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Increasing the availability of unloading equipment in the port service industry through lean manufacture and kaizen approaches with the PDCA Cycle method

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ABSTRACT

PT Krakatau Bandar Samudera is a company engaged in port services which one of its business units serves the unloading of cargo raw materials owned by PT Krakatau Posco using crane and conveyor facilities, in the process of service PT KBS experienced several problems including the availability of conveyors below the target, the dominant problem that occurred was the belt Tearing on the edge whose dominant root cause is the dumper adjuster is easily damaged and how to set the dumper is difficult so that with the cause of the problem causes the conveyor belt to become side travel so that the belt rubs against the conveyor and belt construction become torn at the edges. To overcome this problem, researchers use lean manufacture and kaizen approaches with the PDCA Cycle Step, the resulting solution is to change the dumper setting system from manual using block levels to using a hydraulic actuator system. After an improvement in availability, initially 95.5% increased by 2.1% to 97.6%. So that there are no more complaints from management and from customers related to the availability conveyor.

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1. INTRODUCTION

As we know that ports around the world have the same function, namely as a means for the entry and exit of goods or people from one region or country to another region or country. Ports are usually equipped with sea terminal facilities or facilities which include docks as a place to lean ships and load and unload goods or passengers. And usually also equipped with equipment facilities to load unloading goods such as cranes and conveyors as a means of transportation from ships to storage warehouses before being distributed to the raw material processing factories.

Each port has a standard performance or discharging rate on loading and unloading equipment, usually those that use conveyor parameters use the flow rate of unloading material tons per minute but there are also those who convert to hours or to days, here is the average data of loading performance as well as unloading or discharging rate at dry bulk carriers top 30 economies.

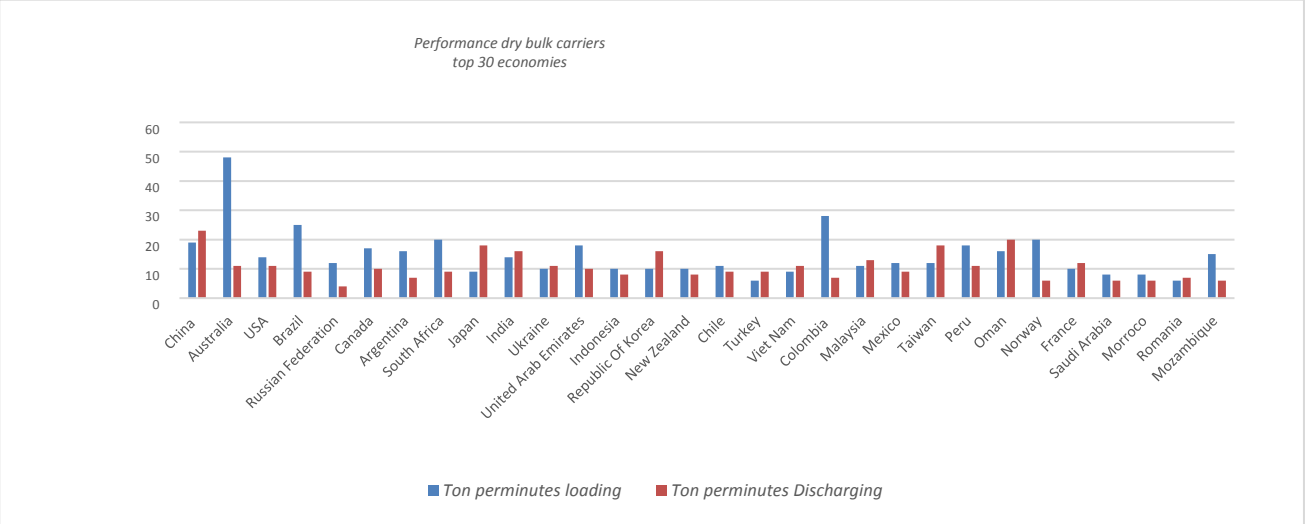

Figure 1. Performance graph of dry bulk carriers top 30 economies on average in 2018 – 2021[1]

In the chart above, Indonesia ranks 13th with a loading performance of 10 tons / minute and discharging 8 tons / minute.

