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Wear Analysis and Corrective Maintenance Worm Screw Press at PT. XYZ

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Abstract

PT. XYZ is one of the palm oil processing companies located in the Riau area. The purpose of this study was to determine the right type of machine maintenance, especially for the worm screw press, because this part often experiences wear and tear which affects the results of pressing palm oil into oil. Wear and tear can partially reduce the surface of the machine and affect the performance of each machine. The service life of the worm screw press provided by the manufacturer is 1000 hours. However, usage at the Sebanga Multi Sawit factory reaches 1300-1500 hours. This proves that there is a need for further studies on good maintenance methods on screw press machines. The calculation of the wear rate and the depth of wear is used to determine the amount of wear that occurs. Solutions that can be done are welding, pack carburizing, and flame hardening on the worm screw press.

Keywords: Corrective maintenance, wear and tear, worm screw press

INTRODUCTION

Oil palm has long been known as an oil-producing plant and palm kernel which usually produces a product in the form of edible oil. The benefits of Crude Palm Oil (CPO) and Palm Kernel (PK) include raw materials for industries such as butter, soap, cosmetics, textiles, biodiesel, and others [1].

The palm oil processing process includes several processes and passes through several stations sequentially. It can be seen that to produce crude oil, a process cannot take place optimally if the previous process has not been completed. It is necessary to ensure good maintenance of the machines at each station can work properly. For this reason, routine maintenance is very important to do so that the smooth production process does not experience obstacles. Maintenance is translated as care or maintenance, Maintenance or maintenance is the conception of all activities needed to maintain or maintain the quality of a facility or machine so that it can function properly as it was originally [2].

The process of forging begins with palm kernels after being boiled and threshed from the stumps, chopped in a digester machine until it resembles porridge. The results of this chop are compressed on a screw press machine to extract the oil from the mixture [3]. Screw press is a very important tool in oil palm mills, because if this screw press has a problem, then the CPO oil compression process is disrupted and results in less CPO oil produced and the separation of shell and fiber is not maximum. This machine consists of 2 mixed iron rods in the shape of a spiral (screw) with a horizontal arrangement and rotate in opposite directions. The crushed palm will be pushed and pressed by the cone on the other side, so that the palm fruit becomes squeezed [4]. Worm screw press is the main component of the press machine which is located in the screw press cage. The damage that occurs can reduce the effectiveness of the machine in processing palm oil.

One screw press unit is used in the pressing process with a capacity of 12 tons/hour. In the screw press, the pulp that has been crushed in the digester will be squeezed so that the palm oil is separated from the fibers and seeds through the holes in the press cage. The worm screw press section is an important indicator to determine the quality of the palm fruit pressing. Problems that often arise with worm screw presses are wear and damage. If the wear experienced by the worm screw press is bad enough, it will greatly affect the imperfect pressing results. Like fruit flesh that has been pressed, it still contains a lot of oil so that it can cause losses for the company. The service life of the worm screw press provided by the manufacturer is 1000 hours. However, usage at the Sebanga Multi Sawit factory reaches 1300-1500 hours. To avoid damage and problems with this machine, regular maintenance or repair of the equipment is needed to avoid unwanted events that can harm the company. This study aimed to analyze the wear of the US-12 worm screw press as the basis for developing a maintenance strategy at PT.XYZ palm oil mill to consider the effectiveness of using the press machine.

RESEARCH METHODS

Data Collection

This is done to find out the data to be processed

1. Primary Data
   In this study, data were collected by interviewing production machine operators and direct observation at the palm oil processing plant.
2. Secondary Data
   Secondary data in this study include company profile, company organizational structure, production capacity, palm fruit processing process, and US-12 type pressing machine spesifications.

