X-RAY TUBE HEATING

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Fundamental of Radio Physics

Fall semester

Week 9

Date: Dec. 16th 2025

Outline

- X-ray tube heating
- Factors affecting the heat capacity
- Focal spot area and size
- Rotating anode speed
- Anode body

Objectives

The student should be able to do the followings;

- Explain the x-ray tube heating
- Differentiate between factors affecting the heat capacity
- Draw focal spot area and size for x-ray tube
- Give reason of rotating the anode with speed
- Explain the anode body

X-ray tube heating

- The target-heating problem is caused by heat deposition that exceeds the rate of heat dissipation in the focal track of the rotating anode.
- The high rate of energy deposition in the small volume of an x-ray target heats the target to a very high temperature.
- A target should have high thermal conductivity to transfer heat rapidly to its surroundings.
- A rotating anode increases the volume of target material that absorbs energy from impinging electrons, thereby reducing the temperature attained by any portion of the anode.
- The anode is attached to the rotor of a small induction motor by a stem that usually is molybdenum.
- Energy deposited in the rotating anode is radiated to the oil bath surrounding the glass envelope of the x-ray tube

Heat Capacity

- To determine whether the target of an x-ray tube might be damaged by a particular combination of tube voltage, tube current, and exposure time,
- The target-heating problem is caused by heat deposition that exceeds the rate of heat dissipation in the focal track of the rotating anode.
- Heat capacity can be further improved by increasing the speed of anode rotation. Most rotating anodes revolve at 3400 rpm (revolutions per minute).
- The anodes of high-capacity x-ray tubes rotate

at 10,000 rpm.

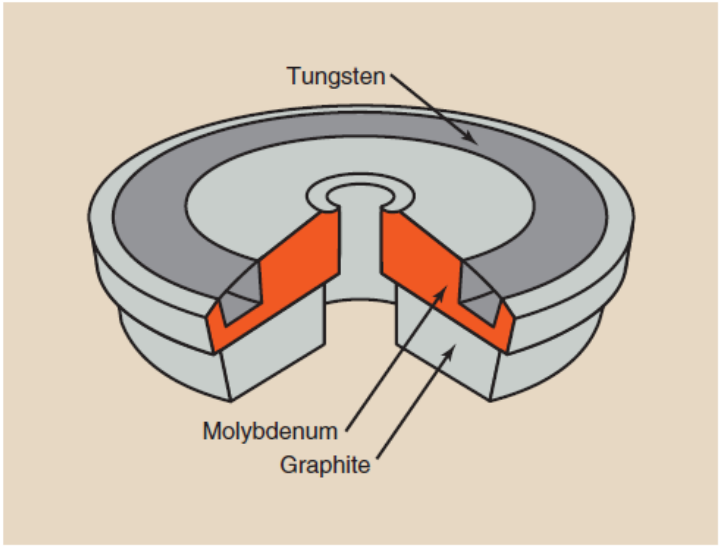
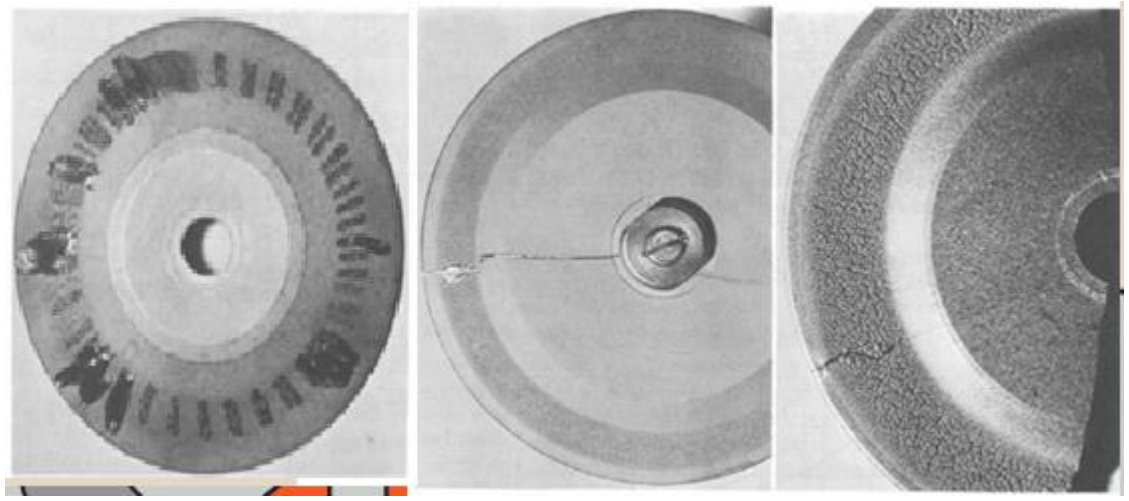


