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PLASMA FOCUS DEVICE AS A X RAY SOURCE FOR RADIOGRAPHY APPLICATIONS IN NUCLEAR MALAYSIA

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ABSTRACT

A 3.375 kJ plasma focus is designed to operate at 13.5 kV for studying X-ray source in Argon discharge. X-rays are detected by a film from the mammography radiographic plate using radiography technique. The feasibility of plasma focus as a high intensity flash X-ray radiation for a good contrast in radiography image is presented.

Keywords: Film, irradiation, plasma focus, radiography, X-ray source

INTRODUCTION

The photographic film was widely used in radiation natural detection and traceable effect produced from radiography technique. Radiation-sensitive photographic emulsion is an important material coated on a radiographic film which required for dosimetric measurements. Its sensibility might be controlled and has a wider range of preparation process that can be adapted to different type of radiations. The blackening of photographic emulsion on the film indicates the effects of ionizing radiation.

The photographic measurement method employed in radiation dosimetry show the following advantages: permanent measurement record, simultaneous record of different radiations type, repeated reading of the same film, large area dosimetry especially for electrons beams, linearity of dose, dose rate independence, and good spatial distribution of dose or energy permitting realization of little detectors. The blackening observed on the film after exposing to X-rays is expressed in terms of optical density (OD), as expressed by the equation below:

$$D = \log_{10}(I_0/I) \qquad (1)$$

Where D is the OD, I_0 and I are the intensities of light before and after passing through the exposed film respectively.

The degree of blackening is determined based on the OD measured by a densitometer (Scarlat et al., 2008). Plasma Focus (PF) is pulsed power devices that generate dense magnetized plasma by means of electrical discharge in rarefied gases. These devices produce pulsed energetic beams consists of ions, electrons, electromagnetic radiation (EMI), X-rays and high energy neutrons. The current interest is related with dense plasma physics and innovative applications of pulsed radiation sources (Dubrovsky et al., 2000; Gribkov, 2000). From applications point of view, the feasibility of a small PF as a high-intensity flash X-rays source for obtaining a good contrast for biological object has been demonstrated in several laboratories (Da Re et al., 2001; Zambra et al., 2012).

Baijan et al. (2010) have reported the first preliminary studies of X-rays producing by the experimental Plasma Focus device in Nuclear Malaysia. This device is originated from University Malaya which has produced a focus plasma with Argon as the filler gas, therefore X-rays radiation is produced. The aim of the present study is to explore the possibility of Plasma Focus Devices developed in Nuclear Malaysia to be used in X-rays radiography applications.

MATERIALS AND METHODS

Experiment Setup

The X-rays radiography experiments were carried out using 3.375 kJ plasma focus device as shown in Fig. 1. The parameters have been controlled according at 30 µF, 13.5 kV and 40 nH capacitor charger. The filling gas, Argon, was used at working pressure 1.5 mbar. There are the electrodes enclosed in the vacuum chamber. The outer electrodes are made of copper rods and arrange in a coaxial configuration. The inner electrode is cylindrical and hollow at its front surface. An X-ray film installed inside of mammography radiographic cassette was placed at the top of vacuum chamber in perpendicular with the axial axis. It is located at 10 mm above the vacuum chamber as shown in Fig. 2. The object used as a filter is place in between the vacuum chamber and the film cassettes.

Figure 1: Plasma focus device

The X-rays radiation is emitted upward from the vacuum chamber than penetrating the filter and transmitted X-rays will expose on the radiographic film. Four exposures were made for each filter thickness such as 1 mm, 2 mm and 4 mm and also without any filter. The filter leaves on the film surface an unshielded border and gives images which provides a blackening corresponding to the radiation intensity.

