The increasing number of applications from the industry for conducting the Code of Practice (CoP) milling audits in their mills is indeed commendable and a healthy sign as far as the marketability of our palm products are concerned. Our level of readiness for conducting audits is also satisfactory even though there is a severe shortage of competent auditors in MPOB. Despite that during our Phase II audit within three months after the Phase I audit, the mills we audited have displayed tremendous transformation to the delight of the auditors as well as the mill management and in all the cases cost was not an issue at all. The recent amendment to the USA FDA by-law came at the right time. It stipulates that all palm products entering USA must be certified.

Many mills have the wrong perception that to prepare a mill for CoP audit they have to invest a lot of money. This is simply a false notion. What they do not realise is that all mills already have many of the built-in ingredients for CoP conformity. There are calibrations of weighbridge, documentation of transactions, regulatory compliance, licenses, oil and kernel dispatch procedures, etc. In fact, probably all mills have 80% to 90% of the requirements. What may be missing are documentation of certain activities that they take it for granted like training workers, cleaning of mill machinery and compound, among others.

One glaring defect is clogged drains in almost all mills, missing lighting covers and unhygienic kernel storage system. The kernel should never be stored on floors without cover as rats and other pests can contaminate
them with their droppings. Likewise no hydrocarbon lubricant is allowed to contaminate palm products. This can happen if the drive motor gearbox of a fruit elevator is located directly above it.

In some cases, mills do not have a standard operating procedure (SOP). This will entail non conformance. So it is best to get all things ready before inviting the auditors for auditing. This is something easy to create as it is based on the exact way a job is performed whether during operation or maintenance. The best person to carry out this job is the mill process supervisor.

To put it in a nutshell, to ensure that the palm products are safe for consumption, conform to set quality standards and the broadest of them all satisfies the requirement on sustainability.

CALL FOR ARTICLES

Personnel of the palm oil mills are invited to send in articles of relevance to the palm oil industry in Malaysia for publication in Palm Oil Engineering Bulletin. By sharing your expertise you will be helping the industry and the nation as a whole. The topics of interest are:

1. Plant modifications done in your mill that resulted in improvements in milling operation or maintenance.

2. Innovations done in your mill that produced improvements in the operation of the mill and that you are willing to share them with others.

3. Any special work done in your mill that directly resulted in improvements in OER and product quality.

Please submit your article to us and we shall be pleased to publish them in Palm Oil Engineering Bulletin. Feel proud to have your articles published in this Bulletin that is circulated throughout the industry and MPOB offices worldwide.
Recent Events

Contributed by: Noor Asmawati Abd Samad*

PAC Meeting

The 31st Programme Advisory Committee (PAC) meeting was held on 4 - 8 April 2011 at MPOB Head Office, Bangi. This annual event enables the research activities of MPOB to be scrutinised by an external body comprising professionals, who are experts in their respective fields. This is to ensure that projects are technically sound and are in line with the needs of the industry and country.

During the PAC meeting, Dato’ Seri Utama Shahrir Abdul Samad, the Chairman of MPOB, also hosted a dinner for the PAC members. On the final day, the PAC members were taken to visit the Sime Darby Biodiesel Plant at Carey Island, Banting, Selangor.

PAC Seminar

More than 300 participants attended a half-day seminar held in conjunction with the 31st PAC meeting at Dewan Bactris, MPOB Head Office on 7 April 2011.

The Seminar was held in six sessions, as follows:

• Seminar 1: Development of High Yielding Varieties of Rice: Reflections on Oil Palm Breeding by Gurdev S Khush, University of California, USA;
• Seminar 2: Development of Next Generations of Biofuels: Issues, Sustainability and Global Challenges by Stanislav Miertus, International Centre of Applied Research and Sustainable Technologies, Slovakia;

* Malaysian Palm Oil Board, P. O. Box 10620, 50720 Kuala Lumpur, Malaysia.
Recent Events

- Seminar 3: Formulating for Stability: How an Oil Spill in the Gulf of Mexico Helps the Cosmetic Industry to Create Greener Formulations by Johann W Wiechers, JW Solutions, The Netherlands;
- Seminar 4: Saturated Fat Reduction in Food Products by Kevin Warren Smith, Fat Science Consulting Ltd, United Kingdom;
- Seminar 5: Global Economic Scenario and its Impact on Commodity Prices by Zakiah Abdul Rashid, Malaysian Economic Research, Malaysia; and
- Seminar 6: Comparing the Experience of the Malaysian and Indonesian Oil Palm Sectors over the Past Years by James Fry, LMC International Ltd, United Kingdom.

The Seminar was held to disseminate and gain knowledge on the latest developments in the palm oil industry.

Dialogue between MPOB Chairman and Smallholders

MPOB organised dialogue sessions between Dato’ Seri Utama Shahrir Abdul Samad, Chairman of MPOB, and smallholders in April this year, in various places in Sarawak namely Sadong Jaya, Betong, Batu Niah and Bekenu.

In his opening address to the smallholders, Dato’ Shahrir encouraged them to adopt new technologies and practice good agricultural practices to gain a higher income thus reinforcing the government’s efforts to make Malaysia a high income nation through the Economic Transformation Programme (ETP) by the year 2020.

He said the government has identified the palm oil sector as one of the catalyst in the National Key Economic Areas (NKEA) with the introduction of eight Entry Point Projects (EPP) covering upstream sector which would concentrate on increased productivity while the downstream sector would focus on added value products in the industry.

To encourage the smallholders to increase the oil palm productivity, the government has implemented the palm oil replanting scheme which encourages replacement of old palms with new ones. The scheme offers RM 7000 per hectare to the smallholders for implementing the replanting exercise.

Licensing of Palm Oil Transporter

From March 2011, MPOB has introduced a new ruling that makes it mandatory for palm oil tankers and their prime mover to obtain a license from MPOB to ensure the safety of palm oil and eventually its downstream products during transportation. Tan Sri Bernard Dompok, Minister of Plantation Industries and Commodities, officially launched the Licensing of Palm Oil Transporter at Port Klang, Selangor on 18 April 2011.
Recent Events

This is to ensure that the palm oil supply chain will not be compromised during palm oil transportation in terms of food safety. Strict action will be taken against anyone found violating food safety regulations leading to activities such as adulteration of palm oil that can affect the quality of the palm oil.

To address this problem, the ministry and MPOB has already implemented a new system of locating the palm oil transporter using the global positioning system (GPS). It is hoped that with this new system, all the tankers’ movement can be monitored as they move from the mills to their respective destinations without having to be concerned about any illegal activities. Till the end of 2010, 39 cases of illegal transfer of palm oil has been reported involving 252.7 t of palm oil worth about RM 674 000.

PLASMA Keratong

MPOB’s Pusat Latihan Industri Sawit (PLASMA) at Keratong was officially launched by Tan Sri Bernard Dompok, Minister of Plantation Industries and Commodities, on 26 April 2011. PLASMA is an institution that will train local skilled workers in the plantation sector emphasising on the maintenance and operating procedure of farm mechanisation.

PLASMA Keratong is the second campus developed by MPOB after PLASMA Lahad Datu which became operational in 2006. With a cost of RM 36 million, PLASMA Keratong’s main campus can cater up to 100 trainees at one time and has facilities such as an administration block, assembly hall, lecture block, mechanisation workshop, hostel and numerous facilities related to the palm oil industry.

Tan Sri Bernard hoped that with the introduction of oil palm plantation courses at PLASMA, the local youth will take up this opportunity to gain knowledge and expertise in the plantation sector.

The Minister also expects the local people will replace the majority of foreign workers working in the palm oil plantation sector by the year 2020.

Besides Tan Sri Bernard, the event was also attended by Senator Dato’ Maznah Mazlan, Deputy Minister of Human Resource; Dato’ Seri Utama Shahrir Abdul Samad, Chairman of MPOB; Datin Paduka Nurmala Abdul Rahim, Secretary General of the Ministry of Plantation Industries and Commodities, as well as Datuk Dr Choo Yuen May, Director-General of MPOB.
Launching of Sixth and Seventh Sustainable Palm Oil Co-operative

Tan Sri Bernard Dompok, Minister of Plantation Industries and Commodities, launched the Kuala Selangor Selatan Sustainable Palm Oil Co-operative at Kuala Selangor, Selangor on 10 May 2011. Dato’ Seri Utama Shahrir Abdul Samad, Chairman of MPOB, and Tuan Haji Idris Omar, Director of Integration Research and Extension Division of MPOB, also attended the occasion.

This is the sixth co-operative launched by MPOB after the launching of co-operative in Tongod and Kunak at Sabah, Saratok at Sarawak, Jasin at Melaka and Kluang at Johor.

The Minister of Plantation Industries and Commodities, also launched the seventh co-operative at the Beluran Sustainable Palm Oil Co-operative at Kg Toniting, Beluran, Sabah on 27 June 2011. Datuk Dr Choo Yuen May, Director-General of MPOB, and Tuan Haji Idris Omar, Director of Integration Research and Extension Division of MPOB, also attended the event.

The objective of the co-operatives is to group the independent oil palm smallholders in a cluster to facilitate them to increase their productivity through good agricultural practices and at the same time improve the quality of the FFB to increase their income within the sustainability guidelines.

B5 Programme for Central Region

The B5 Programme in Malaysia has been implemented on regional basis, starting in the Central Region involving five states, namely, Putrajaya, Melaka, Negeri Sembilan, Kuala Lumpur and Selangor.

The first launching of B5 was held in Putrajaya on 1 June 2011 at Petronas Petrol Station, Precint 9D, Putrajaya by Tan Sri Bernard Dompok, Minister of Plantation Industries and Commodities.

At this initial stage, the deployment of B5 will cover the land transport sector, which encompasses private cars, civil service vehicles and commercial vehicles. From 1 November 2011, B5 will begin to cover the industrial and fisheries sectors as well.
To ensure the success of the programme, the government, through MPOB has allocated RM 43.1 million to finance the development of in-line blending facilities at six petroleum depots in the Central Region.

B5 is a blend of 5% biodiesel and 95% diesel. Biodiesel is produced from palm oil. The alternative fuel was first tested on government-owned vehicles during the initial trials before it was made available at the petrol stations.

**Seminar on Biogas Utilisation and Palm Oil Mill Effluent Treatment**

Tan Sri Bernard Dompok, Minister of Plantation Industries and Commodities, during the official launching of National Biogas and Effluent Treatment Seminar in Kota Kinabalu on 6 June 2011 noted that an enormous amount of empty fruit bunch (EFB) and palm oil mill effluent (POME) produced by mills are opening possibilities for the palm oil mill owners to become independent power producers (IPP) using biogas as the fuel which is generated during the mill effluent digestion process.

In addition, the Minister added that besides producing electricity, biogas trappings and utilisation as a power plant fuel can also make the environment cleaner by reducing the free emission of greenhouse gases into the atmosphere.

During the Seminar, the Minister also presented diplomas to the candidates of MPOB's Diploma Course in Palm Processing. The Diploma was initiated by the Institute of Malaysian Plantation and Commodities (IMPAC) under the ministry.

**Orange Spotting CCCVd of Oil Palm Disease**

A workshop on Orange Spotting CCCVd of Oil Palm was conducted by MPOB from 8-9 June 2011 at the Palm Garden, IOI Resort, Putrajaya.

The objective of the Workshop was to highlight the potential threat by the orange spotting (OS) disease caused by a variant of coconut cadang-cadang viroid (CCCVd) as the palm oil plantation in Malaysia entered the third generation planting.

