

Sustainable Development of Lubricator to Optimization Process of Lubrication in Wire Rope Sling

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Sustainable Development of Lubricator to Optimization Process of Lubrication in Wire Rope Sling

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Abstract. The main business processes of PT Pupuk Sriwidjaja Palembang is selling of bulk urea fertilizer. In distribution process of bulk urea to ships use the Quadrant Ship Loader (QSL). To maintain quality performance of the QSL have been applied preventive maintenance once in 4 (four) months. There is some work in implementing preventive maintenance, one of them is lubrication wire rope. Lubrication wire rope takes the longest time among other jobs, which is about 90 minutes in each time to do preventive maintenance. In this case by making wire rope lubrication tool. Using this tool, the lubrication work on PU-5858L QSL wire rope can be pressed up to 30 minutes in every preventive maintenance exercise. Another advantage of using the wire rope lubrication tool can minimize the occurrence of grease droplets so as to avoid potential environmental pollution, improved lubrication quality by 29%, increased cost efficiency, time of workmanship by 67%, decrease of potential of environmental pollution by 67%, and decrease in employment injury opportunities by 40%.

1. Introduction

PT Pupuk Sriwidjaja Palembang is one of the biggest fertilizer company in Indonesia country. This company had produced ammonia and fertilizer where this operation unstoppable. Maintenance department is part of the important of this company to keep the factory run well. In distribution of the fertilizer used three main of the equipment i.e. portal scrapper, bag ship loader, and quadrant ship loader.

A security and safety are a priority to keep the reliability and credibility of the company, department of mechanical maintenance conducted maintenance each four month as preventive of failure on the wire rope sling in quadrant ship loader. This preventive to avoid from broken rope that lead to a serious accident [1–3]. An Effective lubrication must get into all the length, diameters and core of the wire rope. The wire rope sling in quadrant ship loader is located at jetty, which is potential of the lubricant drip to fall into river that can be a toxic and hazardous waste material.

Wire rope had been operated in high and continuous load, the fluctuation load is affected when the excessive wear and corrosion. The lubrication as the protection when wear increasing that exposed to corrosion, the major of this failure caused of reduction in diameter range of wire from 50% - 90% [4,5]. Another losses of improper lubrication will caused the replacement of wire rope that consume time and cost of addition to down time during replacement [6].

Commonly the effect of innovation activities, as a good investment that has been suggested to improve productivity and as an innovation process is expected to affect technical efficiency. As an output product innovation is expected to affect the efficiency and productivity more [7].

PT Pupuk Sriwidjaja Palembang had committed in developing sustainability to be green company, many innovations of the employee had been applied in factory to support sustainable program. The wire rope lubricator is one of the innovations that gave contribution in maintenance department. Formerly the lubrication process used hand to lubricate in high area of the wire rope, first sustainable innovation



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of lubricator had made from remains of broken drive pulley shaft and Teflon Polytetrafluoroethylene (PTFE). Second sustainable innovation had made from remains plain roller of conveyor and belt conveyor.