FIGURE 6-12 A layered anode consists of a target surface backed by one or more layers to increase heat capacity.

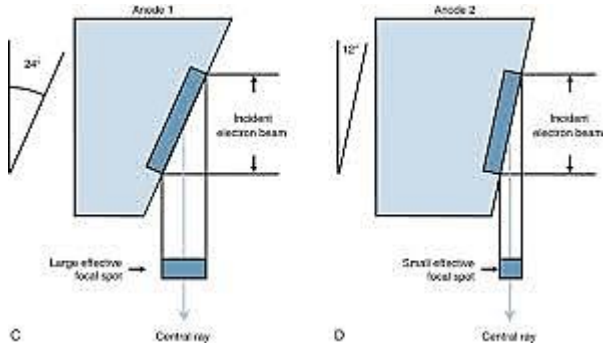


Rotating Anode

- The *rotating anode* x-ray tube allows the electron beam to interact with a much larger target area; therefore, the heating of the anode is not confined to one small spot, as in a stationary anode tube.
- the rotating anode tube provides nearly 500 times more area to interact with the electron beam than is provided by a stationary anode tube.
- The stem of the anode is the shaft between the anode and the rotor. It is narrow so as to reduce its thermal conductivity. The stem usually is made of molybdenum because molybdenum is a poor heat conductor.

Focal spot area and size

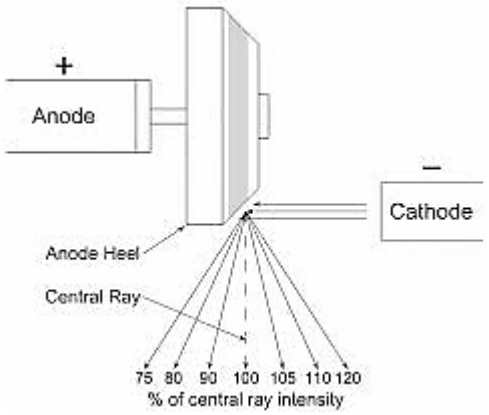
- The focal spot is the area of the target from which where the electron beam strikes the target anode and x-rays are emitted.
- Radiology requires small focal spots because the smaller the focal spot, the better the spatial resolution of the image.
- The effective target area, or effective focal spot size, is the area projected onto the patient and the image receptor.
- The advantage of the line-focus principle is that it improves spatial resolution and heat capacity.

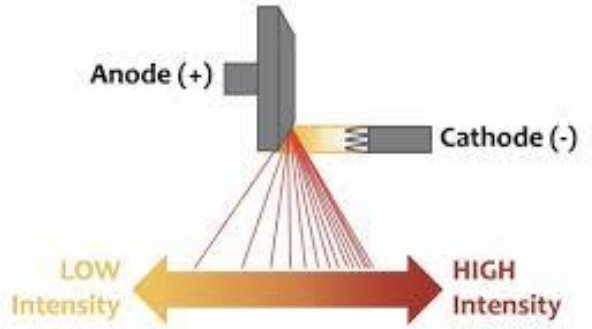


- **Smaller Spot**: used for better spatial resolution, sharper images ,and essential for fine details.
- **Larger Spot**: higher tube currents (more power/mA), allowing for shorter exposure times and greater heat dissipation on the anode.

