FFB Decoring Technology Revolutionizes Palm Oil Milling Process

Loh Tong Weng* and Loh Thim Thak**

ABSTRACT

The decoring technology (patented by Loh, T W) revolutionizes the decades’ old palm oil milling process by utilizing spikelets/loose fruits rather than fresh fruit bunch (FFB) as feedstock in the cooking/sterilization process. The decoring machine and bucket decoring conveyor remove the core of the FFB thus producing a mixture of loose fruits, spikelets, stalk fibre, debris of organic matters and loose sand, etc. The spikelets are mildly cooked continuously for separation of the loose fruits from the stalk. Clean loose fruits are then sterilized in a continuous sterilizer using steam of about 0.68 barg (10 psig) in less than 18 min. Empty fruit bunch (EFB) and sterilizer condensate are eliminated. The sterilized fruits are then fed into conventional digesters. The digested fruit mash is first washed by very hot water to get rid of much oil and sludge therein. The nuts are removed before the nut-free fibre is fed into a screw press. By so doing, additional oil can be recovered thus boosting oil extraction rate (OER). Elimination of EFB and sterilizer condensate also would increase OER for the industry and it is a significant monetary return for the country. The decoring technology also offers many other advantages and benefits such as saving more than 25% in capital cost in mill construction, lower operation and maintenance costs, lower power and steam consumption, and lower wastewater discharge. The oil-free stalk fibre and spikelets together with the excess press fibre are good source of organic materials for making compost, pulp and paper.

INTRODUCTION

For more than four decades, the palm oil industry has been the same using old machinery for processing. The only big change is that the screw presses have replaced the hand presses and hydraulic presses. Lately, there is several patented machinery introduced into the industry. They are the continuous sterilizer, vertical sterilizer, tilting sterilizer, fixed inclined sterilizer and continuous sterilizer using crushed FFB. The advantage of these innovative works is that the FFB cages, railway lines and related machinery are eliminated. This trend is indeed very encouraging.

FFB DECORING TECHNOLOGY

Figure 1 showed a flow diagram of the FFB decoring technology. The patented FFB decoring technology revolutionizes the palm oil milling process in that the bulky FFB is devoid of the main stalk (core) using...
a decoring machine producing a mixture of loose fruits, spikelets, debris of stalk fibre and other organic matters, and loose sand, etc. The main stalk fibre and other foreign materials are then removed by a vibrating bar grate. Only clean spikelets and fruits are further processed. As a result, a long list of machinery from the existing FFB hoppers to the fruit elevators before press station is made obsolete. Since clean fruits are processed, the de-sanding cyclones are not required anymore.

Each spikelet weighs from 80 g to 280 g whilst the FFB weighs from about 1 kg to 50 kg. This huge reduction in weight and size after decoring enables automation of the milling process a reality. The spikelets are continuously mild cooked in a mild cooker in order to detach the fruit from the stalk. The loose fruits obtained from the mild cooker are then sterilized continuously in a continuous sterilizer. The continuous mild cooking and sterilization of spikelets and fruits respectively ensure even cooking/sterilization of the fruits resulting in even desiccation in nuts. These nuts are therefore cracked with very high cracking efficiency. As a result, only dry pneumatic separation of the cracked mixture is sufficient. Hence, the hydro cyclones and clay baths are made redundant.

The fully sterilized fruits are continuously transferred from the sterilizer to the conventional digesters for digestion. There is no loss of condensate. The digested fruit mash is fed into a new washing system as shown in Figure 2 for reducing oil loss in press fibre instead of straight into the screw presses as is done in the conventional method of milling process. After washing and separation, only well-washed and nut-free fibre is fed into screw press for pressing. Since there is no nut present in the fibre, a much higher pressure can now be applied at the screw press resulting in better oil extraction and much reduced oil loss in the press fibre. As a result, the cake breaker conveyors (CBC), the pneumatic separation columns, fibre cyclone systems and the nut polishing depericarper drums are made redundant.

**FFB DECORING MACHINE**

The FFB decoring machine shown in Figure 3 removes the FFB main stalks by cutting it into stalk fibre with a rotating taper cutter. In the FFB decoring process, all the mud, debris and sand etc. adhering to the FFB are loosened up. The FFB <13 kg are decored in a bucket decoring conveyor while FFB >13 kg are decored by the FFB decoring machine.

