Betatron

Betatron is a type of particle accelerator and is used to accelerate electrons. It uses the electric field induced by a varying magnetic field to accelerate electrons to high speed in a circular orbit. The word betatron derives from the fact that high-energy electrons are often called β-particles. The betatron was the first important machine for producing high energy electrons.

It was developed in 1935 by Max Steenbeck in Germany to accelerate electrons, but the concepts ultimately originate from Rolf Widerøe, whose development of an induction accelerator failed due to the lack of transverse focusing.

Principle:

In a betatron, the changing magnetic field from the primary coil accelerates electrons injected into the vacuum torus, causing them to circle around the torus in the same manner as current is induced in the secondary coil of a transformer (Faraday's Law).

The stable orbit for the electrons satisfies

$$\theta_0 = 2\pi r_0^2 H_0,$$

where

θ_0 is the flux within the area enclosed by the electron orbit,

r_0 is the radius of the electron orbit, and

H_0 is the magnetic field at r_0.

In other words, the magnetic field at the orbit must be half the average magnetic field over its circular cross section:

$$\Leftrightarrow H_0 = \frac{1}{2}\frac{\theta_0}{\pi r_0^2}.$$

This condition is often called *Widerøe's condition*.

Applications

Some of the Applications are stated below:

- Provides high energy beam electrons of about 300 MeV.

- Used as a source of X-rays and gamma rays if electron beam is made to direct on a metal plate.
- The X-rays produced with the help of betatron can be used in industrial and medical fields.
- High energy electrons can be used in particle physics.
- Possible solar flare mechanism.
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Betatron Oscillation

Betatron oscillation are the oscillations of particles about their stable or equilibrium orbits in all circular accelerators. These are the stable oscillations about the equilibrium orbit in the horizontal and vertical planes.

Hill's Equation describes this type of traverse motion by :

$d2x/ds2+K(s)x=0$

Limitations

This type of a particle with maximum energy can impart is limited by the strength of the magnetic field due to the saturation of iron and by practical size of the magnet core.

It is actually a transformer, which acts as the secondary coil of the transformer. This accelerates the electrons in the vacuum tube around a circular path. It works under constant electric field and variable magnetic field.