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CALIBRATION OF THE LOW ENERGY ELECTRON ACCELERATOR DOSE PROFILE

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ABSTRACT

This paper describes dose profile calibration for Low Energy Electron Accelerator (LEEA). This locally designed LEEA of 300 keV and 10 mA has been operated and serve for irradiation purpose. In the setup, the electron beam is energized by the electric field with high voltage power supply, scanning and passing through the titanium foil, to irradiate the sample. The dose profile by the energetic beam mapping results have been obtained by using Cellulose Triacetate (CTA) dosimeter for the calibration purpose.

ABSTRAK

Makalah ini menerangkan penentukuran profil dos untuk Pemecut Elektron Tenaga Rendah (LEEA). LEEA reka bentuk tempatan 300 keV dan 10 mA ini telah dikendalikan dan berfungsi untuk tujuan penyinaran. Dalam persediaan, pancaran elektron ditenagakan oleh medan elektrik dengan bekalan kuasa voltan tinggi, mengimbas dan melepasi kerajang titanium, untuk menyinari sampel. Profil dos oleh hasil pemetaan rasuk bertenaga telah diperoleh dengan menggunakan dosimeter Cellulose Triacetate (CTA) untuk tujuan penentukuran.

Keywords: Electron Accelerator, Cellulose Triacetate (CTA) dosimeter, electron beam

INTRODUCTION

A localized own developed accelerator technology so-called the low energy electron accelerator (LEEA) [1][2][3] has been upgraded from 140 keV to 300 keV as shown in figure 1. At the upgrading stage various auxiliary systems were upgraded such as insulating gas system [2], scanning power supply [3], window cooling system [4] and filament power supply [5]. As the LEEA has passed through the beam commissioning and also dose mapping profile by Cellulose Triacetate (CTA) since 2020 [6]. Whereby the dose profile mapping needed to be calibrated with refer to the conveyor speed. Dose profile of the electron accelerator is an essential parameter which must be determined accurately. Typically, the so-called surface absorbed dose need to be identified as expressed in Equation [1]. The process and results will be described and discussed as follows.

$$Surface absorbed dose, D_{surface} = \frac{KI}{S} [\text{Gy}] \quad .(1)$$

whereby,

$\boldsymbol{K}$= Constant parameter dependence of the beam energy
I = Beam current [A]
S = Conveyor speed [ms-1]

According to the Equation 1, the surface absorbed dose can be measured by the CTA [7] and the speed of conveyor must be calibrated and identify through an experiment as described in next section.

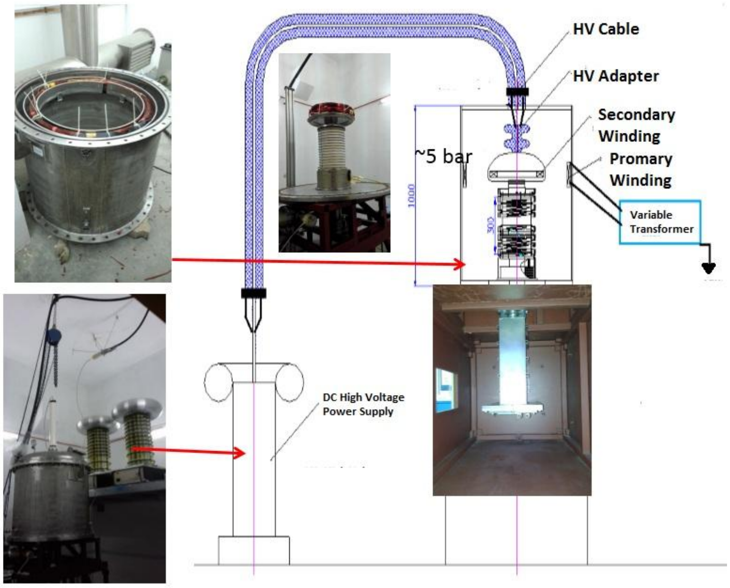

Figure 1. Low energy electron accelerator.