*Figure 4* shows the decoring machine sizing and its principle. The decoring machine is a very simple machine. It comprises a set of FFB centre chutes, a set of centre cum feeding mechanisms and a taper cutter. The said centre chutes and feeding mechanisms are hinged at the top and spring loaded at the bottom.

The feeding chutes and centre cum feeding mechanisms can automatically adjust themselves to accept FFB of different sizes by the action of the springs.

All FFB > 13 kg automatically glide down the specially designed FFB feeding hoppers to the operators. These FFB are then manually directed into the opening of the centre chutes with stalk ends facing downwards. They fall down into the taper chutes first by gravity, and are then fed downward into the cutter by the feeding mechanisms. The taper shaped feeding chutes together with the spring loaded centre cum feeding mechanisms ensure that the FFB are firmly held while being decored. The centre of the FFB stalks and the cutter spike coincides perfectly bunch after bunch, without missing any. The cutter spike works like a centre drill. When it is already in the stalk, it helps to hold the FFB in position while decoring is in progress. The decoring time for each bunch is very short as the taper cutter is very sharp and spinning at high speed of about 2000 rpm.
Figure 1. Fresh fruit bunch (FFB) decoring technology flow diagram.

Legend:
1. Fresh Fruit Bunches (FFB)
2. FFB Ramp
3. FFB feeding hoppers
4. FFB decoring machine
5. Operator
6. Decored mixture conveyor
7. Sorting belt conveyor
8. Vibrating bar grate
9. Spikelet + some fruits
10. Conveyor for stalk fibre + debris
11. Totally Enclosed Screw Conveyor (TESC) for mild cooker
12. Vibrating perforated plate
13. Fruit conveyor
14. Empty spikelet
15. Sterilizer inlet augur conveyor
16. TESC for sterilizer
17. Sterilized fruits
18. Sterilizer outlet augur conveyor
19. Gate valve

Figure 2. System for reducing oil loss in fibre.
Figure 5 shows the results of decoring FFB. They are some loose fruits, spikelets, stalk fibre, debris and loose sands, etc. Note that the fruits are shining and not damaged by the decoring process at all.

**DECORING MACHINE THROUGHPUT**

Though the FFB feeding is semi-manually directed, each FFB decoring machine can decore at least 12 t hr⁻¹ FFB as shown in Table 1.

As the FFB decoring machine and the bucket decoring conveyor are modular in nature, any mill designed throughput can be met as shown in Table 2.

Note that the FFB decoring throughput can be increased further by at least some 20% to meet the requirement of the industry by increasing the speed of the feeding mechanisms and the speed of the decoring taper cutter. Contract workers feeding FFB into the decoring machines with attractive contract rates is ideal to achieve consistently high decoring throughput.

**FFB DECORING STATION**

Multiple units of decoring machine can be installed depending on the mill capacity (Figure 6). The stopper weights control the flow of FFB to the operator feeding area. Each operator controls the feeding to the two machines located on either sides of him.

The main stalk fibre and foreign materials drop through the gaps of the bar grate leaving clean spikelets and some fruits are fed into the continuous mild cooker for processing.

After decoring, a mixture of main stalk fibre, spikelets, some fruits, foreign materials such as debris and sand, etc. is conveyed to a sorting belt where the said mixture is inspected. Any abnormal decored results are rectified. When they drop onto a vibrating bar grate where the contaminants are separated. The bar gaps are designed smaller than the smallest fruits. At the vibrating bar grate, stalk fibre and foreign materials are removed leaving only clean spikelets and loose fruits for further processing.
BUCKET DECORING CONVEYOR

*Figure 7 shows the conveyor used to decore the cannon ball types FFB. These FFB are non-directional as far as the main stalk is concerned. The cannon ball FFB are first manually placed into the buckets with the stalk ends facing upwards and are manually decored by a hand drill fitted with a taper cutter.*

CONTINUOUS MILD COOKER

The spikelets plus some fruits are fed into the continuous mild cooker shown in *Figure 8*. The cooker is made of several flights of
TABLE 1. DECORING MACHINE PRODUCTION THROUGHPUT

<table>
<thead>
<tr>
<th>Average bunch weight (kg)</th>
<th>Decoring time/bunch (s)</th>
<th>Decoring throughput (t hr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>4</td>
<td>13.50</td>
</tr>
<tr>
<td>18</td>
<td>5</td>
<td>12.96</td>
</tr>
<tr>
<td>23</td>
<td>7</td>
<td>11.83</td>
</tr>
<tr>
<td>30</td>
<td>8</td>
<td>13.50</td>
</tr>
<tr>
<td>35</td>
<td>9</td>
<td>14.00</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
<td>14.40</td>
</tr>
<tr>
<td>45</td>
<td>11</td>
<td>14.73</td>
</tr>
<tr>
<td>50</td>
<td>12</td>
<td>15.00</td>
</tr>
</tbody>
</table>

Note: Average throughput may be taken as 12.00 t hr⁻¹.