To address this issue, a total of 52 participants attended the Workshop from various background including members from the oil palm industry, legislative department, university and MPOB.

Four prominent speakers, Professor Dr John Randles, Dr Dagmar Hanold, Dr Julie Flood and Dr Ganesan Vadamalai were invited to give talks and review the current research progress focusing on the history, diagnostic tools and bio-security programme of CCCVd. The Workshop served as an excellent platform for sharing knowledge, exchanging ideas, gathering new insights and networking.
25 New Technologies

MPOB recently organised the Transfer of Technology Seminar (TOT) 2011. The annual event was officially launched by Tan Sri Bernard Dompok, Minister of Plantation Industries and Commodities on 23 June 2011 at MPOB Head Office, Bangi.

The TOT seminar provides a strategic platform for MPOB to launch new technologies, products and services in all aspects of oil palm and palm oil for adoption and commercialisation by the industry and entrepreneurs. This event also enables potential interested parties comprising industry players, entrepreneurs and plantation owners to interact and exchange ideas on the commercialisation of technologies with MPOB inventors and scientists.

A total of 300 participants from the industry attended the Seminar. The Seminar introduced 25 new technologies and 14 services. This included the farm machinery, food and non-food formulations, oleochemicals, biomass utilisation, green energy, milling and processing and others.

MPOB also launched a publication highlighting research findings on the Life Cycle Assessment for Palm Oil and Palm Biodiesel, a project requested by the industry. Apart from this, another new product, Enhanced Bio Organic Fertiliser (TKJ Organicplus) was also launched during the event.

An agreement was signed with All Cosmos Bio-Tech Holding Corporation (ACBT) for the commercialisation of Co-active Bio-fertilizer GanoEF1 for Controlling the Fungal Infection by Ganoderma in Oil Palm. Another agreement was signed with Nafas Jentera Sdn Bhd on the Production and Marketing of Oil Palm Fresh Fruit Bunch Motorised Cutter (Cantas™).

To date, the total number of technologies launched for adoption and commercialisation is 500 technologies and 106 services.

GSAS Seminar

MPOB recently organised the Fourth Graduate Students Assistantship Scheme (GSAS) Seminar at MPOB Head Office in Bangi. The event was officially launched by Datuk Dr Choo Yuen May, Director-General of MPOB.

In her opening speech, Datuk Dr Choo said that MPOB has allocated RM 7.5 million for the purpose of developing new human resource specialising in the field of research and development related to the palm oil industry. Since 1995, MPOB has established a fund which is called MPOB GSAS and sponsored a total of 129 students to pursue their advanced studies at the local universities.

This year’s GSAS Seminar focused on downstream activities that have been completed by students sponsored under the scheme. A total of six papers were presented by MPOB senior researchers and by GSAS graduates.
### 2011 MPOB TRAINING PROGRAMME SCHEDULE

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<th>TITLE</th>
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<td>COURSES</td>
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<td>1</td>
<td>OIL PALM</td>
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<td><strong>Kursus Kemahiran Menggred Buah Sawit</strong></td>
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<td>Bil. 1: Wilayah Tengah</td>
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<td>Peperiksaan Bil. 17: Semenanjung</td>
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<td><strong>A1.2 Intensive Diploma in Oil Palm Management &amp; Technology (IDOPMT)</strong></td>
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<td><strong>A1.4 Kursus Pengurusan dan Penyelenggaraan Tapak Semaian Sawit</strong></td>
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<td>Semester III</td>
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Forthcoming Events

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<td>A2.3</td>
<td>The 25th MPOB Oil Palm Products Surveying Course</td>
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<td>The 23rd MPOB Oil Palm Products Surveying Examination</td>
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2011 MPOB CONFERENCES/SEMINARS

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<td>POIC Seminar</td>
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<td>National Seminar on Biogas and Palm Oil Mill Effluent Treatment</td>
<td>6 – 7 Jun</td>
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<td>2nd International Conference on Tocotrienols and Chronic Diseases</td>
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<td>8.</td>
<td>International Conference on Oil Palm and the Environment</td>
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<td>MAEPS Serdang, Selangor</td>
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<td>9.</td>
<td>Third MPOB - IOPRI Seminar on Pests and Diseases</td>
<td>14 Nov</td>
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<td>10.</td>
<td>PIPOC</td>
<td>15 – 17 Nov</td>
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<td>11.</td>
<td>ISOPB - MPOB Seminar on Breeding for Sustainability in Palm Oil</td>
<td>18 Nov</td>
<td>KLCC, Kuala Lumpur</td>
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Note: *To be confirmed.

For enquiry or further information, please contact:

HRD & Conference Management Unit
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Fax No.  : 03-8925 7549  
E-mail  : rubaah@mpob.gov.my  
MPOB’s website : www.mpob.gov.my  

All information are correct as at press time.
Creating a Business Plan to Generate Knowledge-based Income

Puvaneswarri Nanjappan*

INTRODUCTION

During the launch of the National Seminar on Palm Oil Milling, Refining, Environment and Quality on 27 September 2010, Tan Sri Bernard Dompok, Minister of Plantation Industries and Commodities mentioned that the palm oil industry experienced an increase in production and export in 2010. He also noted that the total oil palm planted area increased to 4.76 million hectares as of July 2010 and that the total production of crude palm oil for the first seven months increased by 0.9% to 9.50 million tonnes. Additionally, Vision 35:25 had been introduced to increase productivity to 8 t of palm oil per hectare per year by producing 35 t of fresh fruit bunches (FFB) per hectare per year with an oil extraction rate (OER) of 25%.

BUSINESS PLAN

The Malaysian palm oil industry is transforming into a knowledge-based industry. But does the industry fully exploit the results of its R&D efforts and protect its innovations via intellectual property rights. Technologies and innovations are easily adopted and copied. Therefore, there is an urgent need to create a business routine which, amongst others, includes the steps of identifying, protecting and managing the results of these R&D activities.

The palm oil milling process involves major steps of sterilisation and digestion of FFB, oil extraction, oil clarification, sludge separation and kernel separation. Various methods of oil extraction have been used in the palm oil industry. Currently, most palm oil mills use mechanical screw presses to squeeze out the oil from the mesocarp fibre. However, mechanical methods have their limitations as some oil will still remain in the mesocarp fibre, ranging from about 5.0% to 8.0% oil as a ratio to dry matter. The residual oil in the pressed mesocarp fibre can be recovered by solvent extraction method. With the rising palm oil price, there is a great demand for oil extraction from FFB, mesocarp fibre and empty fruit bunches.

MG EcoTech Group of Companies, for example, has been using their technical know-how in biotechnology and process engineering to provide effective solutions in treating all sorts of organic waste.
generated by various industries. They have a unique business value chain which has created a winning formula of generating knowledge-based income streams on a sustainable basis. The business value chain includes a sequence of processes, i.e. R&D and technical know-how, IPR, branding, licensing and sale of technology and know-how, manufacturing, and sales and marketing of products. A company which has its own R&D and technical know-how should have a business plan which can provide a successful path from developing a technology to the commercialisation of the said technology. The technology to be commercialised must be recognised as property (in the form of patents, designs or trademarks).

**CLONES OF OIL PALM TREES**

Malaysia’s economy is significantly driven by two main crops – oil palm and rubber. New clones of oil palm and rubber are regularly created. These need to be protected not only in Malaysia, but also in other countries that are recognised for growing such crops (e.g. Indonesia). In recent times, new varieties of other cash crops (especially commercially viable vegetable varieties, orchid varieties etc.) are being developed. With the horticulture industry in Malaysia developing so rapidly, protection of the new varieties will definitely become important and play a significant role in Malaysia’s economy. Additionally, further research is being conducted to increase the productivity of oil palm and rubber trees.

**INTELLECTUAL PROPERTY RIGHTS**

**What are Intellectual Property Rights Good for?**

Intellectual property rights (IPR) are a protection of moral and material interests resulting from the authorship of any scientific, literacy or artistic production. Like other property rights, IPR allow the creator or owner of a patent, trademark, industrial design, and so forth to benefit from his or her own work. IPR can also be used as legal artillery in the battle for a place in the market, whether in attacking competitors or as a defence when attacked. Therefore, these weapons of yours must be strong, relevant and sustainable.

IPR give the owners exclusive rights to manufacture a product and use their technology, industrial design, trademark, geographical indication or copyright, grant IPR licences to third parties, obtain cross licenses, and strengthen their negotiating position against third parties. The IPR are granted by the governments of each country. There are no rights to stop others from using the technology, invention, innovation or industrial design unless the said invention and innovation is protected according to law. Anyone can exploit the technology without consent if it is not protected. If you do not acquire protection for your invention, all the risks and costs borne by you will be taken advantage of by other parties. The costs involved are those related to the years of R&D costs, initial market introduction costs and costs incurred in obtaining regulatory approvals.

Long considered a business tool, IPR are akin to insurance against destruction by competitors once a product is successful in the market. It gives you exclusive rights in all aspects of commercial exploitation of the product – to manufacture, sell and offer and to import. These exclusive rights are similar to monopoly rights granted by the government. Besides that, using IPR effectively enables small and medium industries to maintain premium pricing, gain brand awareness and develop new products.

**PUBLIC DISCLOSURE**

The disclosure of inventions is always an issue for R&D institutes and universities, since they are required to publish their inventions in journals and articles. Disclosure to the public is a critical issue in determining whether an invention is
Patentable, because novelty of an invention is one of the three criteria for an invention to be patentable. An invention is novel if it is not anticipated by prior art, and under the Malaysian Patents Act 1983, prior art includes everything disclosed to the public, anywhere in the world, by written publication, oral disclosure, use or in any other way, prior to the date of the patent application claiming the invention. The written disclosure can comprise manuscripts, journal articles, proceedings, and different forms of publication. As for the oral disclosures, whether the oral presentation is a disclosure or not is still a grey area. If, for example, you speak at a seminar and the participants are given a copy of the presentation where details of your invention are revealed, then it is clearly disclosed. In a situation where copies of the presentation or hand-outs were not provided but the participant takes detailed notes or records your presentation, it would also be considered as disclosure. Therefore, you have to carefully plan your presentation in order to prevent such disclosures.

Besides written and oral disclosure, distribution of research materials and prototypes may be considered as disclosure under certain conditions. If the research material clearly states this for testing and/or evaluation for research purposes under written agreements, i.e. non-disclosure agreement, then it would not be considered as a disclosure. If the research material is distributed without any restrictions and made available to the public, then it may be considered as a disclosure.

Not all disclosures result in the loss of potential patent rights. In order to bar an invention from being patented, the disclosure of the invention has to be an enabling disclosure. In such a case, the disclosure has to include sufficient details of the invention for a person skilled in the art to understand and practice the invention. However, in Malaysia, there is a provision in the Patents Act which provides a grace period of 12 months from the date of the disclosure to file for a patent application. The best solution for such a scenario is to try not to disclose anything before filing the patent application for your invention.

SEEKING PATENT RIGHTS OVERSEAS

Patent rights are territorial rights, meaning they are effective only in the particular country that issues the patent. Patent rights are critical for enhancing the value of commercialisable inventions and as such, foreign protection is a business decision on the part of applicants and inventors that requires careful consideration. Let us take the example of the Malaysian Palm Oil Board (MPOB). As all are aware, MPOB is the premier oil palm research institute in Malaysia and has invested a substantial amount of funds – something which will certainly continue in the future – in its research and development. MPOB does research on seedling, planting, harvesting, producing palm oil and much more, and in order to reap the rewards of their research results, they have been taking steps to find ways and means to protect their rights locally and in foreign countries.

