

Wear Control in Press Screws in Palm Oil Mill

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Abstract: Tests were carried out on carefully collected samples to determine the mechanical properties and chemical composition of the screws. This is aimed at recommending the best of tribological material for the system. The tensile test result shows that the ultimate tensile strength of the press screws is $1.26E07 \text{ KN m}^{-2}$ with an overall per cent elongation of 19.1%. Hardness test indicated that the screw is of medium hardness, with a hardness number of HRC40.10. The chemical analysis shows that the screw is a carbon steel with a carbon content of 0.317%, alloyed with Silicon (Si) and Manganese (Mn) elements. A press screw made of silicon-manganese cast steel with 1.20% carbon content, 1.27% silicon and 1.30% manganese is recommended. It is suggested that the material be hardened by heating to 1050°C and quenched in oil. Tempering is at 240°C for 6 h to ensure adequate toughness and minimal loss of hardness.

Key words: Tensile test, hardness test, chemical analysis, press screw, material

INTRODUCTION

Severe metal wear is identified as the major problem facing oil palm mills in the developing countries. A study carried out at Rison Palm oil mill, Ubima in Rivers State in Nigeria revealed that the press screw unit constitute the heart of severe wear and breakdown in the industry. Unfortunately, the cost of importing the screws is too high for the local oil palm mills. The high running cost occasioned by this problem has forced the mills to operate at far below their installed capacities. The present practice of electrode-filling of the worn out screws has not helped issues, as the screws rapidly wear out in the next few



Fig. 1: Worn-out screw

days. A picture of the worn out screw is shown in Fig. 1. It is easily observed that flight 1 experiences most wear.

MECHANICAL PROPERTIES AND CHEMICAL COMPOSITION

Tests were conducted to determine the mechanical properties and chemical composition of the screws.

Tensile test: Two test specimens were prepared each from collected samples from two different screws. Tensile test was conducted in accordance with the procedures described in the American Standard Specifications (American Society for Testing and Materials, ASTM tensile test specimen specifications; George, 1961). Sufficient cooling fluid (a mixture of oil and water) was applied during the cutting and machining operations to avoid micro-structural changes in the specimens. Test specimen diameter is 4.9 mm instead of 5.0 mm to allow for proper fitting of specimen in the testing machine. A type W tensiometer (Monsavato Ltd. Instrument Group, Witshire, SN35HN, 1980) was used for the test.

RESULTS AND DISCUSSION

The tensiometer recorded the extension of the specimen as increasing tensile load was applied.

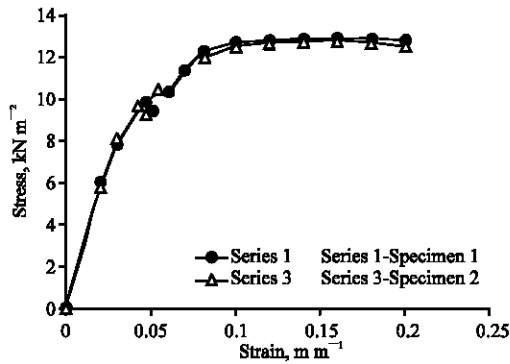


Fig. 2: Stress/strain curves for the press screw material

| | |
|--|-----------------------|
| Length of test specimen | 28 m |
| Diameter of specimen | 4.9 mm |
| Cross sectional area | 18.86 mm ² |
| Diameter of test specimen after breakage | 4 mm |
| Cross sectional area of test specimen after breakage | 12.57 mm ² |
| Maximum load on specimen 1 | 12.64 KN |
| Change in length of specimen 1 | 5.35 mm |
| Maximum load on specimen 2 | 12.56 KN |
| Change in length of specimen 2 | 5.60 mm |