TABLE 2. INSTALLED CAPACITY OF DECORING MACHINE

<table>
<thead>
<tr>
<th>No. of decoring machine</th>
<th>Mill throughput (t hr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>72</td>
</tr>
<tr>
<td>7</td>
<td>84</td>
</tr>
<tr>
<td>8</td>
<td>96</td>
</tr>
<tr>
<td>9</td>
<td>110</td>
</tr>
<tr>
<td>10</td>
<td>120</td>
</tr>
<tr>
<td>15</td>
<td>180</td>
</tr>
<tr>
<td>20</td>
<td>240</td>
</tr>
</tbody>
</table>
Figure 6. Fresh fruit bunch (FFB) decoring station.

Figure 7. Decoring conveyor for cannon ball fresh fruit bunch (FFB).
totally enclosed screw conveyor (TESC) connected in series. Atmospheric steam is admitted into this mild cooker. Two units of sluice valve are installed, one at inlet and one at outlet of the cooker for containing the steam at atmospheric pressure.

The mild cooking time is about 15 min. The wet heat of the steam will change the characteristics of the plant natural gum (lignin) so that the fruits detach from the spikelets easily. The empty spikelets are separated from the fruits by a vibrating perforated plate shown in Figure 9. With proper control of the cooking time, there is no oil oozing out from the fruits in this cooker. Only the fruits are collected for sterilization. The TECS are designed to have sufficient steam chest above the screw of the TESC so that all TESC have ample steam supply.

**CONTINUOUS STERILIZING STERILIZER**

The fruits are fed into this sterilizer. This sterilizer comprises one set of steam pressure locking device of a taper gate valve and augur conveyor at inlet, several units of TESC, one set of steam pressure locking device of an augur conveyor and a taper gate at outlet.

The continuous sterilizer shown in Figure 10 consists of multiple flights of TESC connected in series. Steam at about 0.68 barg (10 psig) is admitted to this sterilizer. The sterilizing time is <18 min. The sterilization time versus steam temperature/pressures are given in Figure 11. At the outlet, the sterilized fruits are elevated and discharged into the distribution conveyor over digesters via a two-stage augur conveyor. The design and construction of the TESC in this sterilizer is similar to that used in the mild cooker.

**SYSTEM REDUCING OIL LOSS IN PRESS FIBRE**

The system for reducing oil loss in press fibre is as shown in Figure 2. For every 100 t FFB processed, the mash passing through digesters (MPD) is about 75 t. This is fairly constant. After digestion, the quantity of digested fruit mash remains at 75 t. It

*see page 41*
Ad
Szetech Engineering Sdn Bhd
(Page 1 of centrefold)
Ad
Muar Ban Lee Engineering Sdn Bhd
(Page 2 of centrefold)
Ad
Muar Ban Lee Engineering Sdn Bhd
(Page 3 of centrefold)
Ad
Modipalm Engineering Sdn Bhd
(Page 4 of centrefold)
Figure 9. Vibrating perforated plate separating fruits and empty spikelets.

Figure 10. Continuous sterilizer.
consists of solid phase of 24 t and liquid phase of 51 t. In the solid phase, there are the nuts (12 t) and fibre (12 t). In the liquid phase, there are crude oil (23 t) and sludge (28 t). The solid phases are fairly consistent. However, the liquid phases could vary quite widely between them due to weather conditions and other agro-factors. This is evident by the wide fluctuations of oil extraction rate (OER) throughout the years.

In the conventional mills, the digested fruit mash containing crude oil, sludge, fibre and nuts is pressed. The pressing pressure is limited in order to avoid nut breakage. It makes real good sense to first remove the crude oil, sludge and nuts leaving only the nut-free fibre to be fed into the press for high pressure pressing.