PT Krakatau Bandar Samudera (PT KBS) or which has the branding of Krakatau International Port (KIP) is a company engaged in port and logistics services, established on March 28, 1996. With a location in Cilegon City – Banten. PT KBS has a capacity of 25 million tons in 1 year, has a berthing capacity of up to 200 thousand tons DWT, equipped with 17 dock slot facilities, also equipped with 11 cranes with types: 4 GSU (Grab Ship Unloader), 2 PHC (Portal Harbor Crane), 4 Jib Cranes and 1 CSU (Continuous Ship Unloader). 3 line conveyors, 10 closed warehouses, PLB (Bonded Logistics Center) and open warehouses. For performance at PT Krakatau Bandar Samudera assuming using 1 crane with a capacity of 18 thousand tons / days, the average is 18 000 T/D or 750 T/H or 15 T/M.

The lean concept applied at PT KBS Port by implementing a sustainable production flow is free from the disruption of detour congestion or waiting time [2]. That is using a conveyor system. However, in operation, there are several problems that often occur in equipment that cause delays and have an impact on demurrage are damage to Conveyor System 03 at pier 6. Please note that pier 6 is a dock that is specialized in serving Raw Material cargo owned by PT Krakatau Posco. Pier 6 is equipped with 2 GSU units with a capacity of 40 tons and 1 line conveyor system with a capacity of 3,600 tons / day. Because at Pier 6 there is only 1 line conveyor so that if the conveyor has a problem and stops, the cargo unloading automatically stops. According to research[3] shows that the effectiveness of loading and unloading performance has a significant effect on revenue. The effectiveness of loading and unloading performance According [4], the capacity of the terminal is very dependent on the ability of port equipment in loading and unloading all ports in the world in carrying out the process of loading or unloading ship cargo is inseparable from risk.

Vargas, Soto, Gutiérrez and Ravelo[5] in their research entitled "P-D-C-A Cycle As TQM Tool-Continuous Improvement of Warranty". After repairs were made using the PDCA method, the results obtained were Reduce 75% of concerns regarding braking, reduce warranty costs for the company, satisfied customers, company reputation achieved, warranty regarding concerns reduced on brakes, the company no longer experiences high-scale losses related to brake warranty problems[6].

2. LITERATURE REVIEW

2.1. Lean Factory

Linguistically, Lean is the part of meat that mainly consists of lean muscle (fat free) while lean thinking is an approach that aims to get rid of all waste (fat) that carries weight on the system [2].

Lean manufacturing is the systematic elimination of waste. Most of these benefits lead to lower unit production costs – for example, more

effective use of equipment and space leads to lower depreciation costs per unit produced, more effective use of labor results in lower labor costs per unit produced and lower defects lead to lower cost of goods sold [2]

Another way to look at Lean Manufacturing is that it aims to achieve the same output with fewer inputs – less time, less space, less human effort, fewer machines, fewer materials, less cost. Another way to look at Lean Manufacturing is that it aims to achieve the same output with fewer inputs – less time, less space, less human effort, fewer machines, fewer materials, less cost.

2.2. Availability

Availability is the ready condition of an equipment / machine both in quality and quantity (quantity) according to the needs used to carry out the operation process. Readiness (availability) can be used to assess the success or effectiveness of maintenance activities that have been carried out. Availability relates to the probability of a piece of equipment to perform its operations. How to calculate Availability is the operating time divided by the planned time [7].
To calculate availability use the following formula:

$$\mathbf{A} = \frac{\mathbf{AWH}}{\mathbf{NWH}} \mathbf{X\ 100\%} \qquad (1)$$

A : Availability
AWH: Actual Business Hours
NWH: Normal business hours.

3. RESEARCH METHODS

3.1. Subject and Object of Research

This research was conducted at PT Krakatau Bandar Samudera which is engaged in port and logistics services with a location in Cilegon, Banten, Indonesia. The study was limited to the care division.

