Fundamentals of Radio-physics

First Semester

Week 2-3 : The anode and Line-focus Principle

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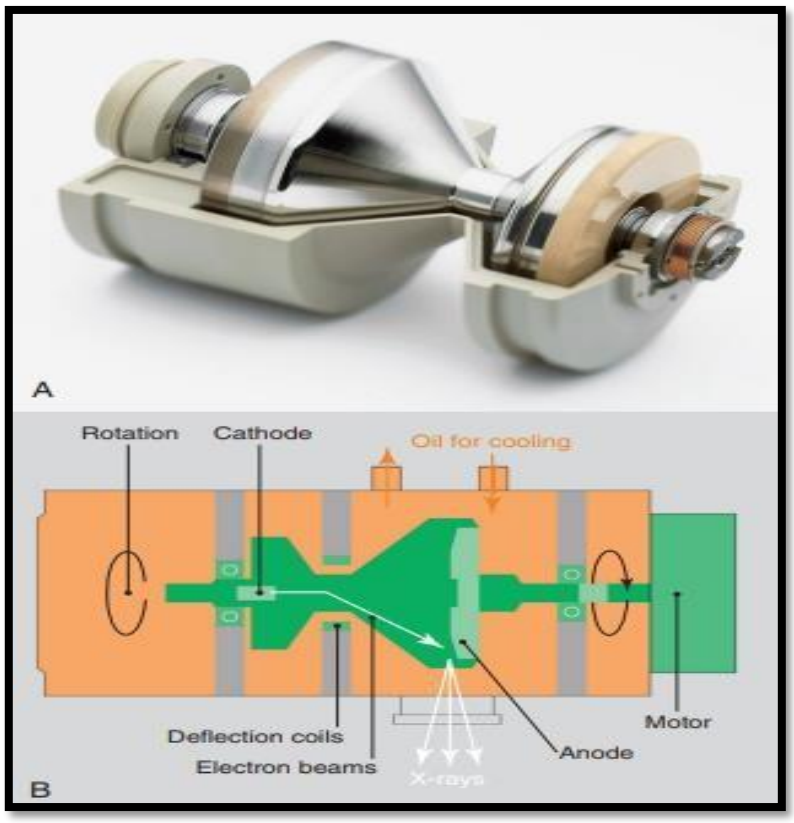
- **The anode** is the target electrode, consists of **stator and rotor** which is maintained at a positive potential
- **What is the purpose of anode?**

1. Serves as a target surface for the high-voltage electrons
2. The anode is an electrical conductor
3. The anode also must be a good thermal dissipater



This very high capacity x-ray tube revolves in a bath of oil for complete heat dissipation

The electron beam is deflected electromagnetically onto the anode. The cooling oil is in contact with the back of the anode, allowing optimum cooling.

➢ Structure

- Most x-ray tube **anodes** are **made of tungsten**
- The **high atomic number** of tungsten gives more efficient bremsstrahlung production compared to **lower atomic number** target materials.
- An alloy containing **tungsten and rhenium** is also **used because** the addition of 5-10% rhenium prevents grazing of the anode surface.
- **The body of the anode is made** of **materials** that are **light** and have a **good heat storage capacity**, like molybdenum and graphite.
- **Molybdenum** is also often **used as the target material** for anodes used in mammography **because** it has an intermediate atomic number (Z=42) and the produced characteristic x-rays are of energies suited for this purpose.

➢ Anode types

- **Stationary Anode**

1) Made of tungsten
2) 2-3 mm thick.
3) Embedded in large mass of copper
4) Consist of one filament
5) Triangular/ rectangular shape
6) Anode angle = 15-20^0

- **rotating anode** is a small metal disc (usually tungsten or copper) that receives the electron beam from the cathode and emits it as X-ray. The anode is positioned at an angle that will direct the X-ray beam into the arc of the C, where the subject of a given scan will be positioned.
- Made of tungsten or alloy of tungsten with Rhenium.
- Has beveled edge
- Angle of bevel is 6 to 20 degrees
- Speed of rotation is 3000rpm practically
- a tungsten disc rotates during an exposure, thus effectively increasing the area bombarded by the electrons
- the energy is dissipated to a much larger volume as it is spread over the anode disc.

➢Line-focus Principle

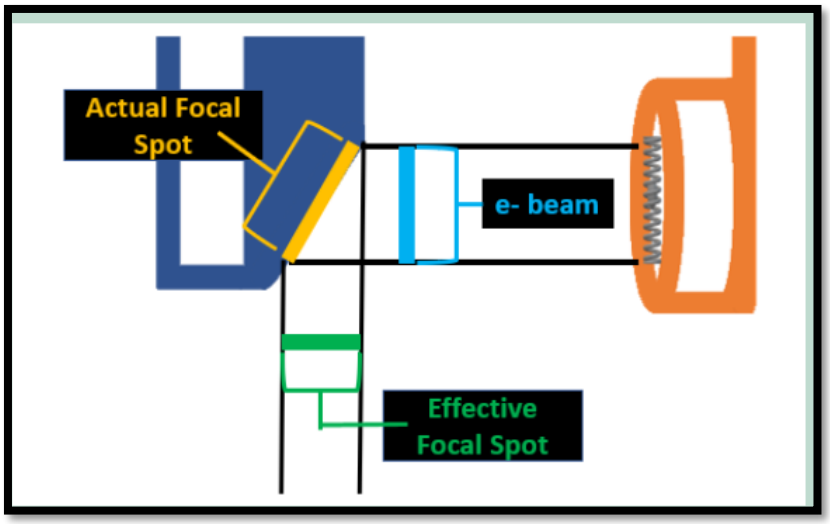
The line-focus principle describes the **relationship between the actual and the effective focal spots i**n an x-ray tube, where the electrons in the tube current bombard the target, and the effective focal spot, which is the same area as seen from directly below the tube.