There are several factors that need to be considered for filing patent applications in foreign countries.

- The demand and market for the invention in those countries – depends on whether the invention is a vendible product, i.e. something that can be sold, or an intermediate product, i.e. method of extracting oil from the oil palm fruit.
- Whether resources are available to produce the invention – for example, it is not feasible to file an oil palm related patent application in a country that does not have oil palm plantations. Additionally, you will need to consider whether there is sufficient manufacturing capability for the existing invention in the foreign country.
Feature Article

• Whether there are any competitive advantages that exist in manufacturing the invention in that country.
• The nature and effectiveness of patent enforcement in the country – this relates to the ability to monitor and enforce the patent once it is issued, where necessary action ought to be taken if there is an infringement.
• Cost associated with the filing of the patent applications in foreign countries. Filing patent applications in foreign countries is an expensive affair. Therefore, the applicant would need to seriously consider all costs related to the filing of the application.

A company related to the oil palm industry, CHD IP Technology Sdn Bhd, protected their invention on Method and Apparatus for Sterilising Oil Palm Fruit by filing patent applications in 25 countries. The patent applications in Malaysia and United Kingdom have been granted under patent No. MY-134916-A and patent No. GB2421169 respectively.

BENEFITS OF PATENT COOPERATION TREATY

The Patent Cooperation Treaty (PCT) is an international law treaty, and an application filed under the PCT – called an international application or PCT application – provides the opportunity to amend the specification and claims as well as to delay national filing, giving the applicant enough time to prepare budgets, look for licenses and decide on the countries in which to file the national phase applications. Only one application is filed in one language at the Receiving Office (RO). In Malaysia, the RO is the Intellectual Property Corporation of Malaysia (MyIPO). The PCT application also provides an International Search Report and written opinion, which will give an overall view on the novelty, inventive step and industrial applicability of an invention.

PCT applications give Malaysians another window of opportunity to exploit their inventions/technology overseas. Seeing that manufacturing industries are moving towards lower cost countries, Malaysians will be able to obtain patent rights in those countries strategically via the PCT route and this gives greater prospects in terms of licensing the technology for royalty income.

CONCLUSION

All the three points mentioned above, i.e. business plan, seeking patent rights overseas and PCT benefits, will lead to generating knowledge-based income, which in turn is hoped to bring about growth to the nation. Will the palm oil industry protect and manage their advantages in generating the knowledge-based income?
WARNING NOTICE

Malaysia Patent No: MY 137253-A
Recovering Oil From Palm Mesocarp Fibre

THE TRADE AND PUBLIC are hereby informed EONCHEM TECHNOLOGY SDN. BHD. of PLO 525, Jalan Keluli 9, Pasir Gudang Industrial Estate, 81700 Pasir Gudang, Johor, Malaysia is the owner of Malaysian Patent No. MY- 137253 -A in respect of recovering oil from palm mesocarp fibres.

The Patent claims a process and assembly of apparatus to extract remaining oil from mesocarp fibres of oil palm after initial extraction of oil. Flow chart of the process is shown below:

NOTICE is hereby given that, any person who, or firm or company which imports, exports, manufactures, offers for sale, sells or uses the process and/or the assembly of apparatus as claimed in the MY-137253-A Patent which does not originate from EONCHEM TECHNOLOGY SDN. BHD. would be committing an act of infringement and legal proceedings will be taken against such persons, or firms or companies.

Parties interested in the MY-137253-A Patent should contact EONCHEM TECHNOLOGY SDN. BHD. at the following address:

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(Registered Patent Agent for EONCHEM TECHNOLOGY SDN. BHD.)
Heat Transfer Theory and Heat Pipe Development for Palm Oil Industry Application

Andrew Yap Kian Chung*

ABSTRACT

Heat could be transferred in three ways which are conduction, convection and radiation. The recent development to produce a faster heat transfer material was the heat pipe that combines the principles of both thermal conductivity and phase transition to efficiently manage the transfer of heat between two solid interfaces. The objective of this research work is to introduce the heat pipe phenomena using existing heat transfer theory and discuss the application in palm oil industry which may enable more biomass saving.

INTRODUCTION

Antoine Lavoisier (1743 – 1794) proposed the caloric theory in 1789 suggested that heat is the manifestation of motion at the molecular level. Benjamin Thompson (1753 – 1814) showed that heat can be generated and James P Joule (1818 – 1889) proved the sceptics of caloric theory in 1843 and put the theory to rest (Yunus and Michael, 1994).

Heat transfer process complies fundamental thermodynamic laws and the rate of heat transfer that may be constant or variable. Practically most cases are concerned with steady state heat transfer but there are cases of transient heat transfer. In general, there are three ways heat may be transferred which are conduction, convection and radiation. The heat transfer being from high temperature to lower temperature medium.

CONDUCTION

Conduction is the transfer of heat in physical contact. Fourier’s Law states that the rate of heat flow, $F$ through a single homogeneous solid is directly proportional to the area, $A$ of the section at right angle to the direction of heat flow and to the change of temperature with respect to the length of the path of the heat flow, $\frac{dt}{dx}$.

$$F \propto A \frac{dt}{dx} \rightarrow Q = -\lambda A \frac{dt}{dx}$$  \hspace{1cm} (1)

where $\lambda$ is the thermal conductivity of the respective material. The value of thermal conductivity for most solids is approximately constant over a wide range of temperature. Thus, integrating equation above yield.
\[ \int_{0}^{x} F dx = -A \int_{t_{1}}^{t_{2}} \lambda dt \rightarrow F = \frac{\lambda A}{x} (t_{2} - t_{1}) \]  

(2)

Newton’s Law of Cooling states that the heat transfer from a solid surface at a temperature \( t_{2} \) to a fluid of temperature \( t_{1} \) is given by:

\[ F = \alpha A (t_{2} - t_{1}) \]  

(3)

where \( \alpha \) is the heat transfer coefficient.

Consider a composite wall with \( n \) layers of material with thickness \( x_{1}, x_{2}, \ldots, x_{n} \) and thermal conductivity \( \lambda_{1}, \lambda_{2}, \ldots, \lambda_{n} \). Fluid A at temperature \( t_{2} \) with heat transfer coefficient \( \alpha_{a} \) on one side of the composite wall and fluid B at temperature \( t_{b} \) with heat transfer coefficient \( \alpha_{b} \) on the other side of the composite wall. In steady state and heat transfer by conduction only, then the specific heat transfer rate, \( f \) at respective layer is shown in the equation below.

From fluid A to wall layer 1:

\[ f = \alpha_{a} (t_{a} - t_{1}) \]

From layer to layer within the wall:

\[ f = \frac{\lambda_{y}}{x_{y}} (t_{y} - t_{y+1}) \]  

\( y = 1, 2, \ldots, (n - 1) \)

From wall layer \( n \) to fluid B:

\[ f = \frac{\lambda_{n}}{x_{n}} (t_{n} - t_{b}) = \alpha_{b} (t_{n} - t_{b}) \]  

(4)

Combine all the equations above yield

\[ (t_{2} - t_{1}) + (t_{1} - t_{2}) + \ldots + (t_{n} - t_{n}) = \sum_{y=1}^{n-1} \frac{x_{y}}{\lambda_{y}} + \frac{x_{n}}{\lambda_{n}} \]

\[ (t_{a} - t_{1}) = \sum_{y=1}^{n} \frac{x_{y}}{\lambda_{y}} + \frac{x_{n}}{\lambda_{n}} \]  

(5)

**CONVECTION**

Convection is the mode of energy transfer between a solid surface and the adjacent liquid or gas which is in motion involving effects combination of conduction and fluid motion. In order to apply Newton’s Law of Cooling, value for the heat transfer coefficient need to be determined. Forced convection is concerned with the heat transfer between a solid surface and a forced moving fluid by external means such as fan, pump, etc. The thickness of the fluid film on the surface in term of fluid properties and fluid velocity is governed by the Reynolds number. Exact mathematical solution to such problem is difficult to obtain but approximate solution can be obtained by making suitable assumptions. Reynolds postulation expresses the heat transfer in term of the friction resistance to the flow.

Force per unit area:

\[ \sigma = \frac{m v}{A} \]

Heat transfer per unit area:

\[ f = \frac{m c \Delta t}{A} \]  

(6)

where \( c \) is the specific heat capacity of the fluid, \( m \) is the fluid mass flow rate, \( v \) is the bulk velocity of the fluid, \( \sigma \) is the shear stress in the fluid at the wall and \( \Delta t \) is the temperature difference between the surface and the bulk of the fluid. Simple Reynolds analogy can be applied for fluids with Prandtl, \( Pr \) number defined below approximately unity. For most gases, dry vapour and superheated vapour, \( Pr \) lies in between 0.65 to 1.2.

\[ Pr = \frac{c \eta}{\lambda} ; \eta \text{ is the fluid dynamic viscosity} \]  

(7)

Natural convection is concerned with the heat transfer depends on the cubical expansion coefficient, \( \Phi \) due to the differences fluid density, \( \rho \) causing a natural circulation.

\[ \rho_{1} = \rho_{2} (1 + \Phi \Delta t) \rightarrow (\rho_{1} - \rho_{2}) = \rho_{2} \Phi \Delta t \]  

(8)

The heat transfer depends on the fluid viscosity, fluid thermal conductivity and the velocity of the convection current dependent on the up-thrust determined as:

\[ (\rho_{1} - \rho_{2}) g \rightarrow \rho_{2} \Phi \Delta t g \]  

(9)

where \( g \) is the local gravity acceleration. In many cases of natural convection, the heat
Transfer coefficient could be estimated based on the Grashof number, \( Gr \) as defined:

\[
Gr = \frac{\Phi g l^3 \Delta \Phi}{v^2} ; l \text{ is characteristic length}
\] (10)

Typical values of \( \alpha \) is shown in Table 1.

**TABLE 1. TYPICAL HEAT TRANSFER COEFFICIENT VALUE**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Heat transfer coefficient ([\text{W/(m}^2\cdot\text{K})])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural convection of gases</td>
<td>2 - 25</td>
</tr>
<tr>
<td>Natural convection of liquids</td>
<td>50 – 1 000</td>
</tr>
<tr>
<td>Forced convection of gases</td>
<td>25 - 250</td>
</tr>
<tr>
<td>Forced convection of liquids</td>
<td>50 – 20 000</td>
</tr>
<tr>
<td>Convection in boiling and</td>
<td>2 500 – 100 000</td>
</tr>
<tr>
<td>condensation</td>
<td></td>
</tr>
</tbody>
</table>

**RADIATION**

The agitation of a substance molecules emit thermal radiation consists of electromagnetic waves propagate in straight lines at the speed of light without requiring any medium. The radiated energy per unit area per unit time is known as emissive power, \( E \). When the radiation strike a body, energy can be absorbed, reflected or transmitted according to the fractions of absorptivity, \( \beta \), reflectivity, \( \gamma \), and transmissivity, \( \tau \). Since the amount of radiation transmitted through the most solids and liquids encountered in engineering is negligible, then yield:

\[ \beta + \gamma + \tau = 1 \] (11)

An ideal black body absorbs all the radiation. A grey body is an ideal surface assumed to have a constant emissivity, \( \varepsilon \) over all wavelengths and for all temperature. The wavelength for maximum emissive power, \( \phi_m \) is given by Wien’s Law shown below:

\[ \phi_m = \frac{2900}{t} \text{; } t \text{ in K; } \phi_m \text{ in } \mu\text{m} \] (12)

The Stefan-Boltzmann law states that the emissive power is proportional to the fourth power of absolute temperature as shown in the equation:

\[ f = E = 5.67 \times 10^{-8} t^4 \text{ [Wm}^{-2}\text{]} ; t \text{ in K} \] (13)

The radiation intensity variation is given by Lambert’s Cosine Law:

\[ I_o = I \cos \theta \] (14)

where \( I_o \) is the radiation intensity in any other direction at angle \( \theta \) to the normal and \( I \) is the normal radiation intensity (Eastop and McConkey, 1994).

