Week 7 lecture #03

03-03-2023

HVE

• Liquid is used as Dielectric i.e, Transformer.

Properties of Liquid Dielectric:-

(i) Dielectric Strength.
(ii) Relative Permittivity.
(iii) Loss Tangent.

Dielectric Strength:

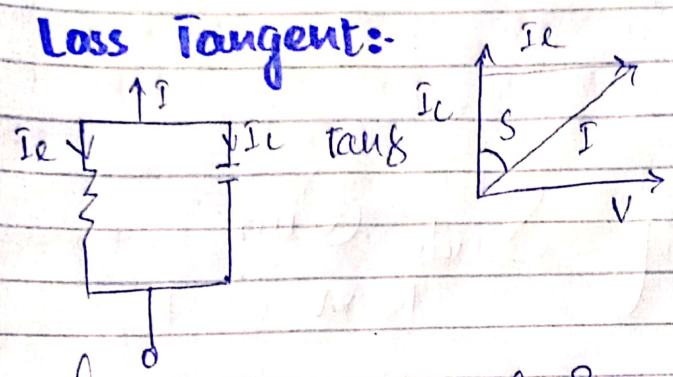
Maximum Voltage
Dielectric breakdown.

Relative Permitivity:

$\varepsilon_r = \varepsilon / \varepsilon_0$ → Free space
Permittivity of material

↳ Property of a material due to which it opposes external field.

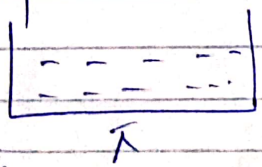
Loss Tangent:



Signal loss as signal Propagate down the transmission line. (**electrical conductivity**)

Basic Properties of Insulating oil:

Viscosity (fluid resistance to flow)
Thermal Stability. (resist breaking under heat stress)
Density and Specific Gravity.
Flash point → The lowest temperature at which liquid will form a vapour in the air near its surface. that will flash on briefly ignite to exposure to an open flame.



→ Pour Point

Note:

If loss tangent is more than zero it is easier of understanding the power loss
loss tangent should be of loss value

loss tangent → Angle b/w current and voltage.

Pour Point: Pour Point is a temperature at which liquid will become solid

Impurities Present in Liquid:

i) Fine Water Droplets and water Vapours:
ii) Dust
iii) Carbon and sulphur ion
iv) Dissolved gases

Breakdown in Pure Liquid Dielectric:

Thermionic and (Field Emission) — external field from Die ice are of liquid and % of and gas

↓

Temperature is so high that electron emits and come in ~~solid~~ liquid (T → 1500°C). if external field is apply ~~there~~ to electrode so that the charges of liquid that attracts the electrodes of winding.

Knogeous inel

Monday
06-03-23

LECTURE 8.1

Why we are learning breakdown?
↳ short circuiting in high voltage is important.
So we are studying breakdown.

Why liquid is more physible in breakdown?

↳ Dielectric strength of liquid is more.
Every liquid has different characteristics.
↳ Dielectric breakdown is more.
↳ High Permittivity.
↳ High ability of opposing Electric field.

Loss Tangent → 90° if $\tan 90° = 0$ Electric conductivity is zero.
↳ if electric conductivity occur then current will flow and breakdown occurs.

Liquid
- Pure
- ~~chemical~~ commercial liquid.

NOTE:- Avalanche breakdown is occur in Pure liquid.

- If temperature is too high then electron come in Dielectric the electron reach at the electrode and +ve at the surface of Dielectric then these electron gain Energy from the external field. and collision start and further electron and +ve charges.

Region of applying External Field:-

↳ 3 Region.

Breakdown in Commercial Liquid:-

(1) Breakdown due to Solid Particle.

If solid Particle is in Liquid Particle
- We don't know no. of particles.
- We don't know size of particles.

ε_2 = Permittivity of Solid
ε_1 = Permittivity of Liquid.
$\varepsilon_2 > \varepsilon_1$

When we applied External field, particle will polarize and for of attraction occur on particle and take solid Particle in stronger electric field, by this force, solid particle reach up of electrode. If particles are more they will accumulate there and both electrodes will short and breakdown occur.

NOTE
یہ سارے ذرات جمع ہو جائے گے اور جتنے زیادہ ذرات ہوں گے اتنا ہی Breakdown occur ہو گا۔

If Particles are more then breakdown will also be more.

