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Quay Container Crane Productivity Effectiveness Analysis: Case Study PT 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 includes 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 and breakdown losses. Improvement efforts by eliminating six main loss factors in relation to increasing the effectiveness and productivity of Quay Container Crane (QCC) were proposed.

***Keywords**:- oee, quay container crane, six big losses, fishbone, productivity.*

I. 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 [6]. 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 [14]. 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 [1]. 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 [7]. 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 berth QCC by almost four times [13]. 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 [12].

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) [17]. 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.

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 [5], 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.

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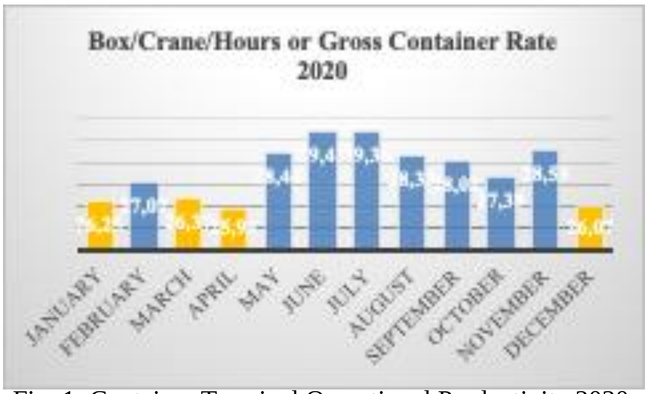

Fig. 1: Container Terminal Operational Productivity 2020

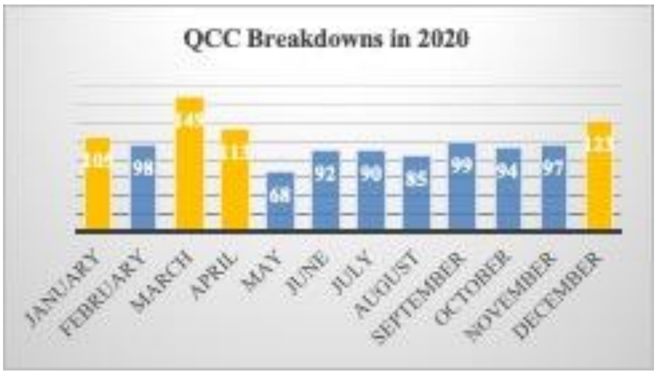

Fig. 2: QCC Breakdowns in 2020

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 twist lock 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 twist lock, there is a metal leg called a seeker attached [3].

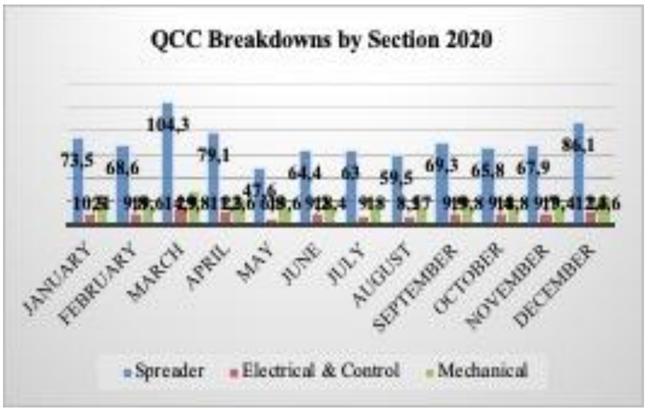

Fig. 3: QCC Breakdown by Section 2020

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 [11]. 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 [14] 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 [19] 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.

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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% [18]. 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.

II. METHODS

This research method uses the OEE calculation, by looking at the primary and secondary data. This research was conducted through a problem-solving approach (problem solution) which aims to find out the root of the existing problems. Data and information are needed so that problems can be analyzed through reports and direct interviews from internal sources. Data collection is done to obtain information related to certain phenomena, conditions or variables. This study examines certain aspects and objects in detail (case studies) related to the problem to be studied and provides possible solutions to solve these problems, especially the problem of the effectiveness of QCC during container loading and unloading operations.