**HEAT PIPE**

During the steam age, the general principle of heat pipes was commonly classified as two phase thermo-siphons. Thermo-siphons transfer heat by single-phase convection. RS Gaugler of General Motors suggested the modern concept for a capillary driven heat pipe in 1942 and later patented the idea (Gaugler, 1944). However, the technology at that period presented no clear need for such a device and it lay dormant for two decades. George Grover at Los Alamos National Laboratory demonstrated the benefits of employing capillary action in 1963 and subsequently published in the *Journal of Applied Physics* in 1964 (Grover et al., 1964).

RCA was the first corporation to undertake research and development of heat pipes funded by the US government for commercial applications from 1964 to 1966. NASA played a large role in heat pipe development during the late 1960s. Feldman, Eastman and Katzoff discussed applications of heat pipes to areas outside of government concern in 1967 and 1968. The rotational heat pipe concepts with its applications to turbine blade cooling and to cryogenic processes were introduced in 1969. In the meantime, many other applications have firmly established that heat pipes can solve many critical problems in heat transfer and temperature control. Sony was incorporating heat pipes into...
both forced convection and passive finned heat sinks cooling system for some of their electronic products since 1980. During the late 1990s, the number of US heat pipe patent applications increased three-fold due to the increasingly hot microcomputer. Today most development and production of heat pipes have moved from the US to Asia especially China. Modern CPU heat pipes are made from copper and use water as the working fluid.

The basic heat pipe is a closed container made of a high thermal conductivity material such as copper or aluminium which contains a mesh or sintered powder capillary wick structure to exert capillary pressure and a small amount of working fluid such as water, ethanol, acetone, sodium or mercury which is saturated in both the liquid and vapour phase at operating conditions as shown in Figure 1. Air is removed to eliminate diffusion during the bulk transfer of the vapour. Thus, the heat transfer rate is dependent on the vapour condensation to liquid at the cold end (Faghri, 1995).

Heat pipe contains no mechanical moving part and requires no maintenance. The heat transfer efficiency often expressed in terms of equivalent thermal conductivity is better than an equivalent cross-section of solid copper and even has demonstrated a heat flux of more than 230 MWm\(^{-2}\), nearly four times the heat flux at the surface of the sun (Danneskiold, 2000). However, non-condensing gases that diffuse through the wall or due to the working fluid impurities and chemical breakdown may eventually reduce the heat transfer efficiency especially during low vapour pressure at low temperature.

The heat transfer mechanism in heat pipe is a combination of both the thermal conductivity and phase transition principles as shown in Figure 2. When one end of the tube is heated the liquid turns to vapour absorbing the latent heat of vaporisation. The hot vapour flows to the colder end of the tube where it condenses to liquid and gives out the latent heat. The condensed liquid then flows back through the wick to the hot end of the tube. Wick may not be necessary if fluid surface tension can be overcome.

The heat pipe is partial vacuum thus the working fluid will take up latent heat and evaporate below its atmospheric boiling point. The latent heat of vaporisation is usually very large exceeding the sensible heat capacity. Pressure difference drives a rapid mass transfer approximately at the speed of sound in the absence of non-condensing gases to the condensing end where the excess vapour releases latent heat and condenses. The heat pipe will operate when the hot end is just slightly warmer than the working fluid melting point thus enabling considerable quantities of heat to be transported with a small temperature difference from one end to the other. The pressure drop is very small thus the heat pipe thermal cycle is essentially an isothermal process with minimum heat loss due to the Second Law of Thermodynamics (Patrick and Edward, 1979).

Active control of heat flux is carried out by manipulating the liquid volume of the evaporation section. Variable conductance heat pipes employ a large reservoir of inert immiscible gas attached to the condensing section. Varying the gas reservoir pressure changes the volume of gas charged into the condenser which in turn limits the area available for vapour condensation. Thus, a wider range of heat fluxes and temperature gradients can be accommodated with a single design.

**HEAT PIPE DESIGN**

The development of a practical heat pipe design requires the application of the theory in combination with a variety of considerations including physical, thermal and mechanical constraints; application require-
Figure 1. Approximate temperature range of various working fluids applicability.

Figure 2. Heat pipe thermal cycle.

Liquid wicking capability in a body-force field is a ratio of surface tension forces, $\delta$ working against body forces proportional to the Wicking Height Factor, $H$ as shown in the equation which represents a basis of fluid comparison.

$$\max H \propto \frac{\delta}{\rho g}$$

It decreases with increasing temperature because the surface tension decreases faster than the liquid density. The relative merit
of the vapour phase can be described by the Kinematics Viscosity Ratio, \( \omega \), which decreases with increasing temperature.

\[
\min \frac{\omega}{\alpha, \frac{\eta_s}{\eta_l, \rho_s}} \quad (16)
\]

Superior fluid properties with high liquid transport factor, high Wicking Height and low Kinematics Viscosity Ratio will require a smaller heat pipe diameter which will compensate for the pressure.

The homogeneous wire mesh wick design that is able to provide fine capillary sizes to achieve high static height but permeability factor is low. The composite wire mesh wick design avoids the compromise between fine and coarse capillaries but presents a priming reliability problem. Thus, alternate layers of coarse and fine wire mesh are used to disperse any inclusions so that the bubble entrapment problem and composite ratio could be minimised. The axially grooved design offers large open flow channels which are sensitive to gravity. Both the homogeneous

and composite wicks are centrally located, spirally wound geometries. This arrangement removes the main wick from the wall thus provides optimum heat transfer at the evaporator and condenser sections.

**Application in Palm Oil Mill**

Boiler is the unit operation where heat pipe could find its application in palm oil mills via the incorporation of economisers. A palm oil mill boiler essentially consists of a fuel feeder, a furnace with water walls, vertically laid to form a wall and connected to top and bottom headers/drums known as steam and mud drums. Through the down comer tubes and riser tubes, the water circulation is established by means of thermosiphonic action. After the raw water treatment, the water is further softened in softener units and pumped into boiler feed water tanks where it is heated by process steam condensate. The water is then de-aerated either by vacuum produced by steam ejector pumps, jet type de-aerating contact heater or other methods. The feed water pump pumps the feed water into the boiler drum, its level being controlled by an automatic drum water level control system, so that the water level in the drum is maintained constant.

The heat of combustion of biogas is transferred by radiation and conduction to the water wall tubes and to the super-heater as well when it is located in that zone.

The advent of the water cooled furnace wall led to the integration of furnace, economiser, boiler, super-heater and air pre-heater into modern steam generators. High pressure steam generator requires more super-heating and reheating surface and less boiler surface. **Figure 4** shows a schematic flow diagram of a common steam generator system. Feed water at 232.2°C to 260°C and high pressure enter the economiser and leaves it saturated or as a wet steam (two phase mixture). It then enters the steam drum at midpoint. The
steam drum water flows through insulated down-comer tubes which are situated outside the furnace to another header connected to risers. The water in the tubes receives heat from the combustion gases and boils further. The density differential between the water in the down-comer and that in the water tubes helps circulation. Steam is separated from the bubbling water in the drum and rises to the top and goes to the super-heater from which to the turbine inlet through a main stop valve. The bleed-off steam from the turbine is used to heat the feed water.

Atmospheric air from a forced draft fan is pre-heated by the flue gases after it leaves the economiser. From there it flows into the furnace, where it mixes with the fuel and burns to about 1649°C. The hot combustion gases (about 900°C) impart part of their energy to the water tubes and then the super-heater and economiser and leave the later at about 270°C. From there they pre-heat the incoming atmospheric air in the pre-heater, leaving it at about 149°C which is well above the dew point of SO₂ vapour in the gases to prevent condensation acids that would corrode metal components in its path. An induced draft fan draws the flue gases from the system and sends them up the stack.

The economiser is the heat exchanger that raises the temperature of the water leaving the high pressure feed water heater to the saturation temperature corresponding to the boiler pressure. This is done by gases leaving the last super-heater. These gases at high enough temperatures transfer heat to the super-heater and enter the economiser at 298°C. Part of their energy is used to heat the feed water. As the economiser is introduced before the feed water heating, the water temperature at economiser inlet would be low consequently reducing the outer tube temperature below the dew point of the flue gases. This cause condensation and corrosion because of the presence of SO₂ and SO₃ in the gases. The moisture also will promote the deposition of ash on its tube surface, thus fouling the outer tube.

Figure 4. Schematic flow diagram of a modern steam generator.
surfaces reducing heat transfer. Modern steam generators receive heated feed water and their economisers operate above the dew point of gases thus eliminating external corrosion and fouling. Economisers are generally placed between the last superheater and the air pre-heater. In some cases, a low temperature economiser is placed after the air pre-heater. Such an economiser is called a stack cooler and acts as a low pressure feed water heater except that the heating medium is the flue gas instead of steam bled from the turbine.

THE RANKINE CYCLE

William John M Rankine (1820-1872) devised a vapour-liquid reversible cycle which is most convenient to draw it on both the \( P-v \) and \( t-s \) diagrams with respect to the saturated liquid and vapour lines of the working fluid usually water. The original ideal Rankine cycle shown in Figure 5 is much simpler compared to the real modern power plant cycle. The curved lines to the left of the critical point are the saturated liquid lines and the regions to the left of these lines are the sub-cooled liquid regions. The curved lines to the right of the critical point are the saturated vapour lines and the regions to the right of these lines are the super-heat regions. The regions under the domes represent the two phase mixture regions.

The cycles start with adiabatic reversible expansion through a condensing turbine. The exhaust vapour usually in the two phase region then undergoes constant temperature and pressure heat rejection in the condenser. The saturated liquid at the condenser pressure is adiabatic reversible compressed by the pump to sub-cooled liquid at the steam generator pressure. The portion bringing the sub-cooled liquid to saturated liquid in the steam generator at constant pressure is called an economiser. The portion heating the saturated liquid to saturated vapour at constant pressure and temperature in the steam generator is called boiler. Super-heater heats the saturated vapour to produce super-heated steam. Based on a unit mass of vapour in the saturated cycle, the analysis yield.

\[
\begin{align*}
q_A &= h_1 - h_4 \\
\text{Turbine work} &= h_1 - h_2 \\
\text{Heat rejected} &= h_2 - h_3 \\
\text{Pump work} &= h_1 - h_3 = V_3(P_4 - P_3) \\
\text{Network} &= \frac{w_n}{q_A} = \frac{(h_1 - h_2) - (h_3 - h_4)}{(h_1 - h_4)} \\
\text{Thermal efficiency} &= \psi = \frac{w_n}{q_A} \quad (22)
\end{align*}
\]

External irreversibility is primarily the result of the temperature differences between the primary heat source and the working fluid; condensing working fluid and the heat sink fluid. Internal irreversibility is primarily the result of fluid friction, throttling, mixing in turbines, pump and pressure drops in heat exchangers, pipes, bends, valves, etc. In the thermodynamic analysis of cycle and power plants, the power output and the thermal efficiency which is the ratio of the network to the heat addition are of prime importance as an economic measure of heat rate.