NOTES

• Local breakdown occurs in b/w electrodes

In commercial liquids, the presence of solid impurities can not be avoided.

Permittivity of these particle ε_r will be Different from Permittivity of liquid ε_1.

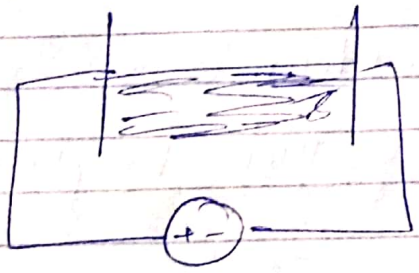
When the field is applied, experience a force $F = \frac{1}{2} \frac{\varepsilon_r - \varepsilon_1}{2\varepsilon_r + \varepsilon_1} \text{grad } E^2$

If $\varepsilon_r > \varepsilon_1$ the Particle get Polarized then force will move the Particle along the region of stronger field.

What a particle reach either electrode, its outward tip will act as extension to the electrodes.

Thus a stable chain of particles is formed, bridging the gap and causes breakdown between electrodes.

If there is only a single conducting particle between electrodes it will give rise to local field enhancement depend upon its shape.



If the field exceeds the breakdown strength of liquid, local breakdow will occur near the particle and will result in the formation of gas bubbles which may lead to Breakdown to liquid.

09-02-23 LECTURE 8.2

Breakdown due to liquid globule:

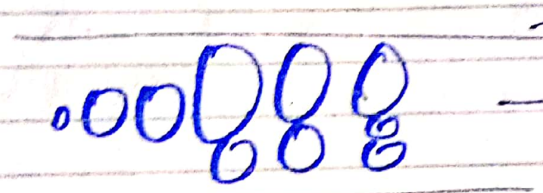
Consider a non-polar liquid globule of Permittivity ε_r is immersed in a liquid of permittivity ε_1 and the gas is subjected to an electric field, it will elongate in the direction of field.

Expression for Critical Field

$$E_c = 48.7 \sqrt{\frac{S}{\rho_1 r}}$$

- S → Surface tension of the liquid.
- r → Radius of globule.

Breakdown will occur when globule become unstable and elongate rapidly reaching about two third of the gap and breakdown channel at the end of globule.



↳ Water drop being gradually elongate by electric field and ultimately cause Breakdown.

Breakdown due to gaseous bubbles:

Following processes might lead to formation of bubbles of gases in the liquid

(1) Change in temperature and Pressure
(2) Gas pockets exist on the surface of electrodes
(3) Due to irregular surface of electrodes Electric field in a gas bubbles.

$$E_s = \frac{3E_0}{2 + 1/\varepsilon_1}$$

- E_s → field in liquid on the surface of bubbles.
- ε_1 → Permittivity of liquid

→ When field E_1 become equal to the limiting field for gaseous ionization, a discharge will start to flow through the bubble.

→ This will results in gas formation through the decomposition of ion molecules and may lead to breakdown of gap.

→ When field E_b become equal to the limiting field for gaseous ionization, a discharge will take place through the bubble.

→ This will result in gas formation through the decomposition of oil molecules and may lead to Breakdown of gap.

24-02-2023 **Lecture #**

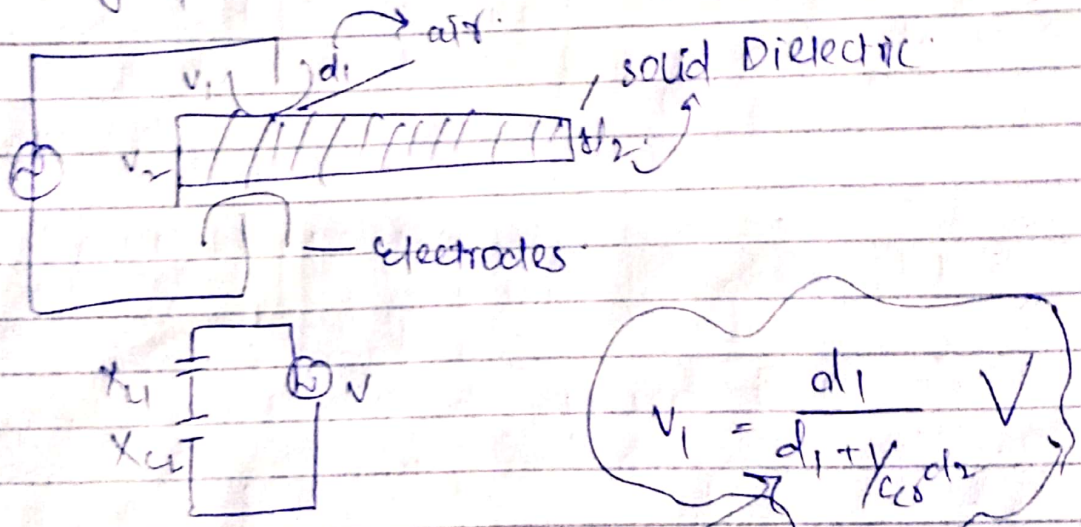
Mam Solid have more Dielectric Strength if it is less than leakage current start flowing.