CALIBRATION OF THE CONVEYOR SPEED

For Low Energy Electron Accelerator (LEEA) [8], the disposal conveyor is utilized as the sample handling system as shown in Figure1. In the experimental setup, the speeds of the conveyor are adjusted by adjusting the voltage of the control module. The tachometers are utilized to measuring the rotating speed as shown in Figure 2. The measured data from Tachrometer is converted into the speed unit of meter per second by equation (2).

$$S = \frac{N_S C_p S_{RPM}}{60} [ms^{-1}] \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

N_s = Number of gaps of sprocket

C_p = Chain pitch distance [m]

S_{RPM} = Conveyor speed measured by Tachometer [Number in minute]

Figure 2. Experimental setup of the conveyor speed calibration.

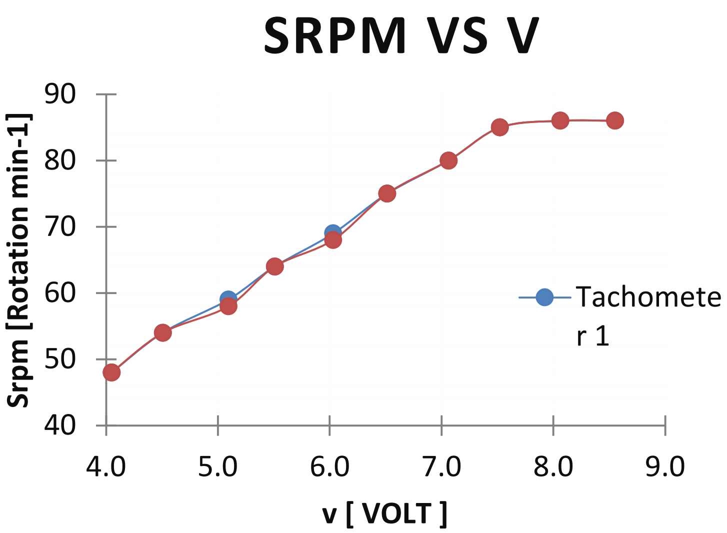

Figure 3. Conveyour Speed (Unit as rotation per min) Measurement with TwoType of Tachometer

By using the Equation (2) and measured data of the relationship beween conveyor speeds Vs voltage is plotted as shown in Figure 3. With the data of Figure 3, the conveyor speed is converted into the ms^{-1} unit as shown in Figure 4.

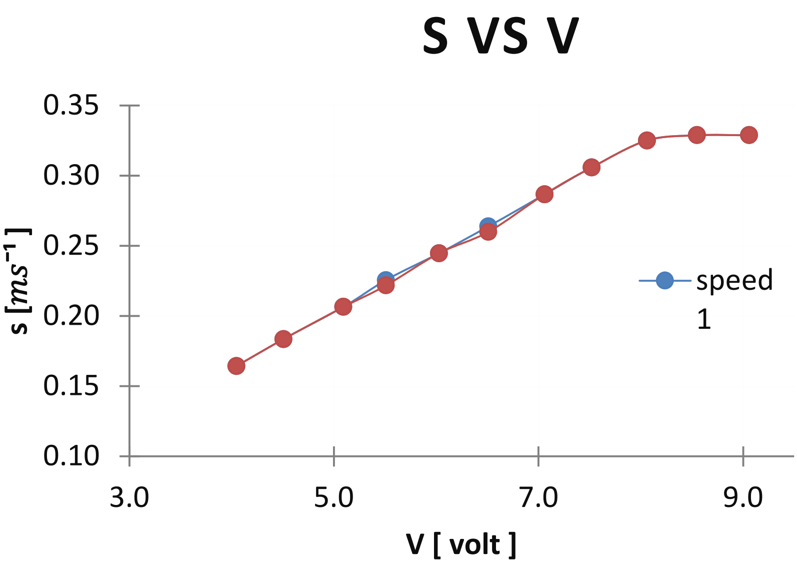

Figure 4. Conveyour Speed in ms^{-1}

Both of the tachometers able to measure the rotation speed of the sprocket with the similar measurement results. With the results, it has been converted into the speed of meter per second unit for the surface absorbed dose identification in next section.