No.	Variables	Dimension	Indicators
1.	**Overall Equipment Effectiveness**	Availability	Loading Time Total Downtime Planned Downtime
		Performance Efficiency	Production (output) Ideal Cycle Time Operating Time
		Quality	Production Total Defect Rework
2.	**Six Big Losses**	Breakdowns	Loading Time Planned Downtime Total Breakdown
		Setup & Adjustment	Loading Time Available Time Planned Downtime
		Idling & Minor Stoppage	Loading Time Tooling Failure Available Time
		Reduced Speed	Operating Time Ideal Cycle Time Loading Time Production (output)
		Rework	Ideal Cycle Time Loading Time
		Yield Scrap	Ideal Cycle Time Loading Time Product Scrap

Table 1: Research Variable

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:

Availability = LT – DT / LT x 100% (1)
Performance Eff. = ICT - PA / OT x 100% (2)
Quality Rate = PA - DA / PA x 100% (3)
OEE = Availability x Performance x Quality (4)
Breakdown Losses = Total DT / LT x 100% (5)
Setup/Adjustment Losses = TSA / LT x 100% (6)
Idling/Minor stoppage Losses = NPT / LT x100% (7)
Red. Speed Losses = PT – (ict x RP) / LT x 100% (8)
Rework Losses = ICT x Rework / LT x 100% (9)

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 [15].

III. 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 [18].

a) 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 2.

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

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whole still require evaluation for improvements to be made in an effort to increase the effectiveness of loading and unloading equipment.

b) 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.

QCC No.	Availability (%)	Performance (%)	Quality (%)	OEE (%)
11	98,07	19,98	100	19,59
12	98,20	29,33	100	28,80
13	98,41	45,71	100	44,98
14	98,43	63,03	100	62,04
15	98,31	51,90	100	51,02
16	97,99	51,24	100	50,21
17	98,27	50,27	100	49,40
18	98,45	37,70	100	37,11
Average	**98,26**	**43,64**	**100**	**42,82**

Table 2: OEE Calculation Results

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% for QCC No.11, QCC No.12 is 2539.88 hours or 93.86%, QCC No.13 of 3965.72 hours or 96.55%, QCC No.14 of 5449.54 hours or 97.45%, QCC No.15 of 4479.83 hours or 96.60%, QCC No.16 is 4409.38 hours or 95.80%, QCC No.17 is 4204.21 hours or 96.43% and 3257.33 hours or 95.90% for QCC No.18. Other losses were followed, for QCC No.11, namely: Breakdown Losses (160 hours/8.05%), Idle and stoppages losses (3 hours/0.15%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours/0%), Scrap Losses (0 hours/0%). QCC No.12: Breakdown Losses (162.21 hours/6%), Idle and stoppages losses (3.95 hours/0.14%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours /0%), Scrap Losses (0 hours/0%). QCC No.13: Breakdown Losses (137.81 hours/3.35%), Idle and stoppages losses (3.66 hours/0.1%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours/0%), Scrap Losses (0 hours/0%). QCC No.14: Breakdown Losses (139.05 hours/2.5%), Idle and stoppages losses (3.03 hours/0.05%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours/0%), Scrap Losses (0 hours/0%). QCC No.15: Breakdown Losses (154.04 hours/3.33%), Idle and stoppages losses (3.27 hours/0.07%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours/0%), Scrap Losses (0 hours/0%). QCC No.16: Breakdown Losses (189.27 hours/4.11%), Idle and stoppages losses (3.62 hours/0.09%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours/0%), Scrap Losses (0 hours/0%). QCC No.17: Breakdown Losses (151.7 hours/3.47%), Idle and stoppages losses (4 hours/0.1%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours /0%), Scrap Losses (0 hours/0%). As for QCC No.18, namely: Breakdown Losses (135.84 hours/4%), Idle and stoppages losses (3.4 hours/0.10%), Setup and Adjustment Losses (0 hours/0%), Rework Losses (0 hours/0%), Scrap Losses (0 hours/0%).

