# A COMMERCIAL SCALE IMPLEMENTATION OF ROLEK™ PALM NUT CRACKER: TECHNO-ECONOMIC VIABILITY STUDY FOR PRODUCTION OF SHELL-FREE KERNEL

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**ABSTRACT**

*A new generation of palm nut cracker, known as Rolek was successfully invented through a smart partnership between MPOB and Hur Far Engineering Works Sdn Bhd (HFEWSB). A few units of this invention were installed and commissioned at three palm oil mills processing different types of nuts. A systematic evaluation was carried out to obtain their commercial performances such as cracking efficiency, kernel and nut quality, shell fragment sizes and maintenance cost. The data obtained from Rolek were then compared with commercial nut cracker (ripple mill). The machines were tested with two types of nuts as input material; 95%* tenera *nuts in Mill A and more than 25%* dura *nuts in Mills B and C. From the analysis, it was found that all mills achieved more than 98% cracking efficiency with less than 10% broken kernel. The results have also shown that all the mills produced less than 2% half cracked nuts and shell fragments were found to be uniform and small in size capable of maximizing separation of shell and kernel in the winnowing column. Concerning other parameters, Mill A showed a lower maintenance cost and longer operating hours before replacement of parts as low as RM 0.056 $t^{-1}$ FFB processed at 650 operating hours, compared to Mills B and C, as it processed 95%* tenera *nuts having thinner shell that would be easily cracked. Therefore, the type of nuts processed is found to be the main contributing factor for the higher maintenance cost of Rolek if the consideration was made based on the parts replacement in the certain operating hours. The details of all these studies are discussed in this paper. The use of Rolek promises significant quality improvements and lesser maintenance cost than other convectional nut crackers.*

**Keywords:** nut cracker, shell-free kernel, cracking efficiency, cracked mixture, KER.

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## INTRODUCTION

Malaysia is amongst the top palm kernel producers in the world with a total production of 3.70 million tonnes of kernel in 2004 (MPOB, 2004). Kernel is obtained from palm fruitlet after removal of mesocarp fibres and shell. The composition of palm kernel in fresh fruit bunch (FFB), is about 5%-7% depending on the type of planting material. Considered as a by-product from the milling process, palm kernel is not accorded the same recognition as palm oil resulting in no major effort being given to improve its quality.

This statement was supported with a study done by MPOB on the quality of palm kernel delivered to kernel crushing plants. The study indicates that kernel produced from mills contain high percentage of broken kernel, shell and dirt (Rohaya *et al*., 2005). The high percentage of shell and dirt in palm kernel were found to affect not only the quality and quantity of kernel oil during the pressing, but also downgrade the quality of Malaysian palm kernel cake either for export market or local fodder industry.

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Kernel quality is highly dependent on the process control measures exercised by the mill during kernel recovery which include nut cracking efficiency, cracked mixture separation, and kernel storage and handling. Realizing the need for quality improvement of palm kernel, its oil recovery rate and the quality of palm kernel cake, MPOB in collaboration with HFEWSB, invented a new generation of palm nut cracker known as *Rolek™*.

## DESCRIPTION OF ROLEK

The objectives of Rolek invention is to achieve maximum cracking efficiency of palm nuts and promote better separation of shell and kernel through the production of uniform and small size shell. Rolek is designed to crack various sizes of palm nuts. The commercial capacity of this unit varies from 4 to 6 t $hr^{-1}$ of nuts. The main concept of Rolek's design involves two types of cracker rods, namely, rotary and stator rods. The rotating rods interact with stator rods in all stator rings to break the nuts in the cracking compartment. Both outer and stator rods are sleeved. The thickness of the sleeve can be varied in order to set the precise gap between rods. This provides a maximum interaction and dynamic force between nuts and rods for clean cracking without causing high kernel breakage, half and uncracked nuts. The design of Rolek and its working principle are illustrated in the *Figures 1a, b* and *2.*

Currently, more than 30 units of Rolek have been adopted in Malaysia and Indonesia, and more are expected to be sold in the near future. There are now two packages of Rolek in the market which are as follows:

- three units of Rolek nut crackers for different nut sizes. This package is suitable for mills with nut grading screen; and
- one unit of Rolek nut cracker with variable rods gap for all nut sizes. This package is suitable for mills without nut grading screen.

Besides its higher cracking efficiency, the system was designed to offer very low maintenance cost as well as easy and time saving in maintenance activities or services compared to ripple mill or commercial nut cracker.

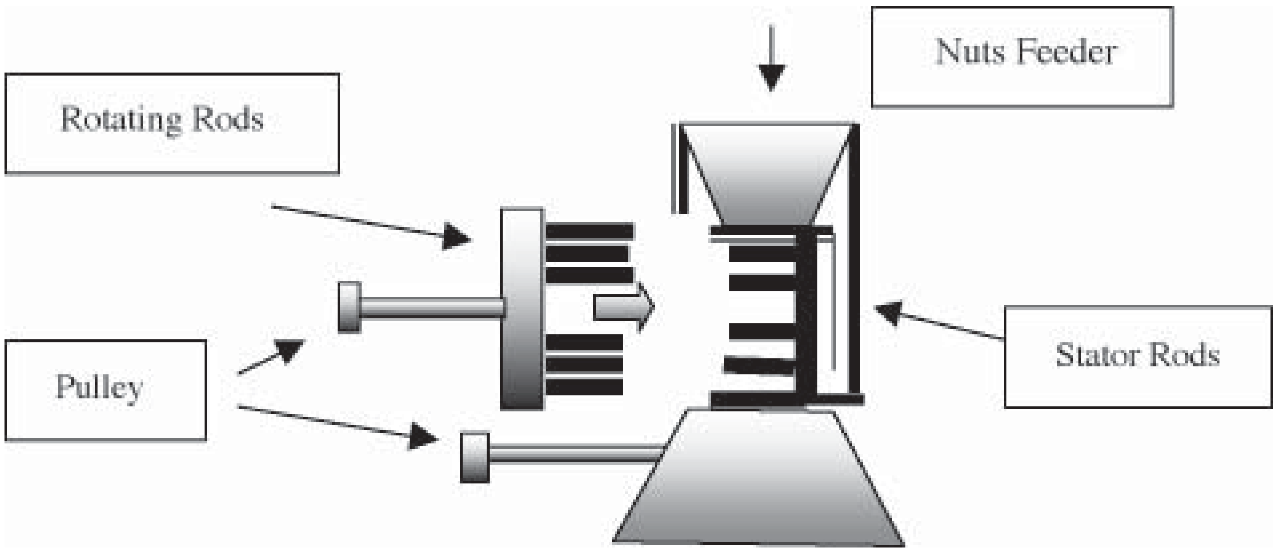
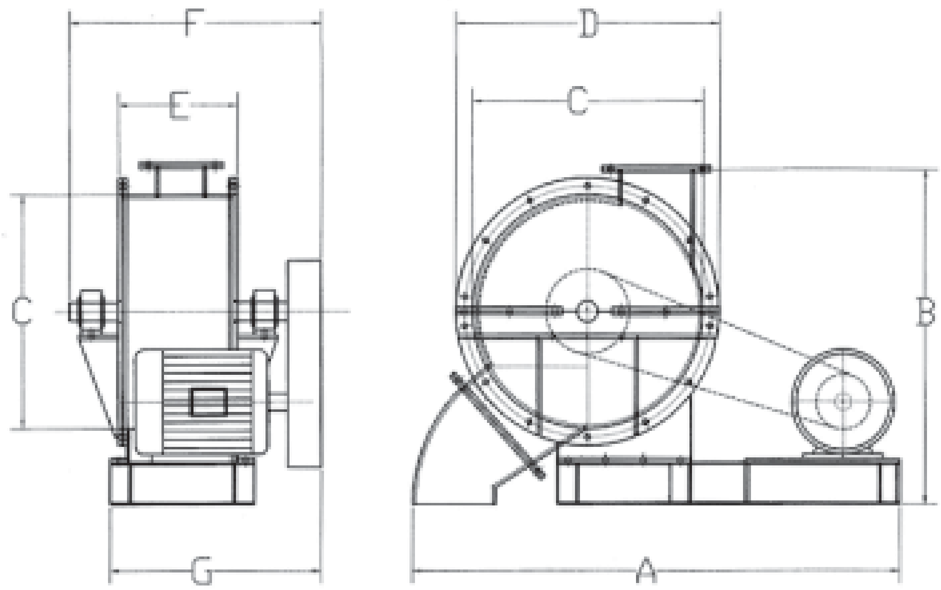