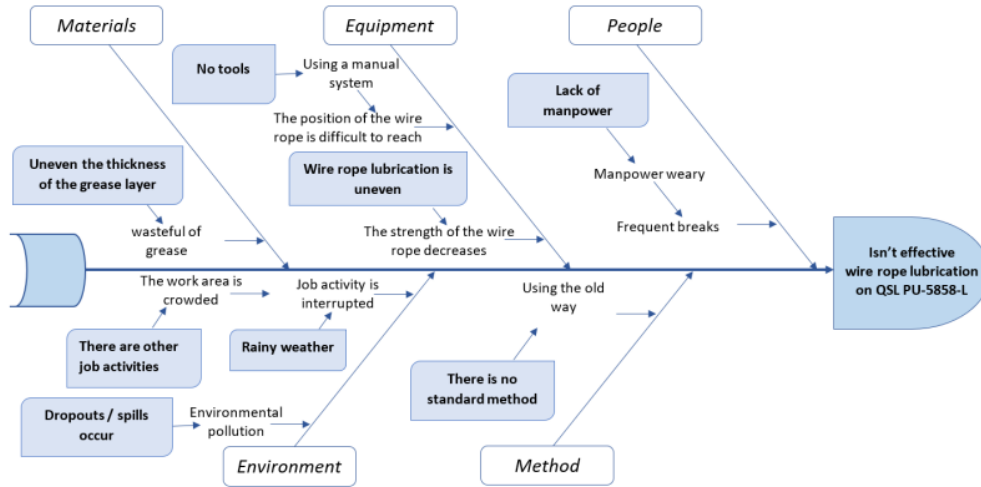


Figure 1. Analysis of fishbone diagram.

In above diagram, the fishbone diagram calculates the possibility of ineffective lubrication process on wire rope at the Quadrant Ship Loader i.e. by manual operation (hand and stick), uneven lubrication on wire, not equal in thickness film, and grease spill out.

2. Sustainable Development Procedure

2.1. State of the problems

The sustainable development of the wire rope started from the problem by craftsman in field, Table 1 shown the state of the problem of this development.

Table 1. States of the problems

Quality	Wire rope rusted due to uneven lubrication, oil-exposed surface is only about 70%
Cost	The use of grease reaches 18 kg at a cost of 4,590,000 IDR each time doing preventive maintenance
Delivery	It takes a relatively long time of about 90 minutes in every wire rope lubrication job
Safety	Wire rope lubrication work is done on high ground so there is a potential risk of work accident
Morale	Dissatisfaction in uneven wiring lubrication work
Environment	The amount of grease is wasted in every time doing wire rope lubrication work so that it can pollute the environment

In Table 2 describes the targets and benefits in terms of quality aspects and as result of the improvement goals then achieved a product to facilitate of the craftsman's job.

Table 2. Objective of the problems

Quality	Lubrication of wire rope surfaces over 90%
Cost	Use of grease below 9 kg at a cost of 2,295,000 IDR in each time carry out preventive maintenance. Reduce potential losses when loading urea to ship up to 800 tons each time doing preventive maintenance
Delivery	Reduces processing time up to 30 minutes in each wire rope lubrication work
Safety	Avoid working in high places to reduce the risk of work accident
Morale	Improving workers' satisfaction with the results of wire rope lubrication work
Environment	Minimize the wasted grease to avoid environmental pollution

Maintenance activities on Quadrant Ship Loader PU-5858L equipment require time with details, as follows:

Table 3. The process of preventive maintenance activities

Activities	Time (minutes)	Ratio	Cumulative
Lubrication on wire rope	90	50%	50%
Replacement of grease on plummer block pulley	30	17%	67%
Adjusting chain chute trimmer	20	11%	78%
Replacement roller on conveyor	15	8%	86%
Adjusting on break boomhoist	10	6%	92%
Added oil level to gearbox	10	6%	97%
Adding the oil level to the liquid clutch	5	3%	100%
Total	180		

From the table and diagram above can be seen that the work of lubrication on the wire rope takes the longest time is about 90 minutes

2.2. Innovation development

The innovation was achieved from the problems in field application, the several obsolete components in fabrication such as pulley, plain roller, belt conveyor, etc. which the obsolete component would be sold in low price. The innovation aims to develop the Eco-product that was invented from the obsolete component to solve on field problems. In Figure 2 showed several sections in development process, i.e. planning design, preparing, machining, assembly, installation, testing and results.

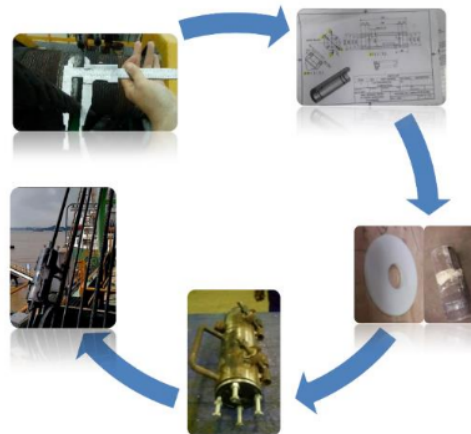


Figure 2. The innovation development process sections

The innovation of lubricator has been modified for the second times, formerly this innovation has been made by shaft drive pulley of conveyor and PTFE (high cost and weight), and more machining time process. The evaluation had made to improve the lubricator to be more effective and gave contribution in sustainable product as a form of environmental concern. The obsolete component was used in second innovation of lubricator wire rope, as shown in Figure 3.