3.2. Research Steps

The stages of this research are as follows:

1. Collection and Analysis, the need for data collected and analyzed to calculate availability is maintenance-related data such as corrective, breakdown and preventive maintenance.
2. Identify the problem, after getting the results of the necessary data then identify the problem using the Pareto Diagram tool.
3. Determine the root cause of the problem, using the fishbone diagram tool
4. Determine the dominant root cause using the Nominal Group Technique (NGT) tool
5. Create a repair plan with the 5W1H tool
6. Carrying out repairs starts from designing to installing tools and trials.
7. Conduct an evaluation.

4. RESULTS AND DISCUSSION

4.1. Dominant problem

The result of data analysis is that the availability value for the January – December 2021 period has decreased below the company's predetermined KPI target of 95.5%. From the results of the availability calculation above, then stratify the data and Pareto Diagram to determine the dominant problem. Following are the dominant problem data that often occur in the conveyor system for the period January – December 2021:

Problem area	Amount of damage	Percent	Cumulative Percent
Repair Belt Torn Edge	40	37,04%	37,04%
Replace *roll*	36	33,33%	70,37%
Rubber skirtboard broken	17	15,74%	86,11%
setting cleaner belt	15	13,89%	100,00%

Figure 2. Damage data on the conveyor system for the period January-December 2021

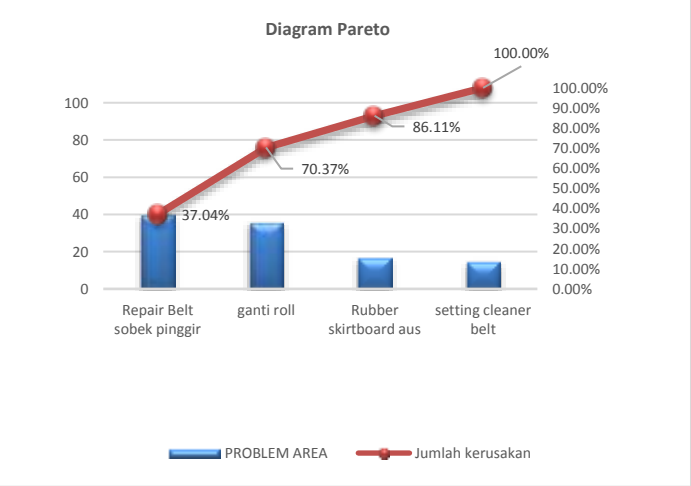

Figure 3. Pareto Diagram

Based on the results of the pareto diagram above, it can be seen that the dominant problem that occurs in the conveyor system is the damage to the belt on the edge. So this problem must be traced and the root cause of this problem arises.

4.2. Cause analysis

Analysis of the dominant cause of the problem is a torn belt at the edge using 5 Why.

Table 1 Why-why analysis

	Why	Why	Why	Why	Why
One	The falling material is not center belt	Dumper position does not fit	Dumper is difficult to set	Cara setting dumper manual	Employees fixated on one method
Machine	The falling material is not center belt	Dumper position does not fit	Heavy dumper settings	The adjuster is bent	Perishable dumper adjuster
Method	The falling material is not center belt	Dumper position does not fit	Dumper not set correctly	Dumper is difficult to set	Cara setting dumper manual
Milieu	The falling material is not center belt	Dumper position does not fit	Difficult to set dumper	Access to the place of setting is difficult	Narrow hopper setting place