From the results 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.

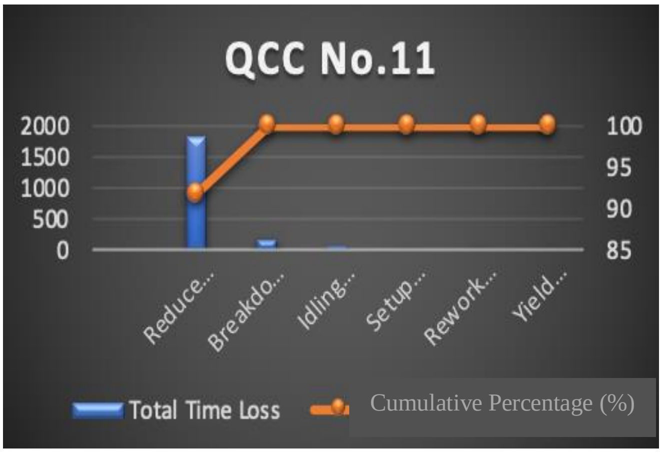

Fig. 4: Pareto Diagram QCC No.11

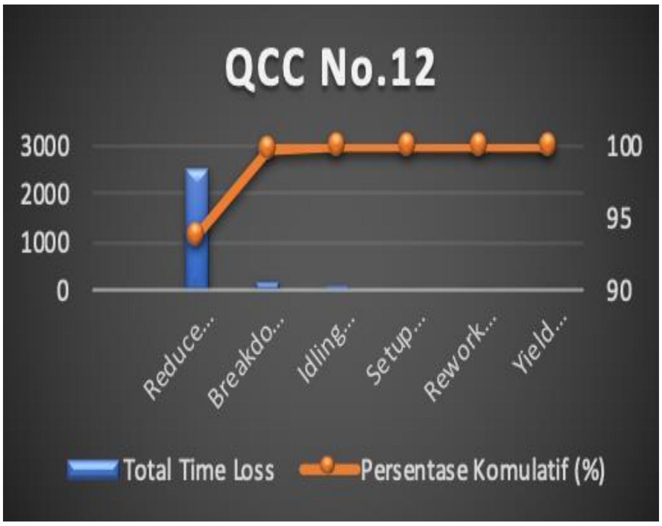

Fig. 5: Pareto Diagram QCC No.12

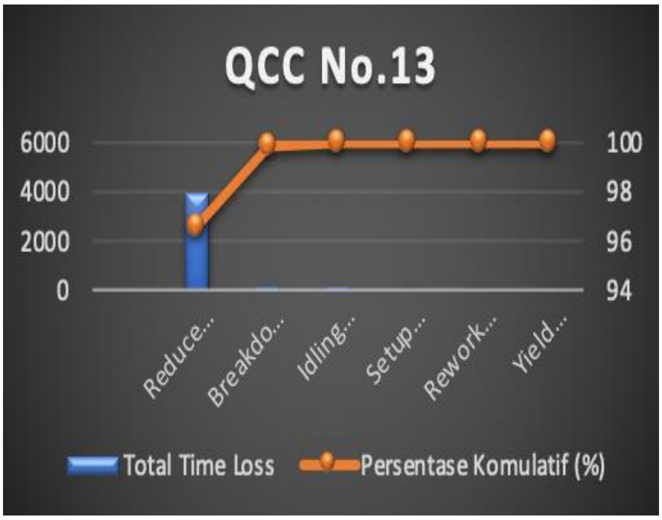

Fig. 6: Pareto Diagram QCC No.13

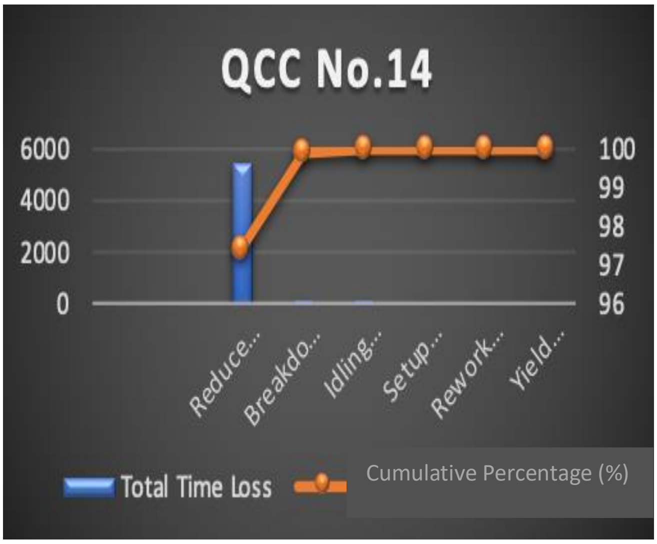

Fig. 7: Pareto Diagram QCC No.14

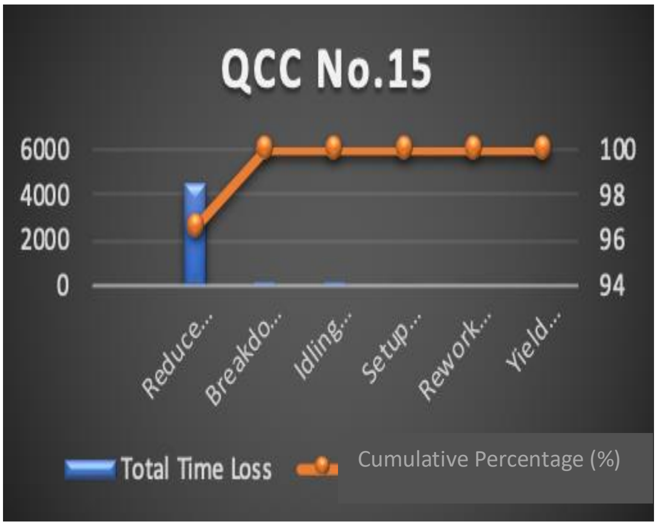

Fig. 8: Pareto Diagram QCC No.15

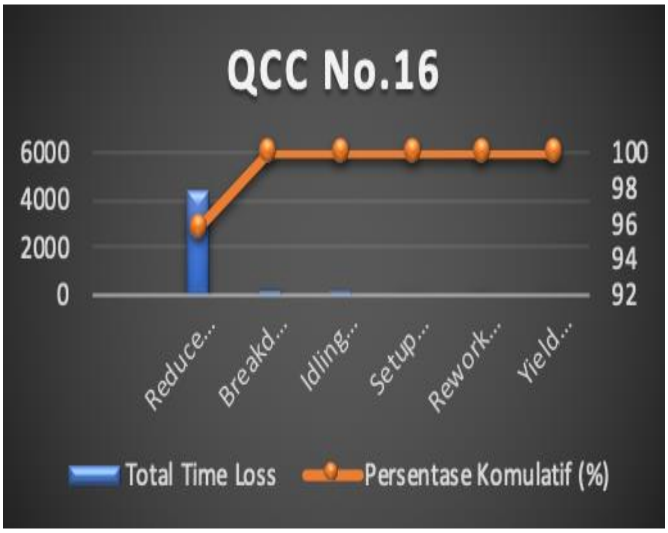