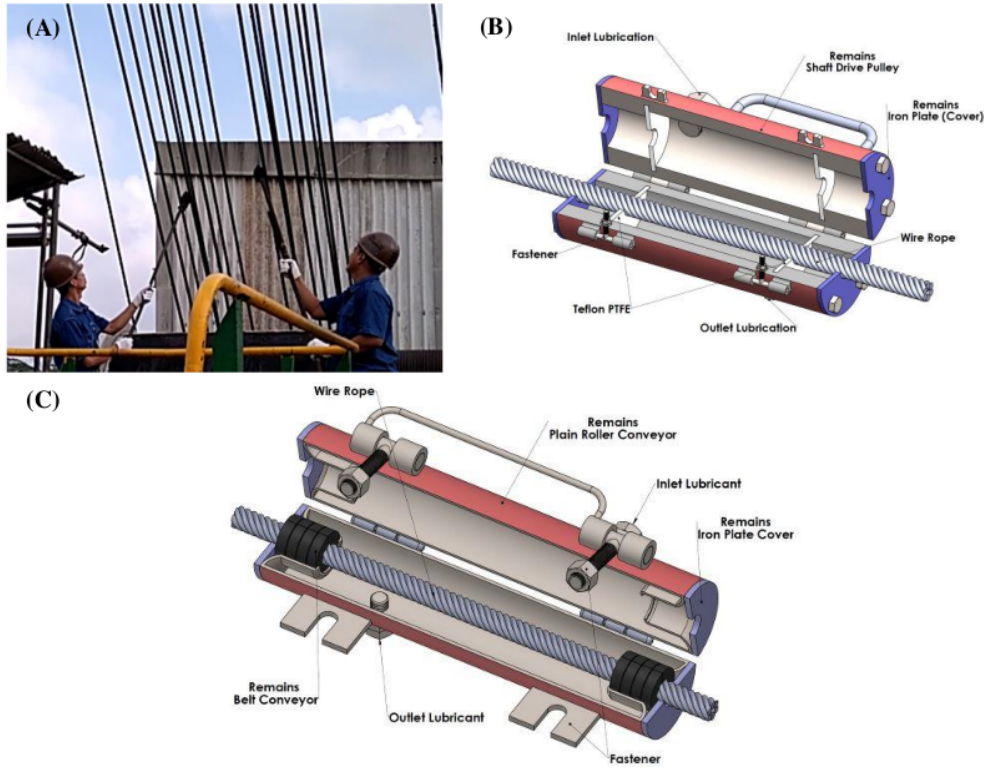


Figure 3. (A) Manual application by hand and stick; (B) The first innovation lubricator; (C) The second innovation of lubricator

2.3. Efficiency of lubricator

The calculation of lubrication is aims to achieve the adequate design and efficiency in wire rope application, the efficiency of lubrication process has been calculated from the second innovation of lubricator, that the comparison magnitude volume consumption of lubricant design which able to reach optimal length wire rope. The volume consumption denoted as V_C and length lubricator (plain roller) denoted as L_p .

$$V_L = \frac{1}{4} \pi (d_p^2 - d_w^2) \cdot L_p \quad (1)$$

Where, V_L is volume lubricant in full condition, and in equation (2) showed the volume consumption in condition lubricator in straight line process of wire rope and c denoted as compound thickness.

$$V_C = \frac{1}{4} \pi \frac{r_p^2 r_w}{(r_p - (r_w + c))} \cdot L_p \quad (2)$$