In this patented system, the digested fruit mash is first washed by very hot water to drain much of the crude oil and sludge therein. The washing is done in a washing conveyor. The diluted crude oil is filtered and collected in a crude oil tank. The feed rate of digested fruit mash into the washing conveyor is controlled by a sluice valve. After washing, a mixture of nuts and fibre is obtained. The fibre is separated from nuts by a vibrating separator. The fibre drops onto a vibrating screen. The nuts are conveyed to the nut station by a steam jacketed nut conveyor. The already evenly desiccated nuts are further dried to obtain the best cracking efficiency. Washing continues at the vibrating separator and the vibrating screen. The diluted crude oil from the vibrating screen is collected/stored in the crude oil tank. The well-washed nut-free fibre is fed into a screw press. At the screw press, very high pressing pressure is applied to press out as much residue oil in the fibre as possible. The diluted crude oil from the screw press is collected/filtered and stored in the crude oil tank. From time to time, the diluted crude oil is pumped to the clarification for further processing. The very hot water used for washing can be well-regulated so that the clarification of diluted crude oil is at the optimal level.

By so doing, the existing oil loss of about 6.5% may be reduced to below 2% on fibre
sample. The reduction of 4.5% oil loss in fibre can be translated to 0.54% OER gain.

ADVANTAGES AND BENEFITS OF DECORING TECHNOLOGY

Extra Electrical Power Output

Now the boiler pressure of 20.41 barg (300 psig) can be expanded to 0.68 barg (10 psig) instead of the current exhaust pressure of 3.06 barg (45 psig) using condensing steam turbines generators. The enthalpy at 0.68 barg is much lower than that at 3.06 barg. Therefore more electrical power output per kg steam is achieved.

Lower Noise Level in Mills

There will not be anymore frequent steam blow-offs from the conventional sterilizers, vertical sterilizers, fixed incline sterilizers and tilting sterilizers as these sterilizers will not be in use. Also, the CBC, the pneumatic separation columns, fibre cyclone systems and the nut polishing depericarper drums will not be in use. The said machinery have a noise levels ranging from 75 dB to 110 dB. As a result, the noise level in the mills will also be reduced. The mill workers will be more comfortable working in the reduced noise environment.

Nut Desiccation

The TECS allows good steam penetration and mixing in the process of mild cooking and sterilization of spikelets and fruits respectively. This ensures that the fruits and nuts will be evenly cooked and sterilized. The sterilization conditions will not be severe and the sterilization time will be shortened. As a result, all nuts will have the same degree of mild desiccation. After further nut conditioning in the steam jacketed nut conveyor, optimal desiccation in nuts will be achieved. As a result, nut cracking efficiency will be high. There would be negligible or nil broken kernel and hence dry pneumatic separation of the cracked mixture is sufficient. Hydro cyclones and clay baths will not be required anymore.

In comparison, the sterilization of assorted sizes of FFB plus dirt in the conventional sterilizers, vertical sterilizers, tilting sterilizers and fixed incline sterilizers, the small FFB and the outer layers of large FFB are over-sterilized whilst the inner layers of large FFB are under-sterilized. This is because the steam pressure for sterilization is high at 3.06 barg (45 psig) and the batch-cycle time is long from 70 min to 90 min. This has resulted in very uneven desiccation in nuts. Further nut drying aggravates the problems in that the kernel in over-desiccated nuts is brittle giving rise to a lot of fragments of broken kernel after cracking.

Elimination of EFB and Sterilizer Condensate

The FFB decoring machine and decoring bucket conveyor remove the main stalks of the FFB. In the decoring process, the mud, debris, and sand, etc. adhering to the FFB have been loosened up and removed. After mild cooking of the spikelets, the fruits and empty spikelets are separated. The non-oil bearing materials such as main stalk fibre, empty spikelets, debris and sand, etc. are removed before actual sterilization takes place.

Besides attractive monetary returns, there are other attractive benefits which include the followings:

- a long list of machinery from the FFB hoppers to the fruit elevators before the press station have been made obsolete leading to a reduction in capital cost for a new mill by about 25%;
- only nut-free fibre is fed to the press, hence a reduction of the pressing capacity of about two-thirds of the conventional one;
- the nuts are separated from fibre before pressing. Hence, induced nut breakage...
is avoided. This can improve kernel extraction rate (KER) although marginally. As a result, the cake breaker conveyors, pneumatic separation columns, nut polishing depericarper drums and fibre cyclone systems are not required anymore resulting in huge power saving here;