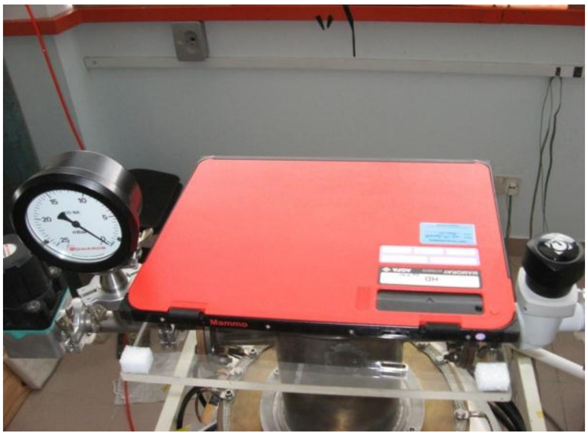
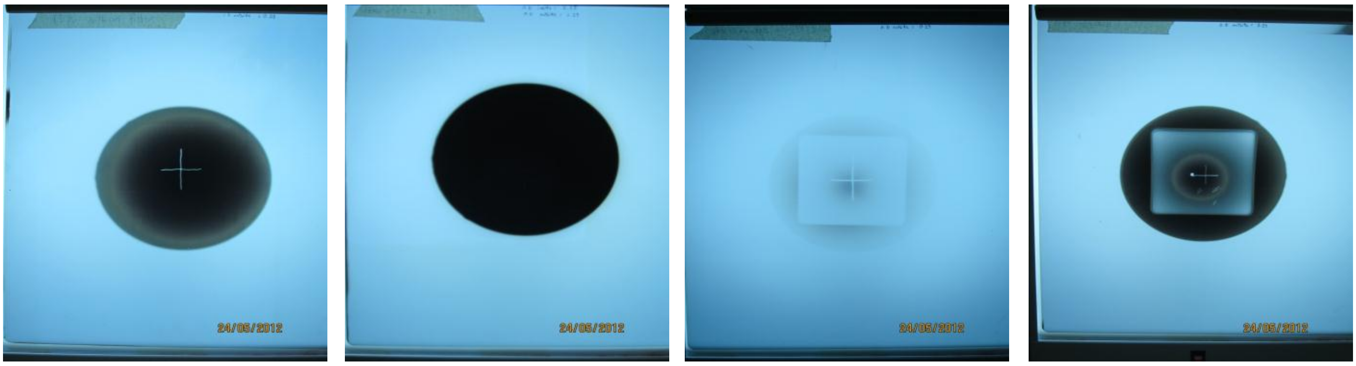


Figure 2: Mammographic radiographic chasing position at the discharge chamber

After irradiation, the image of the developed films have been digitized and analysed using a dedicated image processing computer code which gives the optical density of the films on the basis of pixel values.

RESULTS AND DISCUSSION

The white areas on the film (Fig. 3) are considered background as it was not exposed to X-rays radiation. The images after subtraction with the background have been normalized therefore deducing the blackness of the unshielded border. Therefore comparison from different discharges could be made. The images after subtraction are given in Fig. 3.



(a) Without filter (b) 1 mm Al (c) 2 mm Al (d) 4 mm Al

Figure 3: Images obtained after one discharge according to filter thickness of aluminum (Al)

The optical density values for bare film and with the filters obtained from digitized images is tabulated against the filter thickness as shown in Table 1.

Table 1: Optical Density (OD) values in function of the different thickness filter

Film	**Al thickness** (mm)	**OD**
a	0	2.39
b	1	2.56
c	2	0.54
d	4	1.79

This table shows that OD for 2 mm thickness of filter was the lowest whereas it was higher for 1 mm and 4 mm thickness of filter. This result of OD value indicates that the X-ray exposures were not corresponded with the time of exposure. It is not expected since the thickness of filter increased linearly. Therefore, further investigation shall be made in the future to investigate this phenomenon.

CONCLUSIONS

The measurement of effective energy photons emitted by a short intense pulse was successfully employed by monitoring of X-rays emission from plasma focus device. We have pointed out also that this inexpensive technology is possible to be used in radiography applications. The advantages of producing X-rays by plasma focus is a very short exposure time such as in nanosecond, therefore the risk of over doses to the operator would be minimized.

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