields. He created a few vital phrases and was useful a lot. Pareto charts are used to identify the most important problems. Usually, 75% of the total yield of 25% of the items. This fact is shown in the figure, where coating machines 35 and 51 account for about 75% of the total. In fact, the most important items can be identified by listing them in descending order. However, graphics have the advantage of providing a visual impact, showing some important characteristics to note. Resources are then directed to take the necessary corrective action [17].

![Figure 5: Pareto Chart (Source: Bestervield.,et.al., 2019)](image)

2.6 Fishbone
A cause-and-effect diagram is a conversion drawing of lines and symbols designed to represent a meaningful relationship between effect and cause. Developed by Dr. Kaoru Ishikawa in 1943 and is sometimes known as the Ishikawa diagram. A cause-and-effect diagram is a structured approach that allows for more detailed analysis to find the causes of problems, non-conformances, and gaps. Cause and effect diagrams can be used when a discussion meeting uses brainstorming to identify why a problem occurs, a more detailed analysis of the problem is needed and there is difficulty in separating cause and effect [15].
The occurrence of deviations in the quality of work, humans will always find that there are 5 main causes that need attention, namely:

1. Man, including anyone involved in the process.
2. Method, how the process is run and what special requirements are needed to run a process.
3. Machines, including all equipment, computers, tools, and others needed to produce goods or services.
4. Materials, including raw materials, spare parts, pens, paper, etc. that are used to produce goods and services.
5. Environment, including the surrounding conditions such as location, time, temperature, and culture where the process runs.

2.7 Methods

This research refers to the background and is oriented to the interests of the company and refers to the formulation of the problem. The first step focuses on eliminating major losses, then analysing with fishbone diagrams, and making the proposed corrective steps to be carried out after the results of the OEE calculations are known, the six major losses and finding the root of the problem using cause and effect analysis.

OEE variables are obtained from the following factors:

Table 2: Research Variables

<table>
<thead>
<tr>
<th>No.</th>
<th>Variabel</th>
<th>Dimensi</th>
<th>Indikator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Overall Equipment Effectiveness</td>
<td>Availability</td>
<td>• Loading Time&lt;br&gt; • Total Downtime&lt;br&gt; • Planned Downtime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance Efficiency</td>
<td>• Hasil Produksi&lt;br&gt; (output)&lt;br&gt; • Ideal Cycle Time&lt;br&gt; • Operating Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality</td>
<td>• Hasil Produksi&lt;br&gt; • Total Defect&lt;br&gt; • Rework</td>
</tr>
<tr>
<td>2.</td>
<td>Six Big Losses</td>
<td>Breakdowns</td>
<td>• Loading Time&lt;br&gt; • Planned Downtime&lt;br&gt; • Total Breakdown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setup &amp; Adjustment</td>
<td>• Loading Time&lt;br&gt; • Available Time&lt;br&gt; • Planned Downtime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Idling &amp; Minor Stoppage</td>
<td>• Loading Time&lt;br&gt; • Tooling Failure&lt;br&gt; • Available Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduced Speed</td>
<td>• Operating Time&lt;br&gt; • Ideal Cycle Time&lt;br&gt; • Loading Time&lt;br&gt; • Hasil Produksi (output)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rework</td>
<td>• Ideal Cycle Time&lt;br&gt; • Loading Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yield Scrap</td>
<td>• Ideal Cycle Time</td>
</tr>
</tbody>
</table>
The population in this study is a Quay Container Crane. Primary data collection is done through interviews and documentation. Interviews were conducted with operators, maintenance personnel and section heads of frit production sections. The data analysis methods used are:

\[
\text{Availability} = \frac{\text{Loading Time} - \text{Down Time}}{\text{Loading Time}} \times 100\% 
\]

\[
\text{Performance Efficiency} = \frac{\text{Theoretical Cycle Time} - \text{Processed Amount}}{\text{Operating Time}} \times 100\% 
\]

\[
\text{Quality Rate} = \frac{\text{Processed Amount} - \text{Defect Amount}}{\text{Processed Amount}} \times 100\% 
\]

\[
\text{OEE} = \text{Availability} \times \text{Performance Efficiency} \times \text{Quality Rate} 
\]

\[
\text{Breakdown Losses} = \frac{\text{Total Breakdown Time}}{\text{Loading Time}} \times 100\% 
\]

\[
\text{Setup and Adjustment Losses} = \frac{\text{Total Setup/Adjustment}}{\text{Loading Time}} \times 100\% 
\]

\[
\text{Idling and Minor Stoppage Losses} = \frac{\text{Non-Productive Time}}{\text{Loading Time}} \times 100\% 
\]

\[
\text{Reduce Speed Losses} = \frac{\text{Actual Production Time} - (\text{Idle cycle time} \times \text{Process Result})}{\text{Loading Time}} \times 100\% 
\]

\[
\text{Rework Losses} = \frac{\text{Idle Cycle Time} \times \text{Rework}}{\text{Loading Time}} \times 100\% 
\]