Next, find the root cause of the problem using the fish bone diagram tool

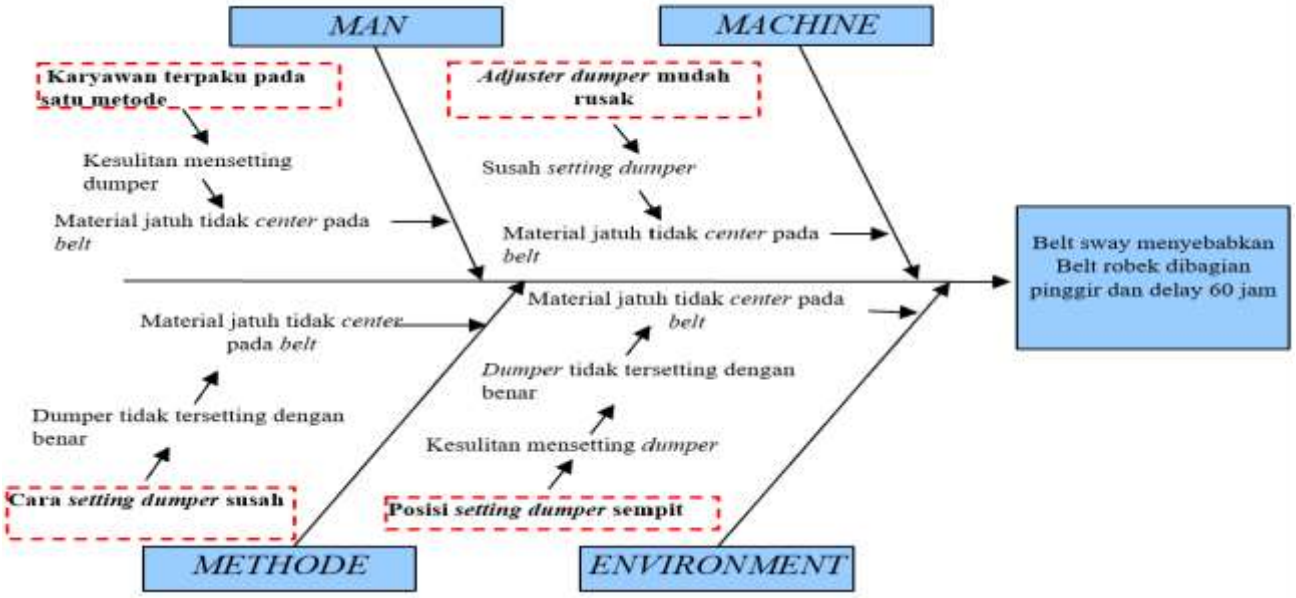

Figure 4. fishbone diagram

From the analysis of 5 why and fishbone diagrams above, there are 4 root problems that cause belt tearing at the edges, namely:

Table 4. 1 Root causes

No	Aspects	Cause
1	One	Employees fixated on one method
2	Machine	Perishable dumper adjuster
3	Method	How to set dumper difficult
4	Milieu	Narrow dumper setting position

4.3. Nominal Group Engineering (NGT).

After knowing the source of the cause then determining the dominant problem, to determine the dominant problem the author uses the Nominal Group Technique (NGT), NGT is carried out in a Group Discussion (FGD) forum with the number of members involved in the FGD as many as 5 people consisting of 1 manager, 2 supervisors and 2 foremans, consensus will be prioritized. The scale used is a scale of 1-10 with the observation that the most influential or dominant cause will be given a score of 10, while for the root cause with the least influence is given the number 1 as shown in Table 4.5.

Table 2. NGT calculation result

No	Cause	Scorer					Entire
		HS	MT	AS	HAVE	HW	
1	Employees fixated on one method	4	5	5	4	5	23
2	Perishable dumper adjuster	5	6	6	7	5	**27**
3	How to set dumper difficult	6	6	5	6	5	**28**
4	Narrow dumper setting position	5	6	5	4	5	25

NGT is the result of Forum Group Discussion conducted by:
HS : Heri Setiawan : Manager
MT : M Taufiq: Conveyor specialist mechanic (Supervisor)
AS : Asep Somantri: Crane Mechanic Specialist (Supervisor)
HS : Harsono: Analist mechanic (foreman)

HW : Hirwansyah : Mechanical analist (foreman)

$\text{NGT} \geq \frac{1}{2}(5 * 10) + 1$, then obtained NGT $\geq$ 26

From the calculation of NGT with the formula (3.2) that the dominant cause that causes the belt sway so that it tears the edges is a variable that has an NGT value greater than or equal to 26. Table 4.6 is the data from the calculation of NGT.

Table 3. The result of the calculation of the value of NGT.

No	Causative Variables	Shoe
1	Perishable dumper adjuster	27
2	How to set dumper difficult	28

The results of Table 4.8 explain that the dominant cause of belt sway tearing the edges is caused by:

1. Perishable dumper adjuster
2. How to set dumper difficult

4.4. Make Plans and Recommendations for Improvement

Once the dominant cause is known, the next step is to make an improvement plan, in the improvement plan the researcher uses the 5W2H formula as in table 4.