• clean and sand-free fruits are processed, hence, de-sanding cyclones are made redundant.
• the nuts are evenly desiccated resulting in good cracking efficiency. Dry pneumatic separation of cracked mixture is sufficient. Thus, hydro cyclones and clay baths are made redundant;
• the continuous mild cooker and the continuous sterilizer are of screw conveyor type of much lighter construction. Thus, they cost less than the conventional sterilizers and other types of sterilizers;
• screw conveyors are used in place of roller chain conveyors in many areas. Overall, the mills can be made much smaller in size;
• removing mud, debris and sand, etc. adhering to FFB resulting clean fruits are processed resulting lower wear and tear to machinery parts. Hitherto cleaning FFB is impossible. As a result, an estimated reduction in the maintenance cost of RM 1 t\(^{-1}\) FFB processed could be achieved;
• no more oily EFB and sterilizer condensate. Much lower POME production is achieved. This would lead to the implementation of a zero discharge of treated effluent into river system for mills more feasible. Therefore, the mills can become more environmental-friendly;
• semi-manual FFB feeding can be replaced by robotic feeding easily, resulting in fully automatic milling process is achieved thereby reducing manpower requirement substantially;
• lower steam consumption and lower electrical power requirements. Electrical power reduction at press station alone is estimated to be 160 kW for a 60 t hr\(^{-1}\) mill. There will be a saving in biomass fuels which can be sold off for additional monetary gain;
• boiler pressure can be easily maintained as there is no sudden surge of demand of steam. This can result in less black smoking emission at the boiler chimneys;
• spikelets/fruits can be sterilized in conventional sterilizers, vertical sterilizers, tilting sterilizers, fixed inclined sterilizers and continuous sterilizers to improve mill throughput and product quality; and
• no more noise pollution in mills.

**CURRENT STATUS**

The response from the industry is extremely encouraging. Several units of commercial-stage FFB decoring machine are in the market performing demonstrations for the interested parties. FFB decoring demonstrations have generated positive reactions. It is anticipated that a 30 t hr\(^{-1}\) processing line based on the revolutionary FFB decoring technology and inventions mentioned herein will be added to the existing mill in near future.

The decoring technology and inventions herein mentioned can be readily retrofitted into existing mills. Figure 12 shows how part of the existing FFB hoppers can be modified to feed FFB into the decoring machines. The system of reducing oil loss in press fibre can be installed underneath the existing press platform which can be dismantled or retained. All screw presses are to be relocated to a level below the existing press platform. Only about one-third of the pressing capacity of the conventional one is required by the said system.

The foot prints of the revolutionary milling processing line of 40 t hr\(^{-1}\) are narrow at about 3.5 m wide by 55 m long from FFB feeding hoppers to press station. Therefore this 40 t hr\(^{-1}\) milling processing line can be installed in most of the mills.
A new main mill building of 8 m width x 60 m length will be able to house 2 x 40 t hr⁻¹ lines. All the machinery in the processing lines is cheap.

**CONCLUSION**

The palm oil industry seems to have reached a crossroad where it must make major improvements in order to enhance its sustainability. It therefore requires major paradigm shift in mentality and innovations to achieve this goal. Many industrial players are innovative to come up with novel ideas in milling process such as the various types of sterilizers. However, thus far, these innovations have brought about only incremental improvements.

The FFB decoring technology and inventions mentioned herein are think-out-of-the-box inventions. Both the FFB decoring machine and the bucket decoring conveyor are proven machinery. The continuous mild cooker, continuous sterilizer and the system reducing oil loss in press fibre are made of or assembly of proven machinery components in use for decades. They are therefore expected to work well without doubt.

The decoring technology and inventions mentioned herein can provide many advantages over the current milling process. In addition it can bring in many benefits to the millers. It can also provide increased OER to some extent. The payback on investment (POI) is therefore extremely short.

**SUMMARY OF KEY BENEFITS**

**Benefits**

- Gain extra OER;
- Better oil quality;
- Lower plant capital cost, lower operation and maintenance costs;
- Continuous and fully automatic milling process is achieved;
- Lower energy consumption and lower POME production;
- More biomass can be saved;
- Possibility of zero discharge of treated effluent into river more;
- Mills are more environmental-friendly;
- Spikelets/fruits can be sterilized in conventional sterilizers, vertical sterilizers, tilting sterilizers, fixed incline sterilizers and continuous sterilizers to improve mill throughput and product quality; and
- Less noise pollution in mills.