CAFEi2012-102

NEUTRON BACKSCATTERED TECHNIQUE FOR QUANTIFICATION OF OIL PALM FRUIT OIL CONTENT

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ABSTRACT

Nowadays, non-destructive and real time method becomes a well-liked method to researchers in the oil palm industry. This method has the ability to detect oil content in order to increase the production of oil palm for better profit. Hence, this research investigates the potential of neutron source to estimate oil content in palm oil fruit since oil palm contains hydrogen with chemical formula $C_{55}H_{96}O_6$. For this paper, oil palm loose fruit was being used and divided into three groups. These three groups are ripe, under-ripe and bruised fruit. A total of 21 loose fruit for each group were collected from a private plantation in Malaysia. Each sample was scanned using neutron backscattered technique. Neutron count per minute is increase from bruised fruits to ripe fruits. The higher neutron count, the more hydrogen content, and the more oil content in palm oil fruit. The best correlation result came from the ripe fruits with r^2=0.98. This research proves that neutron backscattered technique can be used as a non-destructive and real time grading system for palm oil.

Keywords: *Non-destructive technique, Neutron backscatter technique, Oil palm content.*

INTRODUCTION

Malaysia has produced 18.91 million tons of palm oil in 2011 which is increased by 11.3% against last year (16.99 million tons) [1]. This is due to the improvement of fresh fruit bunch (FFB) yield as the weather conditions was getting better and more areas have increase their productivity. Thus, oil palm industry has started to get the attention of researchers to identify the quality fruit in determining the oil content.

It is crucial to harvest oil palm FFB at the right stage of ripeness for better quality and higher quantity of oil production. Currently, Malaysian Palm Oil Board (MPOB) has graded the FFB manually based on mesocarp colour from reddish orange(ripe) to yellow (unripe) and empty sockets of detached palm oil fruits[2]. However, this method is less relevant because the final results are varying from one individual to another.

Lately, non-destructive and real time method has becomes a trend in the oil palm industries. In 1992, Kaida and Zulkifli[3] was developed a microstrip sensor to determine the appropriate time to harvest oil palm fruits based on moisture content of the fruit. Unfortunately, this method is not applicable to the tall palm trees. Some researchers [4-7] was used vision technology to grade the palm FFB. However, this technique is really depends on light intensity under oil palm canopy and radiation from sunlight.

Presently used methods to predict oil content in palm oil fruits mostly restricted to the colour of mesocarps. Due to the lacks of available techniques, a new method using nuclear technology is introduced. Jonah et al. [8] was used Am-Be neutron source to determine the hydrogen content of oil samples from Nigeria. They found that this technique was economical and suitable to determine moisture in solid sample. A fast neutron transmission technique to measure the moisture content in sugar and wood samples also has been reported [9]. A total of 2.8 MeV of neutron was transmitted through the wood and sugar samples and detected by NE213 Scintillation detector. In addition, Norpaiza et al. [10] was conducted an experiment with neutron device for in-situ detection to measure water content in a bulk of used paper using neutron backscatter technique.

Although this technique is normally used in big industry, there is still new in agricultural field, Consequently, this paper is to introduce the potential of neutron source in order to study the relationship of mesocarp oil content with the count per minute (cpm) of neutron with respect to the oil palm fruit maturity since oil palm contains hydrogen with chemical formula $C_{55}H_{96}O_6$. This technique can make in-situ measurement of oil content. It is not only non-intrusive but also quick, fairly accurate and also yields constant results. A fast neutron source (Am-Be 241) and a portable backscattering neutron detector was used for oil content measurement. Theoretically, slow neutron counts can be correlated to the hydrogen in palm oil fruits. At this time, there is no research is carried out using Neutron Backscatter Technique (NBT) on actual palm oil plantation to determine oil content in FFB. Therefore, an aim of study is to use the NBT as a tool for real time grading system of palm oil.