Table 4 Improvement plan with 5W2H formula

Problem	Why	What	Where	When	Who	How
Belt tear the edges	So that the dumper setting is more practical, easy and fast	Find and prepare used actuators that can be used		May 2022	Heri	Check the condition of the motor and pump actuator function
		Creating frames for the actuator		May 2022	Asep	Making construction from plate and H beam
	Belt tidak side travel	Installing the actuator on the dumper	A101 and A103 conveyors	May 2022	Harsono	Installing a connected actuator with a dumper

4.5. Carry out repairs (DO)

In carrying out this repair, it is divided into two parts, namely repairing the A101 diareal conveyor and repairing A103 diarrhea. Repair activities carried out on the A101 and A103 conveyors are designing, making and installing dumper adjusters with the aim of making dumpers in their settings easier and less easily damaged, the process of implementing repairs is explained as follows:

Repair process on conveyors A 101 and A103

1. Review and Measurement

In this case, a review of the existing mechanism and measurement of important dimensions was carried out to redesign the system, the existing condition of the dumper adjuster is still manual, to set it requires a tool in the form of a chain block because the dumper itself is part of the transfer chute which has dimensions of 220 x 160 x 2 cm weighing approximately 510 kg so setting it if not assisted by auxiliary devices will be heavy.

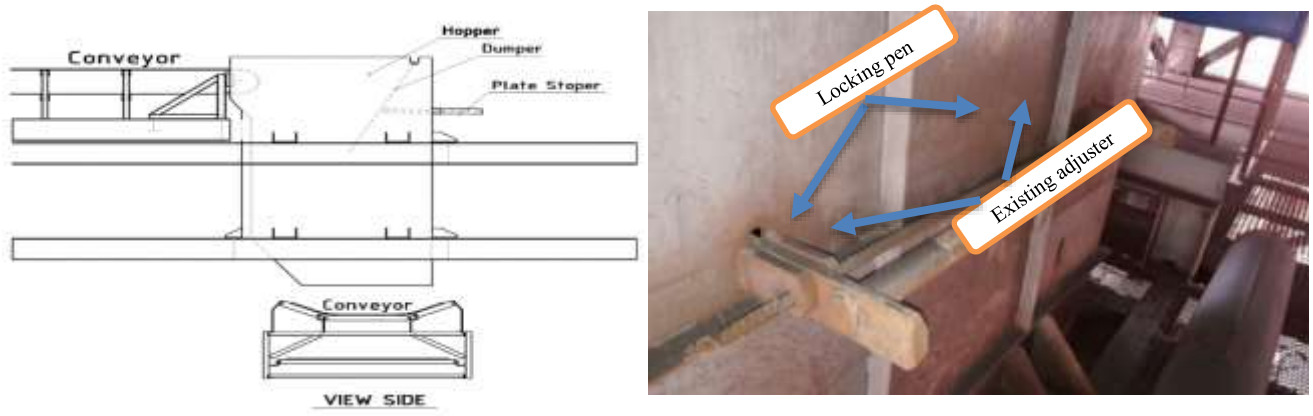

Figure 5. Existing dumper adjuster before repairs are carried out
KBS Resources PT

2. Design and prepare used actuators that can still be used to be modified into adjusters.

The second step taken is to prepare and service a used actuator that can still be used to be used as a dumper adjuster, the process of service and repair actuator is carried out at the mechanical workshop of PT Krakatau Bandar Samudera and by the mechanical team itself. In addition to service actuators, the team also makes frames and makes actuator cylinder mounts.