*Figure 1a. A conceptual design of Rolek palm nut cracker.*




| DIMENSIONS | | | | | | |
|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G |
| 4'-10.5' (1486) | 3'-27.5' (1029) | 27.5' (699) | 31.5' (800) | 13.75' (349) | 30' (762) | 25.5' (641) |

**TECHNICAL SPECIFICATION OF COMMERCIAL ROLEK**

| | |
|---|---|
| Model | Small, medium, big and mixed nuts |
| Maximum capacity /unit | 6 t $hr^{-1}$ for capacity of 45 t $hr^{-1}$ mill |
| Electrical input | 20 hp, 415 V 3 Phase 50 Hz |
| Maximum speed | 1450 rpm |
| Gross weight | 690 kg |

*Figure 1b. Schematic diagram and technical specification of Rolek.*

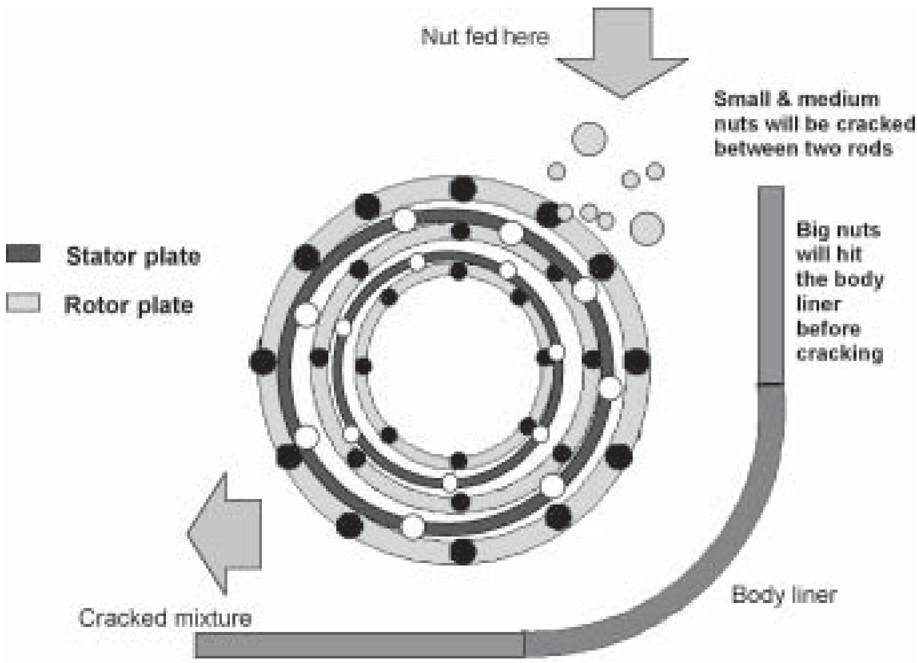



*Figure 2. Working principle of Rolek palm nut cracker.*

## METHODOLOGY

### Commercial Trials and Evaluation

In total, seven units of Rolek were installed in two separate mills for their commercial performance evaluation. The first mill is a 45 t $hr^{-1}$ mill located in Perak that process is about 95% *tenera* nuts. Before installation, the kernel extraction rate of the mill was less than 6%. Since the mill is equipped with nut grading screen, three units of Rolek for different nut sizes were installed at the kernel recovery plant (*Figure 3*). The second and third mills on trial are 54 t $hr^{-1}$ and 40 t $hr^{-1}$ mills located in Johor. Each mill was installed with two units of Rolek for mixed sizes of palm nuts as shown in *Figure 4*. In order to have a set of difference performance data, these mills were selected as it process more than 25% of *dura* nuts daily. All the evaluations were carried out by MPOB personnel assisted by mills's technical staff.

Details of the performance parameters, sampling procedures and calculation for the evaluation are as follows:

***Cracking efficiency and cracked mixture quality.*** The measurement by weight on the number of uncracked and half cracked nuts after cracking by the machine will indicate the cracking efficiency. It can be determined using the formula as below:

$$\text{Cracking efg, } \eta = \frac{\text{wt sample} - (\text{wt of uncr} + \text{half crk nuts}) \times 100\%}{\text{Sample wt}}$$

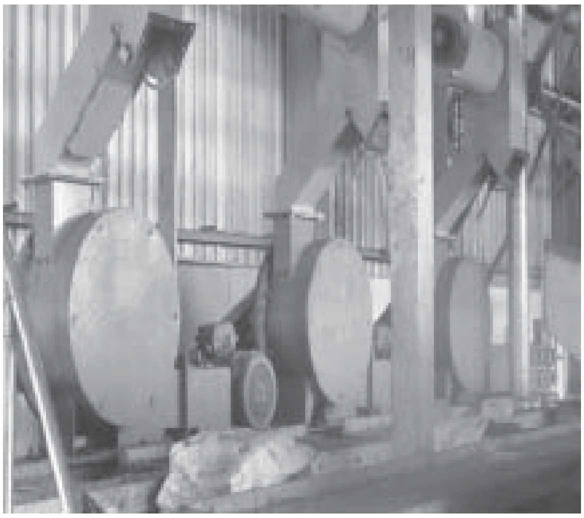


*Figure 3. Three units of Rolek nut cracker for three different sizes installed at Mill A.*


*Figure 4. Rolek for multiple sizes of palm nut installed in Mills B and C.*

The cracked mixture is collected every 1 or 2 hr and the weight for every sample is maintained between 1.1 to 1.3 kg. The sample were sorted and weighed for whole kernel, broken kernel, shell, uncracked and half cracked nuts. These data are useful to analyze the quality of cracked mixture.

***Determination of cracker throughput.*** It is defined as nut flow rate or the amount of nuts fed into the machine at any point in time. The nuts flow rate can be determined by sampling the nuts at the chute every 30 s. The collected sample is weighed and the value is converted to hourly basis. The determination of nut's flow rate is essential during commissioning in order to ensure that the machine is operating with a uniform feeding rate, as well as to establish a baseline data for future machines optimization.

***Maintenance cost analysis.*** This analysis is vital as the maintenance cost plays an important role in the proper mill management and hence, also serves as main criteria when selecting a new machine. The analysis focuses on the parts replacement of Rolek based on the total operating hours and FFB processing rate. The data obtained from this analysis is then compared to the commercial ripple mill.

## RESULTS AND DISCUSSION

### Size Distribution and Type of Palm Nuts

This analysis was carried out to study he exact percentage of nut type and its size distribution being processed on each mill. From the analysis, it was found that Mill A processed about 95% *tenera* nuts with 5% *dura*. The size distribution of nuts ranged from 9 to 17 mm in diameter and the average size was 14 mm. This represents the nut condition in most of the mills in Malaysia. However, in Mills B and C, it processed more than 25% *dura* nuts. The nut size ranged from 7 to 25 mm with average sizes between 13 to 15 mm. The size distribution of *tenera* and *dura* nuts for Mills B and C are shown in *Figure 5*. It was also found that some nuts in Mills B and C contained more than one kernel inside the nuts as shown in *Figure 6*. The Rolek performance will show different sets of results when cracking nuts having different characteristics.