Boiler horsepower, blhp, was originally used to indicate the size of the boiler. One blhp was defined as 0.9290304 m\(^2\) of boiler heating surface but later was changed to the amount of heat required to evaporate 13.6078 kg hr\(^{-1}\) of water at 37.7778°C to saturated steam at 482.63 kPa which is equal to 9782.1272 W. Later on this was changed to the amount of heat necessary to vaporize 15 6489 kg hr\(^{-1}\) of saturated water to saturated steam at 101.325 kPa which is 9810.6576 W and is now rounded so that the modern value is 9812 W (El-Wakil, 1984).

DISCUSSION AND CONCLUSION

Heat pipes must be tuned to particular cooling conditions. The choice of pipe material, size and coolant all have an effect on the optimal heat pipes operating temperatures. If all of the working fluid in the heat pipe vaporise and the condensation process cease to occur; the heat pipe
Figure 5. Rankine cycle with t-s and P-V chart for steam.
thermal conductivity is effectively reduced to the heat conduction properties of its solid metal casing alone. An overheated heat pipe generally will continue to conduct heat at around 1/80 of the original conductivity equivalent to copper heat conductivity.

If the working fluid does not undergo phase change below a certain temperature, the thermal conductivity will reduce to that of the solid metal casing. Thus, the desired operational temperature range is one of the key criteria for the working fluid selection. The lowest operational temperature limit should be a few degrees Celsius above the freezing point of the selected working fluid.

Most of the traditional heat pipe diameter is above 3 mm due to the material limitations and the heat pipe thermal conductivity efficiency is proportional to the diameter as shown in the Appendix.

**NOMENCLATURE**

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<th>Symbol</th>
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<td>A</td>
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<tr>
<td>E</td>
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<td>q</td>
<td>Specific heat</td>
<td>kJ(kg)⁻¹</td>
</tr>
<tr>
<td>s</td>
<td>Specific entropy</td>
<td>kJ(kgK)⁻¹</td>
</tr>
<tr>
<td>t</td>
<td>Temperature</td>
<td>°C</td>
</tr>
<tr>
<td>v</td>
<td>Fluid velocity</td>
<td>m s⁻¹</td>
</tr>
<tr>
<td>w</td>
<td>Specific work</td>
<td>kJ kg⁻¹</td>
</tr>
<tr>
<td>x</td>
<td>Distance</td>
<td>m</td>
</tr>
<tr>
<td>Φ</td>
<td>Cubical expansion coefficient</td>
<td>-</td>
</tr>
<tr>
<td>α</td>
<td>Heat transfer coefficient</td>
<td>W m⁻²K⁻¹</td>
</tr>
<tr>
<td>β</td>
<td>Absorptivity</td>
<td>-</td>
</tr>
<tr>
<td>ε</td>
<td>Emissivity</td>
<td>-</td>
</tr>
<tr>
<td>γ</td>
<td>Reflectivity</td>
<td>-</td>
</tr>
<tr>
<td>τ</td>
<td>Transmissivity</td>
<td>-</td>
</tr>
<tr>
<td>η</td>
<td>Dynamic viscosity</td>
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<tr>
<td>ω</td>
<td>Kinematics viscosity</td>
<td>m²s⁻¹</td>
</tr>
<tr>
<td>λ</td>
<td>Thermal conductivity</td>
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</tr>
<tr>
<td>σ</td>
<td>Shear stress</td>
<td>Pa</td>
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<tr>
<td>ρ</td>
<td>Density</td>
<td>kg g⁻¹</td>
</tr>
<tr>
<td>ψ</td>
<td>Thermal efficiency</td>
<td>-</td>
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<tr>
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<td>Grashof number</td>
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<tr>
<td>Pr</td>
<td>Prandtl number</td>
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**REFERENCES**


### TABLE A1. TYPICAL OPERATING CHARACTERISTICS OF HEAT PIPES

<table>
<thead>
<tr>
<th>Temperature range (°C)</th>
<th>Heat pipe working fluid</th>
<th>Heat pipe vessel material</th>
<th>Measured axial heat flux [kW cm⁻²]</th>
<th>Measured surface heat flux [W cm⁻²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-200 to -80</td>
<td>Liquid nitrogen</td>
<td>Stainless steel</td>
<td>0.067 @ -163°C</td>
<td>1.01 @ -163°C</td>
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<tr>
<td>-70 to +60</td>
<td>Liquid ammonia</td>
<td>Nickel, aluminium, Stainless steel</td>
<td>0.295</td>
<td>2.95</td>
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<tr>
<td>-45 to +120</td>
<td>Methanol</td>
<td>Copper, nickel, stainless steel</td>
<td>0.45 @ 100°C(x)</td>
<td>75.5 @ 100°C</td>
</tr>
<tr>
<td>+5 to +230</td>
<td>Water</td>
<td>Copper, nickel</td>
<td>0.67 @ 200°C</td>
<td>146 @ 170°C</td>
</tr>
<tr>
<td>+190 to +550</td>
<td>Mercury +0.02%</td>
<td>Stainless steel</td>
<td>25.1 @ 360°C*</td>
<td>181 @ 750°C</td>
</tr>
<tr>
<td>+400 to +800</td>
<td>Potassium</td>
<td>Nickel, stainless steel</td>
<td>5.6 @ 750°C</td>
<td>181 @ 750°C</td>
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<tr>
<td>+500 to +900</td>
<td>Sodium</td>
<td>Nickel, stainless steel</td>
<td>9.3 @ 850°C</td>
<td>224 @ 760°C</td>
</tr>
<tr>
<td>+900 to +1500</td>
<td>Lithium</td>
<td>Niobium +1% zirconium</td>
<td>2.0 @ 1250°C</td>
<td>207 @ 1250°C</td>
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<tr>
<td>1500 + 2000</td>
<td>Silver</td>
<td>Tantalum +5% tungsten</td>
<td>4.1</td>
<td>413</td>
</tr>
</tbody>
</table>

**Diagram:**

- **Heat Pipe Operational Temp (°C)**
- **Maximum Heat Transport (Watts)**

- 3.0 mm
- 6.35 mm
- 9.53 mm
- 12.70 mm
- 15.88 mm
- 22.23 mm
Feature Article

Development of a Pre-treatment Plant for Residues from the Malaysian Palm Oil Industry

Robbie, H*; Teng Kek Hup** and Harold Boerrigter‡

ABSTRACT

In the overall chain for the palm oil production, large quantities of biomass by-products are generated, up to almost five times the oil production (on dry weight). Most of the materials are generated in Malaysia and Indonesia, accounting for 87% of world’s palm oil production. The use of these residues as by-products for materials, energy, green chemicals or biofuels offers perspectives for development of an economic and environmental sustainable food oil production chain that fits well in the development of a bio-based economy. This requires that any biomass extraction from oil palm plantations does not negatively affect the nutrient balance and soil organic matter content.

The present work describes the development of a 5 t hr⁻¹ pre-treatment plant (PTP) line-up for these materials to arrive at a standardised or commodity product that can easily be handled in road transport and intermediate storage. Results are included for the pre-treatment of (i) empty fruit bunch from the palm oil mill, (ii) both fresh and (iii) plantation dried oil palm fronds, and (iv) oil palm trunks from replanting.

A full PTP suitable for processing of all materials includes a two-stage size reduction, belt dryer (suitable for using pre-heated air), and a cubing machine to produce compacted cubes. The technology selection and equipment sizing were fully supported by results of an extensive field test programme carried out in Malaysia with local biomass and with commercially available equipment. The developed PTP line-up is generic with few equipment for all biomass materials assessed (expect for the initial size reduction steps). As all required technologies are commercially available, the PTP can be installed commercially when a project opportunity arises.

INTRODUCTION

In the overall palm oil production chain, large quantities of biomass by-products are generated, up to almost five times the oil production (on dry weight). Most of this material is generated in Malaysia and Indonesia, accounting for 87% of world palm oil production (AOCS, 2011).

The main residues from the plantation and the palm oil mill comprise empty fruit bunches (EFB), oil palm trunks (OPT), oil...
palm fronds (OPF), fibres and shells. Fibres and shells are typically used in the mill for energy generation, with some minor alternative material use of fibre for the production of particleboard, eco-mat, and others. EFB is used for mulching, however, large volumes are not utilised effectively due to the high cost of transportation to other industries like cement factories which can substitute fossil fuel with EFB. The high moisture content of EFB reduces its energy content making it an unattractive fuel. However, with the green energy technology funding and other incentives initiated by the government of Malaysia, many investors are seriously considering EFB as a potential fuel for renewable energy generation as well as for the production of paper and pulp. The material has only limited application for plywood and fibreboard manufacturing. OPF are generated during pruning operation and as part of the good agricultural practice (GAP), the OPF is left in the field for providing a continuous supply of recycled nutrients and a soil cover to promote surface water infiltration and erosion control. Trunks are only available during replanting time after a 20 - 25 year growth cycle and they are generally left in the field for eventual bio-degradation. Results from the Malaysian Palm Oil Board show that the palm trunks can be a useful source for the production of plywood and particleboard with acceptable quality. It can also be used for the production of plastic composites, for the local automobile industry.

The palm oil industry is undergoing rapid changes, not only in the technologies for the palm oil production itself, but also for the use of the residues derived from it (Kandiah, 2010). The potential for commercialisation of oil palm-based biomass is huge, given that the residues are readily available in very large quantities amounting to 16, 75 and 14 million tonnes annually for EFB, OPF, and OPT, respectively (on wet basis) (Anis et al., 2008). In 2007, it was estimated that the oil palm biomass is more than 30 million tonnes per year from the more than 400 mills (4.2 million hectares) in Malaysia alone.

The use of the residues as ‘by-products’ for materials, energy, green chemicals, or biofuels offers perspectives for development of an economic and environmental sustainable food oil palm production chain that fits well in the development of a bio-based economy. This requires that any biomass extraction from oil palm plantations does not negatively affect the nutrient balance and soil organic matter content.

The pruned OPF as a soil conditioner cannot be substituted directly by fertiliser additions. Therefore, OPF should not – or only limitedly – be removed from plantations. No data is available to determine how much OPF can be removed without compromising sustainable oil palm production. EFB contains relatively small amounts of nutrients, but is often used to promote oil palm growth on small areas of poor soils in plantations. Its recycling may not be necessary to maintain soil fertility in some fertile coastal clay soils and there is a clear opportunity to take these as a feed material for alternative applications.

OPT and OPF from replanting could probably be removed without compromising the sustainability of the palm oil production. Removal of OPT and OPF improves access for machinery for land preparation and replanting, and it may reduce damage to replanted palms. There is no significant impact from the extracted nutrient load as it would otherwise be largely lost in drainage water (Giller et al., 2009).

SCOPE/OBJECTIVE

Utilisation of the EFB, OPF and OPT has technical challenges, as the materials are heterogeneous, have a high moisture content, and are very fibrous. This hinders large-scale processing and application where standardised feedstock is desired. The present work describes the develop-
ment of a pre-treatment plant (PTP) line-up for these materials to arrive at a standardised or commodity product that can easily be handled in road transport and intermediate storage. This leads to the following requirements.

