Repair of Screw Press Using Hardfacing Process

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INTRODUCTION

Wear in machine components is unavoidable and this normally leads to failure of the component. Wear is defined as the progressive loss of substance from the operating surface of a body occurring as a result of relative motion at the surface (1).

The most common type of wear is abrasive wear. This occurs when non-metallic material slide or roll under pressure across a metallic surface. The common practice is to replace the damaged component. However, this will lead to higher costs due to scrap and inventory. There is also an urgent need to conserve non-renewable materials in compliance with green technology.

Hardfacing is a surfacing process used to improve wear resistance of a component without affecting the component when used. The process uses welding to create deposits that have excellent wear and abrasion resistance, on the surface of the component which has suffered wear.

This article takes a look at the hardfacing process used in the maintenance of a screw press in palm oil production, to prolong its working life.

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WEAR OF A PRESS SCREW

Screw press (Photo 1) is an important component used for the extraction of crude oil. During the process, called digestion, the oil palm fruit is mashed up under steam-heated conditions and the screw press is used to press out the oil from the digested mash (2).

The screw press has an oil extraction efficiency of as high as 95% (3). However, during the process, the screw press flights wear out rapidly. The screw would normally be subject to severe abrasion wear, due to contaminant in the fruit such as sand and small stones.

Photo 1: Screw press

Photo 2: Abrasion wear of P20 screw press

Photo 2 shows a P20 screw press which has been subjected to abrasion wear, after 700 hours of working life. The P20 screw has the capacity to process 20 tonnes ffbs/hr (tph).

Each screw flight was initially 370 mm in diameter with flights 1, 2 and 3 having thickness of 55 mm, 40 mm and 34 mm respectively as shown in Photo 3. The materials used for the

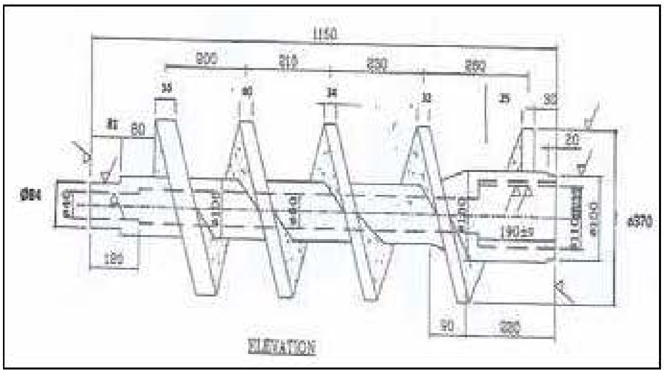

Photo 3: Press screw sizing

screw were low alloy steel or chrome moly steel with hardness of 35HRC-50HRC.

However after in use for 700 hours, all three screw flights showed severe reduction in diameters and thicknesses as shown Photo 4 and 5 respectively due to abrasive wear.

Flight 1 was observed to have undergone the highest reduction in diameter and thickness compared to the other flights. Observation by Basil (4) on the wear pattern of the press screw supports the wear of the observed flights. Flight 1 was severely affected mainly because the actual pressing of the entrapped oil was concentrated near the outlet of the press (Photo 6), which was closer to flight 1. High pressure from the hydraulic cones facilitates the pressing action at the outlet.

It was noticed that when the clearance of the flights due to wear, exceeded 22 mm, there was an excessive loss in oil extraction from the fibre and a high breakage of nuts, which exceeded the standards set by the palm oil industry. This would potentially cause a reduction in the throughput

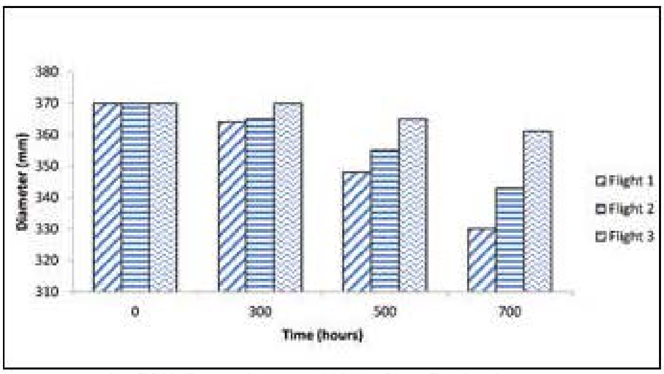

Photo 4: Change in screw flights diameters due to wear

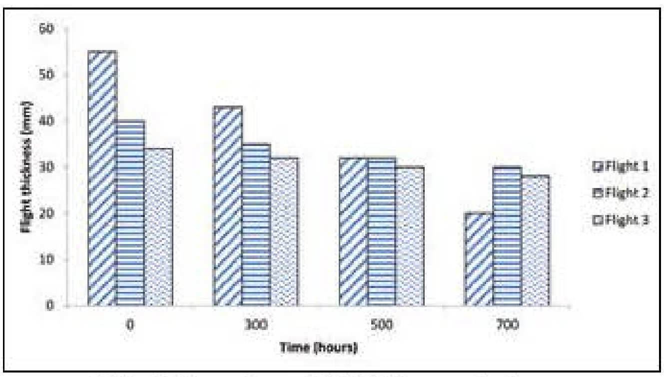

Photo 5: Change in screw flights thicknesses due to wear

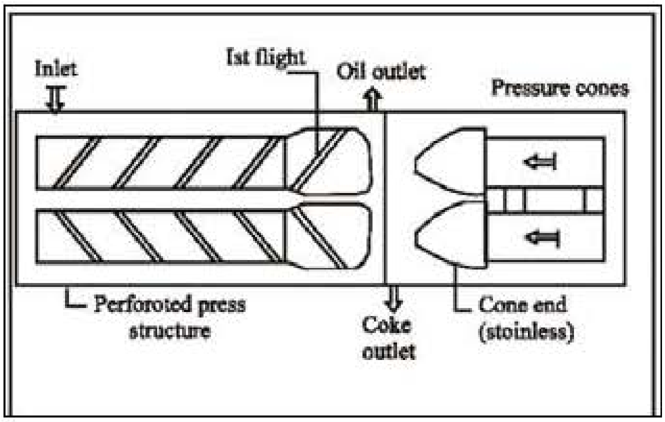

Photo 6: Position of 1st flight near the outlet [4]