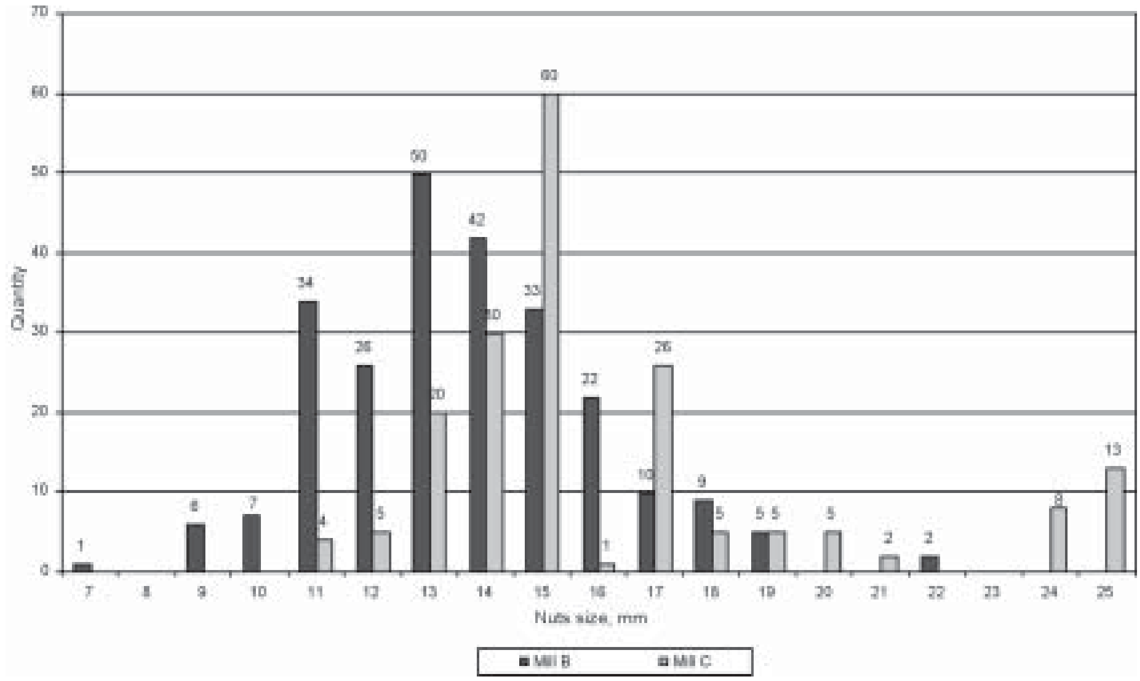



*Figure 5. Distribution of nuts size in Mills B and C.*

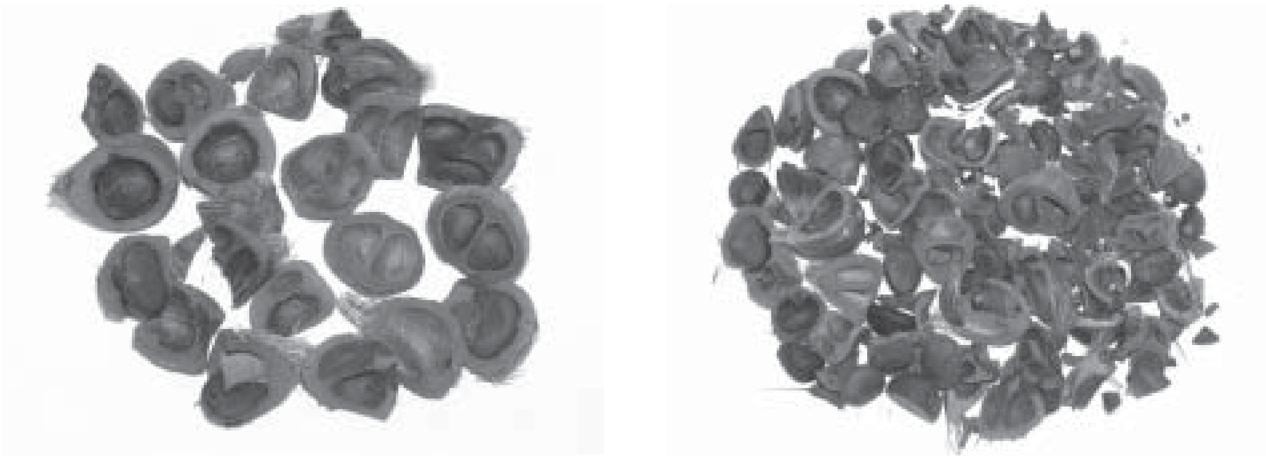


*Figure 6. Cross section of* dura *nut.*

**Cracking Efficiency and Cracked Mixture Analysis**

A summary of the cracker performance and cracked mixture composition for all mills are tabulated in *Table 1.* The cracking efficiencies of mills could hit 99%. The cracked mixture characteristics can be summarized as follows: whole kernel ranged from 25%-50%, broken kernel in the range of 8% to 10 %, uncracked and half cracked nuts were less than 1% and 2% respectively. Cracking performance, broken kernel and half cracked nut analysis by each mill is illustrated in *Figures 6* to *11*. All these data were consistent and achieved the targeted performance as shown in the *Table 1*. Any incremental change on each parameter, especially broken kernel and half cracked nuts would indicate wear, needing of replacement of parts such as inlet and body liner plate.

The low ratio of broken kernel combined with small and uniform size of shell fragments in the cracked mixture produced by Rolek promotes maximum separation of shell and kernel either in dry or wet separation. These premium conditions of cracked mixture also reduce the amount of kernel carried over with shell into the boiler and kernel losses during the separation process. The use of Rolek has also helped in eliminating the production of pulverized and powdered kernel usually produced by ripple mills, but not often detected by millers.

**TABLE 1. CRACKING PERFORMANCE AND CRACKED MIXTURE ANALYSIS RESULTS**

| **Parameter, %** | **Rolek** | | | **Typical ripple mill*** |
|---|---|---|---|---|
| | **Targeted performance** | **Mill A – *tenera*** | **Mills B & C - *dura*** | |
| Whole kernel | 25 - 50 | 40 – 50 | 25 – 35 | 30 - 32 |
| Broken kernel | < 10 | 8 – 10 | 9 – 10 | 15 - 25 |
| Uncracked nut | < 1.5 | 0.5 - 1.0 | 0.5 – 1.0 | 1.0 – 2.0 |
| Half cracked nut | < 2.0 | 1.0 – 2.0 | 1.0 - 1.5 | 1.0 – 3.0 |
| Shell (small & uniform) | - | 35 - 55 | 30 -45 | - |
| Big shell | - | - | 20 - 30 | - |
| Cracking efficiency | > 98 | 98 – 99 | 98 | 98 (pulverized kernel) |
| KER, % | - | 6.5 – 7.2 | 6.3 – 7.0 | 5.5 - 6.0 |

Notes: *Courtesy and source: Rohaya, M H and Osman, A (2002). The quality of Malaysian palm kernel: effect of shell and broken kernel on the quality of final products. KER-kernel extraction rate.