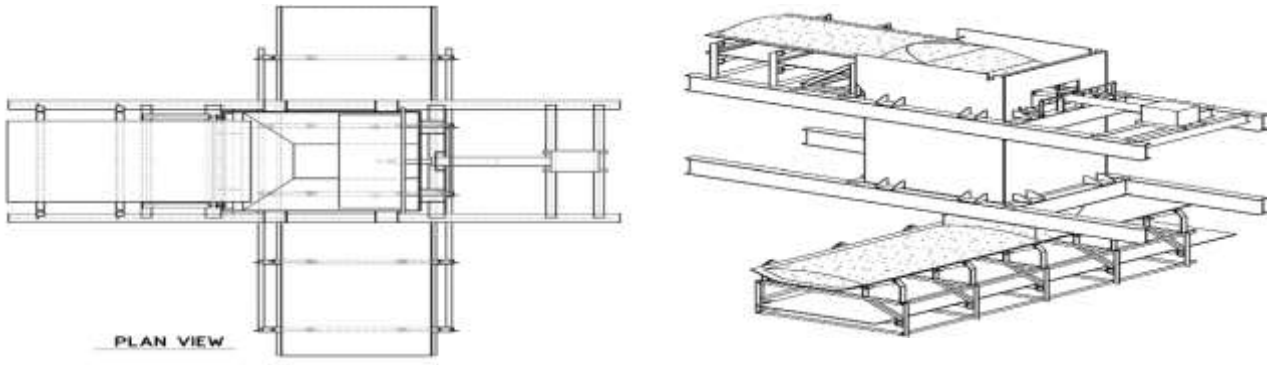

Figure 6. Design an image of a dumper adjuster using an actuator
KBS Resources PT

Figure 7. Used actuators that can still be used to become dumper adjusters
KBS Resources PT

3. Install actuator for dumper adjuster in transfer chute A101 and A102

In this process, the replacement and installation of the dumper adjuster was carried out, which was still a manual operating system to be automatic using a hydraulic actuator.

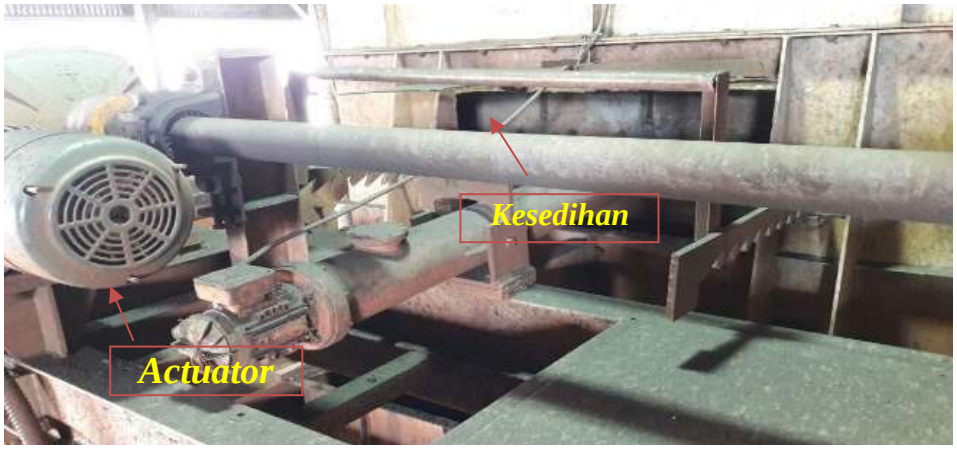

Figure 8 New dumper adjuster using actuator already installed on dumper inchute A103 KBS Resources PT

In this evaluation stage will provide an overview before and after making improvements, making comparisons using QCDSME formulas and Beam diagrams.

Table 5. Before and after comparison with QCDSME formula

No	Attribute	Before	After
1	Quality	Belts often side travel reduce belt quality and often stop operation for belt setting and repair	Belts are not side travel anymore, conveyors do not often stop for setting and repair
2	Cost	High demurrage costs in case of delay due to belt repair	No demurrage due to belt conveyor damage
3	Delivery	Repair belt for 100 hours in 1 year	No more belt repair when the conveyor is operating
4	Security	The process of operating the belt has the potential to damage the belt and construction	Safe belt operation process
5	Moral	Causing discomfort to the dispatcher for fear of the belt tearing	No concern on the operator
6	Milieu	Potentially damaging the construction of the belt conveyor during belt side travel	Does not have the potential to damage conveyor construction