Data obtained was used to plot the stress/strain curves in Fig. 2 for the two specimens (Janitsky and Baeyertz, 1939). The mechanical properties of the screw are as follows (Bernstein and Zaimovsky, 1983):

| | |
|-----------------------------------|-----------------------------|
| Upper yield stress | 9.821E06 KN m ⁻² |
| Lower yield stress | 9.236E06 KN m ⁻² |
| Ultimate tensile strength | 1.26E07 kN m ⁻² |
| Overall elongation after fracture | 19.1% |

Hardness test: Otto Wolpert Werke hardness testing machine (W-testor, 1961) was used. The tester utilizes the depth of indentation under applied constant load as a measure of hardness of the material. A minor load of 15 kg was first applied to seat the test specimen (Hahn and Kolb, 1961). The dial gage was then adjusted for zero error before a major load of 150 kg was applied. Depth of indentation was automatically recorded on the dial gage in terms of arbitrary hardness numbers. A Rockwell C scale was used with a diamond indenter.

Table 1 gives a summary of the hardness test result.

Average hardness number of press screw material HRC 40.10

This suggests that the screw is a hard steel of medium carbon content (Lessells, 1954).

Table 1: Hardness test result

| | Rockwell hardness HRC (kg mm ⁻¹) | Vickers hardness HV (kg mm ⁻²) | Brinnellhardness HB (kg mm ⁻²) |
|----------|---|---|---|
| Sample 1 | 39.80 | 390 | 385 |
| Sample 2 | 40.40 | 397 | 390 |

Chemical analysis: An emission spectrometer (SSM2 model) was used for the analysis. Test samples were polished by iron bombardment of the surface and the test was carried out instrumentally.

The print-out from the emission spectrometer gave the following result, showing an average per cent chemical composition of the test samples.

| C | Si | S | P | Mn | Ni |
|--------|--------|--------|--------|--------|---------|
| 0.3166 | 1.0945 | 0.0305 | 0.0222 | 0.9038 | 0.0577 |
| Mo | V | Cu | W | As | Sn |
| 0.0123 | 0.0081 | 0.0950 | 0.0047 | 0.0108 | 0.0098 |
| Co | Al | Pb | Ca | Zn | Fe |
| 0.0072 | 0.1017 | 0.0047 | 0.0003 | 0.0050 | 97.1325 |

The above result shows that the screw is a carbon steel alloyed with Silicon (Si) and Manganese (Mn). With carbon content of 0.317%, the material can be classified as medium carbon steel (Bain, 1939). Generally, silicon contents of over 0.50% are classified as silicon steels. When silicon is present up to 2%, the steel can be used as structural steel, especially when high yield strength is needed. When silicon dissolves in ferrite, it results into increased strength and hardness of the material. Because silicon has graphitizing effect, when manganese is also present up to 1%, as in this case, the manganese acts as carbide stabilizer. Both elements (Si and Mn) combine to strengthen the ferrite and increase its harden-ability, so that silicon-manganese steels respond to oil-quenching, while subsequent tempering provides a good combination of strength and impact toughness.

RECOMMENDATION

In order to arrest the severe wear problem in the press system, it is recommended that the press screw be made of a silicon-manganese cast steel with the following per cent composition:

| C | Si | Mn | Fe |
|------|------|------|---------------|
| 1.20 | 1.27 | 1.30 | approx. 95.68 |

with other elements still in their per cent composition as in the above test samples. The material should be hardened by heating to about 1050°C and quenched in oil (Kragelsky, 1981). Tempering is at 240°C for 6 h. Generally, silicon contents of over 0.5% are classified as silicon steels (George, 1961).

CONCLUSION

It is sometimes difficult to achieve accurate combinations of the alloying elements in their right proportions, so that one practically aims at close approximations. Manganese cast steel is likely to give a better performance under abrasive wear conditions. Manganese is known to make steels harder. It increases its tensile strength. Ductility is a well desired property in steel when wear resistance is of paramount import. Whilst hardness increases with increase in carbon content of steel, ductility, however decreases. This is due to increased amount of cementite in the micro structure (Arthur and William, 1979). With a carbon content of 1.2%, a high percentage of manganese is thus needed to improve on the ductility of the material.

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