Focal spot area and size

- The smaller the anode angle, the larger the heel effect.
- **Anode Heel Effect** is a phenomenon where x-ray intensity is higher on the cathode side and lower on the anode side of the beam, due to photons being absorbed within the angled anode itself. This results in non-uniform image density and requires careful positioning (thicker body parts towards the cathode) to optimize image quality.
- the radiation intensity on the cathode side of the x-ray field is greater than that on the anode side.





Anode body

Anode components:

1- Target

2- Anode Body/Base/Stem

3- Rotation Mechanism

- When the radiologic technologist pushes the exposure button of a radiographic imaging system, there is a short delay before an exposure is made. This allows the rotor to accelerate to its designated rpm while the filament is heated. Only then is the kVp applied to the x-ray tube. During this time, filament current is increased to provide the correct x-ray tube current

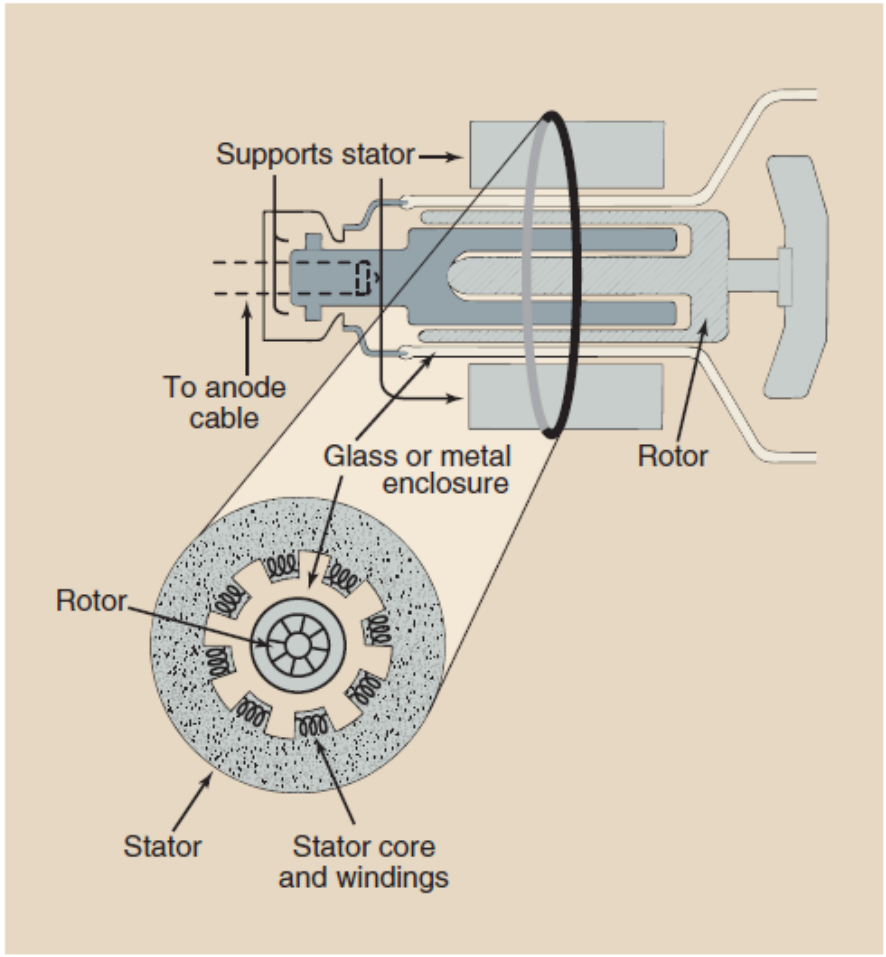


FIGURE 6-15 The target of a rotating anode tube is powered by an induction motor, the principal components of which are the stator and the rotor.

References

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