Data Processing

The following formula was carried out to determine the result of data processing calculations.
Calculating the wear volume rate of the US-12 type screw press to determine the volume of wear that occurs during the machine operating per day and per month [5].

$$V = KL \frac{W}{H} \quad (1)$$

In order to determine the depth of wear of the US- 12 type screw press that occurs per day and per month [6].

$$Wd = K\frac{WL}{HA_{ca}} \quad (2)$$

Based on the calculation results, the maintenance repair solution and the implementation steps can be given accordingly. This aims to help companies reduce the failure of press machines to operate with proper maintenance.

RESULTS AND DISCUSSION

Fig. 1 shows chart of Palm fruit processing at PT.XYZ. Several steps of the palm fruit processing process are involved such as boiling, threshing, and stirring at the initial steps. Additionally, palm fruit requires pressing in order to take part in deeper processing. In this case, worm screws are required. Finally, oil and kernel are processed separately to obtain CPO and kernel storage.
US-12 Type Press Machine Specifications shown in **Table 1.** It describes the specification of the US-12 Type Press Machine that included of the capacity, cone pressure, shaft rotation, dimension and also the weight of the machine.

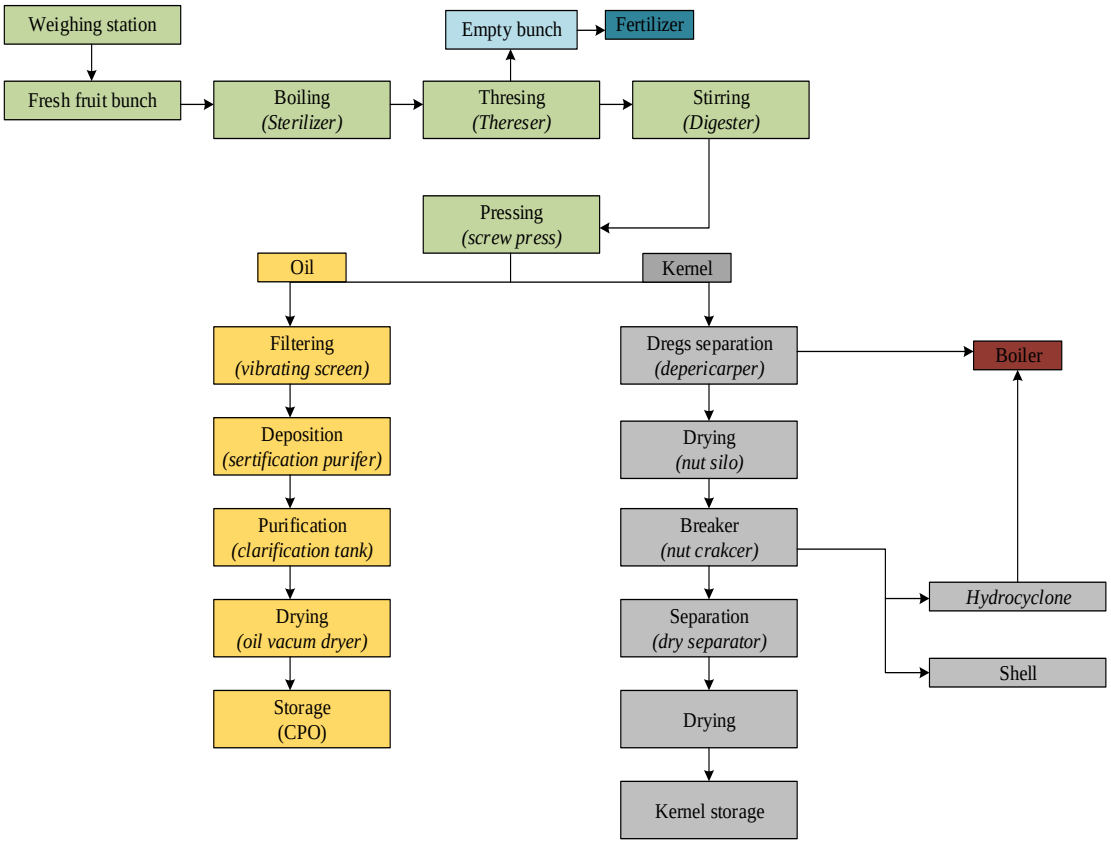

Fig. 1. Palm Fruit Processing

Table 1. US-12 Screw Press Catalog

No	Data description	Explanation
1	Machine	*Screw Press* US-12
2	Capacity	10-12 ton/hour
3	Cone pressure	50 bar
4	Shaft rotation	10-12 rpm
5	Machine length	3900 mm
6	Machine width	800 mm
7	Machine height	730 mm
8	Machine weight	5000 kg