The result of the OEE value is analysed using the six big losses method so that the failure factor and root cause analysis of performance can be found using a fishbone diagram and then make recommendations for improvements that can be made [18].

3. RESULTS AND DISCUSSION

The container loading and unloading equipment that is the object of research is the Quay Container Crane (QCC), where breakdowns often occur so that it can stop the operational process of loading and unloading containers at PT JICT. To obtain the effectiveness of using QCC optimally, it is necessary to first measure the effectiveness of QCC by using the OEE (Overall Equipment Effectiveness) indicator. Measurement of the effectiveness of this QCC used data sourced from the Engineering Information section. The data needed in this study is the Availability Rate, Performance Rate and Quality Rate data for the period January 2020 to December 2020. In accordance with the standard OEE value introduced by Nakajima (2008) is 85%, availability is 90%, performance is 95% and quality rate is 99% [12].
3.1. Overall Equipment Effectiveness (OEE) Quay Container Crane

The calculation of the Overall Equipment Effectiveness value is obtained from the multiplication of the availability rate, performance rating and quality rate values. With this calculation, the Overall Equipment Effectiveness value for the period January 2020 - December 2020 can be obtained as shown in Table 3.

Table 3: Overall Equipment Effectiveness Calculation Results (Source: Researcher, 2022)

<table>
<thead>
<tr>
<th>QCC No.</th>
<th>Availability (%)</th>
<th>Performance (%)</th>
<th>Quality (%)</th>
<th>OEE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>98.07</td>
<td>19.98</td>
<td>100</td>
<td>19.59</td>
</tr>
<tr>
<td>12</td>
<td>98.20</td>
<td>29.33</td>
<td>100</td>
<td>28.80</td>
</tr>
<tr>
<td>13</td>
<td>98.41</td>
<td>45.71</td>
<td>100</td>
<td>44.98</td>
</tr>
<tr>
<td>14</td>
<td>98.43</td>
<td>63.03</td>
<td>100</td>
<td>62.04</td>
</tr>
<tr>
<td>15</td>
<td>98.31</td>
<td>51.90</td>
<td>100</td>
<td>51.02</td>
</tr>
<tr>
<td>16</td>
<td>97.99</td>
<td>51.24</td>
<td>100</td>
<td>50.21</td>
</tr>
<tr>
<td>17</td>
<td>98.27</td>
<td>50.27</td>
<td>100</td>
<td>49.40</td>
</tr>
<tr>
<td>18</td>
<td>98.45</td>
<td>37.70</td>
<td>100</td>
<td>37.11</td>
</tr>
<tr>
<td>Average</td>
<td>98.26</td>
<td>43.64</td>
<td>100</td>
<td>42.82</td>
</tr>
</tbody>
</table>

The results obtained from the Overall Equipment Effectiveness QCC No. 11-18 period from January to December 2020 is still far from the standardized value. Here is the chart of OEE QCC No.11-18. Based on the OEE calculation, it can be seen that the effectiveness of QCC No. 11-18 as a whole still require evaluation for improvements to be made in an effort to increase the effectiveness of loading and unloading equipment.

3.2. Six Big Losses

The calculation of losses in this study is used to determine what loss factors are the six big losses that cause the results of the OEE (Overall Equipment Effectiveness) percentage value to be not optimal in the QCC Spreader. So, from the results of this calculation, it can also be determined which factors are the main priority to be improved. The OEE analysis highlights 6 main losses (six big losses) that cause loading and unloading equipment to not operate normally.