Fig. 9: Pareto Diagram QCC No.16

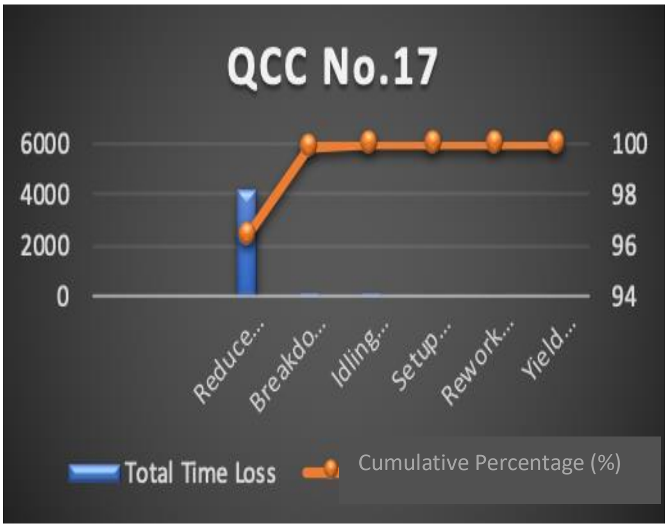

Fig. 10: Pareto Diagram QCC No.17

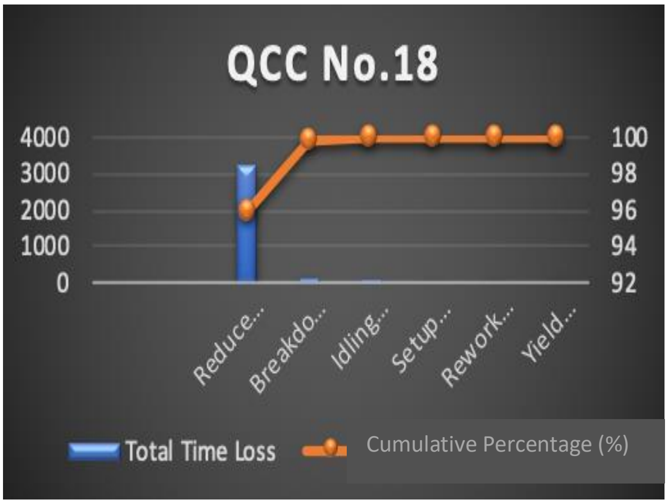

Fig. 11: Pareto Diagram QCC No.18

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The Pareto diagram shows that the sorting of losses from the largest to the smallest is reduced speed losses, breakdown losses, idling & stoppages losses, setup & adjustment losses, rework losses and scrap losses.

c) 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.