Before still manually using block levels

After using the Actuator leave the license on or off

Table 9. Comparison before and after repair

Table 6. Achievement of Availability conveyor for the period April – August 2022

No.	Moon	Unit Name	Normal Business Hours	Actual working hours	Details (Jam)	Availability (%)
1	April	Conveyor System	660	642,0	18,0	97,3%
2	May	Conveyor System	682	664,2	17,8	97,4%
3	June	Conveyor System	682	665,3	16,8	97,5%
4	July	Conveyor System	660	644,6	15,4	97,7%
5	August	Conveyor System	682	669,3	12,7	98,1%
		Average availability				**97,6%**

After obtaining the results of the calculation of the availability of conveyor equipment for the period April – August 2022, then make a comparison of the results before and after making improvements as follows:

Table 7. Data on dominant problems for the period April – August 2022

PROBLEM AREAS	Amount of damage	percentage	CUMULATIVE PERCENT
Broken roll	25	45,45%	45,45%
Rubber skirt board wear out	20	36,36%	81,82%
Setting the cleaning belt	10	18,18%	100,00%
Belt tear edge	0	0,00%	100,00%
	55	100%	

Before repair After repair

Figure 2. Before and After Comparisons with Pareto Diagram

From the Pareto Diagram above, it can be seen that the peripheral torn belt repair dropped from 1st to 4th with the amount of damage down from 60 times the previous repair to no repair at all when operating but the availability value is still below the target of 97.6. Which can be seen in the Pareto Diagram whose data was taken from June – December 2022 for the highest dominant problem is often replacing damaged rolls when the conveyor is operating, so that the researchers carried out the PDCA process for the second time.

5. CONCLUSION

After conducting research, researchers concluded that:

Problems that often occur that cause availability not to be achieved are: torn edge belts, damaged rolls during operation, worn rubber skirt boards and cleaner belts that are not optimal in function. Of the four dominant problems after research using the Pareto Diagram tool, it can be seen that the most dominant is the repair of the peripheral belt.

Furthermore, the root cause of the dominant problem of peripheral belt repair results from 5 why analysis and fishbone diagrams is: from the human side, employees are fixated on one method, from the machine aspect, namely the adjuster is easily damaged, from the aspect of the method of setting the dumper is difficult, the

environmental aspect of the position of the dumper setting is narrow.

Of the four causes of the problem, researchers look for the dominant cause using the NGT tool, it can be determined that the cause of the dominant problem is: adjuster dumper is easily damaged, how to set a dumper is difficult. To resolve the root cause of the dominant is to change the dumper adjuster from manual to hydraulic system so that the dumper setting process becomes easier and faster and the result is a belt conveyor not side travel So that the availability conveyor which was previously 95.5% increased by 2.1% to 97.6%.

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REFERENCES

[1] UNCTAD, *Review of Maritime Report 2021*. 2021. [Online]. Available: http://unctad.org/en/PublicationsLibrary/rmt2015_en.pdf

[2] S. Mazumdar, *Manufacturing Techniques*. 2020. doi: 10.1201/9781420041989-9.

[3] M. Handajani, "Analisis Kinerja Operasional Bongkar Muat Peti Kemas Pelabuhan Tanjung Emas Semarang," *J. Transp. J. Transp.*, vol. 4, no. 1, pp. 1–12, 2020, [Online]. Available: https://journal.unpar.ac.id/index.php/journaltransportasi/article/view/1761

[4] M. Jurjevic, Č. Dundović, and S. Hess, "Model odredivanja konkurentnosti luka i prometnih pravaca," *Teh. Vjesn.*, vol. 23, no. 5, pp. 1489–1496, 2016, doi: 10.17559/TV-20140709100013.

[5] A. Realyvásquez-Vargas, K. C. Arredondo-Soto, T. Carrillo-Gutiérrez, and G. Ravelo, "Applying the Plan-Do-Check-Act (PDCA) cycle to reduce the defects in the manufacturing industry. A case study," *Appl. Sci.*, vol. 8, no. 11, 2018, doi: 10.3390/app8112181.

[6] M. M. M. Jagtap and S. N. Teli, "PDCA Cycle As TQM Tool-Continuous Improvement of Warranty," *Ijrmee*, vol. 2, no. 4, pp. 1–5, 2015, [Online]. Available: http://www.ijrmee.org/download/1429341448.pdf

[7] T. K. Agustiady and E. A. 2016 Cudney, *Strategies and Implementation Guide*.

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