MATERIALS AND METHODS

The Neutron Backscatter Technique (NBT) principles appropriate to the interaction of neutrons with matter. Neutrons emitted from radioisotope sources are energetic particles, and referred to as 'fast neutrons' which are difficult to detect. Fast neutrons do not interact with the electric fields of atoms and molecules. These fast neutrons interact with matter to become slow or thermal neutrons. Thermal neutrons are most likely to interact with atoms of a similar size to the neutron itself. Hydrogen is the atom closest in size and mass to the neutron and therefore accounts for the majority of the collisions that release energy and reduce the fast neutrons to thermal neutrons. The thermal neutrons are scattered in all directions but have a short travel path. Some of them are scattered back towards the scanning head and these are the neutrons counted by the detector.

Fast neutrons, in the range 0.5-11 Me V, lose their energy by scattering process. In elastic scattering, the neutron is slowed down in the collision and its direction of motion is changed. In the energy range 30eV-0.5 MeV, elastic scattering is essentially the only process by which a neutron can be slowed down. If neutron energy before collision is denoted by E_1, and after collision by E_2, it is possible to show that in a head-on collision, the energy transferred to the nucleus is

$$E_2 / E_1 = [(A-1)/(A+1)]^2 \qquad (1)$$

where A is the mass number of the nucleus. From equation (1) it can be seen that it is possible for a nucleus to lose all of its kinetic energy in a head-on collision with a hydrogen nucleus. It is clear from the above equation that it is possible for a nucleus to lose all of its kinetic energy in a head-on collision with a hydrogen nucleus. Hence, the presence of hydrogen is a major factor in the slowing down of fast neutrons. The concentration of thermal neutrons near the fast-neutron source is increased by the presence of hydrogen. The higher the concentration of these elements, the shorter are the distances traveled by the thermal neutrons and the higher is their density near the source. Therefore, the more concentrate the palm oil fruits, the higher cpm will be recorded. Neutron detector will detect the interaction between neutron and hydrogen, which can determine the moisture content and show or estimate the oil content in oil palm fruitlets.

Experiments have been conducted in the laboratory of Plant Assessment Technology Group, Malaysian Nuclear Agency. Palm oil fruitlets were put in a special box in order to study the different percentages of oil contents in three different groups, which are ripe, half-ripe and bruised fruit. Hydrotector which utilizes the NBT is a portable and in-situ nucleonic gauge was used in this research. This gauge used 50 mCi of Am–Be 241 neutron source and consists of a sealed radioisotope source, a detector, a telescopic pole handle and the electronic controller unit or rate meter. Consequently, the Am–Be 241 (half-life 458 yr) source emitted neutrons in all directions but only one beam of fast neutrons is set downwards to the palm oil fruitlets due to the presence of shielding.

To ensure the stability of equipment before and after measurements, a standard paraffin block which contains high hydrogen atoms will be used in sequence. The investigation technique was conducted as a spot measurement in which the measurement head is placed on palm oil detached fruits. Each count was repeated three times. As a result, the thermal neutron counts are obviously differ where it have been compared.

RESULTS AND DISCUSSIONS

Figure 1 shows the comparison of thermal neutron counts obtained from measurements of palm oil fruitlets. This figure indicates that the thermal neutron count has directly increased with the increment of number of fruitlets. However, the thermal neutron counts are seen not increased linearly with further increases of number of palm oil fruits. This is due to the size of each fruits. Smaller fruits will contribute to small increment of neutron counts. At certain point, the count of neutron backscatter particle was become saturated. This indicates that, hydrogen concentration in palm oil fruits have been at the maximum rate.

As can be seen, there is an increment in thermal neutron counts with every addition of palm oil fruit. As expected, the thermal neutron counts detected are higher for ripe fruits with coefficient of determination, r^2 = 0.98 and lower for bruised fruits (r^2 = 0.96). This situation indicates that, ripe fruits has highest quality among others and later lead to higher quantity of oil palm produced. Due to low quality, bruised fruits has show low in neutron counts and indicate that hydrogen content is much less than other two. The number of backscatter neutron counts is directly proportional to the concentration of hydrogen atoms in front of the neutron detector has caused this result. For that reason, oil content in the fruits is detected based on hydrogen atom concentration and this concentration can be used to calculate the quantity of oil content.

