Construction of 15 MeV NDT System Based on S-band LINAC

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1. Introduction

Generally, non-destruction testing (NDT) is carried out by using ultrasonic, radiation, neutron, eddy-current, and X-ray. Non-destruction testing by using X-ray is particularly the most useful technique to inspect with high resolution. Therefore, the NDT with high energy X-ray source is widely used for inspection of heavy structures and defect in the devices [1,2].

In this paper, the constructed 15 MeV NDT system based on S-band LINAC at the Radiation Equipment Research and Fabrication Center in Advance Radiation Technology Institute (ARTI) is shown and described about the RF conditioning and electron beam characteristics.

2. Methods and Results

2.1 15 MeV NDT System

Figure 1 (a) and (b) show the three-dimensional modeling view and installed equipments of the 15 MeV NDT system at the Radiation Equipment Research and Fabrication Center. The 15 MeV NDT system is composed of X-ray generator with high energy based on S-band linear accelerator, 2D and 3D X-ray detectors,

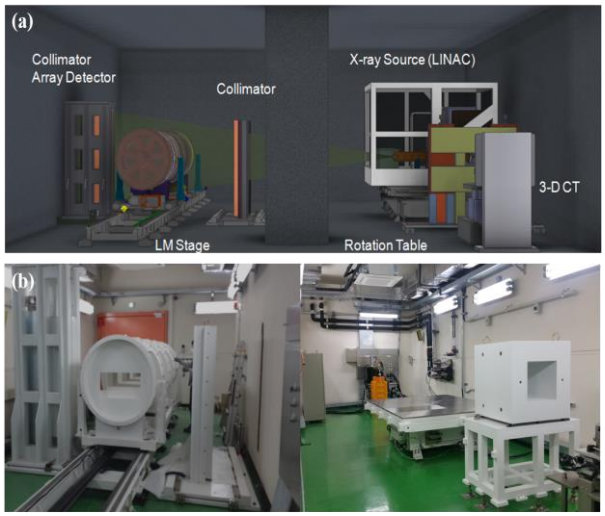


Fig. 1. (a) Three-dimensional modeling view (top) and (b) photograph showing constructed 15 MeV NDT facility (bottom).

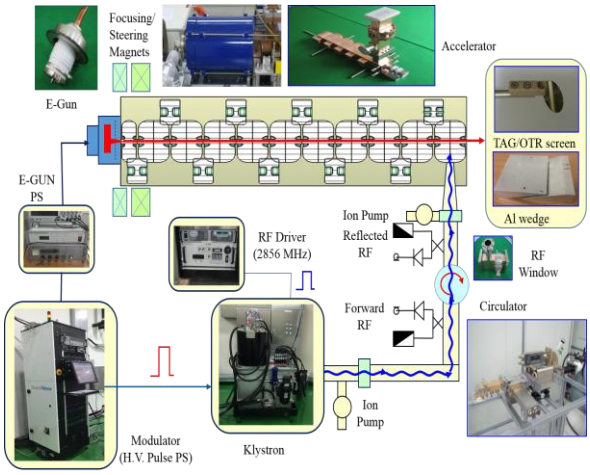
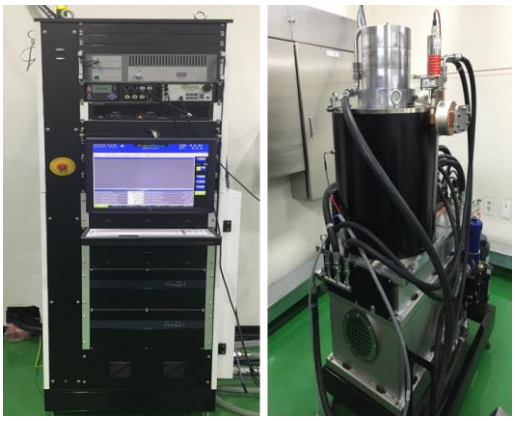


Fig. 2. Overall schematic diagram of X-ray generator in 15 MeV NDT system.

Table I: Main driving parameters of the linear accelerator

Beam energy	15 MeV
RF frequency	2856 MHz
Klystron output power	7.5 MW
Pulse width	6 μ s
Repetition rate of RF pulse	100 Hz
Electron gun high voltage	14 kV
Electron gun current (nominal)	1.6 A



(a) (b)

Fig. 3. (a) Modulator and (b) Klystron of 15 MeV NDT system.