Table 4: Percentage of Six Big Losses QCC No. 11-14 January –December 2020 (Source: Researcher, 2022)

<table>
<thead>
<tr>
<th>No.</th>
<th>Six Big Loss</th>
<th>QCC No.11</th>
<th>QCC No.12</th>
<th>QCC No.13</th>
<th>QCC No.14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Time Loss</td>
<td>Percent Loss (%)</td>
<td>Total Time Loss</td>
<td>Percent Loss (%)</td>
</tr>
<tr>
<td>1</td>
<td>Breakdown Losses</td>
<td>160</td>
<td>8.05</td>
<td>162.2</td>
<td>6.00</td>
</tr>
<tr>
<td>2</td>
<td>Setup and Adjustment Losses</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Idling and Stoppage Losses</td>
<td>3</td>
<td>0.15</td>
<td>3.95</td>
<td>0.14</td>
</tr>
</tbody>
</table>
From the data concluded, it is known that Reduce Speed Losses is the highest loss experienced by QCC No.11-18 in a year, which is 1825.35 hours or 91.80%.

To be able to see the order of the percentages of the six factors starting from the largest for each QCC, it can be seen in Tables 6, 7 and 8.
### Table 7: Sorting of Percentage of Six Big Losses QCC No. 14-16 (January-December 2020)
(Source: Researcher, 2022)

<table>
<thead>
<tr>
<th>No.</th>
<th>Six Big Loss</th>
<th>QCC No.14</th>
<th>QCC No.15</th>
<th>QCC No.16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Time Loss</td>
<td>Persen tase (%)</td>
<td>Percent age Komulative (%)</td>
<td>Total Time Loss</td>
</tr>
<tr>
<td>1</td>
<td>Reduce Speed Losses</td>
<td>5449,54</td>
<td>97,45</td>
<td>97,45</td>
</tr>
<tr>
<td>2</td>
<td>Breakdown Losses</td>
<td>139,05</td>
<td>2,5</td>
<td>99,95</td>
</tr>
<tr>
<td>3</td>
<td>Idling and stoppage Losses</td>
<td>3,03</td>
<td>0,05</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Setup and Adjustment Losses</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Rework Losses</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Yield scrap losses</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5591,62</td>
<td>100</td>
<td>4637,17</td>
</tr>
</tbody>
</table>
Table 8: Sorting of Percentage of Six Big Losses QCC No. 17-18 (January-December 2020) (Source: Researcher, 2022)

<table>
<thead>
<tr>
<th>No.</th>
<th>Six Big Loss</th>
<th>QCC No.17</th>
<th>QCC No.18</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Time Loss</td>
<td>Persentase Komulatif (%)</td>
<td>Persentase Komulatif (%)</td>
</tr>
<tr>
<td>1</td>
<td>Reduce Speed Losses</td>
<td>4204,21</td>
<td>96,43</td>
</tr>
<tr>
<td>2</td>
<td>Breakdown Losses</td>
<td>151,7</td>
<td>3,47</td>
</tr>
<tr>
<td>3</td>
<td>Idling and stoppage losses</td>
<td>4</td>
<td>0,1</td>
</tr>
<tr>
<td>4</td>
<td>Setup and Adjustment Losses</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Rework Losses</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Yield scrap losses</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4359,91</td>
<td>100</td>
</tr>
</tbody>
</table>

From the results of sorting the percentage of the six big losses factor, it will be illustrated with a Pareto diagram so that it is clear that the order of the six factors that affect effectiveness in QCC is clear. This diagram illustrates that the largest percentage of six big losses is in Reduce speed losses. Pareto diagrams for each QCC can be seen in Figures 6 - 13.

Figure 6: Pareto Diagram QCC No.11 (Source: Researcher, 2022)

Figure 7: Pareto Diagram QCC No.12 (Source: Researcher, 2022)
3.3. **Fishbone Diagram**

To obtain analysis results that are in accordance with the objectives of this research, tools that are relevant to the data that have been collected are needed, so to facilitate the identification, a Cause and Effect Diagram is made and an improvement plan will be formulated. The causal diagram of Reduce speed losses and Breakdown losses made because these benchmarks contribute to large losses for the company so that it is necessary to handle these dominant losses.
Analysis of the factors that contributed the most to the low effectiveness of the Quay Container Crane (QCC) was carried out using a fishbone diagram (cause-and-effect diagram). Some of the influencing factors are:

a) Man
Lack of operator competence and skill from technicians which is the root of the problem that can lead to high reduce speed losses. In addition, many QCC operators are over 50 years old, which affects their performance.