- **Moisture content.** The moisture content of biomass ex-PTP plant must at least be below 15% to prevent degradation. A moisture content of 10% was set as design value.
- **Density.** Compacting is required to reduce transport volumes. Via compacting, also the fibrous and heterogeneous biomass materials are homogenised and become easier to handle in a downstream process with less risk of plugging.
- **Product size.** The PTP output specification for the compacted biomass was set to smaller than 30 mm. However, with minimal small particles to reduce dust and fines emissions during transport and processing.
- **Low dust and fines load.** Dust and fines in the process lead to health and safety (HSE) issues and result in loss of biomass material. The PTP design must target at minimal dust and fines formation and losses.

The envisioned scale of PTPs is 5 t hr⁻¹ (dry output), matching typical EFB availability in a palm oil mill, as well as with current typical equipment capacities in the palm oil industry. Specific objective is to develop a technology line-up that is (i) lowest in capital cost, (ii) robust (i.e. minimum operator intervention required), and (iii) suitable for all three materials. Specific items investigated were mechanical dewatering versus a forced dryer, drying in a solar bay drying versus a belt dryer, and compacting to cubes or to pellets.

**EXPERIMENTAL**

**Feedstock**

The three different residues assessed in this study differ significantly in their fibrous nature, composition, particle size and moisture content.

EFB was available directly ex palm oil mill as chunks from shredded bunches (after the so-called primary pressing, which is a common processing step) with ~60% moisture content. The length of the as-received EFB chunks varied from 5 to 10 cm (2 to 4 inches).

OPF was assumed to be extracted from the plantations either fresh with ~70% moisture content or after a certain period of on-field natural drying with an average moisture content of ~15% (Figure 1). However, there is a significant difference between the thick part of the stem (moisture content ~45%) and the leaves (moisture content ~7%). For designing a pre-treatment, and especially the drying section, the average moisture content of the shredded dried OPF has to be taken, which was determined to be ~15%. Upon the field drying degradation of the matter in the stem had taken place, resulting in loss of the binding material but the fibrous structure remained, which was more difficult to cut.

**Figure 1. Dry oil palm fronds in the field.**

For the design of the pre-treatment line-up, OPT from replanting were assumed to be available as complete trunks with ~70% moisture content. For purpose of the test programme, a palm trunk was cut into block sizes. In this way, the biological characteristic of the trunk can be better preserved. These blocks were sawed into
smaller chunks with a chain saw to prepare feedstock for the shredding tests. For industrial processing of trunks, the sudden abundant supply within the three months replanting period could be a challenge. In a separate study (not reported here) the authors have investigated if the whole trunks could be stored for a prolonged period of time. Conclusion from that work was that OPT can be stored outside for a period of six months without detrimental degradation of the material. Outside storage of OPT allows for peak storage for pre-treatment facilities.

**Size Reduction**

Purpose of the size reduction is to reduce the size of the fresh bulky incoming biomass to allow the drying stage, with the second requirement to minimise the formation of small particles and fines. Available equipment comprised commercial EFB shredder, wood chipper and a mobile chopper connected to the drive of a diesel tractor.

**Mechanically Dewatering**

For the investigation of mechanically dewatering system, a Super Press designed by a local manufacturer was tested. This machine is occasionally seen in some palm oil mills where it is used for double pressing of EFB to increase the oil yield. The main function of this mechanically dewatering system is to reduce the bulk of the moisture content (down to about ~40%) to reduce the thermal drying requirements which could be costly. As this Super Press is designed as a heavy duty machine its capacity is lower than the normal pressing units.

**Drying**

For the drying system, a solar bay drying and an encased belt dryer system were investigated. Solar bay drying or natural drying relies on heat from the sun for drying. Tests were conducted in the drying bays at the MARDI R&D Centre in Kuala Lumpur. The bays are equipped with blower fans and Okada sweepers (for material transfer and mixing for even drying purposes), and a thermograph for continuous recording of the solar house temperature and humidity during the tests. For solar bay operation, the main critical issues is the initial distribution of material upon unloading. The initial material distribution shall be carried out fast by a prime mover (e.g. bob cat skid steer loader, tractor shovel, or forklift) before running of the Okada sweeper. This pre-levelling is crucial to allow the Okada sweeper to travel along its travelling path without being blocked by high heaps of material. The sweeper will help in partial material levelling (just few centimetres higher than desired material height, normally set at 8 inch) under its accessible path.

A simple drying belt test rig initially was used to test the so-called encased belt drying. This unit is a scale-down model of a commercial technology developed for the drying of (chicken) manure. The unit was shipped from the Netherlands to Malaysia. In the dryer, cross flow heating is carried out using warm ambient air blown by electrically driven fans. Drying is expected to take place much quicker in this way compared to blowing hot air over the materials as in the solar bays.

To determine (initial) drying curves for the biomass materials, a small batch test set-up was constructed. The unit is a 35 cm by 35 cm square container in which air is fed at a certain temperature and velocity. Temperatures can be controlled between ambient and 80°C with a flow rate of 110 Nm³ hr⁻¹. The complete test rig was continuously weighted, and the weight reduction is attributed to the evaporation of the water. Knowing the initial moisture content, the average moisture content in the drier can be plotted versus the time. The test rig was filled with 3 to 10 kg biomass material, approximately 25 cm in height. Typical test duration was 300 min.
Compacting

For compacting, two types of units have been applied, \textit{i.e.} a pelletiser and a cubing machine. The pelletiser was based on a Flat Die technology developed by Amandus Kahl (Germany). A test unit was shipped from Europe to Malaysia for the test programme. In the pelletiser, feedstock is pressed through the die by the rollers. The quality of the pellets depends to a large extent on the type of die in relation to the feedstock moisture content and particles size. In the test programme various types of dies have been used. Some of the dies were modified on-site to improve the performance.

The cubing machine applied in the tests was a commercial system used to produce cubes from different feedstock. The machine uses a standard die with size of 28 mm x 28 mm (square) and is driven with a 150 hp motor. It has a design capacity of 8 - 10 t hr\(^{-1}\), but effectively the capacity was limited to 4 - 5 t hr\(^{-1}\) according to supplier’s information. The cubing machine can accommodate larger particles as feed than the pelletiser.

**TEST PROGRAMME RESULTS**

Size Reduction

No further size reduction has taken place for the EFB, as it is already shredded in the first stage pressing step at the palm oil mill.

The commercial EFB shredder was used for the initial shredding tests with the fresh OPF, field-dried OPF and trunk chops. Shredding of OPF and trunk chops resulted in complete destruction of the structure of the biomass, excessive fibres, dust formation and material losses. The shredded material was not suitable for further processing. Alternatively the commercially available wood chipper was used for the fresh and dried OPF, and trunk logs, which produced better quality ‘chipped’ materials with respect to fibrous nature and dust load (Figure 2).

In the solar bay drying tests of fresh OPF, a mobile chopper connected to the drive of a diesel tractor was used. This mobile set-up is easily transportable to individual drying bays and the adjustable arc of the discharge chute enables the chopped OPF to be spread at the bay to ease levelling work. Due to the light duty, the chopper was not suitable for the other materials.

Mechanically Dewatering

Tests have been carried out with all (fresh) materials. The work shows that substantial reduction in the moisture content can be achieved (Table 1) however, the palm residue structure appears to be severely damaged and a much more fibrous and low density material is obtained. Furthermore, the process generates a waste water effluent that requires proper handling.

Solar Bay Drying

Several solar bay drying tests were conducted with: (i) as-received (shredded and pressed) EFB, (ii) mechanically dewatered EFB, (iii) shredded OPT and (iv) mechanically dewatered OPT. Samples were taken to measure the moisture content during the drying process to prepare drying. The initial slopes of these curves indicate the drying rate (Table 2). Values for the moisture drop ranging from 0.05% to 2.5% per hour were typically observed, which is in accordance with past results presented by MARDI for fresh OPF (Furuichi \textit{et al.}, 2002). This corresponds with values of 10 to 70 kg hr\(^{-1}\) water evaporation (reference to 1000 kg material on dry basis).

A general observation for solar bay drying was that the mechanically mixing of the material by the Okada sweeper caused a further size reduction during the drying...
process, while fines present in the feed or formed due to the mixing are easily blown-away by the air flow over the drying beds resulting in significant material losses.

For as-received EFB solar bay drying reduces the moisture content from the initial ~45% down to about 10% in roughly 80 hr. Only after 60 hr, the drying curve levels off. For the mechanically dewatered EFB already after 50 hr a level of ~10% is reached; the drying rate is higher. Mechanically dewatered material enables a faster reduction in moisture content, which can be explained by the smaller particle sizes. The tests with OPT gave comparable drying curves for the EFB tests.

In some tests with both EFB materials it was observed that even during the night with the sweepers switched off (fans were running) there was significant moisture reduction. For the double pressed material this was most pronounced. This was explained by degradation (i.e. ‘rotting’) of the material in the stagnant bed layer resulting in an in-bed temperature exceeding 60°C. The drying time was reduced from ~30 hr down to ~15 hr, however, in this uncontrolled process the material was severely degraded resulting more fines in the dried product.
Belt Dryer

Experiments in the belt dryer were performed with: (i) as-received EFB, (ii) mechanically dewatered EFB, (iii) shredded trunks, and (iv) mechanically dewatered trunks. The slopes of the drying (trend) lines are again used to estimate the drying rates (Table 2). The trend data for the initial drying rates as determined in the belt dryer were in good agreement with the results from the batch dryer, although due to the different bed heights the absolute numbers differed.

The forced drying in the belt dryer significantly reduces the drying time compared to solar bay drying, i.e. down to 5 hr from 30 hr and 20 hr for as-received and mechanically dewatered EFB, respectively. For shredded trunks the drying rates in the belt dryer are comparable to EFB, but as the initial moisture content is higher (i.e. ~70% compared to ~50%) the total drying time to go down to 15% moisture is longer for mechanically dewatered material the drying time is reduced from 10 hr down to about 2 hr.

In the batch dryer, the effect of using pre-heated air as drying medium was investigated. This could be an option in case the pre-treatment facility is sited on a location where waste heat is available (e.g. in a palm oil mill). With 60°C air the drying rates were typically two times higher than when ambient air was used.

Pelletising

Pelletising tests were carried out with a wide variety of materials produced in the shredding and drying tests. The tests illustrated that in order to make pellets of reasonable quality the feedstock moisture content must be below 15%, while the feed material must be homogeneous in structure with small particles. Typically the different palm oil materials ex dryer do not meet this requirement for homogeneity and small particles. Even when the feed requirements were met, pelletising proved to be a sensitive process requiring continuous operator attention and even then a lot of off-spec material was produced.

Cubing

Cubing tests have been carried out on dried: (i) as-received EFB, (ii) mechanically dewatered EFB, (iii) shredded trunk, (iv) mechanically dewatered, and (v) chopped OPF. The feedstock had moisture content in between 10% and 15%. The cubes produced are in a standard size of 28 mm. Cubes were produced without problems, even changing the feedstock during a production run did not cause any blockage or any interruption of the machine. As a first indication for cube quality, the density for the different cubes produced is found in between 400 (for as-received EFB) and 800 kg m⁻³ (for mechanically dewatered trunks). It appears that mechanically dewatered material yield higher densities cubes, as these can be compacted better due to the smaller particle in the feed material. This is also visible in the pictures of the cubes (Figure 3), where the fibre is still visible for the non-mechanically dewatered (as-received) EFB.