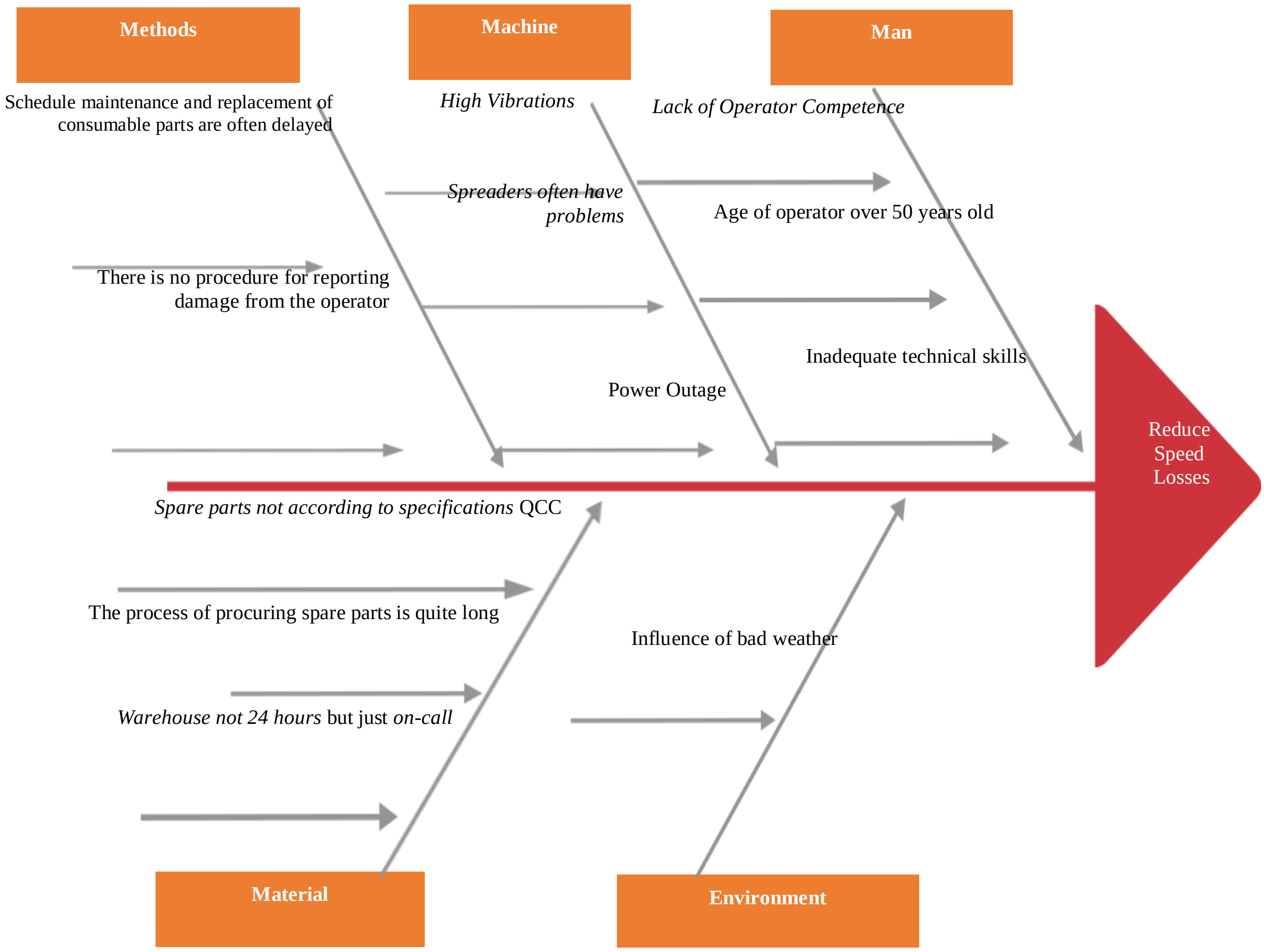

Fig. 12: Fishbone Diagram of Reduce Speed Losses

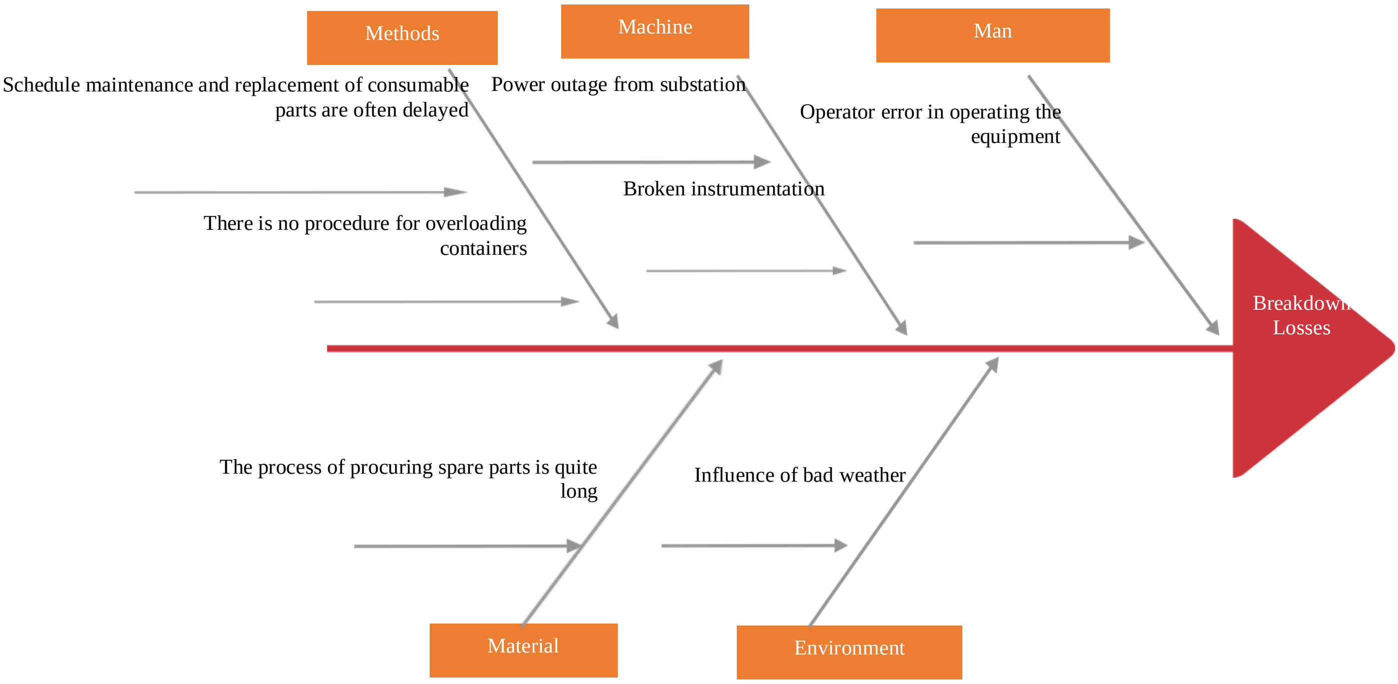

Fig. 13: Fishbone Diagram of Breakdown Losses

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:

- **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.
- **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.
- **Methods:** Scheduling repair/maintenance and replacement of consumable parts that are delayed. And there is no procedure for overloading containers.
- **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.
- **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 12 and 13), 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:

- **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.
- **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.
- **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.
- **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.
- **Environment:** Ensure all QCC protection systems are functioning properly.

IV. CONCLUSION

The results of this study can be concluded that the Overall Equipment Effectiveness (OEE) Quay Container Crane (QCC) is 42.82%. In accordance with the standard OEE value introduced by Nakajima (2008) which is 85% (Wicaksono & Linarti, 2021), the results obtained from the Overall Equipment Effectiveness QCC value for the period January - December 2020 are still far from the standard value. The low value of OEE is caused by the high value of losses that occur in the machine. First, the biggest loss that