Fig. 2 and **Table 2.** show the worm screw press that used in fruit palm process in PT. XYZ and its dimensions, respectively. The dimension's data used to calculate the wear volume rate and the prediction of the depth of wear machine as follows:

Calculating US-12 screw press wear volume rate

Based on table 2 it is known that:

d = 268 mm, then r = 134 mm

dr_{shaft} = 110 mm, then r = 55 mm

$A_{thread\ surface} = (\pi \times r^2)_{thread} - (\pi \times r^2)_{shaft}$

$= (56381.4\ mm^2) - (9498.5\ mm^2)$

$= 46882.9\ mm^2$/thread surface

Assuming that the average palm diameter = 20 mm, then the area for 1 oil palm is [7]:

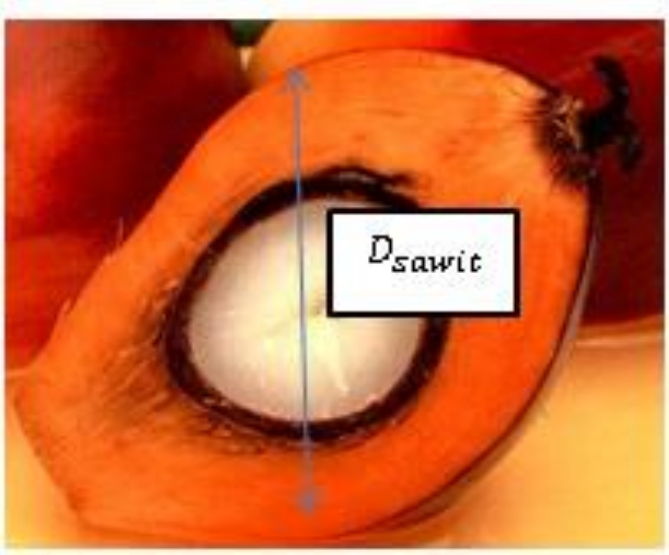

Fig. 3. Palm diameter

$A_{palm} = \pi \times r^2$
$= \pi \times 10^2$ mm
$= 314\ mm^2/palm$

By using the following equation, the number of palm fruit on the surface of the worm screw is:

$$\text{Amount of palms} = \frac{A_{thread\ surface}}{A_{palm}}$$
$$= \frac{46882.9\ mm^2/thread}{314\ mm^2/palm}$$

Then, the total number of palm fruit on the surface of the worm screw is 150 pieces. If the given cone pressure is 50 Bar. So that, the pressure experienced by the palm kernel is:

$$P_{perpalm} = \frac{P_{cone}}{amount\ of\ palms}$$
$$= \frac{50 \times 10^5\ Pascal/thread}{150\ palm/thread}$$
$= 33333.33$ pascal/palm

Then the loading on the worm screw press can be found by:

$W = P \times A_{palm}$
$= (33333.33\ Pascal) \times (314 \times 10^{-6}\ m^2)$
$= 10.46\ N/m^2.m^2$
$= 10.46$ Newton

Then, d_k:
Noted that:
$dr_{shaft} = 268$ mm
maximum distance of critical point = 10 mm
amount of cones = 2
$d_k = dr_{shaft} - (distance \times number\ of\ cone)$
$d_k = 248$ mm
Maka, $L = \pi \times D_{critical}$
$L = 0.78$ m

	Brinell hardness, H_B	Stress σ_{su}, MPa
Cast iron	≤200	—
	>200	—
Cast steel	≤200	≤686
	200–230	686–785
	>230	>785
Alloy steels	≤200	≤686
	200–230	686–785
	>230	>735

Fig. 4. Hardness of Cast Steel Material

The hardness of the worm screw press material, namely cast steel, is around 200-230 BHN (Brinell Hardness Number), so the average hardness price is 215 BHN.