CALIBRATION OF THE DOSE PROFILE

For the dose mapping calibration, the apparatus required are CTA and UV- spectrophotometer as shown in Figure 5 As CTA film dosimeter is form with a long and thin shape as shown in Figure 5, it is a colourless, transparent film with the specification as shown in Table 1 [7]. It utilized for measuring radiation dose in gamma, electron beam or X-ray applications and industrial processes such as sterilization of medical device, crosslinking of cable and curing and coating of polymer surface and irradiation of food.

Figure 5. CTA dosimeter system: CTA film (left), GENENSYS 5 UV- spectrophotometer (right)

Table 1. Specification of the CTA

Parameters	Figure
Film thickness	125 µm (~15 mg/cm^2)
Dimension	width: 8mm,length: 100 m/reel
Composition	cellulose triacetate, triphenyl phosphate
Analysing wavelength	280 nm

The linearity dose response characteristic as shown in Figure 6 make it user friendly with simple measurement procedure [6]. In principle of CTA, its optical density is increasing by the radiation exposure. The absorbed dose is evaluated from the measured value of the increment of the optical density with the wavelength of 280 nm during irradiated. The CTA will be inserted into an UV spectrophotometer and its optical density is measured by the spectrophotometer. The absorbed dose versus the length of CTA is recorded by the spectrophotometer as well.

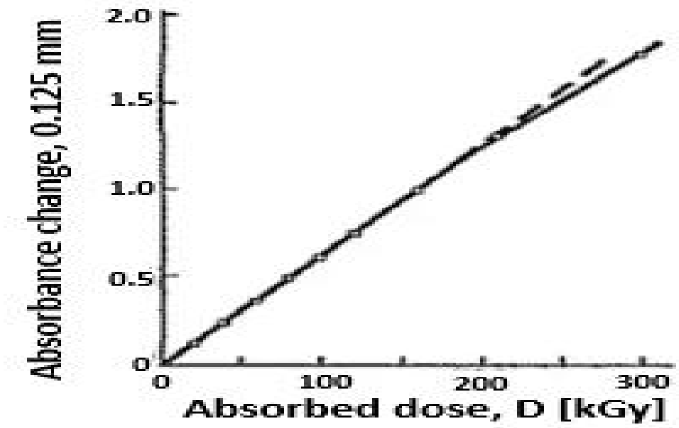

Figure 6. Dependence of absorbance change on the observed dose (measured at 280 nm)

Typically, the industrial electron accelerator is equipped with a magnetic scanning system in horizontal and vertical directions [9][10]. The scanning system is required to avoid the heat at the titanium window and to get a homogeneity dose profile along the titanium window. In this experiment, a desired frequencies of 80 Hz at horizontal axis and 800 Hz at vertical axis are fixed. Whereby the excitation current of individual coils is set according to the beam energy [3]. For the dose profile measurement setup, the electron beam energy is fixed as 200 keV with beam current of 1 mA and 2 mA respectively. The excitation coil currents at horizontal axis and vertical axis are adjusted for ~1.0 A and ~0.5 A. Whereby the dose profile is expected to distribute uniformly along the limited length of the along titanium window [3]. A CTA film is hold on the sample holder and moving by a conveyor with fixed speed as shown in Figure 7. After irradiation, the irradiated CTA is evaluated by a UV spectrophotometer.