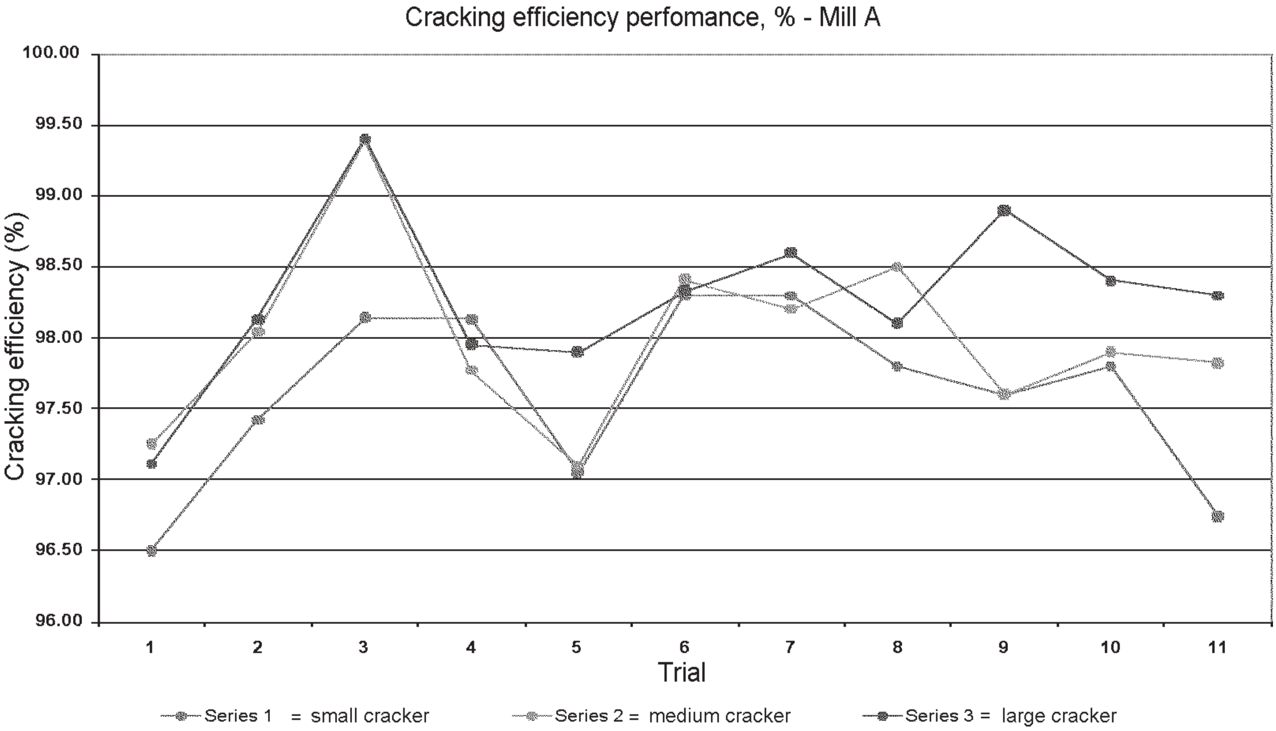



*Figure 6.Cracking performance by three units of Rolek in Mill A.*

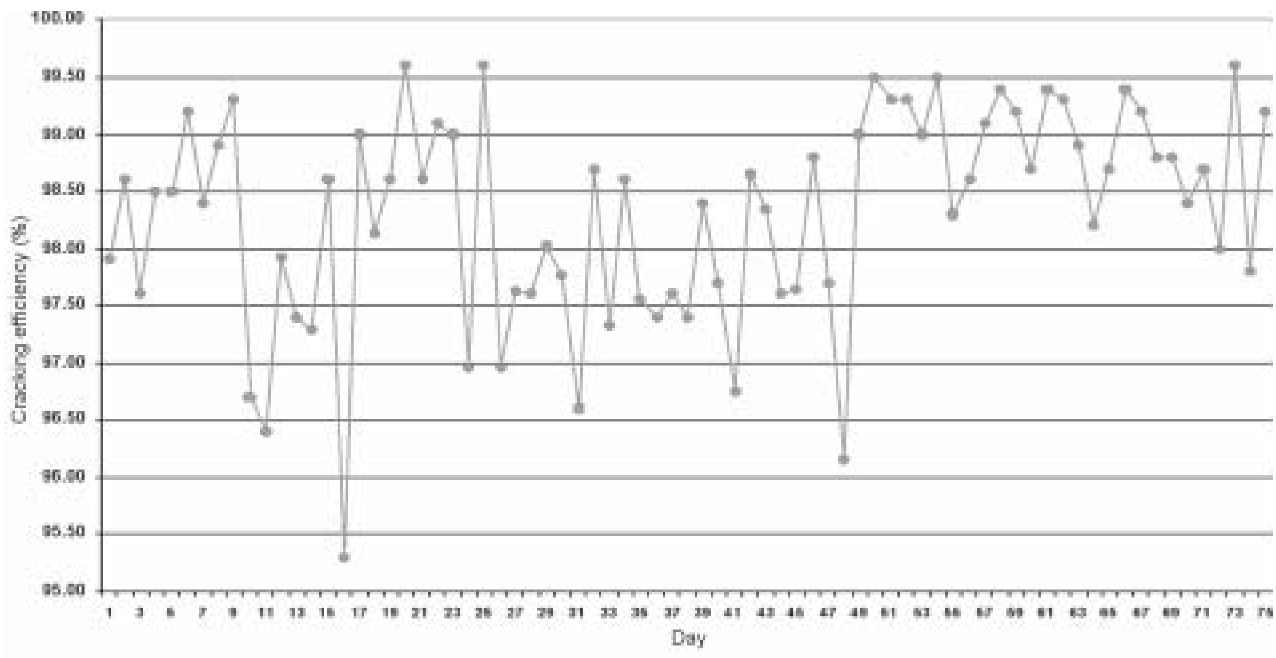



*Figure 7. Cracking performance in Mill B.*

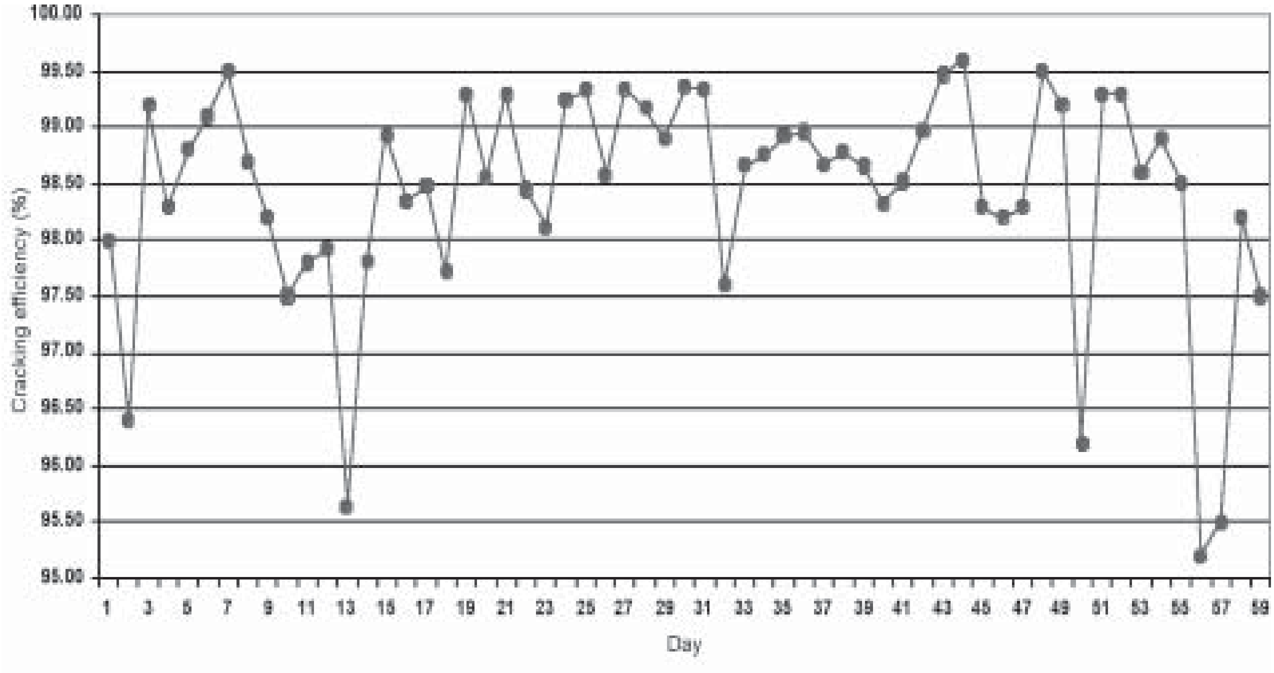



*Figure 8. Cracking performance in Mill C.*

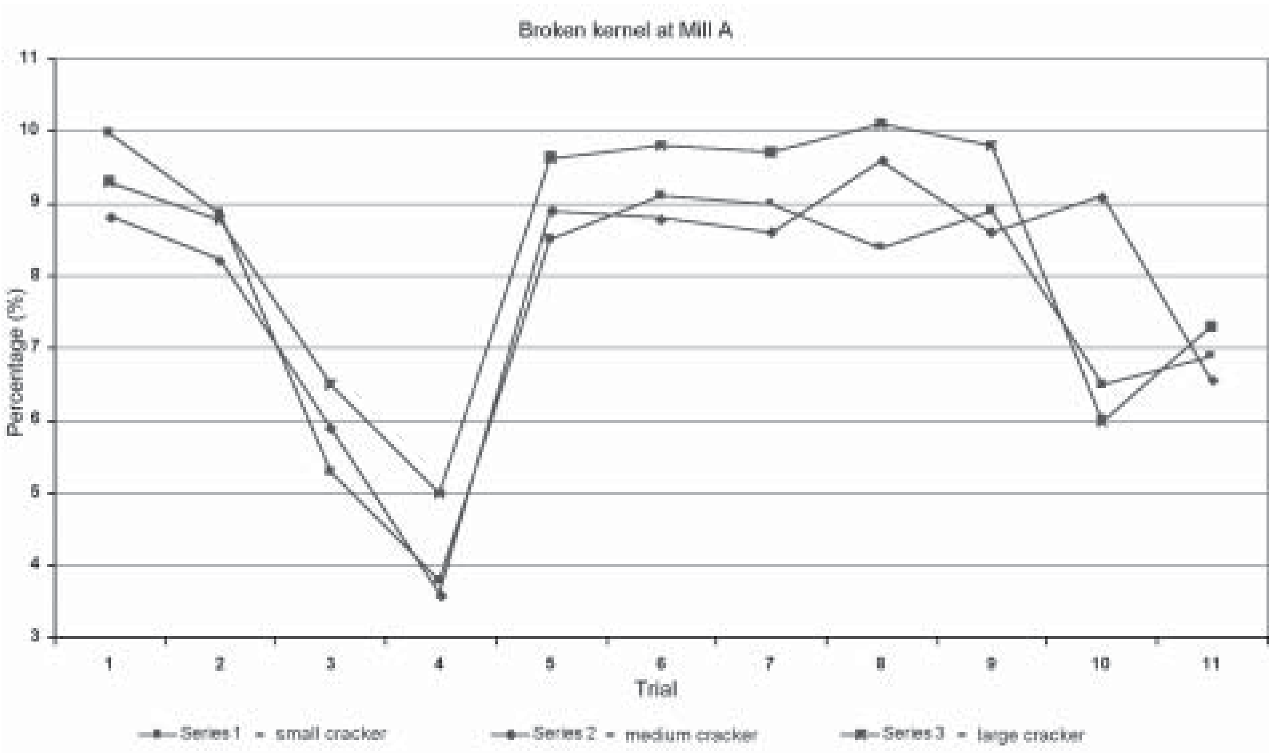



*Figure 9. Broken kernel in Mill A.*

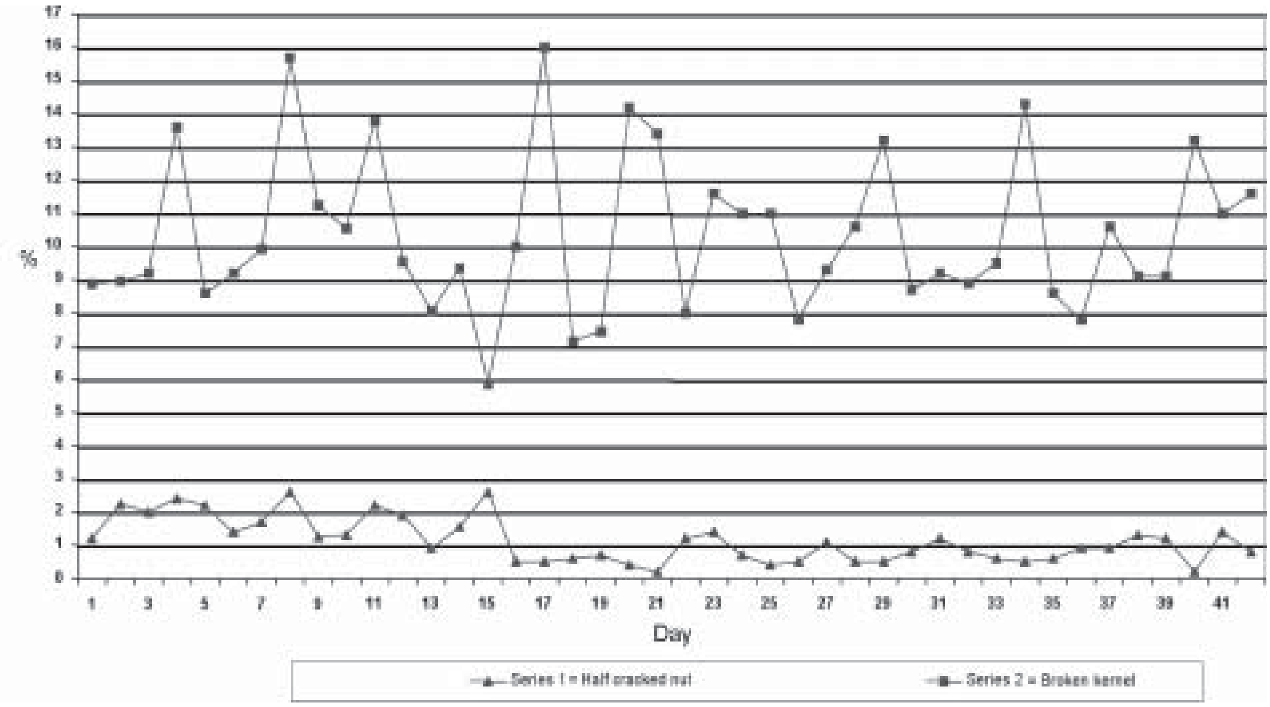



*Figure 10. Broken kernel and half cracked nut in Mill B.*

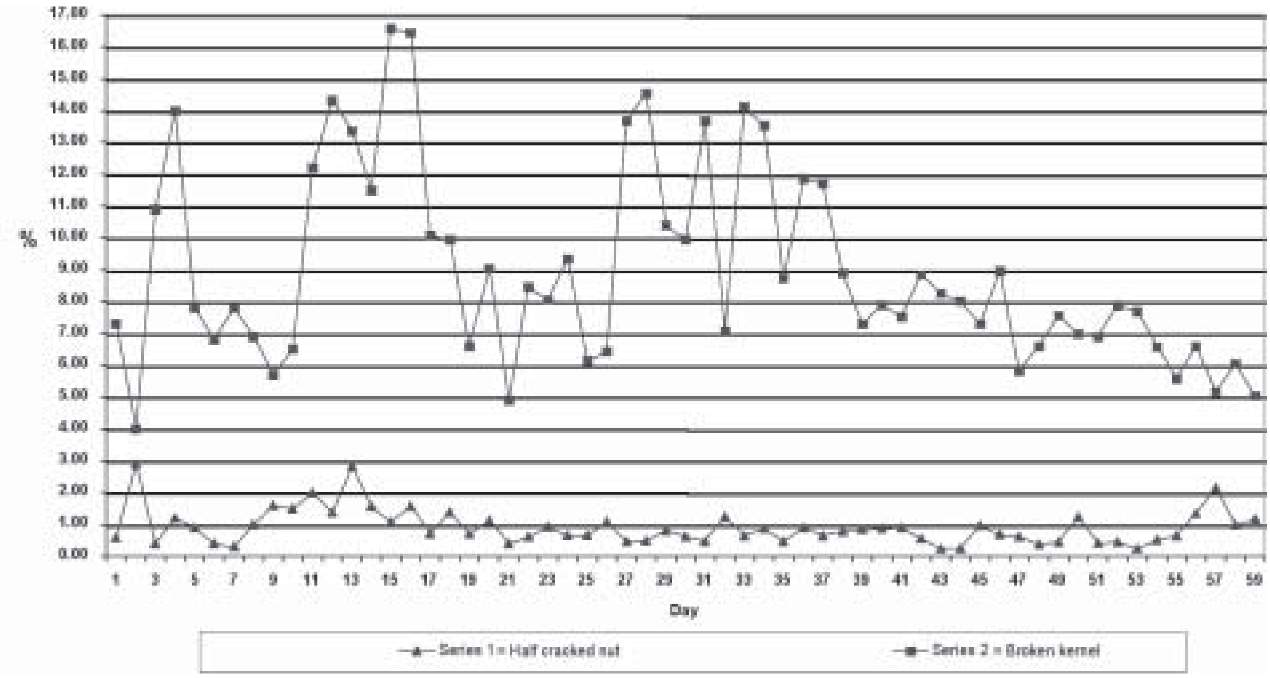



*Figure 11. Broken kernel and half cracked nut in Mill C.*

**Kernel Extraction Rate (KER)**

Cracking performance and efficient separation of kernel and shell play a significant role for obtaining high kernel recovery. The KER from mills involved have shown increasing and consistent trends after the installation of Rolek. KER of Mill A increased from 6.3% to 6.9% while Mill B increased their KER from 6.0% to 7.2%. The KER trend of Mill A was consistent at the beginning of the trial as there was no significance wear and tear of chute or sleeves that can affect to the overall performance due to processing *tenera* nuts. After the installation of three stages of winnowing column at Mill A, there was an increment of KER up to 7.2% as shown in *Figure 12*. Mill A has also achieved consistent KER for more than 700 operating hours, while Mill B was capable of maintaining high KER within the first 200 operating hours as show in *Figure 13*. KER of Mill B showed the tendency to drop after 200 hr due to wear and tear of the chute and the body liner but returned to original condition after parts replacement. The high rate of wear and tear of Rolek in Mill B is associated with the presence of high *dura* nuts in processed. Therefore, Mill B has higher frequency of parts replacement than Mill A. KER of Mill C was not presented in this paper as there was no significant improvement of its KER trend due to inefficient of the wet separation system (hydrocyclone).