Noted that:
1 BHN = 1 kgf/mm^2 = 9.8 Mpa
So that,
215 BHN = 215 × 9.8 Mpa = 2107 Mpa = 2.107 × 10^9 Pa
For the value of the wear coefficient K, namely abrasive wear on 2 body, it can be obtained from **Fig. 5**

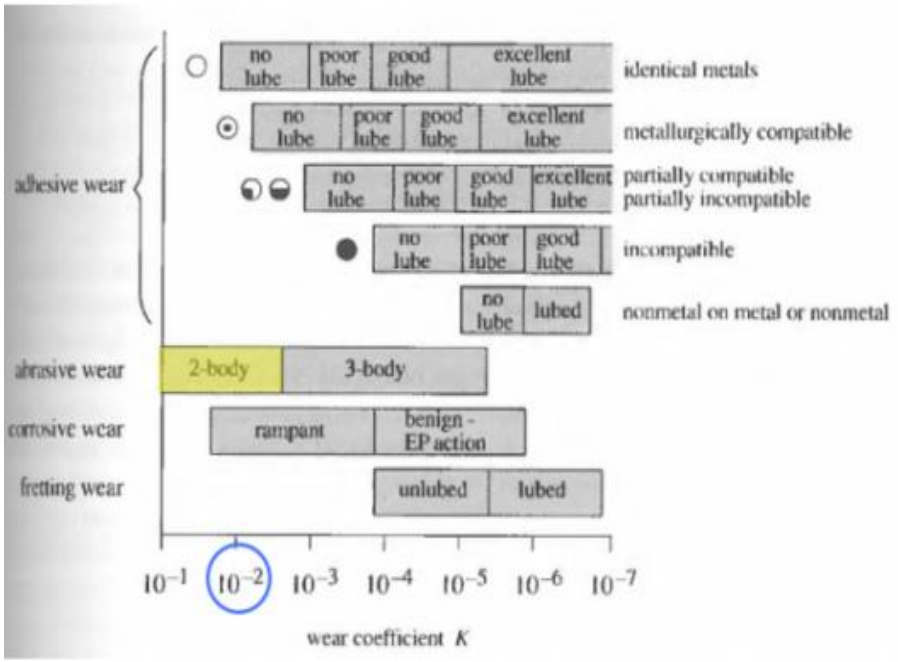

Fig. 5. Wear Coefficient K

So that, the wear volume rate that occurs for 1 rotation of the worm screw is:

$$V = K.L \frac{W}{H}$$
$$= 10^{-2} \times 0.78\ m \times \frac{10.46\ N}{2.107 \times 10^9\ Pa}$$
$$= 3.872 \times 10^{-11}\ m^3$$

$= 0.00000000003872\ m^3$/rotation

Then, $3.872 \times 10^{-11}\ m^3 = 1$ worm screw press rotation
Usage time:
1 day = 14 hours of work = 840 minutes
840 minutes × 11 rounds = 9240 rounds/day
9240 rounds/day × 30 days = 277200 rounds/month
Then, the rate of wear volume per day:

$V_{perday} = V \times n_{perhari}$
$= (3.872 \times 10^{-11}\ m^3)$ x (9240 rotation/day)
$= 357.7\ mm^3$/day

$V_{permonth} = V \times n_{permonth}$
$= (3.872 \times 10^{-11}\ m^3)$ x (277200 rotation/month)
$= 10733\ mm^3$/permonth