DISCUSSION

Objective of the field test programme was to identify the optimum process steps for pre-treatment line-up for palm oil residues. Key results from the tests are:

Size Reduction

• EFB are available from the palm mills after primary pressing. This material can be fed to the dryer without further size reduction. In case the whole EFB are available an additional shredder can be installed as part of the pre-treatment line-up (cost data available).
• OPT are available as whole trunks from replanting. The line-up should include a
cutter to produce logs (not part of field test programme) and subsequently a heavy-duty shredder to make chips-like chunks.

- OPF was assumed to be available dried on the plantation. In contrast to fresh OPF, that is readily shredded, the dried OPF is difficult to shred due to increased fibrous properties. Therefore, OPF is assumed to be shredded in the OPT heavy-duty shredder. If at a later stage fresh OPF are taken as feed, this shredder can be replaced by a simple and cheaper chopper.

Mechanically Dewatering

- Mechanically dewatering with a so-called secondary EFB press is technically feasible and suitable to bring the moisture content from EFB, OPT and fresh OPF down from ~70% to ~40% in one step. This would significantly reduce the downstream drying capacity demand. However, in a line-up with waste heat utilisation the dryer is already smaller in size, so the advantage is less significant.
- The mechanical dewatering option was discarded in the mechanical process as the fibre structure of the biomass is destroyed, making the materials more prone to dust formation and higher fines load in the pre-treatment.

Drying

- Drying curves for all POR biomass materials were determined to allow sizing of the drying equipment.
- Solar bay drying was discarded as a generic line-up option, primarily as it results in significant dust formation (i.e. health and safety issues) and biomass material loses for OPT. Furthermore, the contained belt dryer is also on CAPEX and OPEX which is more attractive option especially when low temperature waste heat can be used for pre-heat of the drying air.

Compacting

- Pelletising is discarded as compacting option, as it proved to require fine and homogeneous feed materials, which conflicts with the target product specification of a low fines content. Furthermore, it is a sensitive process requiring continuous operator attention and even then a lot of off-spec material is produced.
- Cubing is the selected compacting step in the line-up, as it has proven to be robust towards operating conditions and very fuel flexible. On CAPEX and power consumption cubing is comparable to pelletising.

PRE-TREATMENT PLANT LINE-UP

The key item in the 5 t hr⁻¹ (dry output) pre-treatment plant line-up is the cubing machine. For the specific feedstock materials different and dedicated size reduction equipment is selected to address the different physical properties of the materials. Line-ups are described for
PTP’s dedicated for each feedstock and a general line-up for a PTP that can handle all biomass materials. Key characteristics are:

- EFB – the EFB PTP does not include any size reduction, but includes the belt dryer and cube production press;
- OPF (field dried) – the OPF PTP includes only the heavy duty shredder for size reduction step and does not include a belt dryer (i.e. material is collected field-dried);
- OPF (fresh) – this PTP includes a chopper, belt dryer and cuber;
- OPT – the OPT PTP is the most extensive including a two-stage size reduction (i.e. log cutter and heavy-duty shredder), the belt dryer and the cube press; and
- Full PTP – the full PTP design is intended to be the line-up suitable for processing of all materials. This line-up includes the two-stage size reduction, the belt dryer (suitable for using pre-heated air), and the cube press. Furthermore, it includes various parallel conveyer belts and storage bins to allow changes in the mode of operation. The schematic line-up is shown in Figure 4.

**CONCLUSION**

The study describes the development of a dedicated line-up for a pre-treatment plant for all relevant palm oil residues (i.e. EFB, OPF and OPT). The technology selection and equipment sizing were fully...
supported by results of an extensive field test programme carried out in Malaysia with local biomass and with commercially available equipment. Summarising:

- the developed PTP line-up is simple with low equipment count;
- the line-up is generic for all biomass materials assessed (except for the initial size reduction steps);
- experimental validation of technology selection and equipment sizing was obtained; and
- all technologies are commercially available.

The pre-treatment plant can be implemented commercially when a project opportunity arises.

ACKNOWLEDGEMENT

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REFERENCES


Future Milling Concepts or Idiosyncrasies?
- Part 2**

N Ravi Menon*

**Continued from p. 25 of Palm Oil Engineering Bulletin No. 98.

DIGESTION

Let us have a close look at the factors which are involved for good digestion of fruits. Many engineers and machine manufacturers do not appear to be in touch with the fundamentals when they design or manufacture fruit digesters. Even horizontal digesters have been manufactured and installed for fruit digestion. As all millers know too well that vertical digesters must be at least three-quarter full for proper digestion and it is preposterous for them to substitute vertical ones with horizontal units. Yet it is happening here. This is the second factor. The clearance between the digester blades and the body should as close as possible to ensure that all cells do rupture to release oil. Can horizontal units satisfy this condition? The third factor is the temperature which should be at least 90°C.

Consideration must be given to all the above factors when a digestion system is designed. If we are able to separate out nuts then we may come up with a different type of digester for the mash like a domestic kitchen blender that can rupture all the cells more effectively than the conventional digester. The sterilised fruit can be forced through a number of extruders of varying sizes but the nut orientation could pose a problem. Perhaps the mash could be forced through a pair of perforated rollers with curved blades like a potato peeler to capture the mesocarp but allow the nuts to pass through may work if sensibly assembled. Let us assume that the mesocarp peeler has been perfected, and all the mesocarp could be separated from the mash, the next step is to manufacture a dynamic digestion equipment to rupture all the cells in the mesocarp.

A machine similar to the kitchen blender with some modifications probably would do the job. As this machine can only work with some water it may be necessary to add water to it. After the blending operation if most of the oil has come out of the cells, the mash can be transferred to the press using a perforated screw conveyor. The residual oil in the mesocarp can be captured by the press.

The current digester design has ample opportunities for massive transformations. Like most other equipment in palm oil mills the digester design also could have evolved from the perception of a planter coupled with some non-professional input from a fabricator of sorts. Later of course Mongana researchers and Stork of Amsterdam among...
others undertook considerable research work to improve the design. But whether there was any lateral thinking for evolving an alternative system of digestion is unclear. The influential power of an existing system on an alternative system of thinking is something that is difficult to totally ignore. Therefore, let us look at some possibilities to improve oil extraction based on the fact that we try to extract most of the oil using the digester using the following hypothesis.

We are all aware that hot water can wash the oil out of mesocarp fibre and hot water is an environmentally safe solvent unlike hexane. Most of the digesters have steam heaters at two points at the lower half of the digester. If the top coil is used for steam heating and the bottom one for hot water flushing it may be possible to wash down most of the oil from the digester itself leaving very little work for the press screw. Most likely this flushing operation will remove most of the sand as well so that the press screw life can be extended. In addition, when most of the oil is removed in the digester the pressing pressure can be reduced resulting in less broken nuts. In theory it looks good but whether any one has tried out this modification is not known. But one thing commonly found in almost all mills is total absence of digester drainage. The drain pipes at the digester bottom are cold to the touch! That is not what anyone would expect.

DIGESTED FRUIT STORAGE

It was an error right at the beginning of mill mechanisation to place the press directly underneath the digester. Even the digester stirrer drive gear was located directly above the digester and when the greaser whose knowledge was limited to how much grease he can pump into the gearbox including the digester itself was his main focus with of course the disastrous consequence of hydrocarbon contamination of the palm oil. Why after so many years no one thought of placing all the digester away from the press is still a question mark. The advantages are: (a) it is easy to change the liners, (b) the liners can be pre-fabricated and pushed into the digester from the bottom using suitable jacks, (c) the digesters are not dedicated to individual presses and as such they can supply fruits to any press, and (d) possibility for all digesters to operate at full capacity.

All digesters can be clustered together in a neat array and deliver the digested fruits into a convor that can either convey them to a fruit silo or direct into presses as shown in Figure 1. Silos may present problems like clogging that could be difficult to clear if the silo size is large.

PRESSING

Presses can be made in large capacities - not necessary limit it to 15 t or 20 t capacity. The current screw press with double screws rotating in opposite directions might have actually evolved from single screw concept to satisfy high throughput.

It is possible to design and manufacture large presses. If I remember correctly some years ago I have seen a sketch of a press known under the brand Strod press. It was about four times the size of a P 15 press. It could probably give throughputs of even 60 t hr⁻¹. There is no legal limitation on the capacities of screw presses. The advantage would be fine adjustments like maintaining constant gap between the two screws so that oil loss in mesocarp fibre can be kept to a minimum. This can be accomplished by using self adjusting screw press. In addition, water dilution into the screw press also can be done using a hollow shaft instead of a solid one as is the case with the current ones. The screw scroll segments may be slotted into grooves machined on the shaft sleeve (like turbine blades) so that it will not be necessary to renew the whole screw during press overhaul. The oil gutter will be an integral part of the press and will be accessible from the press platform.
Perhaps press manufacturers should consider a single press to cater the requirements of a mill in terms of throughputs. With this approach a number of additional features can be added on to the press like sensors to automatically vary pressing pressure on the mash to reduce nut breakage as well as to reduce oil loss in fibre.

All press components can be made accessible so that maintenance could be made simple. The presses can also be mono-screw type rotating within the stator fitted with adjustable restraining teeth. Probably this will be a better option than the former double screw press. From the design point of view a hollow shaft is better suited for taking shear stress than a solid shaft.

**PRESS CAKE CONVEYOR**

There is a lot to gain if we can heat up the press cake as it travels through this conveyor. During the seventies the press cake breaker conveyors were steam jacketed purportedly to heat up the cake. As it had no significant impact on the moisture content of the cake, the conveyor was forced to shed its jacket. The concept of removing the moisture level in the press cake was good and should have continued. Perhaps a small illustration would clarify the point.

Here is something to ponder. Press cake contains about 45% moisture by weight. In a 60 t FFB per hour mill the moisture transported by the press cake conveyor would be 60% \( \times \) 13% \( \times \) 45% = 3.5 t hr\(^{-1}\). If 2.3 t of moisture can be evaporated using flue gas the moisture load on the conveyor can be reduced to 1.2 t. The heat required for the evaporation would amount to 2300 \( \times \) 2258 kJ or 5193 MJ (enthalpy of evaporation at 1 bar, \( h_{fg} = 2258 \) kJ). If this is done, the de-pericarp fan and its drive motor sizes also could be reduced significantly. The flue gas temperature at about 290°C is still substantial when it leaves the stack. A counter flow of the gas through the conveyor could also trap some of the particles before the flue gas leave the conveyor.
APPENDIX 3

Preparation of Synthetic Palm Oil and of Methyl Esters

The oil was prepared with a view to clarifying certain points connected to the bleaching and the oxidation of palm oil. The fatty acids were extracted from a blend of several palm oil lots with free fatty acid (FFA) ranging from 3% to 7%. They were distilled twice under vacuum. Their optical density was below 0.002 at 420 mμ (milli-microns). [Note that optical density is a dimensionless ratio of refractive indices before and after light penetration at different wavelengths given in milli-microns (CGS units) or nano meters (SI units) equivalent to 10^-9 m]. The fatty acids were then esterified with glycerol (the amount of acid used was 5% in excess of the theoretical quantity). The glycerol had first been distilled over tin chloride (0.5%) dissolved in glycerol. The activity of the catalyst is more or less intense depending on preparation procedure. Preliminary trials carried out on a number of brands led to the selection of Riedel de Haen tin chloride. The esterification is achieved by heating to 175°C for 2 hr at atmospheric pressure, then under a slight vacuum (20 mm – 30 mm of Hg) accompanied by stirring. After 3.5 hr, only 35.5% of the acids remained in the reactor. The vacuum is then intensified until the esterification of glycerol is completed (as assessed by the hydroxyl value).

Total time of the operation: 18 hr – FFA content of the oil: 8.9%.