Focal spot

The focal spot is the area of the target from which x-rays are emitted.

The effective target area, or effective focal spot size, is the area projected onto the patient and the image receptor

The actual focal spot size refers to the size of the area on the anode target that is exposed to electrons from the tube current. **It depends on** the size of the filament producing the electron stream.



 When **the target angle is made smaller**, the effective focal spot size also is made smaller.

 Diagnostic x-ray tubes have target **angles** that vary from approximately 5 to 20 degrees

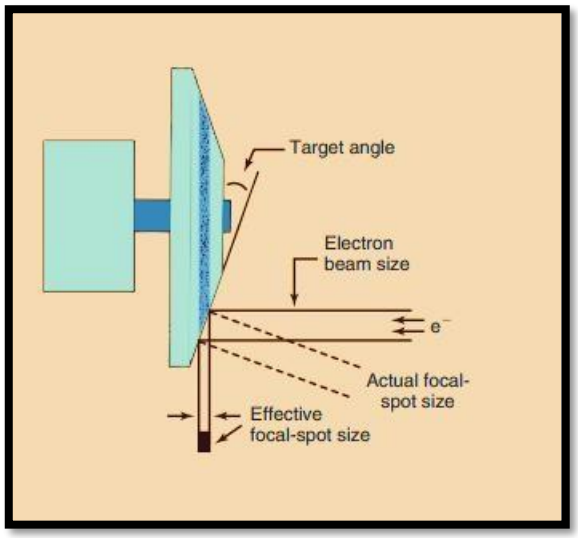
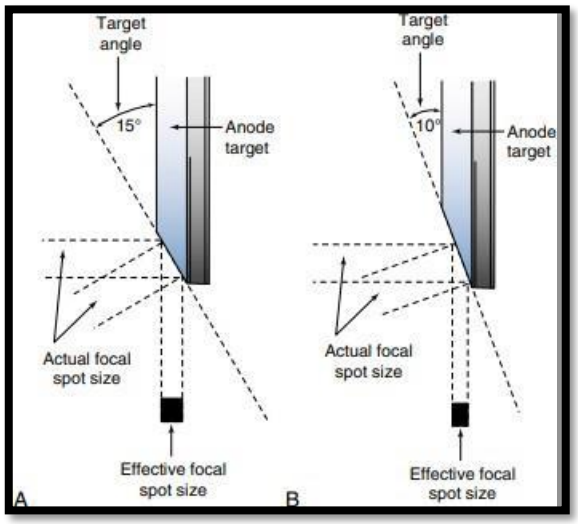
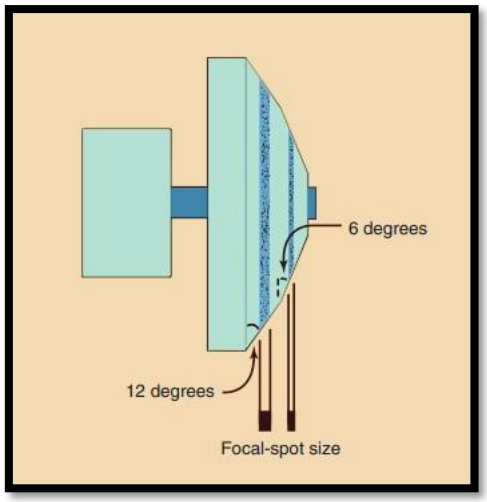


Figure 1: The line-focus principle allows high anode heating with small effective focal spots. As the target angle decreases, so does the effective focal spot size.



 Both actual focal spot sizes are the same, meaning that they can withstand the same heat loading. The smaller effective focal spot results in improved image quality.

Some targets have two angles to produce two focal spots. To achieve this, the filaments must be placed one above the other.



The effective focal spot depends on
1. Actual focal spot size
2. Target angle

➢ Focal Spot Size

-The only **advantage of a large focal spot is increased heat capacity.**
-The **large focal spot is used** when the machine must be operated at power levels that exceed the rated capacity of the small focal spot. The specified size of an x-ray tube focal spot is the dimensions of the effective or projected focal spot

➢ Anode Angle

- The actual relationship between focal spot width (and heat capacity) and the size of the projected focal spot is determined by the anode angle.
- he effective focal length of a focal spot can be calculated using:

Effective focal length = Actual focal length x sin θ

where θ is the anode angle
In practice the tube angles are typically between 6 and 20 degrees for an x-ray tube. So, the sine of theta is between 0.1 and 0.34.
- the track width and heat capacity are inversely related to anode angle.
-Although anodes with small angles give maximum heat capacity, they have specific limitations with respect to the area that can be covered by the x-ray beam.
- X-ray intensity usually drops off significantly toward the anode end because of **the heel effect**.