Breakdown Due to trees and Tracking:

→ Consider a system of solid Dielectric having a conducting film. Some contaminations in the form of moisture as dust particle will get Deposited on the form of insulation and form a conducting film.

↳ The leakage current starts to flow through the conducting film. The current heats the moisture and conducting film separates due to drying.

Tracking is the formation of Permanent conducting path across the surface of insulation



$$V_1 = \frac{d_1}{d_1 + \frac{1}{\epsilon_0} d_2} V$$

Voltage across the air gap.

$$V_1 = \frac{X_{C_1}}{X_{C_1} + X_{C_2}} \times V$$

$$= \frac{1/\omega C_1}{1/\omega C_1 + 1/\omega C_2} \times V$$

$$= \frac{1/\omega C_1}{C_2 + C_1/\omega C_1 C_2} \times V = \frac{C_2}{C_1 + C_2} \times V$$

$C_1 = \epsilon_0 A / d_1$

$C_2 = \epsilon_0 \epsilon_r A / d_2$

$$= \frac{\epsilon_0 \epsilon_r A / d_2}{\epsilon_0 A / d_1 + \epsilon_0 \epsilon_r A / d_2} \times V$$

Electrical Breakdown in Solid Dielectric / Air

Breakdown Due to internal Discharge:

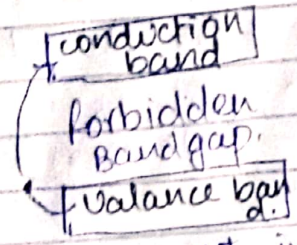
Pre Req.: 11th or 12th Physics.

27-02-2023

HVE

The intrinsic breakdown is classified into two types.
1. Electronic Breakdown
2. Avalanche Breakdown

Electronic Breakdown: The presence of free electron is responsible for breakdown of solids dielectrics



↳ These Electron present in Solid Dielectric will gain sufficient energy from the applied field to cross the forbidden band from valence band to conduction band. When this proceed continously more and more electrons enter into conduction band and eventually it leads to the breakdown.

AVANLACHE BREADOWN:

↳ Similar to the breakdown of gases due to commulative ionization.

↳ Under the influence of applied field, these electron along with the already present electron make ionization collision, resulting in Multiplication of electrons. When electrons are liberated from neighbouring atoms the result in the formation of positive ion which are fixed in the lattice.

↳ These electrons are reach the anode and get absorbed leaving behind a trails of positive ion along the path of ionization.

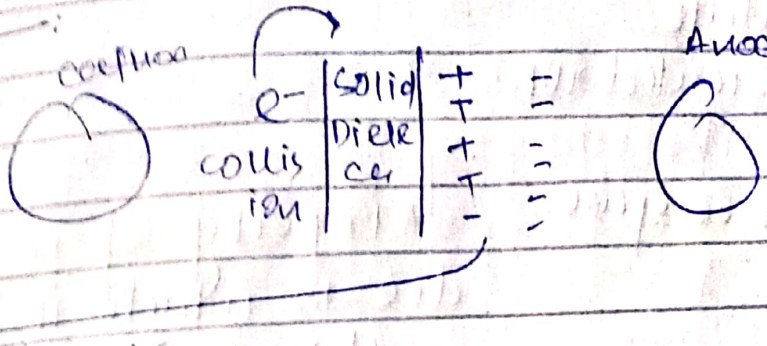
↳ This produce a low resistance path b/w the electrodes. These result in short circuit.

intensity

Time

① High electric field.
② Breakdown Depends on no. of electron
Very short Breakdown.

Avalanche:



In solid dielectric
• Due to collision, increase in electrons and the ions.

Breakdown of Solids Quiz
Next week.