occurs is in the loss category from the performance efficiency factor, namely Reduced Speed Losses or losses caused by a decrease in the operating speed of the machine from the speed determined by the company. This is due to the operator's lack of competence in operating QCC as well as the technician's lack of skills and understanding of increasingly sophisticated QCC equipment. Problems with the spreader are also the cause of the high losses. The spare parts used must be in accordance with the standard or OEM so that the part is not damaged quickly. And long spare parts procurement times make QCC operate using similar parts but not OEM products. In addition, the problem of scheduling repairs/maintenance and replacement of consumable parts is delayed due to ship services and schedules that are not in accordance with the planner.

The second largest loss is the category of losses from the Availability factor, namely breakdown 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. 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 adding maintenance strategies with Predictive Maintenance, intensive material stock reviews, program 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.

In this study, the value of OEE QCC can be known, but the results are still far from international standards. The recommendation is that there must be a standardization of the OEE QCC value from the company, and the OEE QCC value can be used as a KPI for the equipment department. Then after identifying the achievement of the OEE value on the Quay Container Crane based on the six big losses approach, it is necessary to review the service period and the performance of operators and technicians which are currently deemed not optimal. Companies can recruit new operators who are more competent and have good experience in operating QCC, and companies can also provide maintenance and troubleshooting work to third parties/vendors who are experienced and have skills in Repair and maintenance of Quay Container Crane which will certainly reduce costs. speed losses are known as the dominant losses in this study. The company can also cooperate with crane manufacturers regarding the procurement of OEM spare parts which are very difficult to obtain.

Improvements that have been made to increase productivity and performance (OEE) of QCC are also recommended to calculate costs so that later the cost savings received by the company can be calculated. It is recommended that the measurement of the OEE value after the repair is carried out within a period of 1 (one) year so that the results of the measurement of the OEE value are more relevant, consistent and sustainable.

For further research conducted in the same field, it is possible to conduct research on the effect of predictive maintenance in maintenance activities on Quay Container Crane and see its effect on losses. Research using the OEE method can also be carried out for container loading and unloading equipment other than QCC at PT JICT.

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