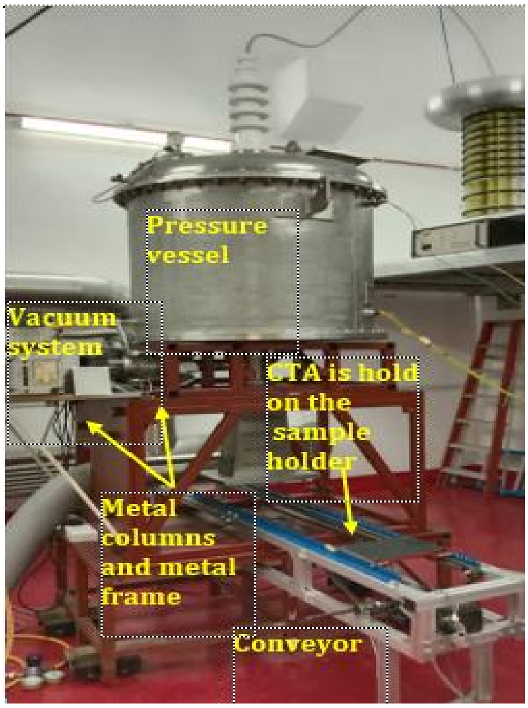

Figure 7 Irradiated CTA is held on a sample holder with a constant speed of conveyor

RESULTS AND DISCUSSION

As the results, the dose profile with dependence of conveyor speed haven been measured experimentally. For the result as shown in Figure 8, the surface absorbed does is increasing with the decreasing of the conveyor speed. The results are within our expectation as the absorbed dose is increasing as the exposure time is longer with lower speed. From the Equation (1), we need to find out the k-value as the surface dose is taken from the average of the surface absorbed dose within the length of the titanium window as shown in Figure 8.

From the Figure 9, the K parameter is calculated as 17.64 can be calculated from the slope of the graph according to equation (1) with 1 mA beam current. As the calibrated parameter K is obtained and this constant parameter could be applied with various beam current with the reference of 1 mA. Basically, the K parameter with different energy or distance between the sample and window will be different and must be identified with the experiment data again.

During the experiment, the dose profile with desired length and homogeneity along the window length as 19.25 cm [3] can been seen but the beam center is shifted to left. This might be cause by the miss-alignment of the electron gun during its replacement last month. As this speculation should be clarified and solve in near future.