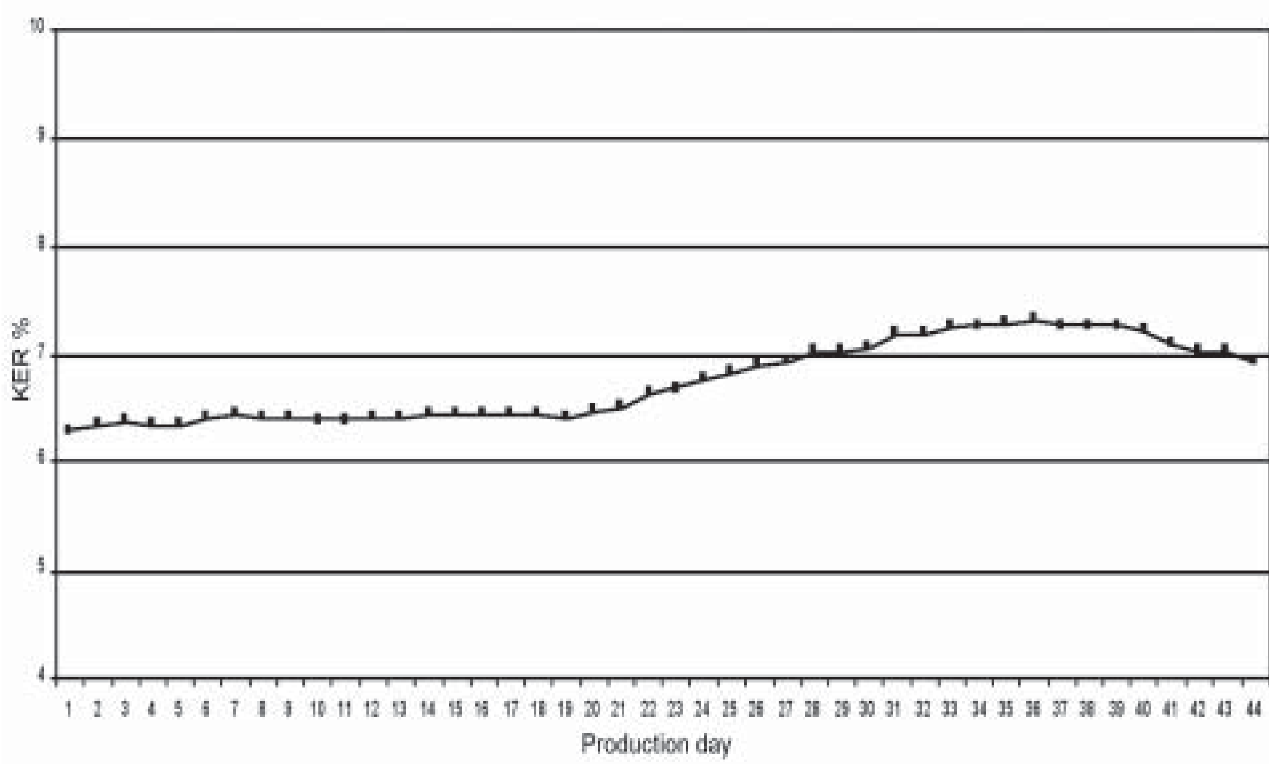



*Figure 12. Kernel extraction rate (KER) performance in Mill A.*

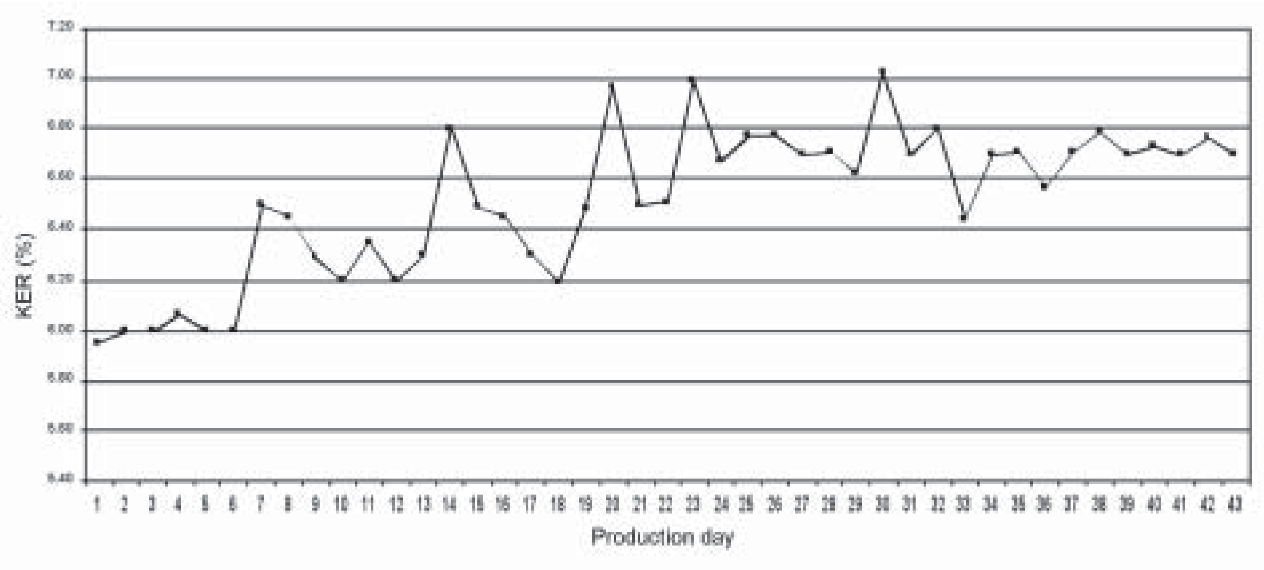



*Figure 13. Kernel extraction rate (KER) performance in Mill B.*

**Maintenance Cost**

The maintenance cost for both mills is presented in *Table 2*. The analysis shows that Mill A has lower maintenance cost than Mills B and C. The maintenance cost for Mill A was RM 0.05 $t^{-1}$ FFB while Mills B and C recorded about 0.07 $t^{-1}$ FFB. Lifetime of replacement parts for Rolek installed in Mill A was two times longer than for Mill B. High percentage of *dura* nuts in Mills B and C has contributed to the higher maintenance cost as the materials have to cater for bigger and harder nuts, causing an increase in the rate of wear of parts. However, the maintenance cost of Rolek is still considered low compared to other commercial nut crackers. The maintenance cost analysis for ripple mill is presented in *Table 3* for comparison**.**

Rolek promises low maintenance and need for less supervision. Most of the maintenance works involve parts replacement such as inlet chute and body liner, and carbon steel sleeves (*Figures 14a, b* and *c*). For mills that process 90% *tenera* nuts, there are two major parts replacements within 650 to 700 operating hours. It is recommended that the inlet chute replacement be done after the first 200 running hours followed by replacement of inlet chute and body liner and carbon sleeves after the next 500 running hours. However, for mills that process more than 25% of *dura* nuts, the operating hours for parts replacement are less than half of that of mills processing *tenera* nuts.