and therefore lead to the replacement of the screws. According to the throughput rule (5), when the throughput drops more than 20%, the press screws need to be replaced. Due to severe wear, the useful working life of the twin press screws used in this work was found to be approximately 500 hours when Flight 1 diameter reduced to 354 mm and the throughput was about 15 tons FFB/hr with throughput drop of 25%. The industry spend millions of ringgit annually to replace these screws. Due to the unavailability of data on the annual cost for press screw replacement, an estimation was worked out based on the annual crude palm oil (CPO) production by Malaysian Palm Oil Board (MPOB) statistics for 2013 and 2014 (6) and the estimated FFB required to produce 1 tonne of CPO (7).

a) Annual CPO production = 28,000,000 tonnes.

b) 5.09 tonnes of FFB required to produce 1 tonne of CPO.

c) P20 screw press will process 20 tonnes of FFB per hour.

Annual FFB required to be processes in a year = 28 Mt x 5.09 t = 142.5 Mtpa of FFB

Total processing time:
142,500,000 / 20 = 7,125,000 hrs/year
Assuming press screws are replaced at 700 hours, total screws required annually:
7,125,000 hr / 700 hr = 10,178 pairs/year

Each pair of new screws was estimated to cost RM3,900. So the total annual cost for new screw replacements would be estimated at around RM39,694,200.

It is believed that with the use of the hardfacing process and the correct selection of maintenance electrode and welding parameters, the life span of the press screws can be further extended. It will also reduce iron contamination in the palm oil, a matter of great concern to the industry as it will increase the risk of oil oxidation.

HARDFACING OF PRESS SCREWS

The hardfacing process of the screw press starts with cleaning the section of the screw which has worn out so that it is free from grease and oil. Flux core arc welding, using 1.6 mm flux core wire with direct current with (DC) inverter was used for hardfacing.

The welding current and voltage in the range of 140 A to 160 A and 24 V to 26 V were used to produce welds with low heat input, ensuring that the temperature of the base metal did exceed 100°C. This minimised the amount of dilution with the base metal and microstructural changes in the base metal. Based on the extent of the wear, the worn section of the screw was rebuilt with a buffer layer. This layer was produced using a ME-56 electrode, an austenitic Ni-based electrode, comprising nickel (N), chromium (Cr), molybdenum (Mo) and iron (Fe). The layer had a hardness of 42-48 HRC.

The surfacing layer was produced with ME-57 carbide electrodes comprising carbon (C), chromium (Cr) and niobium (Nb), with hardness of 57-62 HRC. These ME-75 electrodes had high abrasion resistance as well as impact resistance properties.

Photo 7 shows press screws which had been hardfaced using the ME-56 and ME-57 repair and reclamation electrodes.

Photo 7: Hardfaced screws

With the combination of hardness and abrasive resistance, industrial test run were carried on the hardfaced press screws as in Photo 8. The results show that the press screw's useful working life, based on Flight 1, has extended to 1000 hours. This shows that hardfacing of the screw press with correct selection of maintenance electrode and welding parameters has improved the working life by 50%.

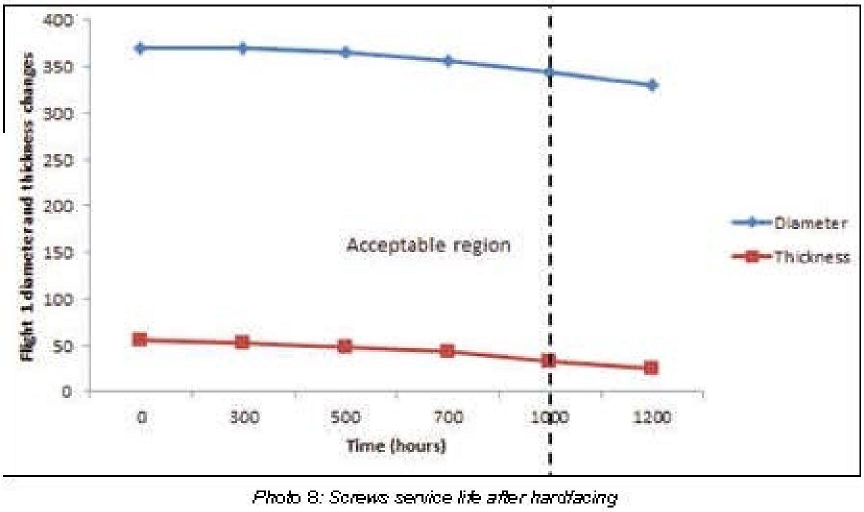

Photo 8: Screws service life after hardfacing

The cost for hardfacing a pair of press screws was about RM2,000. Based on estimation above, the annual cost of repairing 10,178 pairs would be RM20,356,000. This showed that hardfacing can lead to cost savings of RM19,338,200, when compared to replacing with new screws.

CONCLUSION

Press screws are subjected to severe abrasion wear during their working life and therefore need to be replaced to prevent high oil loss, high nut breakage and reduction in throughput. The use of ME-56 and ME-57 repair electrodes to rebuild the worn section of the screw was found to improve the hardness and abrasion resistance of the screws. The useful working life of the screws increased by 50%, leading to cost savings of RM19,338,200 when compared to replacing them with new screws.

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