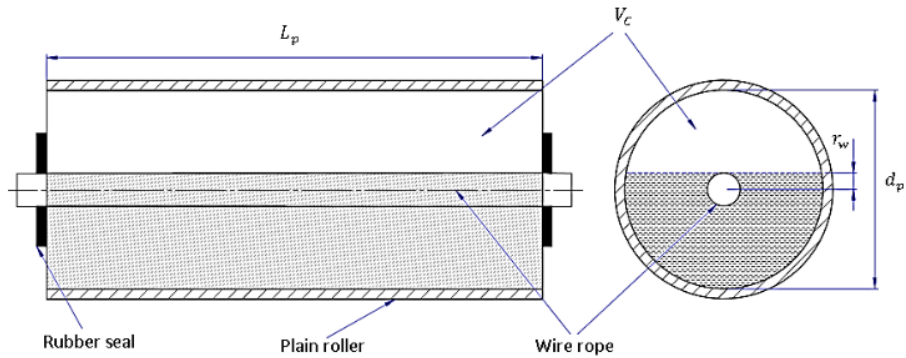


Figure 4. Magnitude volume consumption wire rope in straight line operation.

In equation (3), the calculation volume lubricant consumption for angle application, where from both applications have significant result that shown in Figure 5.

$$V_c = \frac{1}{4} \pi r_p^2 (r_p + r_w + c) \tan \alpha \left(1 - \frac{1}{2} \frac{r_w}{(r_p - (r_w + c))} \right) \quad (3)$$

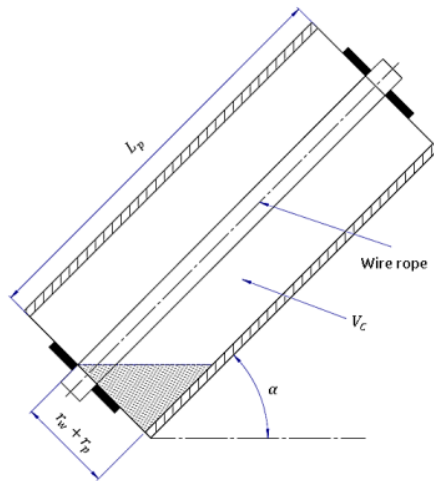


Figure 5. Magnitude volume consumption wire rope in angle line operation.

For calculation of the optimal length of wire rope L_W obtained from the thickness area, on this calculation the strand diameter and number of strands not be included, this aims to simplify the equation.

$$L_W = \frac{2V_c}{\pi(2r_w + c^2)} \quad (4)$$

In this design, length of lubricator (plain roller) L_p is 305 mm with diameter 82 mm and wire diameter be able used in 16 – 22 mm.

2.4. Environmental Improvement

According to ISO 14001 to raising environmental awareness in a plant and office, to increased awareness of the top management is reflected in the environmental policy and declarations increased employee awareness was another important outcome in obtaining better environmental outcomes [8].

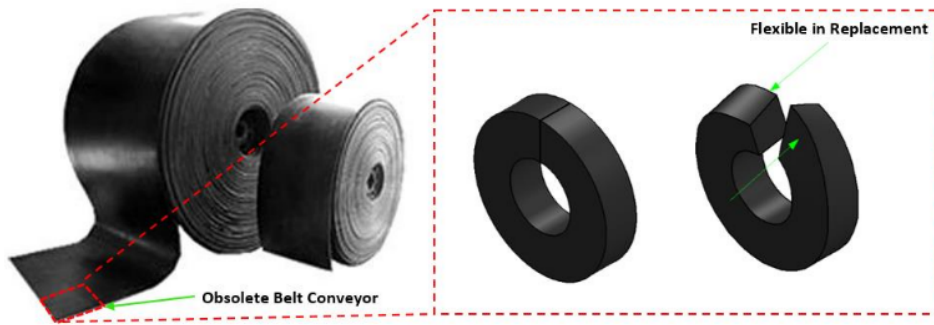


Figure 6. Reusable design of rubber seal of lubricator by obsolete belt conveyor

Obsolete belt conveyor as remains of fertilizer mobile conveyor, this belt would be sold with lower price and unusable (as environment waste). After this innovation, the belt has made as seal component in lubricator and flexible in replacement, as shown in Figure 6. The belt with dimension 100 x 100 mm has machining by lathe machine and generated the belt with outside diameter 44 mm and inside diameters in range 20-30 mm.