It is important to prevent contact between the hot oil and air because under these conditions, the oil assumes a yellow tinge and oxidises quickly owing to the lack of natural antioxidants.

The oil is subsequently dissolved in petroleum ether, neutralised, bleached using active carbon (wynert extra) – if the oil is badly discoloured, this process is ineffective – then washed with metabisulphite to eliminate peroxides (1.2 times the theoretical quantity of metabisulphite is necessary). The oil is then washed with sodium hydroxide to eliminate the excess of metabisulphite then with water until it is neutral. The petroleum ether is finally driven off under CO₂.
The characteristics of the synthetic oil are given below:

- FFA: 0.2%
- Peroxide value: 0.8 milliequivalent
- Iodine value: 53.0 (54 for the initial oil)
- Hydroxyl value: 4.1
- Optical density: 0.04 at 420 mμ

**Preparation of the Methyl Esters of Palm Oil**

Methyl esters were prepared from SPB oil (FFA 1.96%) through transesterification in an alkaline medium and distillation of the esters thus prepared.

Methyl esters are completely colourless with an optical density lower than 0.005 at 420 mμ. The yield is 92%. The FFA content is 0.065%.

**APPENDIX 4**

**Determination of the Flash Point and the Flame Point of Oil**

Oil with a high flash point is preferred for application in metallurgy. A few determinations were carried out to ascertain whether the FFA content had an effect on the flash point. (Determination carried out with the Pensky – Martens apparatus.)

The results in Table 1 show that FFA have no effect, also that there is no relationship between the flash point and the appearance of vapour. The flame point appears very steady.

**APPENDIX 5**

**White Nuts**

Some nuts in the bulk before cracking or in the cracked mixture are observed to have a light colour from pale yellow to brown. The occurrence of this type of nuts has, to our knowledge, never been explained satisfactorily. A number of hypotheses were put forward (malformation, disease of the palm, characteristics of the palm).

In the course of the research work, unripe or under-ripe bunches (from 3 to 15 days away from ripeness) were processed on many occasions with a view either to assess the efficiency of stripping after sterilisation or to evaluating the quality of the oil (bleachability, carotene content).

On some batches of fresh fruit bunches (FFB), up to 35% of the nuts were observed to be white against a normal concentration of 1% at the most. It would appear therefore that white nuts originate exclusively from bunches which have not reached complete ripeness.

It is known that the density of white nuts and the shell thereof is lower than 1. They are consequently carried away with the light fraction, that is kernel, in the mud bath or in the hydrocyclone. The low specific gravity of these nuts and shell has however been made use of to separate them from the cracked mixture in a water bath in which all normal shell and kernels sink. The examination of ‘white nuts’ has shown that in exceptional cases the kernel is not yet formed (milky consistency), that in most instances the kernel is relatively small and finally, that exceptionally the kernel is of normal appearance.

The proportion of white nuts might possibly be used as a criterion of ripeness of bunches.

**APPENDIX 6**

**Density of Oil**

More that 99% of the oil exported from the Congo by Congopalm are shipped in bulk. In the production areas, oil is stored in bulk except in a very few isolated cases. The same remark applies to the transport of oil in the Congo. As a result, the oil is practically not weighed. The determination of the quantity of oil dealt with is carried
TABLE 1. SOWS FREE FATTY ACID (FFA) OF CRUDE PALM OIL (CPO) HAS NO RELATIONSHIP TO ITS FLASH POINT

<table>
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<th></th>
<th>Free fatty acid</th>
<th>Moisture</th>
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<th>Inflammation point (°C)</th>
<th>Vapour emission</th>
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<td>Same oil but dried under nitrogen at 100°C</td>
<td>2.50</td>
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<td>SPB oil</td>
<td>1.35</td>
<td>0.15</td>
<td>280</td>
<td>320</td>
<td>Very low</td>
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<tr>
<td>Same oil but stored for 12 hr at 60°C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Low</td>
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through volume and density measurements. The subject deserves further elaboration.

The determination of the density of liquefied palm oil presents no difficulty. It can be carried out as for any other liquid. Unfortunately, the volume of the oil is usually determined at a temperature below that of complete fusion. In that semi-solid state, the density cannot be obtained by extrapolation of the results pertaining to the liquid oil since the solidification of oil induces a contraction and consequently an increase in density. The dilatometric curves given in Figures 1 and 2 show the extent of the increase in density resulting from the gradual crystallisation of the constituents of the oil. The ratio of solid to liquid fraction is not the only factor affecting density. In order to obtain densities usable for the determination of weight from volume, it would also be necessary to take into account the corrections resulting from the buoyancy of air, the moisture content, the FFA content and the impurities content. The effect of these factors on the density of oil is however comparatively less marked than that of the variations of the ratio of solid to liquid fraction. Moreover, extrapolation is possible to some extent in the case of these factors whereas it is to be precluded in the case of the solid to liquid fraction ratio. This is due to the fact that variations of the ratio are not solely governed by temperature but also by the conditions of cooling or heating (type of crystallation on the one hand and suffusion on the other).

It is therefore not possible in practice to ascertain with accuracy the weight of oil from its density if the oil is not completely fluid. In order to illustrate this statement, reference is made to the data of Table 2 giving the density of three samples of oil at different temperatures reached by cooling and heating.

Figure 1 gives a plot of the density against temperature for oil at 1.82% FFA. The straight line indicates the normal variation of the density, that is -0.00068 per degree for the completely fluid oil.

For the same oil, calculations show that on cooling down the variation of the density against temperature within the range 30°C to 40°C amounts to -0.00145 per degree.

APPENDIX 7

Effect of the Moisture Content of Pulp on the Extraction of Oil

It is a known fact that the extraction of oil from oleaginous seeds (kernel, soyabean) is affected by the moisture content. The same
### TABLE 2. DENSITY OF OIL (kg litre⁻¹)

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<tr>
<th>Temperature °C</th>
<th>Moisture FFA 0.12%</th>
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<th>Moisture FFA 4.23%</th>
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Note: C means gradual heating of the oil. F means gradual cooling of the oil. * 1 liquid oil.
The density used in the determination of the weight of oil equals the true density less 0.0012.

![Figure 1. Density of oil in relation to temperature determined on gradual cooling and heating.](image)

remark has also been made in the case of oil palm fruit.

This point was investigated at laboratory scale. The following factors were considered:
- time of digestion;
- temperature of digestion;
- temperature of the mash subjected to pressing;
- moisture content of pulp; and
- nut content of the digested mash.

**EXPERIMENTAL**

The effect of the above factors on the oil content of fibre and the composition of crude oil was ascertained. The fruits were sterilised according to the Mongana technique. Only the pericarp was subjected
to digestion in a laboratory digester fitted with a jacket using oil as heating fluid. The pulp was extracted in a Carver press under a pressure of 86 bar. The pulp was dried in an oven set at 100°C.

**RESULT AND CONCLUSIONS**

The effect of the moisture content of pulp on the oil content of fibre was determined under the following conditions:

1. No heat applied during digestion or pressing:
   - without digestion.
   - after 10 min digestion.
   - after 40 min digestion.
2. Heat applied during pressing but not during digestion:
   - after 10 min digestion.
   - after 40 min digestion.
3. Heat applied during digestion and pressing:
   - after 10 min digestion.
   - after 40 min digestion.
   - after 60 min digestion.
4. Factory digested pulp:
   - after 10 min digestion.
   - after 40 min digestion.

The main results are shown graphically in Figures 2 to 4. The following conclusions are drawn:

- the optimum moisture content of pulp is 10% corresponding to the lowest oil content in the fibre;
- drying of the pulp below that level entails an increase in the oil content in the fibre;
- above a moisture content of 10%, the oil content of fibre also increases but levels off at and beyond a moisture content of 20%;
- the extraction efficiency is far better for factory digested fruit than for fruit digested in laboratory equipment, even if the appearance of the digested mash is the same in both cases. The pressing of factory digested mash easily yields fibre with an oil content of 15% on dry basis. The lowest oil content recorded on pressing laboratory digested fruit was 20% even when the time of digestion was lengthened;
- the optimum moisture content for laboratory digestion differs from that applicable to factory digestion. In the latter case, the optimum was found to

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**Figure 2. Oil content of dry fibre in relation to the moisture content of mash under various conditions of digestion and pressing.**
be approximately 30% moisture in pulp (moisture content was increased up to 50% by addition of water);
- the efficiency of digestion is affected by the proportion of nuts. However, the lack of sufficient can be compensated by an increase in the time of digestion;
- the lower the moisture content of pulp, the lower the dirt and moisture content of crude oil. The effect of the former on the latter is very sharp;
- the separation of crude oil into its constituents is very fast when the ratio of moisture to non-oily solids is close to or lower than 1. This points concedes fairly well with the optimum moisture content of pulp. This would indicate that when the ratio is higher than 1, the
NOS is highly hydrated and forms a stable suspension in the oil;
• in special instances the moisture content of pulp was reduced considerably. In these particular cases, the moisture content of oil was found to be lower than the saturation limit; and
• the desiccation of pulp or fruit at industrial scale gives rise to technical difficulties (the technique used in the pilot plant consisted in flowing air heated up to 140°C through a rotating drum loaded with fruit).

CALL TO ALL ADVERTISERS
IN THE PALM OIL MILL VENDOR’S LIST

Please note that due to the increased cost of printing, the Editorial Board has decided that with effect from 2012 advertisers will not be able to alter their details with regard to new entries arising from Full Page advertisement that entitle them for four free listing starting from the issue in which the advertisement was placed. However, they will still continue to have their listing in the Palm Oil Mill Vendor’s List but it will commence only from the first issue in the following year. An example is given below.

An advertiser places a one Full Page advertisement in say the second-quarter (Q2) of year 2011. Under the existing system, he will get four listing in the Palm Oil Mill Vendor’s List beginning from Q2 until Q1 of the following year. Under the revised system, the Palm Oil Mill Vendor’s List listing in this case will only commence in 2012 (Q1) ending in 2012 (Q4). The New Palm Oil Mill Vendor’s List will be printed and distributed once a year.

New advertisement, any update or amendment can be made Now till 28 February 2012 for the New Palm Oil Mill Vendor’s List 2012. Please submit the Reply Form early.

We regret any inconvenience caused by this revision.
Did You Know?

In Africa, the crude palm oil as extracted from palm fruits has probably been from time immemorial until the present day part of the people’s staple diet. The Delta area of Nigeria produced the ‘Banga soup’ that requires a free fatty acid (FFA) of over 10%.

Sierra Leone produced ‘Palaver soup’ and its taste depends on an oil having an FFA of over 20%. So the processing technique also will be different.

So high FFA oil is not that bad after all huh?

In case you wish to make a meat dish here is the recipe. This secret is best kept away from your wives. You can surprise her with this finger licking dish!

Cut meat into 3-5 cm cubes, season with salt and cover with water. Boil until the meat is tender and the water has evaporated. Grind fresh red peppers, tomatoes, onions and the high FFA palm oil is added to the meat and cooked 5 min uncovered.

Most of the expatriates who have worked in Africa have acquitted the taste for ‘Palm Oil Chop’ and was a healthy trade in tinned mesocarp to Europe for making this dish.

The above dishes are still available.
### PRODUCTION RATE (per hectare) OF FFB, BIOMASS, CPO AND KERNEL

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<th>Shell 6%</th>
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Note: FFB - fresh fruit bunches.
EFB - empty fruit bunches.
CPO - crude palm oil.
KER - kernel.