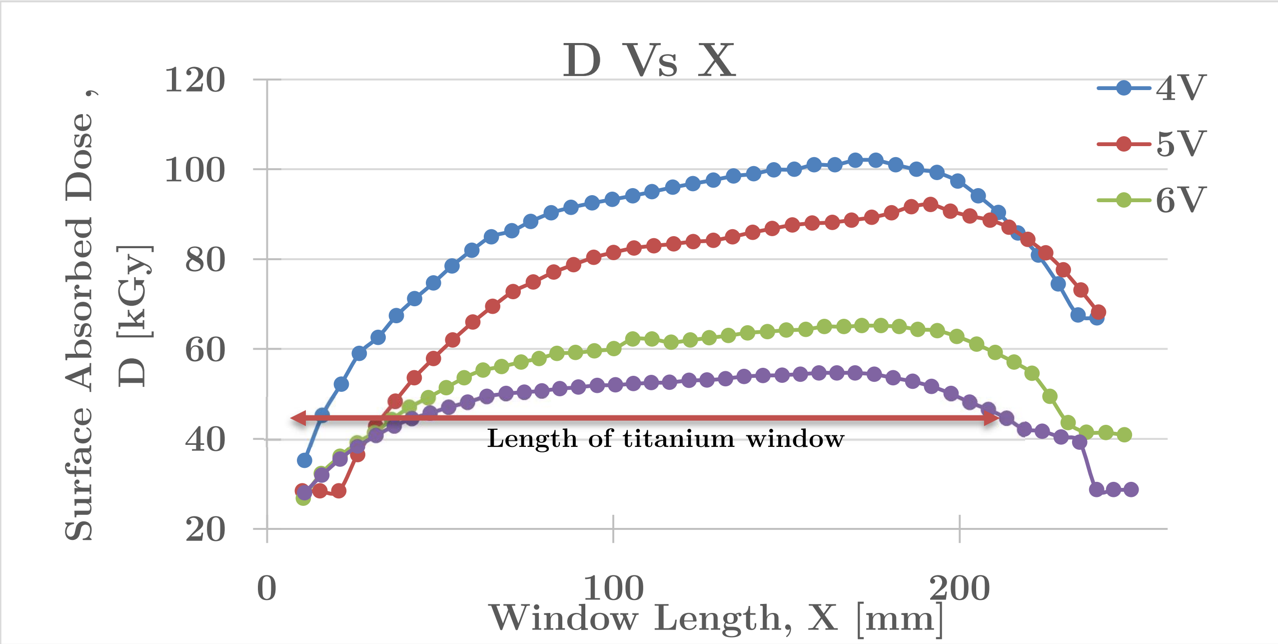

Figure 8. Dose profile dependence of conveyor speed at 200 keV beam energy and 1 mA beam current

According to the experimental data and Equation (1), the K parameters are calculated as shown in Figure 9.

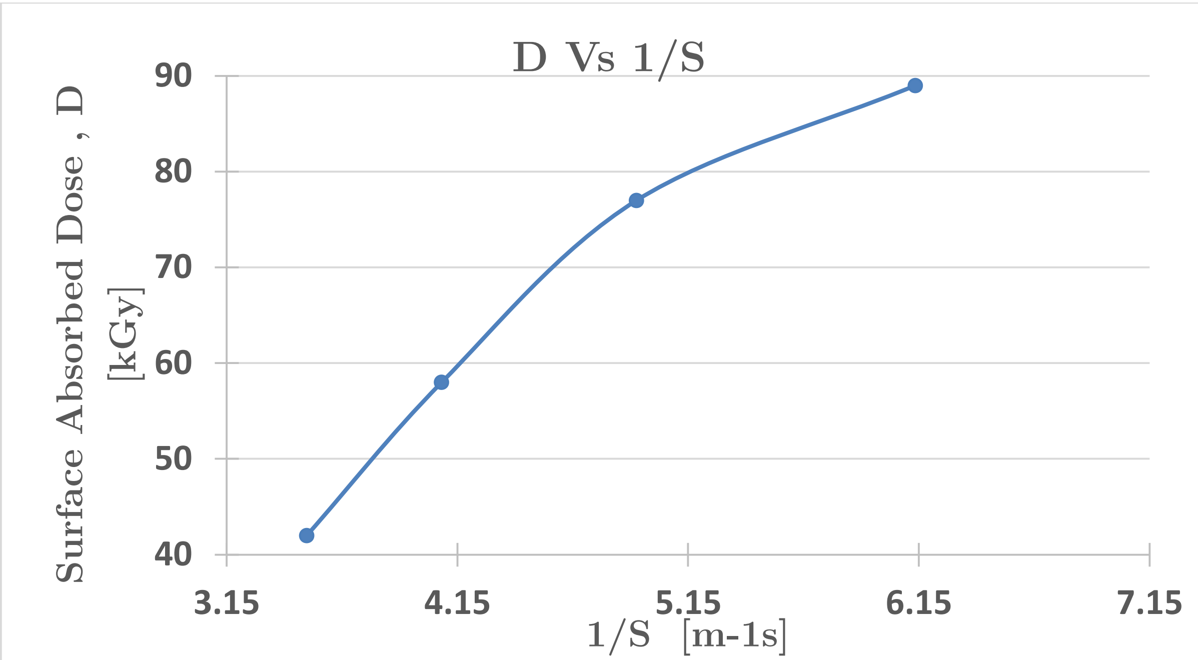

Figure 9. Dose profile with respect to the 1/conveyor speed at 200 keV beam energy and 1 mA beam current

CONCLUSION

In this paper, dose profile of LEEA has been evaluated and calibrated. In near future, dose profile by using calorimeter is planned and will be implemented as well.

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