KARNATAKA RADIOLOGY EDUCATION PROGRAM

X RAY GENERATORS

An X Ray generator is the device that supplies electrical power to the X Ray tube.

It begins with a source of electrical energy.

The X-ray generator modifies this energy to meet the needs of X Ray tube.

The tube requires energy for two puposes

1. **To boil electrons from the filament**
2. **To accelerate these electrons from cathode to anode**

The X –ray generator has a circuit for each of the functions

1. **Filament**
2. **High voltage circuits**
3. **Timer mechanism to regulate the length of x-ray exposure.**

The x-ray generator mechanism continues with two separate compartments

1. **Console/ Contrl panel**
2. **Transformer**

1. **Console: Operator switches ON the machine, selects KVp ,mA, Expose button first initiates x ray process by heating the filament and then exposes. Timing mechanism terminates the exposure.**

TRANSFORMERS

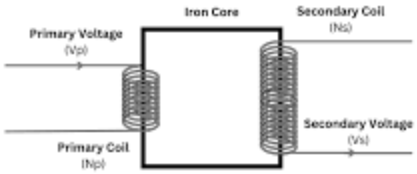
- a grounded metal box filled with oil.
Contains - low voltage transformer (filament circuit) - high voltage transformer (high voltage- a group of rectifiers circuit)
Contains circuits with potential difference as high as V. So immersed in oil, which acts as a insulator.

Defn: a device that either increases or decreases the voltage in a circuit.

Incoming Power supply- 230 V, 60 hz AC.
Filament heating requires- 10 V
Electron acceleration requires- b/w and V
So transformers are used to change the voltage of incoming power supply to appropriate levels.

Design : Two wire coils (copper) wrapped around a closed core.
Core- made of tightly clamped thin sheets of special iron alloys separated from each other by thin insulating layers- to prevent eddy currents.
Primary circuit
Secondary circuit

WORKING OF TRANSFORMER
PRINCIPLE:
When current flows through the primary coil , it creates a magnetic field within the core, and this magnetic field induces a current in the secondary coil.
Current flows through the secondary coil only when the magnetic field is changing (increasing/ decreasing).
No current flows when the magnetic field in core is in a steady state.



First law of transformers
The secondary voltage (Vs) is related to the primary voltage (VP) by the number of ratio of the number of turns (N) in each coil, such that:
Vs/Vp = Ns/Np

Second law of transformers
The product of voltage (V) and current (I) in the two circuits are equal (thereby meeting the Conservation of Energy principle).
VpIp = VsIs

This means that a voltage increase in one circuit must result in a proportional decrease in current (and vice versa).

Types
step-up transformer - secondary coil has more turns than the primary coil (Ns > Np)

step-down transformer - secondary coil has less turns than the primary coil (Ns < Np)

AUTOTRANSFORMER

The autotransformer has a single winding and sends voltage to the filament and high voltage circuit. The autotransformer, also called the variable transformer.

The working principle of an autotransformer is based on the principle of electromagnetic induction, where a fluctuating magnetic field induces a voltage in a coil. An autotransformer works by using a portion of the winding as the primary coil and another portion of the same winding as the secondary coil.

RECTIFICATION: Process of changing AC DC
Device that produces the change – RECTIFIER

RECTIFIERS:
Allow current to flow in only one direction.
High voltage rectifiers can be-
1. Vacuum-tube type- obsolete now
2. Solid-state type-
Present in most of modern day generators
Heart of a solid state rectifier is a semiconductor
(usually a piece of crystalline SILICON).

SEMICONDUCTORS
P-type silicon semiconductor - Impurity-Indium/Gallium/Aluminum
N-type silicon semiconductor - Impurity- Arsenic/Antimony

The process of forming a PN junction (diode)
Forward bias of a PN diode or Solid state Rectifier

The half-wave rectifier is a rectifier which is used for converting the one-half cycle of AC input to DC output.
A full-wave rectifier is a rectifier which is used for converting both the half cycles of AC input into DC output.

RIPPLE FACTOR
Variation in the voltage across the x ray tube expressed as a percentage of maximum value.
Ripple factor (%) = (Vmax –V min) X 100
Vmax

Three basic types of 3 phase generators
-Six pulse , six rectifier
-Six pulse, twelve rectifier
-Twelve pulse

THREE PHASE TRANSFORMERS
Three sets of primary and secondary copper windings
Windings arranged in two configurations-
DELTA or
WYE (STAR)

TRANSFORMER RATING The maximum safe output of its secondary winding.
Expressed in kilowatts.
If rating is exceeded, transformer may over heat and burn out its insulation and windings.

For 3 phase gen- kW= kV x mA 1000
For single phase- kW= kVx mAx 0.7
(As the voltage varies from 0 to some peak value in single phase generator, so to figure out the avg power an avg voltage , the R.M.S(root mean square) voltage is used i.e peak voltage in kV/√2=.707 peak)
Since the transfermer is drivig the X ray tube,the current is assumed to be fairly constant.
Used for comparing generators and when the generator is under load

GRID-CONTROLLED X RAY TUBES
In addition to two electrode of Xray tube here a third electrode is used to control the flow of electrons from fillament to target.
The third electrode is a focusing cup that sorrounds the fillament.,which helps to focus the electrons on the target.
In grid controlled tube the focusing cup can be electrically –ve relative to the fillament.
The voltage across the fillament grid produces an electric field along the path of the electron beam that pushes the electron closer together.
If the voltage is made large enough the tube current may be completely pinched off.a condition in which no electrons go from the fillament to the target.
The voltage applied between the focusing cup and fillament may therefore act like a switch to turn the tube on and off.
As the cup and fillament are closely placed small voltage is necessory to cut-off the tube current.

EXPOSURE TIMERS Control the length of an x-ray exposure.
Four basic types :
1. Mechanical timers- obsolete now
2. Electronic timers
3. Automatic exposure control -most commonly used
4. Pulse counting timers
Mechanical and electronic timers are subject to human error.The exposure time is selected on the basis thickness and density of tissue under exposure.If the estimation is incorrect there is improper radiographic exposure.

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