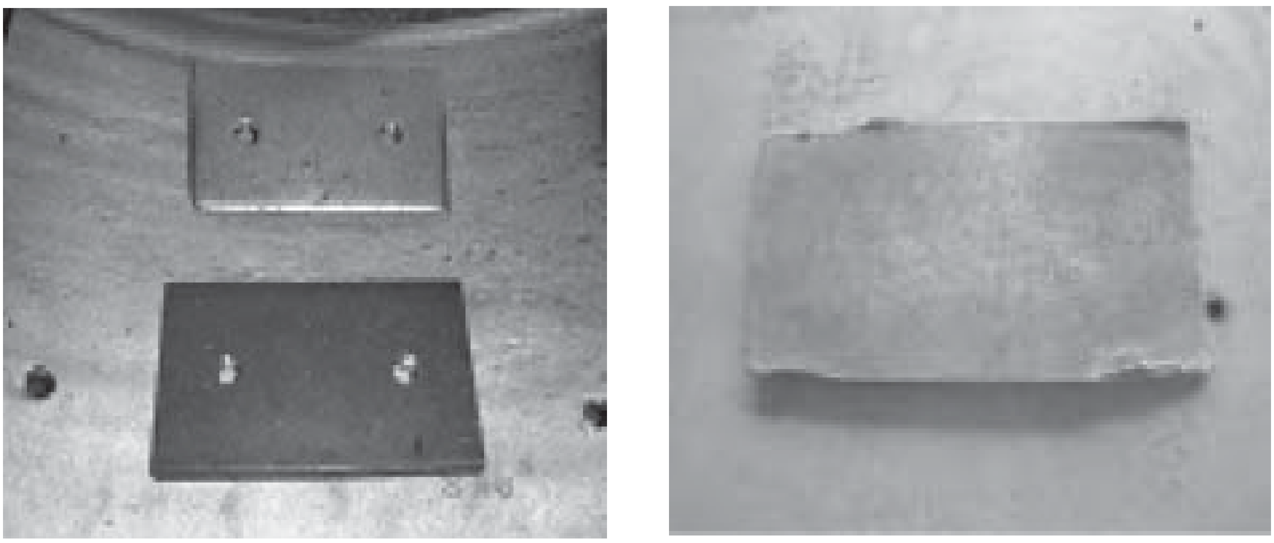


*Figure 14a. Inlet chute liner before and after 200 operating hours.*

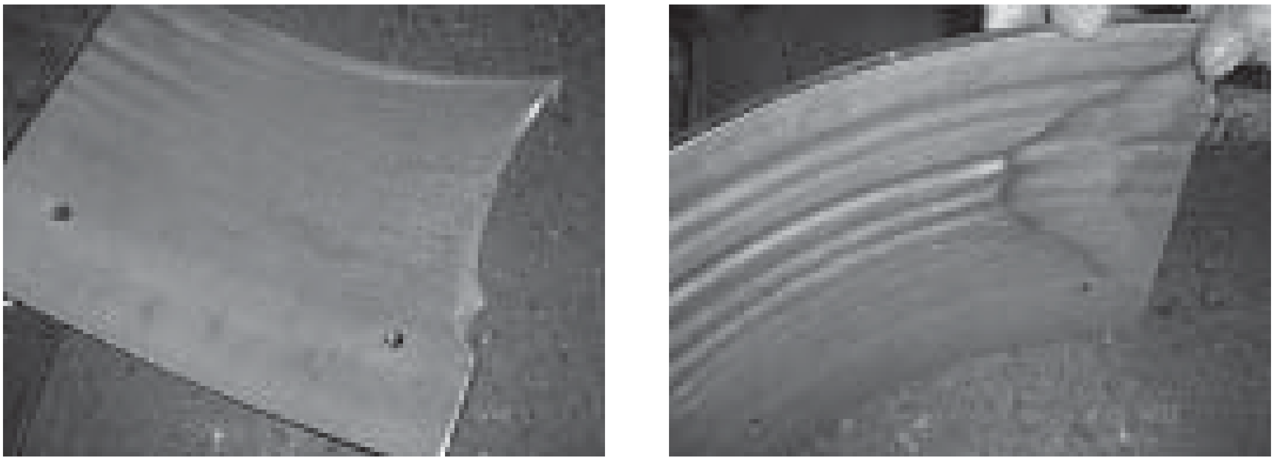


*Figure 14b. Body liner after 400 operating hours.*

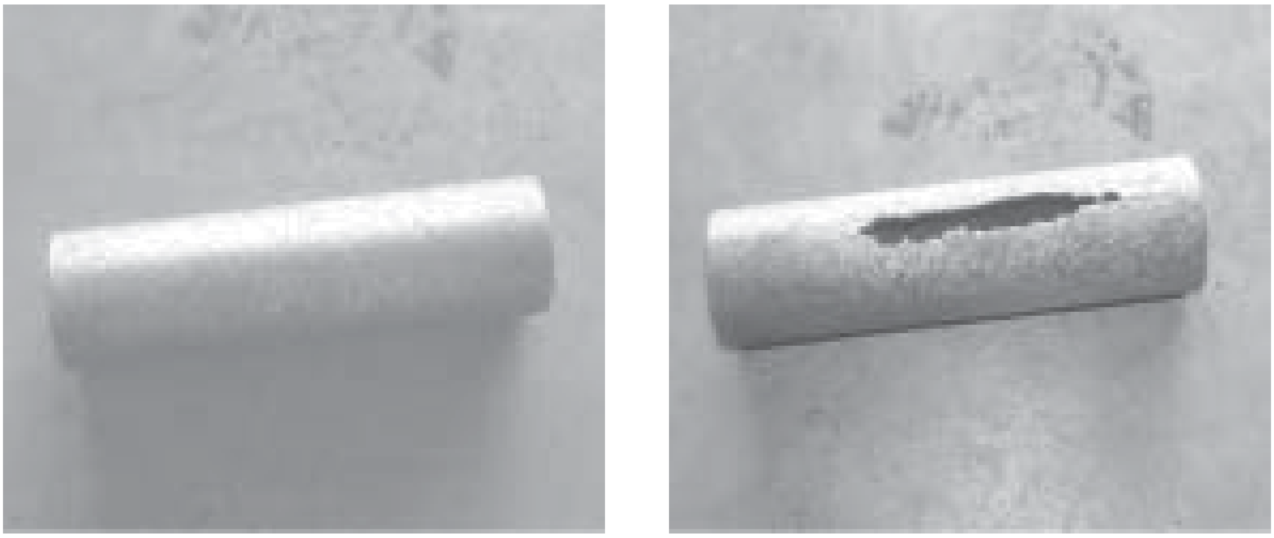


*Figure 14c. Wearing carbon sleeves after 700 operating hours.*

**TABLE 2. SUMMARY OF MAINTENANCE COST IN MILLS A, B AND C**

| **Mill A - *tenera* (13% to FFB Weight) - 3.2 t $hr^{-1}$ of nut processed** | | | **Mills B & C - *dura* ( 25%-50% of composition) (17 % to FFB weight) – 7.85 t $hr^{-1}$ of nut processed** | | |
|---|---|---|---|---|---|
| **Running, hr** | **Part replacement** | **Cost (RM)** | **Running, hr** | **Part replacement** | **Cost (RM)** |
| 1st 200 | Inlet chute liner | 19 | 1st 160 | Inlet chute liner | 19 |
| | | | | Body liner plate | 220 |
| Next 400 - 500 | Inlet chute liner | 19 | Next 220 | Inlet chute liner | 19 |
| | Body liner plate | 220 | | Body liner plate | 220 |
| | Carbon steel sleeves | 630 | | Carbon steel sleeves | 630 |
| Total (based on 650 hr) | | 888 | Total (based on 380 hr) | | 1 108 |
| Total FFB processed, t | | 16 000 | Total FFB processed, t | | 17 550 |
| Total maintenance cost, RM $t^{-1}$ FFB | | 0.056 | Total maintenance cost , RM $t^{-1}$ FFB | | 0.063 |

TABLE 3. SUMMARY OF MAINTENANCE COST FOR RIPPLE MILL IN MILLS B AND C

| Approach 1 Re-conditioned jaw plate | | | Approach 2 new jaw plate | | |
|---|---|---|---|---|---|
| Running, hr | Part replacement | Cost (RM) | Running, hr | Part replacement | Cost (RM) |
| 200 | 4 pieces of bar rod @ RM 156/unit | 624 | 200 | 4 pieces of bar rod @ RM 156/unit | 624 |
| | Re-con. jaw plate Hard facing electrode | 380 | 400 | New jaw plate Hard facing electrode | 1 200 |
| Total cost/2 weeks | | 1 004 | Total cost for bar rod, RM $mth^{-1}$ | | 1 248 |
| Total cost/month | | 2 008 | Overall cost, RM $mth^{-1}$ | | 2 448 |
| Total FFB processed, t | | 17 550 | Total FFB processed, t | | 17 550 |
| Total maintenance cost , RM $t^{-1}$ FFB | | 0.11 | Total maintenance cost , RM $t^{-1}$ FFB | | 0.14 |

To prolong the lifetime of replacement parts used in Rolek, it is recommended that the parts be fabricated using a hardened reclamation materials. The wear and tear due to impact and abrasion factors in Rolek can be reduced by adapting this technology and later extending the life span of these parts. Efforts have been taken by MPOB to implement the technology for the betterment of Rolek.