b) Machine
Problems with the spreader caused by the sensor/limit switch which is often damaged because the part is not OEM but a similar product. Apart from this, it can also be caused by a fairly strong vibration due to operating at full speed. Instrumentation problems often do not work due to communication errors in the PLC or module spreader.

c) Methods
Scheduling repair/maintenance and replacement of consumable parts that are delayed. And there is no procedure for overloading containers.

d) **Material**

The problem of the long spare part procurement process time is caused by the long delivery of goods due to the indent process from the supplier. This happens because the requested part is obsolete so it is rarely marketed.

e) **Environment**

Environmental factors are caused by heavy rain accompanied by lightning which can disrupt the operation of the QCC. Due to the visibility factor and the presence of a protection system (wind speed warning and lighting protection), QCC stops.

In an effort to increase productivity and effectiveness of Quay Container Crane No.11-18, it is necessary to eliminate the problems that have been analysed. The main factors that contribute greatly to the OEE value are Reduce speed losses and Breakdown losses. From the various problems shown in the causal diagram (Figures 14 and 15), the root cause of the problem was searched using the 5 why analysis method on the main factors affecting losses.

The research continued to find solutions using the 5W+H method and direct discussions with the Equipment and Operations division of PT JICT. The proposed improvements for the existing problems are as follows:

1) **Man**

The solution that can be done is to carry out refreshment training for operators and technicians, which aims to improve operator competence and technician skills. And rotate employees who are over 50 years old to other departments.

2) **Machine**

Coordinate with OEM parts suppliers to make long-term cooperation contracts. And to reduce high vibration, the operator must be reduced of speed operation when lifting containers and slowdown settings in all QCC, namely by setting the program back in the PLC according to the standards that have been set.

3) **Methods**

This can be overcome by coordinating and discussing regularly with the operational department so that the maintenance activities and replacement of delayed consumable parts can be carried out. As well as making procedures for overloaded containers.

4) **Material**

The solution is to make a PR Emergency for urgent parts and provide input regarding vendor references to purchasing. And the next stage is to review every month for obsolete stock parts, so that their needs can be anticipated.

5) **Environment**

Ensure all QCC protection systems are functioning properly.

**4. CONCLUSIONS**

The conclusions that can be drawn from this research are:

1. Calculations that have been done, the average OEE value for QCC No.11 is 19.59%, QCC No.12 is 28.20%, QCC No.13 is 44.98%, QCC No.14 is 62.04%, QCC No.15 by 51.02%, QCC No.16 by 50.21%, QCC No.17 by 49.40% and for QCC No.18 by 37.11%. So the average value of OEE QCC is 42.82%. In accordance with the standard OEE value introduced by Nakajima (2008) is 85% [12], the results obtained from the Overall Equipment Effectiveness QCC Spreader No. 11-18 for the January - December 2020 period are still far from the standardized value.
2. The low value of OEE is caused by the high value of losses that occur in the machine.
   a) The biggest losses that occur are in the category of losses from the performance efficiency factor, namely Reduced Speed Losses or losses caused by a decrease in the speed of machine operation from the speed determined by the company. This is due to the lack of operator competence in operating QCC and the lack of skills and understanding of technicians about increasingly sophisticated QCC equipment. Problems in the spreader are also the cause of these high losses. The spare parts used must be in accordance with the standard or OEM so that the part is not damaged quickly. And the long spare parts procurement time makes QCC operate using similar parts but not OEM products. In addition, the problem of scheduling re-pairs/maintenance and replacement of consumable parts is delayed due to ship services and schedules that are not in accordance with the planner section.
   b) The second largest loss is the category of losses from the Availability factor, namely break-down losses. The losses were caused by the QCC operating factors that were not in accordance with the procedures by the operator. And another cause is because the instrumentation of QCC is not functioning properly, due to high vibrations from the spreader movement and the PLC system and communication module which often error. The influence of bad weather is also a factor in these losses because of the protection system at QCC.

3. Improvement efforts by eliminating the six big losses factor in the form of improving QCC performance by conducting refreshment training for operators and technicians, procurement of spare parts according to OEM, intensive implementation of the Preventive Maintenance system and add-ing maintenance strategies with Predictive Maintenance, intensive material stock reviews, pro-gram cost management maintenance and improvement as well as efforts to increase the reliability of the Quay Container Crane (QCC) with updates in the spreader section.

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