3. Result and discussion

The sustainable design of wire rope lubricator gave improvement in maintenance process, and it's closely related to the efficiency of lubricant consumption, time process lubricant, environment, safety issue, the effective thickness of the grease on the surface of the wire rope, and the wire rope lubricant become more efficient.

3.1. Design results and machining process

In design application, the wire rope on QSL with 120 meters in length and is divided into 8 (eight) wire rods with a diameter of 21 mm and lubricant thickness of 0.1-0.5 mm. The lubricator was applied in angle 45 degree at QSL area, where the consumption of lubricant was achieved.

Table 4. The efficiency of lubricant consumption

Application	Volume Consumption, V_c (mm^3)	Length wire, L_w (mm)	Efficiency (%)
Straight wire	140865,7	4222,276	28,14851
Angle Wire 45	226440,786	6787,285	45,24856

3.2. Installation and results test

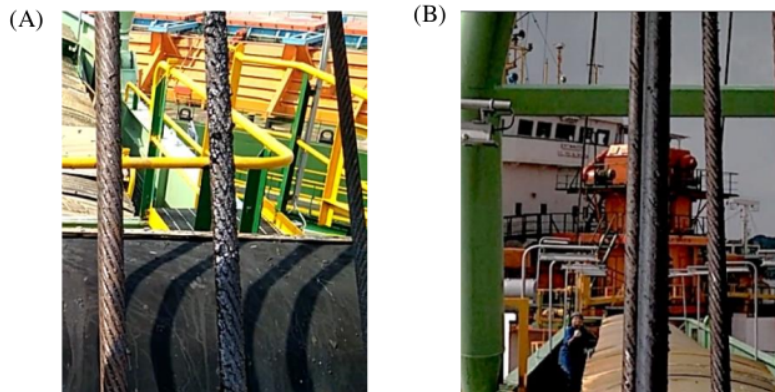


Figure 7. (A) Conditions before innovation; (B) Conditions after innovation

In Figure 7 shown the significant distinction of grease surface, Figure 7 (A) The affected grease surface as well as the thickness of the grease on the wire rope surface are uneven Figure 7 (B) The affected grease surface as well as the thickness of the grease on the surface of the wire rope evenly where the effective thickness.

The cost of making lubrication wire rope is very cheap if we see the benefits obtained after optimizing the use of the wire rope lubricant and become more efficient, as we can see from:

Table 5. Financial benefits

Condition	Cost of Grease	Salary cost	Total cost
Before	18 kg of grease a times = 4,590,000 IDR	1 employee = 6,000,000 IDR	29,300,000 IDR
	In a year 3 times PM = 13,770,000 IDR	4 labor = 9,600,000 IDR	
After	6 kg of grease a times = 1,530,000 IDR	1 employee = 6,000,000 IDR	15,390,000 IDR
	In a year 3 times PM = 4,590,000 IDR	2 labor = 4,800,000 IDR	
Total benefits			13,910,000 IDR

4. Conclusions

The sustainable development products aim to enhance usage obsolete component, economic value, and reduce the environmental burden in the entire product life cycle, to make lubrication on a wire rope is more optimal, faster maintenance time, more efficient use of grease, saving the amount of labor, potential accidents in the workplace decreased and the potential for environmental pollution is reduced because there are no more drops of grease. This tool made by obsolete equipment but on the other hand this tool is very helpful to improve maintenance effectiveness on PU-5858L Quadrant Ship Loader. and the results obtained are improved lubrication quality by 29%, per year, improved lubrication quality by 29%, increased cost efficiency time of workmanship by 67%, potential decrease of environmental pollution by 67%, decrease in employment injury opportunities by 40% and Savings of 13,910,000 IDR.

5. Acknowledgments

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