DON BOSCO INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION

Report on " Industrial Visit to SAMEER"

Topic: Industrial Visit to SAMEER (Society for Applied Microwave Electronic Engineering and Research)

Speaker: Mr. Sharad Chauhan, Mr. Arzaan

Date & Time: September 07, 2016

9:30 a.m. - 1:30 p.m.

Venue: SAMEER, Kharghar

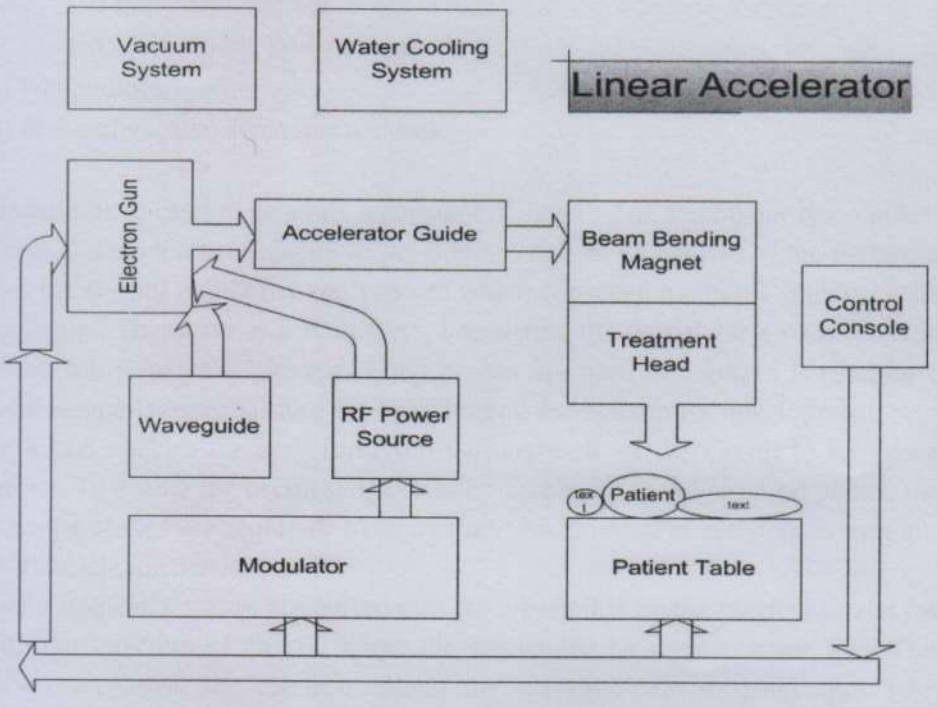
Audience: Students of BE - EXTC

Description:

Sir began the session with a presentation which explained the various projects SAMEER has been working on for the past years. One of the important ones was the 'Linear Accelerator for the Treatment of Cancer'.

It mainly consists of a mechanical console, a control console, CNC copper, dosemetry, brazing furnace, baking oven that has 2 pumps - namely the rotor pump and the turbo pump.

Block diagram:



A linear accelerator is a device that uses high Radio-Frequency(RF), electromagnetic DC waves to accelerate charged particles (i.e.electrons) to high energies in a linear path, inside a tube like structure called the 'accelerator waveguide' which then allows these electrons to collide with a heavy metal target. As a result of these collisions, high energy X-Ray (Photons) are produced from the target. These high energy photons will be directed to the patient's tumor and shaped as they exit the linac to conform to the shape of the tumor. Radiation can be delivered to the tumor from any angle by rotating the gantry and moving the treatment couch.
The resonating cavity frequency of the medical linacs is about 3 billion Hertz(cycles/sec). This is the most common device to treat cancer with external beam radiation.

We were initially taken to the 'Chamber Room' where fabrication of the copper rings were done. In this method, the impure copper was deposited in a machine where the outer cover (impurities) were finely removed and it was made sure that there are no cracks or fingerprints present on these discs to ensure frequency matching and to avoid leakage. The shaping and the removal of impurities done in huge ovens was shown to us.
Sir also took us in the 'Clean room' where we were shown the various equipment namely:
a.) The Heat/Leakage Detector which was completely filled with the Helium inert gas as it has less atomic weight and can pass easily through leaks and is lighter in weight.
b.) A test bench which had the following equipments in it:

(i) An electron gun that generated a current of 0.26 microamperes

(ii) Pulse Transformer

(iii) Self - made grid and cathode

c.) Waveguides

d.) SF6 and vacuum separator window

Modulator is used to generate a constant dc level . The Modulator has a pulse forming network which stores electrical energy to provide flat topped DC pulses to the thyratron. This modulator uses the 6 - phase rectification process which consisted of bulky diodes, capacitors, inductors, regulators, Thyratron as a switch etc. For testing the modulator a resistive type network is used which functions as a klystron. Long probes are used and output is seen on oscilloscope. The oscilloscope is essential tool for fault finding for electronics development, repair or diagnostics work and enables the waveforms on various parts of the circuit to be viewed in a graphical format. To enable the oscilloscope inorder to connect to the required points, oscilloscope probes or scope probes are required. Inductors are used instead of resistors to save power upto 50% in distributed type networks.

Radio frequency waves are pulsed into the waveguide by the magnetron and this is synchronised with the injection of electrons into the waveguide by the electronic gun. The radio frequency waves accelerate the electrons along the waveguide to a speed approaching the speed of light.The X-ray beam is created when the electrons hit and interact with the tungsten target at the opposite end.

The **magnetron** controls the power and frequency of RF waves which determine the energy of the x-rays produced and is preferred for lower electron energies, 4 MeV to 6MeV linacs.

Accelerometer can be mounted in the gantry horizontally for high energy single or dual energy machines with klystrons. The microwave power produced in the klystron or magnetron is transported to the accelerator structure to accelerate the pulsed electron bunches. The digital accelerometer uses electron gun situated at the end of the waveguide. The electrons are produced by heating the tungsten filament within the cathode and then are injected into the waveguide which is filled with SF6. The number of electrons injected are controlled by temperature of filament.

The **waveguide** is a copper tube with the interior divided by copper discs or diaphragms, and is evacuated to a very high vacuum by an ion pump. The ejected electrons interact with the tuned microwave produced by the magnetron/klystron absorb energy and hence, are accelerated. A vacuum is created to ensure that the electron beam is not impeded by the other particles. The part of negatively charged electron beam is controlled by 2 sets of quadrapole magnets called steering coils that surround the waveguide. In addition to this, focussing coils help to further direct the electron beam .

The **water cooling system** provides thermal stability to the system and even allows many components in the Drive Stand and Gantry to operate at a constant temperature. The electrons

further travel through the flate tube where the beam is redirected towards the target. This tube has 3 sets of magnet surrounding it. As a result of this, the beam is positioned properly .

Most linacs have a device called a '**bending magnet**' to change the electron beam's direction. It does this by applying a magnetic field. The bending can be either through 90° or 270°. The problem of the 90° bend is that the pencil beam will smear and become '**chromatic**'. All the electrons will not have identical speeds when they exit the waveguide. On entering a magnetic field attempting to change the direction of flight by 90°, the faster electrons will bend less than the slower electrons and so the 'pencil' will now look decidedly oblong with all the slow electrons acute to the 90° angle and all the faster electrons obtuse to the 90° angle. This produces a spectrum of electron, hence the use of the term 'chromatic' which derives from the splitting of light into different frequencies by a prism. This effect is minimized by turning the beam through 270°. When turning the beam through 270°, the additional thing that happens is that the slower electrons take a tighter circle and the faster electrons take a wider circle. The combination of less speed and less distance and faster speed and more distance counter-balances, so that after a 270° turn, the faster and slower electrons arrive at almost the same time. The 'chromatic' effect has been removed, and the beam is described as '**achromatic**'.

Later, we were shown a room which accommodated the entire setup of the testing of the Thyratron called as the **'Thyratron Trigger Circuit'**.

The cost of Thyratron ranges from 25 to 35 lakhs hence, is tested before being used inorder to avoid damage. Testing equipment consists of transmitter, receiver(delay modulator) which are connected via fiber optic cable to minimize losses and even this cable provides isolation to prevent reverse noise. FPGA boards are used as microcontrollers as they are convenient to use.

2 probes are used and hence, 2 pulses of 1kV are generated with delay (60usec). The polarity of the pulse transformer is particularly important in this application to achieve fast rise times.

The output from the thyratron is observed on the digital oscilloscope. If the output is matched with desired output, the test is passed and thyratron can be used.

Towards the end of the session, Sir showed us the room where the entire setup of the linear accelerator was assembled together which costs around 80 crores. This setup was placed in a building having thick concrete walls in order to avoid the radiations from going out in the atmosphere.The actual working of the Linac is monitored in a room as the radiation from it might harm human health.

Event Photographs:

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