## OTHER BENEFITS OF ROLEK

### Saving of Electricity Requirement

The use of Rolek could reduce the power consumption in the kernel station. A study in Mill B shows that only a unit of 6 t $hr^{-1}$ Rolek is needed to process all nuts in the mill compared to the use of three units of ripple mills. As such, the electricity saved is from 33 kW to 11 kW by using Rolek. The use of Rolek for cracking multi-sizes of nuts also eliminates the use of nut grading drum and its conveyor in the kernel station. These also help millers to reduce their power consumption and maintenance cost.

### High Recovery of Dry Shell

Another significant advantage of Rolek is providing a supreme quality of cracked mixture that later promotes a maximum recovery of shell and fibre via dry separation system. The higher rate of shell recovery will facilitate a surplus quantity than required by boiler. With the rising of fossil fuels price recently, the surplus shell can be sold at a good price to other industries such as cement industry, brick factories and palm oil refinery.

## CONCLUSION

The introduction of Rolek palm nut cracker has in a way set a new and higher standard in palm kernel quality and extraction efficiency. Commercial Rolek machine has proven itself to be more efficient both in operation and economic terms. The simpler design enables easier maintenance that required low level of skill to carry out. This invented and patented nut cracker effects better quality on palm kernel expeller with minimal shell content which will enhance the Malaysian palm kernel world export market. Rolek is not a sole media for getting better KER but it facilitates mills to improve KER by providing excellent cracked mixture for dry separation. Therefore, mills should decide their own objectives of having Rolek, either for lower maintenance cost, easy maintenance or KER improvement. If KER being the main objective, other factors such as efficient dry separation through three stages winnowing column should also be considered. Overall, it provides the palm oil millers using Rolek cracker a better competitive edge.

## ACKNOWLEDGEMENT

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*Appendix 1*

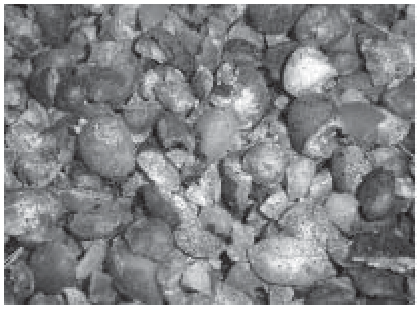
## Quality of products from Rolek and Ripple Mill

**RIPPLE MILL**

Whole kernel

Broken kernel

**ROLEK**



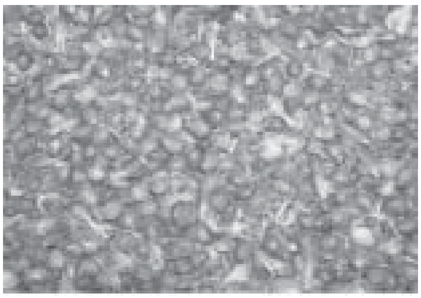
Whole kernel

Broken kernel

Shell fragment

Shell fragment (small & uniform)

Cracked mixture (pulverized kernel)



Cracked mixture