Worm screw US-12 press depth wear rate
Known:
d thread = 268 mm = 134 mm
d non critical = d thread - maximum distance of critical point
=134 mm – 10 mm
= 124 mm

$A_{ks} = (\pi \times r^2)_{thread} - (\pi \times r^2)_{non\ critical}$
$= (\pi \times 134^2 mm) - (\pi \times 124^2 mm)$
$= (56381.84\ mm^2) - (48280.64\ mm^2)$
$= 8101.2\ mm^2$
$= 0.0081\ m^2$

So that, the number of palms in the critical area is:

$$\text{Amount of palm} = \frac{A_{ks}}{A_{palm}} = \frac{8101.2\ mm^2}{314\ mm^2/palm} = 25.80\ palms = 26\ palms$$

W_{Aks} = W × amount of palm

= 10.46 N × 26
= 271.96 N

From the data obtained above, it can be found the rate into the wear and tear of the rotation using equation 2:

$$Wd = K\frac{WL}{HA_{ks}} = 10^{-2} \times \frac{(271.96\ Newton) \times (0.78\ m)}{(2.107 \times 10^9\ Pa) \times (0.0081\ m^2)}$$
$= 12.4279 \times 10^{-8}$ m/rotation

The prediction of the depth of wear above is a prediction of the depth of wear that occurs in the critical area of the worm screw in one turn. So to calculate the depth of wear in a day is as follows:

$Wd_{perday} = 12.4279 \times 10^{-8}$ m/rotation × 9240 rotation/day
= 1.14 mm/day

$Wd_{permonth} = 12.4279 \times 10^{-8}$ m/rotation × 77200 rotation/month
= 34.4 mm/month.

From the data obtained, it is shown that the rate of wear volume that occurs on the surface of the US-12 worm screw press is $357.7 mm^3$/day for cast steel material with a material hardness value of 215 BHN and working hours of 14 hours and for 364 working hours, the volume of wear that occurs reach $10733\ mm^3$. Furthermore, for the depth of wear that occurs on the surface of the US-12 worm screw press is 1.14 mm/day for cast steel material with a material hardness value of 215 BHN for 14 working hours, so that at 364 working hours, the volume of wear that occurs reaches 34, 4mm. Corrective maintenance that can be provided is in the form of increasing the

hardness of the material by using a method suitable for cast steel with a carbon content of 0.20%, including welding with a worm screw press with a thickness of about 15 mm. Carburizing and NiKaNa were found to increase the hardness by 194.51% [9] and 552% [5]. From this study it was found that the hardness of the US-12 worm screw press material affects the volume rate of wear and the rate of depth of wear that occurs on the machine. The smaller the value of the hardness of the material, the greater the wear and tear that will occur. From this study it was also found that the cone pressure on the US-12 worm screw press also affects the rate of wear volume and the rate of wear depth that occurs. The greater the pressure applied, the greater the wear that will occur.

Corrective maintenance to reduce wear

Here are some ways to reduce wear on the worm screw press:

1. Welding
   The additional thickness of the worm screw press is around 15 mm. This improved worm screw press can last for almost half the life of a new worm screw press from the screw press manufacturer or about 300-400 hours of use. The results of the worm screw press after undergoing additional improvements [8].
2. Carburizing process
   Pack carburizing is a method of surface hardening of steel in which the steel is placed in a cementation box containing a carburizing compound and then heated to a certain temperature [9].
3. Hardening process
   Flame Hardening is a heat treatment process in which the surface of the steel is heated rapidly to a temperature above the critical point of the steel (the austenitic temperature) [10].

CONCLUSIONS

Based on the results and discussion have been described, the hardness of the US-12 worm screw press material affects the volume rate of wear and the rate of depth of wear that occurs. The smaller the value of the hardness of the material, the greater the wear and tear that will occur. The cone pressure on the US-12 worm screw press also affects the volume rate of wear and the rate of depth of wear that occurs. The greater the pressure applied, the greater the wear and tear that will occur.

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