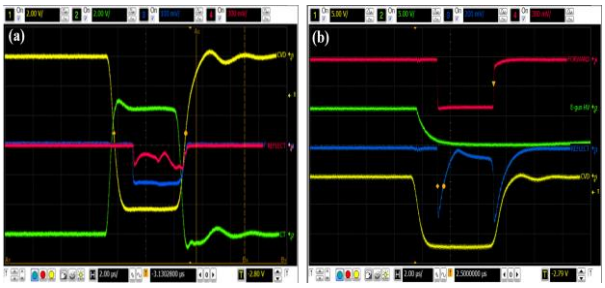


Fig. 5. Variation of reflected waveform at beginning (left) and after 168-hour RF conditioning (right).

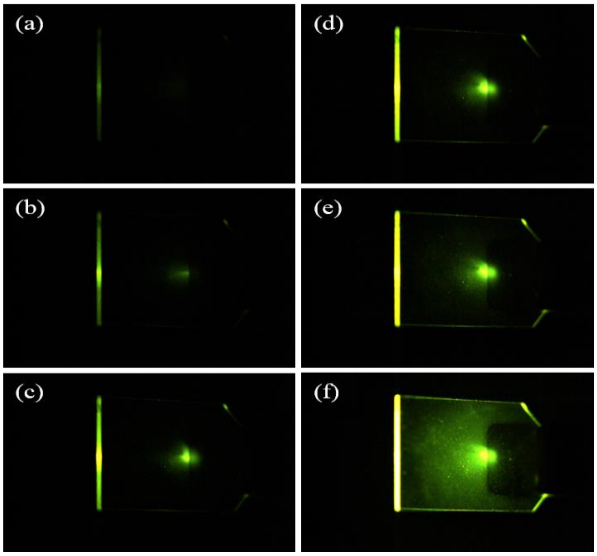


Fig. 6. Comparison of intensity and spot size of electron beam related to the RF input power: (a) 1.9 MW, (b) 2.1 MW, (c) 3 MW, (d) 4 MW, (e) 5 MW, and (f) 6.5 MW

and transport device capable of moving and rotating inspecting objects as shown Figure 1.

As shown in Figure 2, the X-ray generator of 15 MeV NDT system is composed of an electron gun, an accelerating structure, solenoid and steering magnet for beam focusing and deflecting, a modulator and klystron for RF feeding, etc. The beam energy of NDT system based on the S -band (2856 MHz) is 15 MeV and the more detail specifications of main driving parameter are shown in Table I. The operation temperature of system is 30 degree.

The RF power generator of NDT system is provided by a 7.5 MW E3771A klystron operating at 2856 MHz, and is driven by high voltage pulse modulator combination with a 1:43 pulse transformer, as shown in Figure 3. The peak and average power of modulator are 18.6 MW and 25 kW, respectively

2.2 Conditioning & Measurement of electron beam

The conditioning of cavity then commenced with a baselines 1×10^{-7} torr and with a RF pulse width set to 1 μ s and a repetition rate of 1 Hz. The RF power fed into the LINAC was then gradually increased, whilst monitoring the vacuum level [3,4]. Figure 5 (a) and (b) show the variation of reflected waveform before and after conditioning. As shown in Figure 5 (a), the reflected waveform (red line) was unstable. However, the reflected waveform (blue line) was considerably improved during RF conditioning period as shown in Figure 5 (b).

Figure 6 shows the changes in the electron beam image of YAG screen related to the RF input power. The intensity of electron beam was increased in proportion to an increase in the RF input power. Also, the spot size of electron beam was the same tendency.

3. Conclusions

The 15 MeV NDT system based on S-band LINAC has been successfully constructed at the Radiation Equipment Research and Fabrication Center in ARTI. To reduce of arcing in the linear accelerator caused by high RF power, we conducted RF conditioning and confirmed spot size and intensity of electron beam related to RF input power.

Further investigation will be conducted for optimization of 15 MeV NDT system in order to generate stable X-ray beam and find optimized operating condition to increase dose rate and to acquire 2D/3D X-ray images with good quality.

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