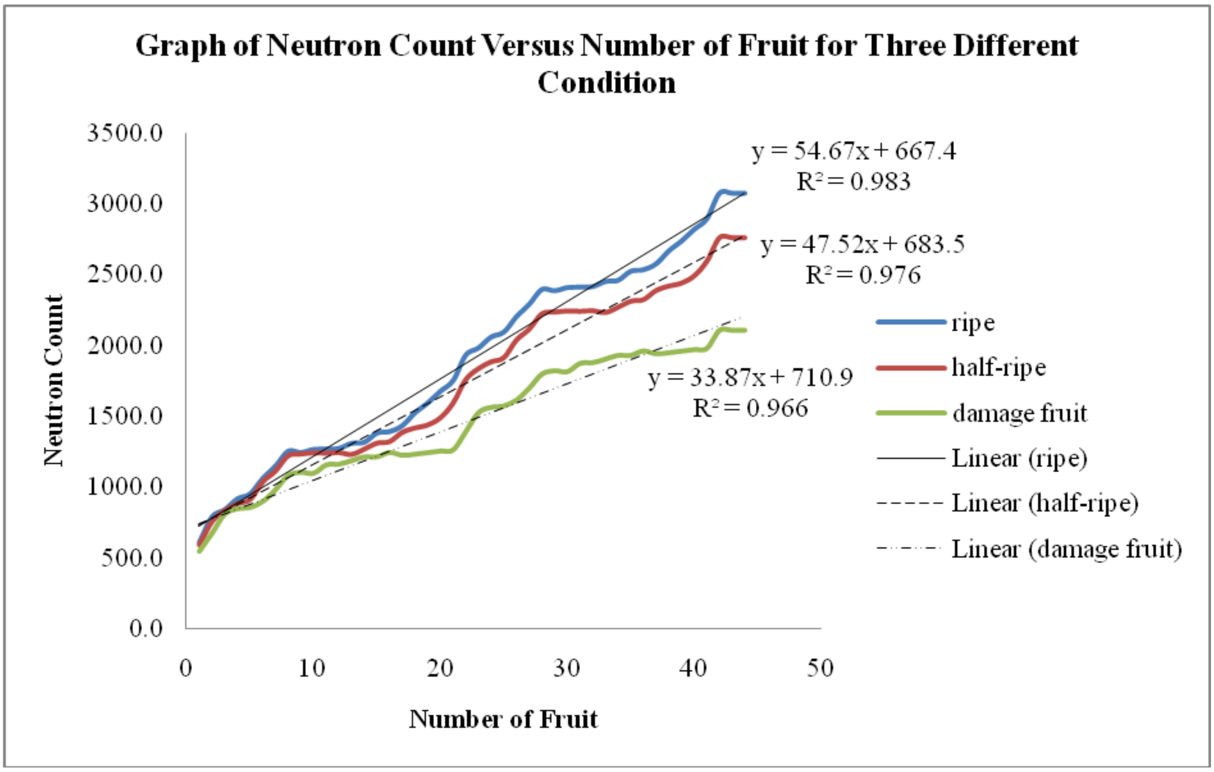

Fig. 1: Graph of thermal neutron count for three condition of palm oil fruits

CONCLUSIONS

A 50 mCi of Am–Be 241 neutron source has been used for the quantification of palm oil fruit oil content. The data from NBT tends to be more reliable than other method. The detected thermal neutron count increases every additional of palm oil fruitlets. It is proven that higher quality palm oil has lead to higher cpm with coefficient determination, r^2 = 0.98. This study indicates that the neutrons have the potential to be employed to grade the palm oil FFB based on quality and oil content.

ACKNOWLEDGEMENT

The authors would like to extend their appreciations and sincere thanks to all staffs of the Plant Assessment Technology Group, Malaysian Nuclear Agency for their support and cooperation.

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